



**HAL**  
open science

## Grass strips in the CAP reform: from scientific results to policy making, the loss of efficiency

Françoise Burel, A. Ernoult, Jacques Baudry, T. Delattre, A. Javelle, P. Kindlmann, J. B. Pichancourt

### ► To cite this version:

Françoise Burel, A. Ernoult, Jacques Baudry, T. Delattre, A. Javelle, et al.. Grass strips in the CAP reform: from scientific results to policy making, the loss of efficiency. 7. IALE World Congress, Jul 2007, Wageningen, Netherlands. hal-01458450

**HAL Id: hal-01458450**

**<https://hal.science/hal-01458450>**

Submitted on 4 Jun 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**25 years of Landscape Ecology: Scientific Principles in Practice**

**Part 2, Theme 6-11, Workshops**

**Proceedings of the 7<sup>th</sup> IALE World Congress  
8 – 12 July Wageningen, The Netherlands  
July, 2007**

**Editors: R.G.H. Bunce, R.H.G. Jongman, L. Hojas and S. Weel**

ISBN 978-90-78514-02-2

This publication should be cited as follows:

Bunce, R.G.H., Jongman, R.H.G., Hojas L. and Weel S. (Eds) 2007. 25 years of Landscape Ecology: Scientific Principles in Practice. Proceedings of the 7<sup>th</sup> IALE World Congress 8 – 12 July Wageningen, The Netherlands, IALE Publication series 4

Published by IALE,

This publication has been made possible with support of the Dutch Ministry of Agriculture, Nature and Food Quality, The Dutch Ministry of Spatial Planning and Environment, Alterra, Wageningen UR, ArgoBecas (Spain)

This publication is available from IALE:<http://www.landscape-ecology.org>

Price: € 40 for members including handling and mailing

Price: € 50 for non members including handling and mailing

Cover drawing: Bob Bunce

The cover drawing is a model landscape designed to show the Congress themes as follows:

Theme 1: The landscape contains policy issues e.g. wind power , urbanization and tourism.

Theme 2: Urban areas, industrial development and motorways are all present.

Theme 3: Agriculture dominates in the centre of the drawing with the motorway causing fragmentation Urban development and tourism are also involved.

Theme 4: There is a large lake with a river flowing into it.

Theme 5: Monitoring is needed to follow changes taking place.

Theme 6: The mountains have tourist pressures and High Nature Value land.

Theme 7: Many changes are taking place e.g. the construction of a ski resort.

Theme 8: The power plant and the wind farm show the impacts of global energy demand.

Theme 9: Many planning issues are included e.g. urban expansion.

Theme 10: The motorway cuts through forests on the mid-slopes.

Theme 11: Forests are being conserved in priority areas

Cover design: Silvia Weel

Printed by Ponsen and Looijen bv Wageningen, The Netherlands

No part of this publication may be produced or published in any form or by any means or stored in a database or retrieval systems without written permission of IALE

IALE assumes no liability for any losses resulting from the use of the research results or recommendation in this publication.





# Content

<b>Content</b> .....	<b>665</b>
<b>Introduction</b> .....	<b>659</b>
<b>Theme 6: Cultural landscapes and landscape management</b> .....	<b>661</b>
6.1 Symposium 11: Alternative principles for landscape Management .....	663
Conserving species within fragmented landscapes_F. Jopp .....	663
Maintaining diversity in developed landscapes. R.H. Gardner .....	665
Climatic shifts in fire regimes – new fire management strategies. G.J. Cary, R.J. Keane, M.D. Flannigan, R.A. Bradstock and K.J. King .....	666
The challenge of restoring disturbed landscape. A. Farina, D. Morri .....	668
Turning landscape conservation projects into biodiversity experiments. H.H. Wagner, E. Jedicke, V. Retzer, H.J. Boehmer .....	670
The use of land use modelling to assess landscape pattern change.P.H. Verburg, K.P. Overmars, A. Veldkamp.....	672
6.2 Symposium 20: Landscape diversity and biological diversity cultural landscapes .....	674
An Analysis of the Architecture of Water and Land Composition in Persian Gardens. A. Shahcheraghi.....	674
The evolution of agrarian practices and its effects on the structure of the enclosures landscape in the Alt Empordà (Catalonia, Spain). A. Llausàs, A. Ribas, D. Varga, J. Vila .....	676
Spatial and temporal relationship between forest spaces that contain Shinto shrines and topographical parameters in central Tokyo, Japan. N. Fujita, Y. Kumagai .....	678
Continuity and discontinuity of rural landscapes-with some consideration to Poland. B. Bożętka .....	680
Pastoral landscapes of the North Caucasus under transition time. R. Gracheva, E. Belonovskaya .....	682
Land use and land cover change in Olzinelles valley, Montnegre, NE Spain (1924-2006). Linking land abandonment to changes in stream biodiversity. I. Otero, M. Boada, A. Badia, S. Piqueras .....	684
The main principles of formation and evolution of structure of cultural-historical landscapes of Central Russia. V.A.Nizovcev .....	686
Does history really matter? Plant species richness in different fragmented landscapes. S. A. O. Cousins .....	688
Can we design transitions in agricultural landscape to sustain ecological processes? J. Baudry, F. Burel, D. Marguerie .....	690
Cultural landscape of the Carpathians and the value of landscape and diversity. J. Oszlányi ..	692
Terrestrial islands of non-reclaimed industrial deposits: plant species diversity and cultural landscape. P. Kovář.....	694
Diversity of semi-natural grasslands in a changing rural landscape. L. Halada.....	696
Managing landscape diversity in Northern Portugal. M. T. Andresen .....	698
Adopting the precautionary principle in designing and managing NATURA 2000 – areas. O. Bastian .....	700
The Swiss agri-environmental programme and its effects on selected biodiversity indicators at different scales. P. Jeanneret, S. Aviron, S. Birrer, S. Dreier, F. Herzog, L. Pfiffner, T. Walter ..	702
6.3 Symposium 21: Mountain Landscapes .....	704
Landslides, land-use change, and carbon dynamics in the Sierra de Las Minas, Guatemala. C. Restrepo, H. Perotto-Baldiviezo, M. Joseph-Haynes, M. Miller, and E. Castellanos .....	704
Landscapes, habitats and biodiversity in the Swiss Alps: changes, causes and prospects .....	706
J.Stöcklin, A. Bosshard, G. Klaus, K. Maurer, M. Fischer .....	706
European mountain zones. M.J. Metzger, R.G.H. Bunce, G. Hofer, T. Wrbka .....	708
Values and threats in Swedish Mountain landscapes – methods to assess landscape characteristics. M. Ihse .....	710
Assessing the role of transhumance in the sustainability of European mountain environments: the TRANSHUMOUNT project. M. Pérez-Soba, R.G.H. Bunce, F. Herzog, A. Gómez Sal, R.H.G. Jongman & I. Austad .....	712
Landscape’s diversity in the alpine belt of the Greater Caucasus. E.A. Belonovskaya .....	714

Landscape patterns in biogeographical mountain regions: an approach from the natural protected areas of the Catalan Pyrenees. D. Varga, J. Vila, C. Barriocanal, A. Lertxundi, M. Saez, A. Llausàs & A. Ribas.....	716
6.4 Open Session 21: Fire and land management.....	718
Post-fire tree residual aggregates in boreal forest landscapes: an assessment of spatial patterns using IKONOS imagery. A. H. Perera and T. K. Rimmel .....	718
Fire impact on the northwestern Patagonia grasslands. L. Ghermandi, S. Gonzalez, J. Franzese, M de Torres Curth, P. Parodi.....	720
Using functional traits to assess bee responses to fire at multiple scales. M. Moretti, B. Pezzatti, F. Zanini, S. Potts, F. de Bello .....	722
Do soil or vegetation processes control spatial pattern during succession following recurrent wildfires in Mediterranean shrublands? M.C. Cobo, H.H. Wagner, J.A. Carreira, M.W. Palmer .....	724
Historic and current fire regimes in the Great Xing'an Mountains, northeastern China: Implications for long-term forest management. Y. C. Yuman Hu, R. Bu, Y. Li, H. Chen .....	726
6.5 Open Session 22: Landscapes, geology and soils.....	728
Does soil erosion necessarily decrease regional net ecosystem carbon balance? - Lessons from multi-scale analyses of a crop-pasture transition belt in northern China. Q. Gao, M. Yu, H.M. Xu, Y.H. Liu, H.K. Jia, X.S. Zhang .....	728
The structure of East European plain as a geosystem forming factor. I.P. Kotlov, Y.G. Puzachenko .....	729
Formation of landscape-geoecological systems in Western Europe. E.P. Romanova .....	731
Geochemical structure and landscape diversity. M.K. Chartko, A.A. Karpichenka, P.V. Zhoomar .....	733
6.6 Posters .....	735
Cultural landscape's temporality vs. durability: village's biographies in Latgale (SE Latvia). A. Zariņa, I. Liepiņš .....	735
Relationship between socio-economic and natural dynamics in a Protected Natural Area (Parque Regional de la Cuenca Alta del Manzanares, Madrid, Spain). P. Fernández-Sañudo, N. López Estébanez; M.J. Roldán Martín, P. De las Heras .....	736
Relict agricultural ecosystems of the East European Plain. O.N. Trapeznikova .....	737
Drought and Desertification Management in Nigeria; An overview. Andrew I. Ayeni.....	738
Potential of restored landfill sites for biodiversity conservation in the UK and its context to landscape.. M.L. Rahman, D. McCollin, J. Ollerton.....	739
A framework of land use change and suitability assessment: towards effective land allocation decisions in northern Akwa Ibom State, Nigeria. U. J. Ituen .....	740
Location of ecological borders for a zone of the river landscape between Bassano del Grappa and Tezze sul Brenta. Italy. G. Caravello, B. Pivotto .....	741
Consistency in livestock grazing intensity classification by local experts and a livestock grazing suitability index. J. Bemigisha, E.J.M Carranza, V. Retsios, M. McCall, A. K. Skidmore .....	742
The analysis and evaluation of forest-tundra landscapes of Western Siberia (on example Urengoy gas field area). D.M. Marinskikh .....	743
The factors that affected forest landscape change of the World Heritage Shimogamo Shrine, Kyoto, Japan after the Middle Ages. A. Imanishi, S. Yoshida, J. Imanishi, Y. Morimoto .....	744
Mountain landscape degradation caused by landslide scars and forest hydrology rehabilitation: Tijuca National Park, SE-Brazil. A. B. Negreiros, A.L. Coelho Netto .....	745
The significance of soil seed bank for vegetation restoration in abandoned croplands on the hilly-gullied Loess Plateau. Juying Jiao, Wenjuan Bai, Mitchley Jonathan.....	746
What relations between a typical product and its landscapes ? A typology of landscapes on the saint nectaire cheese labels. L. Ménadier .....	747
Examination of the hydrology-soil-plant relations, in correspondence with climate change and effects of nature conservation measures on the vegetation on the Galgahévíz peaty meadow Hungary. M. Vona, Cs. Centeri, A. Barczy, E. Falusi, K. Penksza.....	749
Long-term wind erosion on sandy soils in northern Germany and its impact on soil heterogeneity and productivity. M. Bach, R. Duttmann .....	750
Structure of a southern taiga landscape in the border zone of the Wurm glaciation. D.N. Kozlov, M.Y. Puzachenko, M.V. Fedyaeva .....	751
Landscape structure of slopes along the Yangtze River, China. M. Fujihara, K. Hara, M. Tomita, Y. Zhao, Y. Yang, L. Da.....	752
The role of sacred space in Japanese landscapes. K. Short, N. Kamagata, K. Hara .....	753

Is bamboo landscape necessary in Japan? – cultural and ecological examinations. S. Suzuki and N. Nakagoshi .....	754
The Characteristics and Function of Dangsang Forests near seashore of South Coast in Korea. Jai-Ung Choi, Dong Yeob Kim.....	755
Landscape management in the mirror of historical land use coherencies, B. Engstová, V. Petříček.....	756
The roles of isolated trees for biological conservation in human-dominated landscapes. M. Yasuda and F. Koike .....	757
The Picos de Europa Mountains, north-west Spain, an inspiration to non-specialist students to study living cultural landscapes. N.T. Dykes, H.E. Prince, R.P. Lemmey, R.G.H. Bunce.....	758
Semiautomatic delineation of landscape types in the alpine region. E. Szerencsits, B. Schüpbach, H. Conradin, A. Grünig, T. Walter.....	759
Methods of landscape indication for the recognition of soil cover from multispectrozonol space images. S.H. Myshliakou .....	760
Complementary pedological and palaeoenvironmental examination of the buried soil profile underneath the Lyukas-halom kurgan. Á. Pető, K. Joó and T. Bucsi.....	761
Landslide changing landscape in the mountainous rainforest of Rio de Janeiro, Brasil: scar recovery dynamic. A.A. Chirol, A.L. Coelho Netto.....	762
Forming of landscape structure on the south of Valday Hill. M.Y. Puzachenko, D.N. Kozlov, E.V. Siunova .....	763
The European Pond Conservation Network (EPCN). A. P. Hull, P. Nicolet, S. Angélibert , J. Biggs, R. Céréghino, B. Oertli , B. Sajaloli .....	764
Chillingham Park, Northumberland: conservation priorities. S.J.G. Hall, R.G.H. Bunce.....	765
<b>Theme 7 Assessment of landscape change .....</b>	<b>767</b>
7.1 Symposium 12: Land abandonment.....	769
Natural expansion of forests on abandoned farmland: effects of changing economy on land use D. Pettenella .....	769
Landscape change in the Western United States: the expansion of Pinyon-Juniper woodlands in Central Nevada. E. Lingua, P. Weisberg, R.B. Pillai .....	771
Land abandonment in Hungary and its effects on birds. J. Verhulst, A. Báldi .....	773
High resolution modelling of the spatial distribution of land abandonment in Europe under various scenario conditions. K.P. Overmars, M.M. Bakker, P.H. Verburg .....	775
Successional recovery of abandoned rice fields and its ecological effects in Korea. C. S. Lee .....	777
Where do all the trees come from? Land abandonment and forest regeneration in the Swiss Alps. N.E. Zimmermann, J. Bolliger, J. Gehrig-Fasel, M. Gellrich, F. Kienast, G.N. Rutherford .....	779
Secondary succession: interactions between plants and soil biota. P. Kardol, T.M. Bezemer, W.H. van der Putten .....	781
Recent secondary woodlands in a regional sample of Southern-Alpine abandoned landscapes: implications for restoration ecology and silviculture. T. Sitzia, A. Carriero, F. De Natale, P. Gasparini, A. Wolynski, F. Viola .....	783
A landscape level approach to integrate fire risk considerations in forest planning. J.R. González, M. Palahí, T. Pukkala.....	785
Forestry and environmental changes of Jebel Ed Dair area Kordofan region, Sudan. N. Dawelbait .....	787
Effects of land abandonment and restoration on plant species richness in Scandinavian rural landscapes. R. Lindborg .....	789
7.2 Symposium 13: Identification, assessment and management of landscape changes.....	791
In search for explanatory factors of land use change: An interdisciplinary approach in a case study area in Southern Portugal. A.M. van Doorn, M.M. Bakker.....	791
Driving forces of landscape change and their implications for landscape management. A.M. Hersperger, M. Bürgi .....	793
Discrepancies in scale between stratified sampling based landscape monitoring and CORINE land cover registration. G. Levin, J. Brandt, M. Olsen, E. Holmes .....	795
LIFESCAPE - YOUR LANDSCAPE; implementing actions to create functional European landscapes using landscape identity as an inspiration for economic development. L. Jones-Walters, R. Maessen, P. Nowicki, Y.R. Waarts.....	797
Simulating the sociometric analyses of landscape changes in GIS framework: An example of the selected town of Karachi metropolis. S. Qureshi, M. H. Arsalan and R. W. Coles.....	799
Management of landscape changes in Slovakia. L. Miklós, Z. Izakovičová.....	801



Landscape structure changes related to landscape character assessment and protection. Z. Lipský.....	803
The geoagronomic approach to rural landscapes management: a methodological path to characterize contemporary challenges. D. Rizzo, M. Galli, T. Sabbatini, E. Bonari.....	805
<b>7.3 Symposium 23: Concepts and methods of landscape change assessment .....</b>	<b>807</b>
Land-cover change and its impact on nutrient export variance. J.D. Wickham, T.G. Wade, K.H. Riitters etc.....	807
Concepts of landscape assessment and landscape security. F. Müller, G. Zurlini, K.B. Jones	809
Concepts and methods for interdisciplinary land-cover pattern assessment. K.H. Riitters, J.D. Wickham .....	811
Monitoring landscape spatial patterns: morphological concepts and biodiversity related applications. P. Vogt, M.R. Freire, C. Estreguil .....	813
Landscape Modelling and Landscape Scenarios – Challenges for Integration of Antroposphere and Biosphere Processes. R. Seppelt.....	815
Indicators for Multifunctionality Impacts in Landscapes. H. Wiggering, C. Dalchow, M Glemnitz, K Helming, K Müller, A Schultz, U Stachow, P Zander.....	817
Landscape change assessment: integration of remote sensing, GIS and spatial modelling concepts. T. Blaschke, S. Lang, E. Schöpfer, D. Tiede, L. Drăguț.....	819
Spatial correlograms and landscape metrics as indicators of land use changes. Ü. Mander, E. Uuemaa, R. Aunap, A. Kanal, J. Roosaare .....	821
Landscape monitoring and landscape change. W. Fjellstad, W. Dramstad.....	823
Source/sink patterns of disturbance and cross-scale effects as a template for environmental security assessment in a panarchy of social-ecological landscapes. N. Zaccarelli, I. Petrosillo, G. Zurlini, K. Riitters .....	825
<b>7.4 Symposium 24: Land use changes and ecological impacts .....</b>	<b>827</b>
Land Use Based Identification of Agricultural Factors for Improving Sustainable Land Resource Management in Northern Thailand - A Case Study in the Chiang Mai Province. Y. Jiang, D. Schmidt-Vogt, R.P. Schrestha.....	827
Rural landscape changes and its effects on vegetation dynamics in Korea and Japan. J.-E. Kim, S.-K. Hong, N. Nakagoshi.....	829
The analysis of the landscape change of the marginal forestland around urban area A case study of Dadu Mountain in central Taiwan. Chyi-Rong Chiou, I-Chen Hsueh.....	831
Quantifying habitat loss of hygrophytes in regional scale as the base for nature restoration. M. Kamada, E. Harada, M. Ogawa, H. Mitsuhashi.....	833
Landscape ecological study on water demand and sustainable water resource management in relation to social development of Hiroshima city. A. Kikuchi, N. Nakagoshi, Y. Isozaki, T. Nagata .....	835
Cause and consequence of landscape changes of island and coastal area in Korea. S.-K. Hong, J.-W. Park, and B.-S. Ihm .....	836
The environmental effects of different land use/land cover in the loess hilly area, China. L. Chen, B. Fu, J. Gong, W. Wei, Z. Huang .....	838
Agricultural landscape pattern and its spatial relationship with forestland in the state of Selangor, peninsular Malaysia. S.A. Abdullah, N. Nakagoshi .....	840
Assessing Impacts of Human Activities on Riparian Wetlands of the Yellow River in He'nan Province Using Remotely Sensed Data. D. Shengyan, L. Guofu.....	842
The Urbanised Avian Pondscape: How to Create a Balancing Bird Demand Model? Wei-Ta Fang .....	844
Hierarchical theory in the management of fragile subwatersheds --- a case study of Zhifanggou watersheds in hilly gullied Loess Plateau, China. Z.H.Kong, X.S.Zhang .....	846
<b>7.5 Open Session 3: Landscape Change Assessment .....</b>	<b>848</b>
Land use changes in politicized maps in an historical perspective: the example of Kohtla-Järve, Estonia. A. Printsman .....	848
Geo-hydroecological responses to historical and present day land use changes in the Middle Paraíba do Sul river valley: challenges for a sustainable landscape A.L. Coelho Netto, A.S. Avelar .....	850
Long-term changes within China's densely populated rural landscapes. E.C. Ellis.....	852
A Review of Methods Used to Visualise Landscape Change Patterns. E.A. Moylan .....	854
Landscape assessment of the Lower Dyje River area on the basis of individual natural landscape units as a possible source for sustainable management. H. Skokanova .....	856

Analysing the long term impact of landscape change on landscape structure and landscape functions in the national park region Saxon Switzerland. M. Neubert, U. Walz .....	858
Encouraging virtuous landscape change in cultural landscapes. P.H. Selman .....	860
The FORE-SCE model: projecting land use change using a scenario-based modelling technique. T.L. Sohl, K.L. Saylor .....	862
<b>7.6 Open Session 16: Changing land and map measurement.....</b>	<b>864</b>
Measuring urban concentration and land-use diversity in maps of simulated future land use. E. Koomen and J. Ritsema van Eck.....	864
Map comparison to assess the prediction of vegetation response to El Niño in Southern Africa. R.G. Pontius Jr, O. Thontteh, H. Chen .....	866
Improvements in the use of the Relative Operating Characteristic (ROC). B. Parmentier, R. G. Pontius Jr.....	868
A state-space representation for measuring urban change. A. Hagen-Zanker.....	870
<b>7.7 Posters .....</b>	<b>872</b>
Modelling and simulation of landscape changes. E. Pauditsova, K. Pavlickova.....	872
Land-use change detection in arid environments in South-East Spain. M. Piquer-Rodriguez, R. Zurita-Milla, J. Cabello-Pinar, D. Alcaraz-Segura, J. Crompvoets and R.G.H. Bunce .....	873
Landscape change of non-forest areas of Tuchola Pinewoods (northern Poland). T. Giętkowski .....	874
Monitoring local scale <i>Land Use and Land Cover Change</i> processes. The case of Ridaura sessile oak forestland (Natural Park of Montseny, NE Spain). F.J. Gómez, M. Boada, S. Sánchez .....	875
Landscape change trajectory analysis in the assessment of ecosystem space-time properties and dynamics: case study from south-western Finland. N.Käyhkö, H. Skånes .....	876
Demographic Change – Opportunities and Risks for a Sustainable Landscape Development: Case Studies in the Eastern Federal States, Germany. M. Moorfeld, S. Heiland.....	877
Social-Economic Indicators as a Tool of Landscape Use Changes Evaluation. B. Barkova, K. Pavlickova.....	878
The landscape ecological analysis for environmental impact assessment of oil-and-gas production and transport: experience from north-west of Siberia, Russia. V.V. Kozin, D.M. Marinskikh, A.V. Marshinin, I.R. Idrisov .....	879
Landscape changes and management goals: the case of Terres de l'Ebre, NE Spain. J Lascurain, S Imola .....	880
Historical landscape of Šumava in the light of palaeobotanic and antique maps' evidence. K. Křováková, V. Brůna.....	881
Landscape transformations: comparing land cover maps to understand trends and changes. M.C. Mariani, M. Gherardi, G.Vianello, M. Speranza .....	882
Kurgans: Specific values of the Holocene landscape history of the Carpathian Basin. A. Barczi, V. Grónás.....	883
Tools supporting sustainable management of landscape changes: Examples of good practice from the Slovak Republic. M. Kozova, P. Misikova, A. Krsakova, Z. Izakovicova, P. Jancura, E. Stanková .....	884
Models of landscape change based on the entropy of transition matrices of land uses and landscape mosaics. M.J. Roldán Martín; J. Gimeno; V. Valverde; P. Martín de Agar & C. L. de Pablo .....	885
Future climate change impacts on the boreal forest in northwestern Ontario. T.R.A. Muñoz-Márquez, R. Suffling, P.J. Deadman, D. Scott, A. Perera .....	886
The landscape history of Godmanchester (Québec, Canada), two centuries of a shifting relationship between anthropic and biophysical factors. G. Domon and A. Bouchard.....	887
Challenges faced when predicting landscape change. J.A. Hepinstall, M. Alberti.....	888
Land cover changes in the catchment basin of the Yangtze River, China: a case study of Wanzhou and Kaixian regions using satellite remote sensing. M. Tomita, Y. Zhao, K. Hara M. Fujihara, L. Da, Y. Yang .....	889
A Quantitative Analysis of Landscape Pattern Change in Menglun, Xishuangbanna. W.J. Liu, Y.X.Ma , H.B. Hu, H.M.Li .....	890
Identifying potential abandonment of agricultural through change in landscape structure: a case study in Castelo de Vide, Portugal. Santos, C. I. F.; Teixeira, T. M.; Ramos, I. L.....	891
Different changes and methods to evaluate developments in cultural and mining landscapes. M. Mulkova, R. Sedlarikova .....	892
Visualising changes in agricultural landscapes. D. Auclair, S. Griffon .....	893

Land use change in rural areas of Belarus affected by Chernobyl accident: twenty-year monitoring. V.M. Yatsukhna.....	894
Landscape effects of growing biomass crops on farmland bird populations in England. P.E. Bellamy, R. Sage and R.D. Swetnam.....	895
<b>Theme 8: Global change impacts .....</b>	<b>897</b>
8.1 Symposium 14: Effects of climate change on fragmented landscapes .....	899
Introduction to the symposium theme: Climate change in fragmented landscapes; can we develop spatial adaptation strategies? J. Verboom, C. Vos, P. Schippers .....	899
Adapting the landscape to climate change: linking ecosystem networks. C.C. Vos, J. Verboom .....	901
Adaptation strategies for climate change: what have we got now and how can they be improved? J. Piper.....	903
Can we mitigate climate change effects on biodiversity at treeline ecotones? T. Dirnböck, S. Dullinger, J. Peterseil.....	905
The interplay of landscape structure and evolution during range shifting dynamics. J.M.J. Travis, O.J. Burton.....	907
Projecting the shifting climate envelope of species and how the landscape can enhance or hamper the response of populations. P.M. Berry, J.M. Baveco .....	909
Large scale modelling of potential future distribution of tree-species under a climate change scenario in central and southern Italy. F. Attorre, F. Francesconi, M. Alfö, F. Bruno.....	911
Climate change, habitat fragmentation and the resilience of ecological networks. K. Watts, A. E. Eycott, M. Broadmeadow, D. Ray, L. Sing, J. Latham .....	913
8.2 Symposium 15: Consequences of climate change for freshwater wetlands .....	915
Using multiple models to elucidate the effects of climate change on floodplain ecology in the Okavango Delta, Botswana. P. Wolski, M. Murray-Hudson.....	915
Vulnerability of central North American wetlands to climate change. W.C. Johnson, A.G. van der, G.R. Guntenspergen.....	917
Climate change consequences for tidal freshwater wetlands at the east and west coast of the Atlantic. D.F. Whigham, A. Barendregt, C. Craft, S. Neubauer.....	919
Does the NATURA 2000 web still function? The effects of climatic changes on the dystrophic waters and their dragonfly fauna in the biosphere reserve "Pfälzerwald". J. Ott.....	921
8.3 Open Session 14: Modelling and Impacts of global change .....	923
Effects of recent land use and land cover change on the rates and patterns of fires and C emissions in Colombian savannas. A. Etter, A. Sarmiento .....	923
Potential impacts of climate change on birds and trees of the eastern United States: newest climate scenarios and species abundance modelling techniques. L.R. Iverson, A.M. Prasad, S.N. Matthews, M.P. Peters. ....	925
Spatial structure of southern taiga landscape energy balance and temperature field based on remote sensing data. R.B. Sankovskiy, Y.G. Puzachenko, D.N. Kozlov .....	927
Indicative properties of agricultural landscapes for studying changes of the environment due to climatic changes within the forest zone of East European Plain. O.N. Trapeznikova.....	929
8.4 Posters .....	931
Effects of spatial cohesion and climate change on changing butterfly distribution patterns. A. Cormont.....	931
Using the right metric: a comparative analysis of landscape fragmentation measures. L.T. Olson, L. Tischendorf, K.F. Lindsay.....	932
Interrelation of geosystem formative factors at the biosphere level. Y.G. Puzachenko, A.G. Sankovskiy, E.V. Siunova, D.N. Kozlov .....	933
Climatic factors and the development of bogs in northern Eurasia. M.V. Fedyeva, D.N. Kozlov, Y.G. Puzachenko.....	934
Long term trends in landscape patterns on high-diverse marine benthic communities in the NW Mediterranean Sea. N. Teixidó, J. Garrabou, J.G. Harmelin.....	935
Impacts of climate change on the landscapes and human vulnerability of arid central Asia ....	936
E. Lioubimtseva.	
<b>Theme 9: Concepts for Landscape Planning and Design .....</b>	<b>937</b>
9.1 Symposium 17: The Scientific Basis of Design for Landscape Sustainability .....	939
Science as a mediator: facilitating a negotiation process between stakeholders on corridor planning. B.J.H. Koolstra, C.C. Vos, E.G. Steingröver.....	939
Influencing landscape trajectories through alternative futures analyses. D.W. Hulse, A. Branscomb, C. Enright.....	941

Does conservation need landscape ecology? Does landscape ecology need conservation?. J.A. Wiens .....	943
Restoration in the city: insights into the rewilding and recultivating phenomena in the Twin Cities, Minnesota, U.S.A. L. R. Musacchio .....	945
Knowledge transfer from landscape science to practice and back: the role of design as an interface. P. Opdam and J.Nassauer. ....	947
Landscape ecology and design principles for sustainability. J. Wu.....	949
Managing and planning for sustainability in north Australia's landscapes: reflections on a decade of cooperative research. G. Duff, D. Garnett, P. Jacklyn, J. Landsberg, J. Ludwig, J. Morrison, P. Novelty, P. Whitehead .....	951
<b>9.2 Symposium 18: Coupling science and decision making in landscape sustainability: thresholds, models, and prediction.....</b>	<b>953</b>
Linking science, decision making, and management for landscape sustainability. R. J. Aspinall .....	953
Using a landscape ecological approach for the identification of sustainability limits: the scientific and policy challenges. R.H. Haines-Young, M.B. Potschin .....	955
Spatial characterization of landscape functions. L. Willemen, P.H. Verburg, L. Hein, M. van Mensvoort, T. Veldkamp, R. Leemans .....	957
Landscape functional response groups: definition, identification and utility for sustainable land management. J.Q. Radford and A.F. Bennett .....	959
Multiple functions and multiple ownership patterns; implications for the utilisation of landscape ecological models in decision making. A. Gimona, D. van der Horst .....	961
Mapping landscape-functions at the European scale. F. Kienast, J. Bolliger, R.S. de Groot, M. Potschin, R. Haynes-Young, I. Heller .....	963
Understanding and improving ecological function: guiding landscape restoration on private land in the Australian wheat and sheep zone. D.H. Duncan, J.W. Dorrough.....	965
Modeling impacts to water quality from future land cover change in the Chesapeake Bay watershed. P. R. Claggett, C.A. Jantz, J. Reilly, R. Burgholzer, K. Hopkins, and N. Zhou.....	967
Multifunctional use of Landscape Services: Applications and Results of Optimization Techniques of Land Use Scenario Development. R. Seppelt, A. Holzkämper .....	969
Optimal localisation of linear landscape elements using multi-criteria optimisation. Meyer, B.C, Grabaum, R, Wolf, T .....	971
Ecological restoration priorities for achieving integrated environmental and economic objectives. N.D. Crossman, B.A. Bryan .....	973
Alternative Future Growth Scenarios for Utah's Wasatch Front: assessing the impacts of development on the loss of prime agricultural lands. T.C. Edwards, Jr. G. Busch, R.J. Lilieholm, R.E. Toth.....	975
Grass strips in the CAP reform: from scientific results to policy making, the loss of efficiency. F. Burel, A. Ernout, J. Baudry, T. Delattre, A.Javelle,P. Kindlmann, J.B. Pichancourt.....	977
Structural, functional and temporal fragmentation: the impossibility of pleasing everyone. S.A. Hinsley, R.A. Hill, P.E. Bellamy, P.N. Ferns & N.M. Harrison.....	979
Fractal analysis of landscape features in northeastern São Paulo State, Brazil. M.C. Hott, M. Batistella, C. Criscuolo and V.P. Soares .....	981
Effects of land-use change on landscape attractiveness. J. Bolliger, F. Kienast, R. Soliva, K. Gehring, M. Hunziker .....	983
<b>9.3 Symposium 19: Landscape Planning: Building the evidence base and creating the vision .....</b>	<b>985</b>
Managing landscapes of the Australian Northern Territory for sustainability: Visions, issues and strategies for successful planning. D.M. Pearson and J.T. Gorman. ....	985
Green-blue landscape networks link private and public interests at different spatial scales: the case of the Hoeksche Waard. E.G. Steingröver, W. Geertsema, W. van Wingerden .....	987
What are landscape planners up to? C.v. Haaren.....	989
Application of a Leitbild in the pre-alpine Lake District of Salzburg. H. Klug.....	991
Exploring scenario thinking in the discussion on 'landscape quality objectives' as defined by the European Landscape Convention. Case study - Mértola (Portugal). I. L.Ramos .....	993
Landscapes of desire or landscapes of fate. M.B. Potschin, R.H. Haine-Young .....	995
Introduction of the spatial concept: design as a medium for the transfer of scientific knowledge to planning and society. J. Iverson Nassauer, P. Opdam .....	996
Environmental Minimum Requirements in the assessment and planning of agricultural landscapes. O. Bastian, M. Lütz .....	998

Landscape visions, urban sprawl and “reality” – an “anatomy” of a transformation. H. Palang	1000
Linking ecological and economic indicators to ecosystem networks for multifunctional participatory landscape planning. W. Geertsema, C.M. van der Heide, A.T de Blaeij	1002
A transactional approach to understanding visitor perception of sustainable recreational landscape management strategies. D. G. Pitt and R. B. M. van Marwijk	1004
Making visions visible. E. Lange, S. Hehl-Lange	1006
Spatial concepts as vehicles to communicate landscape conservation strategies. L. Ribeiro, T. Barão	1008
<b>9.4 Open session 1: Concepts theory and history</b>	<b>1010</b>
A Healthy Landscape Benefits Both Wildlife and Humankind. C.Y. Chang, W.C. Su, Y.H. Lin, H.F. Tang	1010
The importance of people in landscapes: valuing Aboriginal land management. J. Gorman, M. Luckert, and B. Campbell	1012
Landscape science and landscape ecology: Russian experience, concepts and scientific domains. K.N.Dyakonov, N.S.Kasimov, Y.G.Puzachenko, A.V.Khoroshev	1014
Assessment of the incidence of landscape ecology in urban and spatial planning in Southern Europe: revision of Spanish and Italian case studies. L.M. Valenzuela Montes, R. Pérez Campaña, F. Aguilera Benavente, A. Matarán Ruiz	1016
Landscape-historical geographical information for land use change investigation. N.A.Marchenko	1018
Landscape as a dynamic system. Y.G. Puzachenko, D.N. Kozlov	1020
Towards a clinical pathology of landscape: criteria for a diagnostic evaluation. V. Ingegnoli, E. Giglio	1022
The biological-integrated classification of landscapes: concepts and results. E. Giglio, V. Ingegnoli	1024
<b>9.5 Open Session 25: Landscape modelling and scenarios</b>	<b>1026</b>
Study of land-use changes and their effects on a distinct landscape located in Piedmont (Italy) applying a new multidisciplinary approach. F. Larcher, M. Devecchi	1026
Future scenarios for the Great Barrier Reef catchment, Australia. I. Bohnet	1028
Modelling future land use changes in Europe: Applying the MOLAND urban and regional development model in Algarve, Portugal. L.O. Petrov, C. Lavalle, J.I. Barredo, V. Sagris, M. Kasanko	1030
Linking landscape characteristics and socio-economic profiles for sustainable impact assessment at the regional level – the Spatial Regional Reference Framework (SRRF). C. Renetzeder; M. van Eupen, C.A. Múcher; T. Wrbka	1032
Evaluating the impact of integrated catchment management interventions on provision of ecosystem services using GIS. F. Karanja, N. Reid, O. Cacho, L. Kumar	1034
<b>9.6 Posters</b>	<b>1036</b>
Management of the landscape changes and strategy of sustainable development of the Biosphere Reserve East Carpathian. L. Halada, Z. Izakovičová, J. Oszányi, P. Bezák, M. Boltížiar, M. Moyzeová, F. Petrovič	1036
Landscape Ecological Planning Process for Watersheds in Taiwan. C.Y. Chang, W.M. Huang, W.C. Su, Y.-H. Lin, Y.T. Chang	1037
Numerical simulations for future landscape evolutions: a patchy agricultural mosaic. C. Gaucherel, T. Houet	1038
Preparation of EIA Guideline for Large Recreational Areas Projects. M. Akbarzadeh, S. Babaei Kafaki	1039
The study of ecotonisation of landscape space and current priorities in modern landscape ecology. T.V. Bobra, A.I. Lychak	1040
Perspectives of the landscape research with artworks from the start of the common area. R.U. Syrbe	1041
14 symposia in the Slovak Republic – 40 years of international collaboration: 1967 – 2007. M. Kozová, T. Hrnčiarová, and M. Ružička	1042
Proposing an empiric model of the behaviour of the main ecological functions of the human habitat (HH) in relation with the different types of landscapes (temperate regions). E. Giglio, V. Ingegnoli	1043
Society, culture and people in landscape research. E. Conrad, I. Fazey, M. Christie	1044
US IALE: the first twenty-five years of landscape ecology in North America (1983-2008). G. W. Barrett, T. L. Barrett	1045
<b>Theme 10: Forests, vegetation and landscape</b>	<b>1047</b>

10.1 Symposium 6. Forest fragmentation and biodiversity loss: The forgotten native forests.	1049
Assessing the impacts of forest loss and fragmentation on biodiversity in the temperate landscape in south-central Chile. C. Echeverria .....	1049
Testing the ecological principles of forest landscape restoration. N.C. Brouwers, A. Newton.	1051
Roads, fire and aggressive competitors: determinants of bird distribution in subtropical production forests. M. Maron, S. Kennedy .....	1053
Conservation at large Scale: the Biodiversity Vision of the Atlantic Forest. M. J. Pacha.....	1055
Economic development and forest fragmentation in the Brazilian Amazon from 1986 to 2000. C.B.A. Bohrer, M.C.S. Mello, S.R. Freitas, A.S. Pfaff, E.J. Reis .....	1057
Conserving Wildlife In Fragmented Forest Landscapes Across Their Geographic Range? A Koala Case Study. C.A. McAlpine, M. Bowen, D. Lunney, J.Callaghan, J.Rhodes, D. Mitchell, H.Possingham.....	1059
Assessment of changes in biodiversity levels of forested ecosystems by using remote sensing: a case study in Mozambique. E. Arets, A. Vrieling, P. van der Meer, C.A. Múcher.....	1061
The influence of <i>Prosopis</i> -invasions on the functioning of affected landscapes in Namibia. P. Smit .....	1063
Forest disturbance versus landscape metrics. S. R. Freitas, C. B. M. Cruz .....	1065
Genetic benchmarks applied to landscape conservation and restoration, a case study of <i>Araucaria angustifolia</i> (Brazil). J. V. M. Bittencourt, A. R. Higa, G.H. Griffiths .....	1067
10.2 Open Session 18: Spatial vegetation modeling.....	1069
Imputation of canopy and surface fuel attributes from LiDAR and Landsat ETM+ imagery. A.J.H. Meddens, A.T. Hudak, J.S. Evans, W. A. Gould, G. González .....	1069
Land surface phenologies sensed by cooler earthlight: how passive microwave image series can reveal vegetation dynamics appropriate for landscape monitoring. G.M. Henebry, M. Doubková .....	1071
Diversity patterns of forest tree species (alpha, beta and gamma diversity) in the Central Andes of Colombia. J. E. Mendoza, W. Vargas, F. H. Lozano-Zambrano .....	1073
Old-field succession changes along a precipitation gradient in SE Spain. J. Peña, A. Bonet, J. Bellot .....	1075
Ecological values of regrowth vegetation for conserving and restoring bird communities in highly fragmented landscapes: a Brigalow case study from sub-tropical Australia. M.E. Bowen, C. A. McAlpine , A. House, G. Smith. ....	1077
Landscape scale temperature predictions and vegetation models in mountainous regions. M.B. Ashcroft, L.A. Chisholm and K.O. French.....	1079
10.3 Open Session 19: Vegetation and landscape fragmentation .....	1081
How far past and present landscapes affect plant species richness depends on how landscapes change. A. Ernoult, D. Alard.....	1081
Study on species-area relationship of small land-bridge islands and the small island effect in the Thousand Island Lake region of China. J. Lu, Q. Sun, J. Wu, Z. Xu and G. Zhao.....	1083
Landscape structure and tropical tree seedling diversity in Atlantic rain forest, Brazil.L.F. Alves, J.P. Metzger.....	1085
Predicting invasion patterns of <i>Prunus serotina</i> Ehrh. in a heterogeneous forest landscape.O. Chabrierie, G. Decocq .....	1087
Dispersion of plant species in a scattered landscape on a regional scale; a modeling approach. G.W.W. Wamelink, J. van der Gref, R. Jochem, A.H. Prins, H.F. van Dobben, Grashof-Bokdam .....	1089
10.4 Open Session 20: Forest ecology and forest management .....	1091
Missing the third dimension – the missing parameters for forest birds and their habitats in forest landscape ecology. C. Purschke .....	1091
Simulating the cumulative effects of multiple forest management strategies on landscape pattern and biodiversity. E.J. Gustafson, D.E. Lytle, R. Swaty, C. Loehle .....	1093
Forest landscape models: current status and challenges. Hong S. He.....	1095
The effects of restoration confirmed in pitch pine plantation in South Korea. H.C. Shin, C. S. Lee .....	1097
Landscape approach to sustainable forest management in post-socialist countries: Ukraine and Russia as case studies. M. Elbakidze, P. Angelstam.....	1099
Effectiveness of protected areas in the Carpathians differs among countries in post-socialist times. T. Kuemmerle, P. Hostert, V.C. Radeloff, and K. Perzanowski .....	1101
Structure, growth, and flood-induced dynamics of Tugai forests at the Tarim River in Xinjiang, NW China. S. Zerbe, N. Thevs .....	1103

10.5 Posters .....	1105
Searching for <i>Saintpaulia</i> - the elusive endemic of the Eastern Arcs. J. Nieminen .....	1105
CONEFOR Project - analysis of the connectivity of Spanish forested landscapes: implications for broad-scale forest planning and habitat conservation. L. Pascual-Hortal and S. Saura .....	1106
Forest Fragmentation assessment using landscape matrices and Shannon's entropy index. N. Lele, P.K. Joshi .....	1107
Forest fragmentation and its implication for biodiversity conservation in Xishuangbanna, SW, China. H.M. Li, Y.X. Ma, W.J. Liu, Z.W. Cao .....	1108
Forest floristic indicators and landscape fragmentation in North West Lombardy (Italy): preliminary results. P. Digiovinazzo, E. Ballabio, L. Bottoni, E. Padoa-Schioppa, C. Andreis .....	1109
Modelling vegetation change in the British countryside. A.P. Blain, L.G. Firbank, S. Smart, S.P. Rushton.....	1110
How well do pollen samples reflect changes in grazing pressure in heterogeneous landscapes? H.H. Wagner, F. Gillet, F. Mazier, P. Sjögren, B. Ammann, A. Buttler, C. Scheidegger.....	1111
Landscape ecology analyses in a critical coastal area of Southern Italy. M. T. Carone, T. Simoniello, A. Acampora, M. P. Vaccaro.....	1112
Landscape changes due to native forest loss along a precipitation gradient in the Chaco region, Argentina. M. G. Parmuchi, J. Bono, M. Stamatii, C. Montenegro, M. Brouver, E. Manghi, M. Strada .....	1113
Examining the role of spatial pattern in understanding the implications of forest management policy within the Angkor World Heritage Site, Cambodia. N. Wales, E. Bruce.....	1114
A Bayesian MCMC approach to reconstruct spatial vegetation dynamics from sparse vegetation maps. I. Somodi, I. Miklós, K. Virágh.....	1115
Modeling the dynamics of Mediterranean landscapes under various disturbance regimes. A. Bar-Massada, G. Koniak, Y. Carmel, I. Noy-Meir.....	1116
The effects of landscape structure on the vegetation of field boundaries in Estonia. T. Aavik, M. Zobel, J. Liira .....	1117
Landscape dynamics in Armação dos Búzios (RJ - Brazil) in the 1976-2002 period. H.G.R. Dantas, C.B.A. Bohrer, H.C. Lima .....	1118
Landscape sustainable management and the Atlantic Forest Biosphere Reserve: an ecologic and human study approach of the rain forest remnants from Morro Ferrabrás and Serra Geral, RS, Brazil. J. Konrath, M.D. Bitencourt, W. Mantovani .....	1119
Non-timber utilization and Landscape value of Pistachio-Almond mixture stand. E. Kouhgardi, O. Rafyeian, P. Ahmadpour, F. Ahmadpour .....	1120
Temporal and spatial dynamics in abandoned chestnut coppice forests. J. Vogt, P. Fonti, M. Conedera, B. Schröder .....	1121
Forest quality in southwest Mexico City, assessment towards ecological restoration of ecosystem services. V. Avila-Akerberg, .....	1122
Associations between vegetation and geomorphic units as a basis for predictive vegetation mapping and conservation assessment. E.J.B. van Etten .....	1123
Landscape change and habitat suitability for chimpanzees ( <i>Pan troglodytes verus</i> ) in Guinea-Bissau (Western Africa). J. Torres, M.J. Vasconcelos, L. Catarino, J. Honrado.....	1124
Coastal Landscapes and the Gradient Concept in Landscape Ecology. J. Vicente, A. Lomba, P. Alves, R. Henriques, H. Granja, F.B. Caldas, J. Honrado.....	1125
Influence of landscape features on biotic patterns of bryophyte communities - two case-studies from Northern Portugal. C. Vieira, H. Hespanhol, A. Séneca.....	1126
Effects of trees on spatial heterogeneity of soil properties in a tropical rainforest in Western Kenya and its implication on plant species diversity. W.M. Musila, H. Todt, R. Gliniars, M. Oesker, H. Dalitz.....	1127
Spatial pattern of native forests at Córdoba Mountains (central Argentina). M. Menghi, R. del Sueldo.....	1128
Ecological change in British woodland 1971-2001. K.J. Kirby .....	1129
Does seed dispersal of late-successional species drive secondary succession in the Swiss National Park? M. Irvani, H.H. Wagner, A.C. Risch, C. Scheidegger, P.J. Edwards, M. Schuetz .....	1130
Effect of Landscape Fragmentation on Diversity of Avifauna in the Edwards Plateau of Texas. E. González, W. Grant, N. Wilkins, X. Wu, M. Kjelland.....	1131
Potential habitat map of endangered hygrophytes for conservation planning. E. Harada, M. Ogawa, H. Mitsuhashi, M. Kamada .....	1132

Spatial heterogeneity of nutrient and organic carbon storage under a fragmented landscape of Atlantic Forest, Brazil: the influence of human activities on decomposition processes. F. Noronha, I. Garay, D. Perez .....	1133
Biological forest ecosystem diversity and their impact in semi arid land: analysis followed by remote sensing (Alsat-1 data, Steppe of Algeria). Z. Ahmed .....	1134
Landscape change in the <i>Austrocedrus chilensis</i> forest ecosystems: the role of the restoration in Patagonia, Argentina. E. Rovere .....	1135
Community Based Perpetuation of Deforestation: The Case of Forests Mongu District, Western Province, Zambia. K. Mbikusita Lewanika .....	1136
<b>Theme 11: Landscapes for Life.....</b>	<b>1137</b>
Rehabilitation of the Baltic Coastal Lagoon Habitat Complexes ( <i>BaltCoast</i> ). B. Küper .....	1139
Conservation of <i>Bombina bombina</i> in the Baltic Sea Region ( <i>Bombina</i> ). H. Drews .....	1140
Restoration of ponds as landscape elements and habitat for amphibians - an Estonian experience from LIFE-Nature project. R. Rannap, P. Pappel .....	1141
Restoring Active Blanket Bog in Ireland. K. Donnellan, P. Murphy .....	1142
Restoring Raised Bog in Ireland. M. Delaney, P. Murphy .....	1143
Restoring Priority Woodland Habitats in Ireland. S. Quealy, P. Murphy. ....	1144
Restoration of the Wetlands of Zahorie Lowland. J. Šíbl .....	1145
Restoration and Management of Sand Dunes Habitats in Zahorie Military Training Area. P. Frantisek .....	1146
Restoration of the habitat of the European otter ( <i>Lutra lutra</i> ) in the valleys of Our, Ourthe and Sûre (Belgium, Luxemburg). C. Leclercq .....	1147
Jovsi – the cultural landscape with endangered species. M. Galičič, A. Hudoklin .....	1148
Complex program to save the Hungarian meadow vipers ( <i>Vipera ursinii rakosiensis</i> ) from extinction. B. Halpern, T. Pechy .....	1149
Improving coexistence of large carnivores and agriculture in Southern Europe. A. Mertens, V. Salvatori, S. Ricci, J. Glikman.....	1150
Restoration of Latvian Floodplains for EU priority species and habitats. A. Aunins, J. Reihmanis and I. Račinska, .....	1151
Conservation and development of inland salt meadows in Brandenburg, Germany. H. Roessling, H. Lengsfeld.....	1152
Restoration of the Core Ravine Woodlands of England and Wales: The Ravine WoodLIFE Project. M. Brocklehurst.....	1153
BurrenLife - Farming for Conservation in the Burren. B. Dunford .....	1154
Conservation through plant micro-reserves in the Valencian Community: experiences from the LIFE programme. E. Laguna .....	1155
Optimisation of the pSCI Lippe flood plain between Hamm and Hangfort. O. Schmidt-Formann .....	1156
Conservation and management of Danube floodplain forests. T. Kušik .....	1157
Ecological restoration of the Lower Prut floodplain natural park. C. Sandu, G. A Radu, I. Şandric .....	1158
Amphibian Biotope Improvement in the Netherlands (AMBITION). R. Heringa.....	1159
Protection of <i>Emys orbicularis</i> and amphibians in the north European lowlands. P. Mierauskas .....	1160
Habitat improvement for <i>Microtus oeconomus</i> in Alde Feanen. H. de Vries.....	1161
Ecological military area management: no beating about the bush, please! H. Jochems .....	1162
Rehabilitation of peat and wet habitats on the Saint-Hubert Plateau, Belgium. G. Jadoul .....	1163
Cross-border restoration of heathland on continental dunes. I. Ledegen, P. Muijsers .....	1164
Natural meadows and pastures of Östergötland - restoration and maintenance. D. Nilsson... ..	1165
A LIFE-Nature project on restoration of Priority Habitats for Amphibians within the Natura 2000 Network in Valencian Community (East Spain). I. Lacomba, V.Sancho .....	1166
Monitoring the Mediterranean Temporary Ponds in Crete. I.N. Vogiatzakis, G.Kazakis, D. Ghosn .....	1167
GrassHabit – a LIFE project dedicated to the proper management of Pannonian grasslands. R. Szabó, E. Illyés, A. Horváth, Zs. Molnár, Z. Szilvacsku, Á. Egyházy, Gy. Fülöp, B. Szabó, S. Rév, K. Sipos, T. Parrag, L. Viszló.....	1168
<b>Workshops.....</b>	<b>1169</b>
Workshop Landscape Ecology Education Network (LE-Net). M. Potschin and LE-Net Members .....	1169



Workshop The Global Earth Observation System of Systems (GEOSS) EC-06-02 Global Ecosystem Mapping Task. R. Sayree .....	1170
Workshop Methods of quantifying, valuing and mapping landscape functions to support integrated impact assessment of land cover change. R. de Groot, M. Metzger .....	1171
Workshop “Karst landscapes in Europe: conservation of cave ecosystems in an integrated landscape approach” during IALE Congress 8-12 July 2007. P. Veen, J Nootboom.....	1173
From landscape ecology to functional biodiversity – possibilities to improve the situation of wildlife. C. Schlatter, H. Luka and L. Pfiffner .....	1174
Landscape changes in the Brazilian tropical rain forest: patterns and processes of fragmentation and transition. Mateus Batistella .....	1175
Simulation model validation workshop. R. G. Pontius Jr, Organizer and Chair .....	1176
Can we measure the global impacts of fine-scale changes within anthropogenic landscapes? E.C. Ellis .....	1177
<b>Author list .....</b>	<b>1178</b>

## Introduction

The present volume contains the abstracts of the 7th International Association of Landscape Ecology (IALE) World Congress. The Congress celebrates the first 25 years of IALE, which was founded in a divided world by western and central European participants in the Symposium on Landscape Ecological Problems in Piestany, Slovakia in 1982. IALE initially developed in North America and Europe but has now extended to all continents and to many countries, as is evident from the approximately fifty national representatives in the present volume. IALE continues to expand and new regions are being set up, for example in 2005 and 2006 in Brazil and Argentina

Two other books will be launched at the Congress, one by Landscape Europe and one by the Dutch landscape ecological organization (WLO). The present volumes serve a different purpose, which is to bring together in one document the full range of topics covered by modern landscape ecology and to serve as a guide to the oral presentations and posters of the Congress. They will also be useful after the Congress as a source of reference material on subjects and authors..

We have done our best in the time available to get the book into a consistent format but inevitably with such a large number of abstracts the standards are not as high as in a scientific journal or report. However, we considered it to be more important to include all the abstracts that were sent in rather than being selective. We hope you find them as useful as previous collections of Congress abstracts

The Congress of is being held in Wageningen and Ede, The Netherlands and represents a great opportunity for landscape scientists from the whole world to share their ideas. This book of abstracts presents an overview of the work that will be presented at the congress.

The Congress focuses on the scientific principles of landscape ecology and their practical applications to conservation, land and water management, as well as their relationship with land use planning, both now, and in the future. Many abstracts show the increasing importance of remote sensing and Geographic Information Systems, spatial statistics and modelling. The Congress also demonstrates the way in which landscape ecology is playing an increasingly important role in spatial planning for landscape and biodiversity objectives.

Landscape ecology can be defined as the holistic understanding of the relationships between ecological components of landscapes, including the impact of human activities through planning and management. The underlying motivation for many landscape ecologists is that their research should lead to potential applications for social benefit. Within landscape ecology there is also a strong recognition of the role of man in the functioning of many landscapes as well as in their past development.

The Scientific Committee invited IALE members to propose Symposia and 25 were selected from those who reacted. These Symposia form the core of the Congress and the organisers accepted the challenge to coordinate programmes in their field. Many additional papers and posters were also forwarded to the Organising Committee. All of these contributions were accepted, although many needed editing before being included in the book of abstracts. The Organising Committee first examined whether the contributions could be assigned to existing symposia, but then looked for common topics and scheduled these to complementary Open Sessions. In addition about 250 posters were also sent in, which were subsequently linked to eleven overarching themes, which form the basic structure of the Congress programme. The abstracts of all contributions are included in this book, with two pages for oral presentations and one page for posters. In most cases the full posters are also included in the CD-ROM in the back of the book. The eleventh theme consists of posters describing Landscape oriented EU-Life projects.

The Congress programme has been structured as far as possible to ensure that related Symposia and Open Sessions are not in conflict. Participants can therefore choose to listen to presentations with minimal conflicts of interest, although inevitably some problems will occur. The Workshops have also been integrated within the programme, although at first, because of the number of participants, this was not possible. As the posters are linked to the

themes, they will be set up under these headings in sections of the hall in the Congress venue so that participants can see which posters they wish to visit.

The Congress and the book of abstracts have been made possible with internal support from the Environmental Science Group of Wageningen UR, The Dutch Ministry of Agriculture, Nature and Food Quality, the Dutch Ministry of Environment and Spatial Planning, The Dutch Royal Academy of Sciences, Argos Becas in Salamanca Spain, CTA, the Wageningen Research Schools PE&RC and WIMEK-SENSE, ESF-Eurodiversity, the province of Drente, the Dutch State Forestry and the Dutch Society for Nature Conservation (Natuurmonumenten). The town of Wageningen will also give a reception at the start of the Congress. Finally, the Wageningen Congress Organization Bureau (OBW, Yvonne van Hezik and Ingrid Luitse-Looijen) not only helped with the organization for two years before the Congress but also arranged the social programme.

Bob Bunce, Rob Jongman, Lorena Hojas and Silvia Weel

Wageningen  
12-5-2007

## Theme 6: Cultural landscapes and landscape management



## 6.1 Symposium 11: Alternative principles for landscape Management

### Conserving species within fragmented landscapes

F. Jopp

Laboratory for Soil Zoology & Ecology, D-12165 Berlin, Germany.  
e-mail: fjopp@zedat.fu-berlin.de

#### Land use change and fen wetlands

Fen wetlands are sensitive landscapes that have been greatly reduced by land use change in the last decades. Between 1950 and 1985, about 60% of all western European wetlands (Succow and Joosten 2001) and more than 50 % of the USA wetlands have disappeared (Interagency Workgroup on Wetland Restoration 2003).

Changes in the local water-regime, combined with habitat fragmentation due to agricultural development, are the main external driving forces responsible for this decline (Joosten and Clarke 2002). However, because fen wetlands are highly dynamic systems that are sensitive to stochastic environmental conditions (e.g. seasonal inundations and droughts), the simultaneous effects of land use change and climate change will only be apparent if a broad range of spatial and temporal scales are considered.

#### Interplay of environmental forces

Data analysis of several fen wetland systems has recently revealed the importance of interactions among a suite of environmental variables and the effects of habitat fragmentation and land use change on species biodiversity and persistence: no clear-cut connection between environmental stochasticity alone could be found (Kratz and Pfadenhauer 2001). Instead, the maintenance of diversity within each habitat type depended on local conditions that supported reproduction and the broad-scale connectance among habitat types assured persistence of fen wetland species (Jopp 2006).

#### Sustainable management framework

Modern management strategies must be promoted that recognize the sensitivity of fen landscapes to altered environmental conditions and altered landscape patterns. For this purpose, multi-disciplinary teams with experts from many domains are needed to address a broad array of ecosystems management issues (Richter et al. 2003). Understanding the dynamics of change in these complex, isolated ecosystems is necessary for conserving species diversity and assuring ecological sustainability within fen wetlands.

#### References

- Interagency Workgroup on Wetland Restoration 2003.** An Introduction to Wetland Restoration, Creation, and Enhancement. National Oceanic and Atmospheric Administration, Environmental Protection Agency, Army Corps of Engineers, Fish and Wildlife Service, and Natural Resources Conservation Service
- Joosten, H., Clarke D. (2002).** Wise use of mires and peatlands - Background and principles including a framework for decision-making. International Mire Conservation Group / International Peat Society, 304 p.
- Jopp F. (2006).** Comparative studies on the dispersal of the Great Ramshorn *Planorbis corneus* L. --A modelling approach. *Limnologica* 36: 17-25.
- Kratz, R., Pfadenhauer, J. (2001).** Ecosystem management for fen wetlands-strategies and policies for renaturation (in German: Ökosystemmanagement für Niedermoore. Strategien und Verfahren für die Renaturierung). 317 pp Ulmer, Stuttgart
- Richter, B.D., R. Mathews, D.L. Harrison, and R. Wigington. 2003.** Ecologically sustainable water management: managing river flows for ecological integrity. *Ecological Applications* 13:206-224.

**Theme 6: Cultural Landscapes and Landscape Management**  
**6.1 Symposium 11: Alternative principles for landscape Management**

**Succow, M., Joosten H. (2001).** The landscape ecological study of wetlands (in german: Landschaftsökologische Moorkunde). Schweizerbart, Stuttgart. 622 p.

## Maintaining diversity in developed landscapes

R.H. Gardner

University of Maryland Center for Environmental Science, Appalachian Laboratory,  
Frostburg, MD, 21532, USA.  
e-mail: gardner@al.umces.edu

The Earth's landscapes are being altered at unprecedented scales. The loss of habitat and the increased intensity of human land use are resulting in global declines in species diversity, increased invasions of exotic organisms, and altered patterns of community development. The magnitude and extent of species declines requires an expanded, aggressive strategy that addresses the scope and scale of this issue. The formation of an integrated network that spans regional and national boundaries is now necessary to prevent further species loss and restore damaged ecosystems.

Three priorities should be immediately undertaken by landscape ecologists. The first is the development of a global network for rapid, continuous and coordinated assessment of patterns of Land-Use, Land-cover Change (LULC). Real-time analysis and reporting is a fundamental requirement for assessing trends and predicting future landscape patterns. An international network of research centers devoted to monitoring and mapping, analyzing and reporting of LULC is essential for uniform data development and as an effective lobby for maintaining satellite observing systems. Secondly, our ability to predict the relationships between LULC and species loss remains rudimentary at best. New approaches that effectively link pattern and process must be quickly developed, tested and applied. Unexpected trends in landscape change associated with shifts in societal values or governmental policies will make this objective one of the great challenges of our time. Thirdly, it is essential for landscape ecologists to increase their efforts in public education, training of new scientists, and collaboration among politicians, engineers and the public. Landscape ecologists must communicate the consequences of LULC change and engage the public in the process of reconciling the conflicting demands of biodiversity conservation and land use change caused by human development.

This symposium has been organized to explore these themes, examining lessons learned from recent successes and failures. Biodiversity change provides an early warning system regarding serious declines in ecosystem health and services. Actions which prevent species loss is a critical first step for maintaining an ecologically sustainable future.



### **Climatic shifts in fire regimes – new fire management strategies**

**G.J. Cary<sup>1,2</sup>, R.J. Keane<sup>3</sup>, M.D. Flannigan<sup>4</sup>, R.A. Bradstock<sup>5,2</sup> and K.J. King<sup>1,2</sup>**

<sup>1</sup>School of Resources, Environment and Society, The Australian National University, Canberra, 0200, Australia.

e-mail Geoffrey.cary@anu.edu.au

<sup>2</sup>Bushfire Cooperative Research Centre, Australia

<sup>3</sup>USDA Forest Service, Missoula Fire Science Laboratory, Missoula MT, 59808, USA.

<sup>4</sup>Canadian Forest Service, Sault Ste Marie ON, P6A 2E5, Canada.

<sup>5</sup>Centre for Environmental Risk Management of Bushfires, Faculty of Science, University of Wollongong, 2522, Australia.

### **Introduction**

Formulating responses to potential shifts in fire regimes resulting from climate change requires understanding of the relationships between fire, climate, vegetation and land management at the landscape scale. Since 2000, we have convened multi-investigator teams of landscape and global-level fire modellers, fire ecologists and climatologists to address several facets of this problem.

### **Climate change and fire regimes**

Studies using individual models in specific locations have suggested that, in many landscapes, climate change will result in a greater area burned and an increase in fire frequency. Cary (2002) reported a halving of the average interval between fires in the FIRESCAPE simulation model for a moderate climate change scenario in the Australian Capital Territory region. A decrease in the probability of extinguishment of burning pixels, due largely to enhanced levels of drought in the model system, resulted in a greater likelihood of active fire being present when severe fire weather occurred. Enhanced suppression of fires at the time of ignition is therefore likely to be important for future fire management. A similar result was found using the same model to study the effect of climate change on fire regimes in Glacier National Park, Montana, in a research joint venture between the USDA Forest Service and the Australian National University.

Results from individual models lack the generality that would result from similar studies that incorporate multiple models. An international group of scientists working under the auspices of Global Change and Terrestrial Ecosystems and funded by the US National Centre for Ecological Analysis and Synthesis determined the sensitivity of modelled area burned to variation in terrain relief, fuel pattern, weather and climate in a standardised design across five landscape fire models (Cary *et al.*, 2006). Weather variability and changes in climate (observed; warmer and wetter; warmer and drier) were considered important in explaining variation in area burned in four out of five models compared with terrain relief and fuel pattern which were comparatively unimportant. One of the biggest challenges of this study was generating standardised model input that was relevant to all models and analysing results from diverse models in a meaningful fashion.

### **Management, fire area and climate change**

A similar collection of models was used to explore the importance of fuel management (approach and effort), ignition likelihood and weather variability for area burned in a range of systems. Treating the weather identically to the model comparison described above allowed the importance of management to be compared with the other factors (including climate

change) from the earlier comparison. Weather and ignition likelihood were important in explaining variation in modelled area burned for all models, while fuel management approach and effort were relatively unimportant. This again highlights the effectiveness of managing fires at the time of ignition compared with relying on a strategy of fuel-reduction across the landscape. Specific management actions may involve rapid initial attack of fires, education programs aimed at preventing accidental and deliberate fire lighting, and preventing access to the interiors of flammable landscapes

Fuel amount and fuel treatment have been shown by others to be important in determining area burned by unplanned fires (Fernandes and Bothelo, 2003) but the magnitude of its effect in our model comparison is small compared with variation arising from the other factors. Indeed, a modelling study conducted as part of the Australian Bushfire Cooperative Research Centre found that the area burned by unplanned fires in buttongrass moorland in south western Tasmania declined significantly with increasing proportions of the landscape treated by prescribed fire per annum (King *et al.*, 2006). Preliminary research into the implications of climate change on this relationship indicate that, under a 2xCO<sub>2</sub> climate, the area treated by prescribed burning may have to double in order to maintain the area of unplanned fire at the 1xCO<sub>2</sub> level. However, the subsequent deleterious effect of combined planned and unplanned fires under both a 1xCO<sub>2</sub> and a 2xCO<sub>2</sub> scenario on biodiversity conservation means that a greater dependence on managing fires at the time of ignition, rather than on enhanced programmes of prescribed burning, may remain a more tenable solution to the fire management problem with climate change.

## Conclusion

Results from studies using individual models and collections of models suggest the changes in climate, variability in weather, and variation in ignition likelihood are the main determinants of area burned in fire-prone landscapes. Of these, fire management can affect ignition likelihood which can be modified via rapid suppression of fires, education on fire protection and use, and management of access to fire-prone landscapes. The effect of fuel management on area burned in model systems is measurable but relatively unimportant in comparison. Achieving the same levels of protection from unplanned fires may mean doubling the area treated by prescribed burning and this may prove untenable from the perspective of biodiversity conservation in many systems.

## References

- Cary, G.J. (2002)** Importance of a changing climate for fire regimes in Australia. R.A. Bradstock, J.E. Williams, & A.M. Gill (Eds). *Flammable Australia: Fire Regimes and Biodiversity of a Continent*. Cambridge University Press, pp. 26-48.
- Cary, G.J; Keane, R.K; Gardner, R.H; Lavorel, S; Flannigan, M; Davies, I.D; Li, C; Lenihan, J.M; Rupp, T.S. & Mouillot, F. (2006)** Comparison of the sensitivity of landscape-fire-succession models to variation in terrain, fuel pattern, climate and weather. *Landscape Ecology* **21**: 121-137.
- Fernandes, P.M. & Botelho, H.S. (2003)** A review of prescribed burning effectiveness in fire hazard reduction. *International Journal of Wildland Fire* **12**: 117-128.
- King, K.J; Cary, G.J; Bradstock, R.A; Chapman, J; Pyrke, A. & Marsden-Smedley, J.B. (2006)** Simulation of prescribed burning strategies in south-west Tasmania, Australia: effects on unplanned fires, fire regimes, and ecological management values. *International Journal of Wildland Fire* **15**: 527-540.

## The challenge of restoring disturbed landscape

A. Farina, D. Morri

Working Group in Theoretical Ecology, Institute of Biomathematics, Campus Scientifico  
SOGESTA, The University of Urbino, 61029 Urbino . Italy  
e-mail: farina@uniurb.it

### Introduction

One of the most important challenges facing ecologists today is to prevent the continued loss of biodiversity due to human intervention so that optimal functioning to the earth's ecosystems will be assured. However, even if biodiversity is restored, the long history of landscape alteration that we are now experiencing has created novel systems with unknown dynamics.

New tools are now necessary to understand, manage and restore human-dominated landscapes; ultimately, to restore such landscapes it is necessary to consider a broad spectrum of perspectives and connected factors that range from natural dynamics to social and economic driving forces (Green et al. 2006).

Because humans are the "key species" altering the earth's landscapes, the hypothesis that landscapes are composed of a geo-botanical (meta-ecosystemic) matrix in which all organisms (including humans) interact can now be developed from semiotic and cognitive rules (Farina *et al.* 2005). This perspective shows that landscape health and social health are strictly related with impoverished or simplified (meta-ecosystemic) landscapes associated with human societies. Consequently, similar negative trends (loss of culture, low level of scholarship, fragility in economic processes, diffuse crime, social discomfort, etc.) are broadly apparent. Therefore, the dynamics and constraints that emerge from human processes (i.e., culture, beliefs, economics, etc.), and meta-ecosystems processes (i.e., fragmentation, alien species invasion, spread of new diseases, etc.) can be systematically defined. Efficiency in restoring disturbed landscapes requires a primary shift in ecological and anthropological paradigms that will allow new principles, common to both viewpoints, to be developed. These synthetic principles, derived from each of these sciences (i.e., cognition, semiotics, information and cybernetic), will allow all factors affecting change to be equally considered.

Despite an impressive amount of literature produced on landscape restoration and several empirical evidences, few attempts have been made in order to produce efficient paradigms able to face the challenge made by such complex conditions and to manage human and natural processes as expression of a common, unique emergent complex system (Ingold 2000, Sayer & Campbell 2004).

### A new vision of the landscape

Our reasoning begins from a general consideration that needs and resources are connected by a semiotic interface: the landscape. Entering into details, according to the Peirce's triadic vision of the sign process (Peirce 1931-1958), the landscape is a vehicle of sign utilized by organisms to find resources. In particular, for every need, namely to perform a specific function (feeding, territory patrolling, roosting, exploring, pairing, breeding, etc.) the organism searches for a spatial configuration carrier of meaning (the eco-field) that connects semiotically resources, unevenly distributed in space and time (Farina & Belgrano 2004, 2006). The identification of the eco-field, considered the semiotic interface between a function and a correspondent resource, is executed by the interpretant using cognitive templates that work like a searching image in the surrounding world.

According to this perspective each function, necessary to fill a specific need is coupled with a spatial configuration carrier of meaning (the eco-field) and the entire configurations spatially distinct or overlapped, become the “cognitive landscape”. If the (cognitive) landscape (as sum of every function specific eco-field) is the semiotic interface between organisms and resources, for each species distinct landscapes should exist.

The landscape assumes the role of semiotic interface and the idea of a landscape as a merely collection of patches (mosaic) becomes obsolete and insufficient to explain the observed complexity.

This semiotic process is common to man and animals but it is reasonable to postulate a more broad range of nonmaterial needs in the human dimension and consequently a larger spectrum of human-perceived landscapes.

The restoration process should be powered by re-connecting needs (and related functions) to specific resources that is the process from which landscapes emerge.

In every human society the well-being is passing through the accomplishment of several functions carried out in high-quality-energy context. Larger is the number of needs that are satisfied and more complex and quality relevant becomes the resulting landscape interface.

Namely a full collection of virtuous steps that rarely could be achieved in poor societies when traditional planning of eco-systemic landscapes should be adopted.

According to a semiotic approach, the restoration action must be shifted from the (meta-ecosystemic) landscape to the relationship between needs, related human functions and valuable resources. This process requires the use of high quality energy stored by neg-entropic interactions and sustainable social and economic mechanisms as well.

## **References**

- Farina, A. & Belgrano, A. (2004).** The eco-field: A new paradigm for landscape ecology. *Ecological Research* **19**: 107-110.
- Farina, A.; Bogaert, J.& Schipani, I. (2005).** Cognitive landscape and information: new perspectives to investigate the ecological complexity. *BioSystems* **79**: 235-240.
- Farina, A. & Belgrano, A. (2006)** The Eco-field Hypothesis: Toward a Cognitive Landscape. *Landscape Ecology* **21**: 5-17.
- Green, D.G.; Klomp, N.; Rimmington, G. & Sadedin, S. (2006)** Complexity in landscape ecology. Springer, Dordrecht, The Netherlands.
- Ingold, T. (2000)** The perception of the environment. Routledge, London & New York.
- Peirce, C.S. (1931-1958)** Collected papers of Charles Sanders Peirce. Harvard University Press, Cambridge, Mass.
- Sayer, J. & Campbell, B. (2004)** The science of sustainable development. Cambridge University Press, Cambridge.

## Turning landscape conservation projects into biodiversity experiments

H.H. Wagner<sup>1,2</sup>, E. Jedicke<sup>3</sup>, V. Retzer<sup>4</sup>, H.J. Boehmer<sup>5</sup>

<sup>1</sup> University of Toronto at Mississauga, Department of Biology, 3359 Mississauga Road, Mississauga, ON, L5L 1C6, Canada.

e-mail: helene.wagner@utoronto.ca

<sup>2</sup> WSL Swiss Federal Research Institute, Zürcherstrasse 111, 8903 Birmensdorf, Switzerland.

<sup>3</sup> Johann Wolfgang Goethe-University, Department of Physical Geography, Senckenberganlage 36, 60054 Frankfurt am Main, Germany.

<sup>4</sup> University of Bayreuth, 95440 Bayreuth, Germany.

<sup>5</sup> Technical University of Munich, Department of Ecology (LOEK), Am Hochanger 6, 85350 Freising, Germany.

### Introduction

The design of landscape-level conservation projects frequently relies on hardly demonstrable theoretical assumptions. For instance, the promotion of ecological networks relies on the assumption that corridors and stepping stone habitats increase the exchange of individuals of target species among local populations, thus facilitating the persistence of metapopulations and preserving biodiversity at a landscape scale. This paradigm, however, is rarely tested in the field, partly due to a lack of empirically testable targets and a deficiency in the systematic evaluation of the effectiveness of conservation management strategies. The lack of such standards makes it very difficult to draw general conclusions from existing conservation projects. There are several reasons for that: exchange of knowledge and experience between planners and conservationists on the one hand and ecological scientists on the other hand is usually very limited. Furthermore, no mechanisms for the long-time evaluation of conservation projects exist. At the same time, landscape ecological research is significantly lacking in landscape-level experiments for most species and ecosystems. Our aim is bringing together theory and practice in long time experiments that address key issues of biodiversity management, landscape ecology, and land-use systems, and are highly relevant for application.

### Major issues

We identified two major issues that need to be addressed. First, a meta-analysis of existing projects should be carried out with the goal of identifying critical thresholds for target parameters (e.g. connectivity of a landscape). Second, new long-term projects should be established under an adaptive management paradigm, which involves a close collaboration between science and application with the following components: (1) effective transfer of scientific knowledge, (2) empirical testing of hypothesized effects on target parameters, and (3) adaptation of theoretical and applied knowledge. There are some important challenges to be met.

### Challenges & possible solutions

- **Maintaining continuity** and thus knowledge transfer is a general problem due to the short-term duration of many scientific projects. Long-term projects should be planned in project phases of 3 years (duration of typical PhD programs), e.g. phase 1: baseline data collection, model development, experimental setup (manipulation); phase 2: analysis of short-term effects, initial verification and adaptation of models; phase 3: analysis of long-term effects, final model verification, evaluation and generalization of sustainability of effects, identification of knowledge gaps and issues for continuing research activities.

Personal continuity must be maintained at the level of institutions and senior scientists for at least 12 years. In addition, the transfer of specialist knowledge between generations of PhD students needs to be facilitated e.g. through summer schools or partially overlapping working schedule.

- **Scientifically sound experimental design** needs to be facilitated by establishing a generic procedure involving the components of base-line survey, manipulation, prediction, and evaluation of hypothesized effects. The aspects of replication and randomization need to be addressed. For instance, species with similar requirements (ecoprofiles) are expected to respond to landscape changes in a similar way and thus can be treated as replicates within a study. The study design should account for an increased risk of loss of replicates due to the long-term duration. The application of a standardized procedure will enhance comparability among studies and increase the validity of empirical results.
- **Funding** of such projects, which should be maximally focussed despite of the necessary complexity, will most likely involve multiple funding agencies. This may result in a high administrative effort. Planning should be long-term (in contrast to the actual funding policy of funding agencies), but allow for flexible adaptation of the project. Funding agencies should be involved early in the planning process.
- **Meta analysis** is impeded by the fact that applied projects typically are documented in administrative reports (grey literature) but not in international scientific journals. A meta-analysis should be carried out, involving the following steps: (1) systematic survey of existing landscape-level conservation projects (e.g. by establishing an internet data base); (2) analysis of project aims and context using standard criteria; (3) summary of effects and evaluation of thresholds; and (4) additional field evaluation as deemed necessary.
- **Increase awareness of scientific principles** among all actors in order to facilitate long-term successful collaboration. Communication needs to be tailored to the different target groups to keep scientists, planners, and local managers informed about the goals, progress, and success of a project.
- **Maximizing policy relevance** by taking into account larger-scale social, political, and economic trends and developments will help avoid cuts and disruptions in the funding or implementation of conservation projects and the scientific experiments associated with them.

### Acknowledgements

This paper is the result of a group project within the workshop “Landscape changes and biodiversity: Landscape ecological research towards sustainable land use in Europe” organized by the GfOe Ecological Society Specialist Group Landscape Ecology (<http://www.gfoe.org/gfoe-arbeitskreise/landschaftsoekologie.html>) and held on June 23-25, 2006, in Giessen, Germany.

## The use of land use modelling to assess landscape pattern change

P.H. Verburg, K.P. Overmars , A. Veldkamp

Department of Environmental Sciences, Wageningen University – PO Box 47, 6700 AA  
Wageningen, The Netherlands.  
e-mail: peter.verburg@wur.nl

### Introduction

Human induced landscape changes can have major effects on landscape pattern and biodiversity, either through a complete change of vegetation or crop type or through changes in the spatial configuration of the landscape. An assessment of the effects of land use change on biodiversity requires detailed, spatial information about habitat change. However, uncertainties in predicting the effects of land use change on landscape pattern are large and increasing at higher spatial resolutions. Impact assessment of land use change on biodiversity therefore has to make a trade-off between uncertainties in the different components of the methodology. Depending on the purpose of the study different, scale-specific methods to link land use change scenario studies to biodiversity impact assessment are needed. The choice of method and scale is also important for the use of results within a policy context aiming at alternative strategies of landscape management. The type of information provided and the possibility to support policy discussions is very dependent on the methods chosen.

Two case studies, respectively at regional and continental scales are provided as illustration of the use of land use change modelling in the assessment of landscape and biodiversity change.

### Regional level analysis: San Mariano, the Philippines

The regional study focuses on the effects of land use change on landscape diversity and endemic birds at the forest frontier in the Northern part of the Philippines (Overmars et al., 2005; Verburg et al., 2006a). In this study use was made of three different models to understand the land use changes in the area and its effects on landscape pattern influencing the habitat of endemic birds. A coarse-scale simulation with national extent was used to evaluate the pressure of agricultural expansion and deforestation in this particular region for different scenarios. The modelling approach relied on simple rules and empirical analysis of the relation between land use change and its driving factors. The coarse spatial and thematic resolutions make an interpretation of the effects on landscape diversity and habitat characteristics impossible. For the region itself a more detailed analysis and model is made based on in-depth knowledge of the region. This regional modelling is supplemented with a multi-agent based model to better understand the immigration and settling dynamics. These three modelling approaches aim at different levels of analysis and provide complementary types of information to support the understanding of the local landscape dynamics. For a range of different scenarios the landscape changes in the region were simulated and an assessment of the consequences of these changes for endemic bird species was made.

### Continental level analysis: Europe

The continental study aims at assessing the effects on landscape change for Europe's rural areas due to changes in demography, global trade, technology and enlargement of the European Union (Verburg et al., 2006b). Changes in demand for agricultural products and agrarian structure are likely to have a large impact on landscape quality and the value of natural areas. In addition, several European policies to counteract the adverse effects of such changes in landscape are evaluated on their effects. A spatially explicit, dynamic, land

use change model was used to translate European level scenarios into a high resolution assessment of changes in land use for the 25 countries of the European Union. Simulated scenarios differ in world view, ranging from enhanced global cooperation towards strong regionalization on one hand and strong to weak government intervention on the other. Global economic and integrated assessment models were used to calculate changes in demand for agricultural area at country level while a spatially explicit land use change model was used to downscale these demands to land use patterns at 1 km<sup>2</sup> resolution. The land use model explicitly accounts for the variation in driving factors among countries and the path dependence in land use change trajectories. Results indicate the large impact abandonment of agricultural land and urbanization has on European landscapes and the different scenarios indicate that spatial policies can make an important contribution to preserve landscapes containing high natural and/or historic values. Furthermore, the dynamic simulations indicate that the trajectory of land use change has an important impact on resulting landscape patterns as a result of the path-dependence in land use change processes. The results are intended to support discussions on the future of the rural area and identify hot-spots of landscape change that need specific consideration. One of the specific European scale policies that were evaluated is the so-called 'less favoured areas' policy aimed at reducing land abandonment in marginal areas in order to preserve rural livelihood conditions, cultural heritage and valuable landscapes. Many of these areas coincide with the so-called 'high nature value farmland' areas that are important in terms of agro-biodiversity. The simulations clearly show the trade-offs of compensating farmers in such areas and can be used to identify areas where such policies may be most efficient and successful.

## Conclusions

Both studies address the land use system from a multi-scale perspective by combining models at different levels of organization and scale. The information provided is relevant at a different scale of analysis because of the different levels of detail. However, the information is complementary and relevant to different types of assessment and policy intervention. The case studies indicate that decisions about spatial, temporal and thematic aggregation largely influence the level of detail and type of information that can be obtained in impact assessment. The combination of land use change analysis at different scales respects the hierarchical organization of the land use system and addresses different levels of policy formulation for alternative land management strategies.

## References

- Overmars, K.P., Huigen, M. & de Groot, W.T., 2007.** Comparing Inductive and Deductive Modelling of Land Use Decisions: Principles, a Model and an Illustration from the Philippines. *Land Use Policy*, in press
- Verburg, P.H., Overmars, K.P., Huigen, M.G.A., de Groot, W.T. & Veldkamp, A., 2006a.** Analysis of the effects of land use change on protected areas in the Philippines. *Applied Geography*, **26(2)**: 153-173.
- Verburg, P.H., Schulp, C.J.E., Witte, N. & Veldkamp, A., 2006b.** Downscaling of land use change scenarios to assess the dynamics of European landscapes. *Agriculture, Ecosystems & Environment*, **114(1)**: 39-56.



## 6.2 Symposium 20: Landscape diversity and biological diversity cultural landscapes

### An Analysis of the Architecture of Water and Land Composition in Persian Gardens

A. Shahcheraghi

Islamic Azad University, Science & Research Branch, Tehran, Iran.  
e-mail: a.shahcheraghi@gmail.com

Landscapes often appear different in contrasting countries. This phenomenon arises from variations in climatic, cultural, social, and economic conditions at national and international levels. All these factors can, from time to time, determine the details of a landscape and lead to its development in a given situation.

This paper endeavors to analyze the effects that climate and culture have on the way two elements, such as water and land, are synthesized and organized in relation to historical Persian gardens.

Two thirds of Iran consists of KAVIR (salt deserts) and other wild places usually with very little water. Water in these areas is hidden below ground. However, in the local culture of these areas, water is appreciated as being holy and invaluable.

Nevertheless, despite the adverse climate in Iran, which has a large land area but little water, various gardens have been constructed for over 2500 years. Localities were identified that were suitable to display water in large volumes. In fact, there is a paradox in these gardens because at first glance, it appears that to create a garden within the core of a KAVIR means the creation with opposite conditions to the surrounding area. However, it will soon be realized that the garden is made in a perfect proportion to the surrounding desert because it has been configured according to the amount of water or amount that could be taken from below the surface in the KAVIR and surrounding mountain areas.

The documents and literature that have come down to us from about one thousand years ago, testify that the science of mathematics was used to help calculate exactly how much water would be needed for a given area of ground to construct a garden. Not only these methodologies, but also the science of trigonometry was employed to locate where water existed in sufficient quantities.

Therefore, the local terrain and the KAVIR in the neighborhood of a Persian Garden need to supply the water required for the garden. Local people discovered that latent water existed within the core of KAVIR, and drew it to the surface before creating green gardens in the salt deserts and water is even frequently displayed within the gardens. People also used the configuration of the land to display the water. A piece of ground with a slope and steps up to it contributes to the creation of small-scale waterfalls inside the area of the garden and the water flows with no need of mechanical assistance.

Also, the water deep below the garden flows to the ground surface and returns several times. This pattern of construction is repeated several times in different Persian gardens in the KAVIR.

The presence of water in a Persian garden in the heart of KAVIR brings freshness, vitality, beauty, a good and sweet sound, and a desirable environment. All these appear together as a composition well adapted to the local environment.

Apart from the structure of the gardens, the Iranian culture and beliefs have considerably influenced the development of these combinations of water and ground cover in the Persian gardens, because the people hold water holy in the dry climate.

Therefore, this paper deals with the details of architectural design and scientific principles used in the construction of a Persian garden. It also analyzes the quality of space as derived from the experience of one person in designing such landscapes.

**References**

- Moynihan, E.B. (1982).** Paradise as a Garden in Persia and Mughal India, Second Edition, Scolar Press, London.
- Carroll, M. (2003).** Earthly Paradise: Ancient gardens in history & archaeology, The British Museum Press. London.
- Hobhouse , P. (2001).** Gardens of Persia, Cassel Illustrated.
- Moghtader & Yavari (1998).** Persian Garden: Echoes of Paradise, Mag Publishers, Washington DC
- Moore, Mitchell & Turnbull (2000).** The Poetics of Gardens" , MIT press , London ,Cambridge
- Petruccioli, A. (1994).** Gardens in the Time of the Great Muslim Empires, Leiden
- Porter, Y. (2002).** Palaces and Garden of Persia, [Palais Et Jardins De Perse] Flammarion, Paris

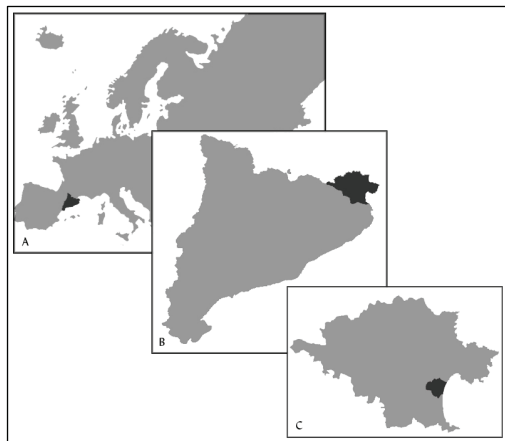
## The evolution of agrarian practices and its effects on the structure of the enclosures landscape in the Alt Empordà (Catalonia, Spain)

A. Llausàs<sup>1</sup>, A. Ribas<sup>1</sup>, D. Varga<sup>1</sup>, J. Vila<sup>1</sup>

<sup>1</sup> Institut de Medi Ambient. Universitat de Girona. Pl. Ferrater Mora, 1. 17071 Girona, Catalonia (Spain).  
e-mail: albert.llausas@udg.es

### Introduction

During the last 50 years, mechanization of the rural environment, and more recently the Common Agricultural Policy have led to deep changes in the agrarian landscapes across Europe, and with special relevancy in the case of mediterranean landscapes (Pinto-Correia *et al.*, 2004). In the north-east of the Iberian Peninsula, a small area of enclosures landscape persists as a relict of what had been an important centre for livestock production in the past.



**Figure 1.** Location of the study area within Europe, Catalonia and the Alt Empordà region.

The contribution presents the results of a study completed in this area with the aim of bringing light to the relationship between the structural change of this landscape of enclosures, the socioeconomic transformation and the evolution of the farming practices that their owners and workers have been developing over time.

### Methodology

A selection of 61 parcels in the heart of the study area was performed in order to secure a rich and diverse sample of different environmental conditions and varying management practices.

The enclosures were mapped at a detailed scale (1:5000-1:7500) from enlarged aerial photographs of years 1957, 1970 and 2001 with the use of Computer Assisted Design software Autocad Map and Geographical Information System software ESRI ArcMap. Special attention was paid to the precise delimitation of pasture surfaces and hedgerow borders, being these two the land covers whose changes were analysed over time.

The physical analysis of the structure and evolution of the landscape was performed through the calculation of multiple spatial indexes commonly used in the practice of landscape ecology (Forman & Godron, 1986). Fragstats and Grass software were used in order to accomplish this goal.

Principal Components Analysis (PCA) was used to uncover which statistics provided little or redundant information, and hence discarding them, and to simplify the volume of data to manage and to work with. A Common Principal Components (CPC) (Flury, 1988) analysis was performed in order to evaluate the degree of match between the covariance matrices resulting from the first PCA.

Past and present data about the cultural practices that farmers developed and develop on their pastures, on their hedgerows, about the characteristics of their exploitations, and about their views on the future of farming and their enclosures was obtained through live interviews with the owners and workers of the parcels. The data gathering method allowed us to collect

around 90% of all the possible data, being unable to reach a few of the owners for 1957 and 1970.

Multinomial Logistic Regression was performed in order to clarify the relationship between a set of discrete dependent variables (the answers provided in the interviews) and a set of continuous independent variables (values for each of the components reflecting the physical characteristics of the landscape).

## Results

The land cover contained in the parcels (pasture, crop, abandonment) seems to greatly influence some characteristics of both the profitable agricultural surface and the hedgerows. More specifically, it has been found that for years 1957 and 2001 exists a significant relationship between the complexity of the polygons and the degree of fragmentation of the hedgerows polygons with the presence of a crop or the presence of the more traditional pasture within the parcels. The more complex a parcel border is and the less fragmented the hedgerow net is, more likely it is to find a traditional pasture cover in the parcel. These same metrics are also linked with the presence or absence of livestock in the field and with the fact that the owner follows an agro-environmental programme.

Now putting the focus on hedgerows, it looks feasible to link polygon surface and some measures of its complexity with the likelihood of it being a hedgerow made of old trees or a mere herbaceous margin. This relationship seems to only work for years 1957 and 1970, while it is not significant for 2001. The biggest and more complex polygons were associated with wide enclosure hedgerows. The function of the hedgerows can also be linked with the physical characteristics as seen from a low scale aerial photograph.

At the whole farm level some observations can be made. Bigger parcels, with low complexity borders are usually linked with dispersed estates throughout the years. For 2001, the farms with larger hedgerows in their parcels are considerably less likely to be receiving subsidies for the maintenance of their production activity than those with smaller hedgerows.

Finally, in relation with the opinion of farmers about the future of their fields, it seems that the degree of conservation of the hedgerow net assessed through the measurement of its fragmentation is related with the likelihood of reintroduction of livestock to graze in the parcels. The most fragmented hedges are not likely to see livestock near them in the future.

## Conclusions

Though not abundant, some significant relationships have been found between the physical characteristics of a cultural landscape and its management practices over time. Therefore, the foundations for the creation of a prediction model of landscape evolution based in the characteristics of the farms in the area and their agrarian practices are set.

## References

- Pinto-Correia, T; Breman, B; Loupe, I. & Van Doorn, A. (2004)** Dealing with land abandonment: the challenge of policy intervention in marginal rural areas. *Colloque International. De la connaissance des paysages à l'action paysagère. Bordeaux, 2-4 December 2004.*
- Forman, R.T.T. & Godron, M. (1986)** Landscape Ecology. Wiley & Sons, New York.
- Flury, B. (1988)** Common principal components and related multivariate models. John Wiley, New York.

## **Spatial and temporal relationship between forest spaces that contain Shinto shrines and topographical parameters in central Tokyo, Japan**

**N. Fujita<sup>1</sup>, Y. Kumagai<sup>2</sup>**

<sup>1</sup> Graduate School of Agricultural & Life Sciences, The University of Tokyo  
1-1-1 Yayoi, Bunkyo-ku, Tokyo 113-8657, Japan.  
e-mail: fujita@fr.a.u-tokyo.ac.jp

<sup>2</sup> Faculty of Regional Environment Science, Tokyo University of Agriculture  
1-1-1 Sakuragaoka, Setagaya-ku, Tokyo 156-8502, Japan

### **Introduction**

Before the 1970s, the meaning and function of shrines and forests in regional spaces were not appropriately defined in the field of city planning (Usugi, 2003). The rapid urbanization of Tokyo—the central city of Japan—has moved beyond its upper limits, with much of its area being filled with new buildings. Green spaces and forests have decreased with the impact of human development. In recent years, political attention and research has focused on how to create new green spaces, for instance, the technique of rooftop gardening for high-rise buildings. However, central Tokyo still has 125 shrines (across 6400 hectares). The term “shrine forests” can imply a Japanese view of nature (Fujita et al., 2005). It also confirms the correlation between geographical features and the uneven distribution of green spaces and urban forests that have been maintained and are improving in some parts of Tokyo (Fujita and Kumagai, 2004). The purpose of this study is to clarify the landscape changes that have taken place over 120 years and analyze this relation with urban forests and geographical features by focusing on the continuity of forest shrines and surrounding green spaces in the Tokyo metropolitan area.

### **Methodology**

#### Study area

The study region is the Tokyo metropolitan area, the field surrounded by the JR Yamanote Line. The Yamanote Line is a 34.5 km loop train line that encloses 6400 hectares of land; this train line passes through the major urban districts of Tokyo.

#### Analysis of the transition of landscape elements and geographical features

Geographical index data was created through an analysis of DEM, using four indexes: elevation, slope, Laplacian, and openness. With regard to the geographical index data, “Numerical Map 5 m Mesh (Elevation),” issued by the Geographical Survey Institute, was used. The features of the digital data of microlandforms are converted into detailed data using aerial laser scanners. This technique has an advantage in that it is possible to extract or compare the differences in microlandforms when the terrain is relative flat, as in a plain field, compared with a mountain area, or when an analysis is carried out on a narrow range (Japan Map Center, 2006). This study made particular use of “Map Name: Tokyo Ward Version” (published on December 1, 2003). The landscape element was measured on the basis of a paper medium, i.e., the Tokyo Shrine Directory; the data were imported in the vector format in order to obtain information on the point coordinates. Subsequently, georeferencing was conducted for each aerial photo image (2 km x 1.5 km for one file; 30 photos in all) in the entire target region; the photo images were imported and mosaic treated. The images were overlaid with shrine points that were included in the target range to create polygons of the shrine forests in that range. A connection was found between the shrine forest polygon and the surrounding green spaces polygon. The transition over 120 years,

from the Edo to the present day period, was compared in six periods, based on the historical events in Japan. These analyses were conducted using TNTmips 7.0 (6.9 for some analyses). TDM digital Orthophoto was used for the aerial photo images (terrestrial resolution: 50 cm, 24-bit full color, taken between April and June 2003)..

## Results

The relationship between the landscape elements and geographical index data were summarized as follows. In terms of elevation, there was no indication of discriminative distribution between the landscape elements and geographical index data. In terms of the relationship with slope direction, there was a trend in which a landscape element was formed in the region pointing in the south eastern direction on the eastern side of the target spot, near the coast. In terms of Laplacian, the relationship was recognized in terms of the presence of green space group formation. In all the target regions, groups of green spaces were formed in regions that had high Laplacian values. Further, when focusing on continuity, it was recognized that shrine forests were located in regions or spots that had high Laplacian values, indicating that the space occupied by shrine forests functioned as a basis for landscape elements. In terms of openness, the relationship was recognized in terms of the presence of landscape element formations. Landscape elements with continuity tended to be located either in regions with high openness or in regions where openness was slightly high. In particular, compared to some of the surrounding regions with low openness, landscape elements tended to be located in spots that had high openness values. The transition of landscape elements and geographical features progressed as follows: LE1 was composed of forests, LE2 was composed of buildings with forests, LE3 was composed of buildings, LE4 was composed of buildings with fields, LE5 was composed of grasslands, and LE6 was composed of buildings with grasslands. The relations that contained urban forests and geographical features became increasingly stronger (Table1). A possible interpretation of these results is that if shrine spaces can be recognized as urban green spaces in the field of city planning, they will be considered as valuable resources with ecological and cultural value.

**Table 1.** The transition of the relation between landscape elements and geographical features. (1: equilibrium; above 1: strong; below 1: poor.)

	LE1	LE2	LE3	LE4	LE5	LE6
~1860	1.06	0.98	-	1.20	-	-
~1880	0.81	1.16	0.69	1.14	0.69	0.39
~1920	1.36	1.05	0.81	1.26	-	1.04
~1950	1.09	1.09	0.86	-	-	1.87
~1980	1.38	1.06	0.87	-	-	-
~2000	1.41	1.13	0.90	-	-	-

## References

- Fujita, N. & Kumagai, Y. (2004)** Landscape change and uneven distribution of urban forest in the center of Tokyo. *Journal of Japanese Landscape Architecture*, **67(5)**: 577-580.
- Fujita, N; Ono, R. & Kumagai, Y. (2005)** Meanings and their position of “shasoh” on the preservation system for national monuments. *Journal of Japanese Landscape Architecture*, **68(5)**: 417-420.
- Usugi, A. (2003)** *Landscapes and Spaceorogy–Space Recognition and Landscape Structure of Japan*, Kokin shoin, Tokyo.
- Japan Map Center. (2006)** *Numerical Map 5 m Mesh (Elevation) Japan Map Center*, <http://www.jmc.or.jp/data/5m/hani.html>.

## Continuity and discontinuity of rural landscapes-with some consideration to Poland

B. Bożętka

Szczecin University, The Institute of Marine Science, Wąska 13 Street, Szczecin, Poland.  
e-mail: Barbara.Bozetka@univ.szczecin.pl

### Introduction

Predominance of cultural landscapes is characteristic for Europe. Meeus (1995) estimates that cultural landscapes cover 70- 90% of the continent whereas agriculture uses approximately 45% of its area. In consequence, the questions of dynamics and stability of rural landscapes are of great importance for landscape studies. Presented study focuses on the concept of continuity and discontinuity in its broad sense-linking functional and visual aspects. The work implies the issue of landscape extinction and stresses the role of socio-cultural factors for landscape continuity. Several examples from the area of Poland are provided, where a sudden interruption of cultural coherence after the Second World War occurred.

### Changes in landscape structure

Contemporary landscapes characterized by progressive globalization and urbanization are widely defined as the post-modern landscapes (Antrop, 2005). Rural areas show two main directions of land transformation: increase of diversity connected with ecological farming or increase in homogeneity within a landscape in a highly developed agri-ecosystems (e.g. Richling and Solon, 1996). Changes of landscape values accompany the differences in landscape structure. Major spatial land transformation processes leading to change in rural landscapes include attrition, expansion, shrinkage, presumably proliferation (identified by Petit *et al.*, 2004 for woodland patches) and isolation.

### Spatial and temporal discontinuity of Polish cultural landscapes

Considering political and socio-economic changes during the second half of 20<sup>th</sup> century in Poland, four phases of radical landscape changes can be observed.

First stage embraces the time of the Second World War with a relatively short period after The War. It is connected with the destruction of the country, changes of its borders and far-reaching migration processes. Second phase is deeply affected by growing strengths of the communist rule which brought with it significant changes in comparison to pre-war times. Under the Soviet control large private ownership was liquidated and cooperative farms supported by the state started to function. Some landscapes associated with regional and national identity e.g. those linked to a nobility class disappeared leaving but remnants. Simultaneously the pressure of industrialization and urbanization acted (tab.1).

Third period beginning in 1989 is linked with a situation that arose after the collapse of the regime. Owing to new political and economic conditions collective farms started to vanish, but urban sprawl and the growth of infrastructure has been continuing. Economic demands and sudden change of lifestyles have led to decline in a number of small private farms. Some traditional rural landscapes are transforming into abandoned or semi-wild landscape. Finally membership in EC is influencing rural landscapes through new investments not only in farming, but also in the nature conservation system.

Therefore landscape coherence was destroyed several times causing a high complication of time layers and spatial landscape patterns. Crucial land use changes in Poland in the period 1930-2000 encounter the increase of the amount of built, industrial and forest areas while the amount of meadows and pastures constantly decreases (Ciołkosz, Poławski, 2006). Specific features following the period of the latest economic transformation include chaotic spatial development with an uncontrolled growth of urban fringes.

**Table 1.** The reshaping of the Polish rural landscape after The Second World War (selected elements).

landscape elements disturbed or lost	new elements
landownership system-large private farms belonging to a nobility class;	large national cooperative farms
organic architecture- wood, brick and clay;	'modern' buildings, anti-ecological technologies, blocks of flats;
numerous elements belonging to ethnic groups;	
manor or palace ensembles;	second homes;
landscaped areas and parks;	new nature protection areas

### Rural landscapes in danger of extinction

Danger of extinction becomes an underlying theme of the research on traditional cultural landscapes. Traditional cultural landscapes comprise among others Meeus's (1995) regional landscapes: coltura promiscua, montados, delta, huerta, polder, kampen and Poland's strip fields. Apart from the importance for diversity, they display the hidden ways of sustainable management techniques (Antrop, 2005).

Two dimensions of discontinuity: material and immaterial influence not only outstanding landscapes. The emphasis is put here on every-day landscapes, because still a large part of Polish rural areas is connected with traditional agriculture. Small, long fields with balks, amidst patches of forests and woodlands; numerous structures forming 'eco-margins'; religious symbols; and scattered housing with domestic and breeding animals in the yard are often recognized as their distinctive features.

Nowadays urbanization and field consolidation constitute serious hazards to the Polish traditional rural landscape which may result in a large-scale changes of landscape diversity and landscape richness.

### Immaterial dimension of discontinuity

Rapid evolution of landscapes in the last 60 years tends to be one of the key characteristics of European landscapes. Changeable socio-economic conditions in Poland accelerated this process and influenced a mental dimension of the landscape. Negative consequences for the mental sphere involve: 1. continuous attempts to depreciate aesthetic values; 2. disappearance of the sense of attachment to place and concern about environmental quality; 3. attitudes towards protection and conservation of landscape values, particularly those of cultural origin. Consequently, the matters of responsibility for the state of the landscape and of the environment appears. Individual attitudes complemented a value system specific for the governing powers.

### References

- Antrop M., (2005)**, Why landscapes of the past are important for the future, *Landscape and Urban Planning* 70 (2005), 21-34.
- Ciołkosz A., Poławski Z.F., (2006)**, Zmiany użytkowania ziemi w Polsce w drugiej połowie XX wieku, *Przegląd Geograficzny*, 78, 2; 173-190.
- Meeus J.H.A., (1995)**, Pan-European landscapes, *Landscape and Urban Planning* 31 (1995), 57-79.
- Petit S., Howard D.C., Stuart R.C., (2004)**, A national perspective on recent changes in the spatial characteristics of woodland in the British landscape, *Landscape and Urban Planning* 69 (2004), 127-135.
- Richling A, Solon J., (1996)**, *Ekologia krajobrazu*, Państwowe Wydawnictwo Naukowe, Warszawa.



## Pastoral landscapes of the North Caucasus under transition time

R. Gracheva, E. Belonovskaya

Institute of Geography of RAS, Staromonetny per.29, Moscow 109117 Russia  
e-mail: gracheva04@list.ru

### Introduction

The alpine meadows of the Caucasus had been formed under human impact for several millennia. Seasonal grazing and mowing are the important factors of stability/instability of these ancient seminatural landscapes, and the variety of traditional land use determines landscape diversity to a great extent. In the crisis time traditional range rules are often broken, and changes in human impact are reflected on the condition of the pastoral landscapes. The last 15 post-soviet years, which disturbed the established local land use regulations, can be considered as a crisis time in the mountain regions. An integrated study of the current range regulation and its impact on mountain environment provides an opportunity to understand: what are the effects of land use changes in the transition time on the high-mountain pastoral landscapes?

### Pastoral landscapes

Pastoral landscapes of the North Caucasus occupy more than 5 million ha, extending from the elevations of 3200 – 1900 m a.s.l. in the East and Central North Caucasus, to the 3500 – 900 m a.s.l. in the West North Caucasus. They lie in the alpine, subalpine and partly in the forest mountain belts of the Great Caucasus and Rocky Ridge.

Pastoral land using is strongly stratified by the traditional cattle breeding. Alpine short grass meadows and carpet-like meadows (3200 – 2500m a.s.l.) are used as the distant pastures during 2-3 summer months only. Subalpine high-grass meadows (2800-2000 m a.s.l.) are used as high-yield hayfields and autumn ranges. Mountain steppe meadows and meadow steppes lie in the slopes and valleys of the North-Jurassic depression in the wide altitude range (between 2500 - 900 m), partly in the forest belt, having both climatic and anthropogenic origin. These are the most populated and the most vulnerable landscapes and are used as the summer pastures. Submontane plains were used for winter grazing before and during the soviet kolkhoz time.

All pastoral landscapes have the fields with active natural local hazards such as avalanches, mudflows, stony streams, landslides, and gully and soil erosion. In the alpine belt the cryoturbation and solifluction are destroy both the soil and plant cover. Range regulation and observance of spatial stratification are the main mechanisms of pastoral landscape stability maintaining.

### Change in the use and conditions of the pastoral landscapes

Overgrazing is usually considered as the major threat to mountain pastoral landscapes. However, at the present time the contrary processes, which are not properly understood, take place in the cattle-breeding area of the North Caucasus because of abandonment of the extensive distant high-mountain pastures and dramatic uncontrolled overgrazing in the nearest ranges and hayfields. The clearest changes in the use of the pastoral landscapes became apparent in the central and west parts of the North Caucasus. In Republics of North Ossetia, Kabardino-Balkaria and Karachaevo-Cherkessia the cattle number decreased up to 5-10 times just after disintegration of the kolkhoz system, and is gradually increasing during the last 10 years. A private cattle breeding is continuing on under the legal irregularity and total neglect of traditional nature protection behavior. Communal distant-pasture cattle tending is being stopped, cattle-driving routes are not used and any control on the range activity is not realized. Winter submontane pastures are used as before in the eastern part of

North Caucasus (Daghestan) only, where increasing rural population expands cattle breeding activity.

#### The distant alpine pastures

Sharp decreasing or stopping of the grazing pressure on the distant alpine pastures results in the different consequences. It is well known that weakening of the grazing pressure leads to the regeneration of natural conditions of landscape. However recovery rates for different situations are not well known. Observations show that 10-year destruction of grazing regularity destroys the complete specific assemblages of alpine and subalpine meadows, and ruderal vegetation extends over the meadows diversity. Nevertheless the meadows bioproductivity and biodiversity can be gradually recovered by plant successions. The most visible and sufficient natural processes under full stopping of pastures reclamation act upon soil surface: tussocks formation, cryoturbation and stony accumulation up to “stone paving” formation. Such natural phenomena are irreversible and great efforts for their overcoming will be required.

#### The nearest pastures and hayfields

At present time total livestock of the Central and partly West North Caucasus is grazed on the nearest slopes including hayfields the whole year round. Even in the regions where cattle numbers decreased up to 20 times, the overgrazing of the nearest pastures run up to 2-4 times. Steppe meadows and meadow steppes take a main impact of uncontrolled grazing, which is reflected in the aggravation of soil and gully erosion and shallow landslides. As a result spatial diversity of projective cover varies from 0-10 up to 40-50%% depending on the slope shape, overland runoff increases sharply and causes avalanche-like destruction of the landscape components throughout slope. Evident effect of erosion and runoff increase is aridization, which becomes apparent in the change of species composition. Wide distribution of annual plants with short and fragile rootage instead of the soil-protecting permanent grasses was observed during the last 15 years within woodless landscapes of North-Jurassic depression. New barren plots of different size – from 1m<sup>2</sup> up to 20-30m<sup>2</sup> - occupies about 25% of the slope surface in Digoria Gorge (North Ossetia), and land quality is strongly degraded. As a whole while the biodiversity decreases, spatial diversity of landscape, caused by the anthropogenic impact, increases.

### **Conclusion**

During the last 15 years mountain pastoral landscapes of North Caucasus are under the influence of the contrary processes: reducing or stopping of human impact in the alpine belt and sharp strengthening of human pressure upon the steppe meadows and meadow steppes of subalpine and forest belts. All these processes modify properties of pastoral landscapes. Evidently, having a socio-economical background these processes took place repeatedly during the long history of mountain land exploitation. What is the long-term influence of these processes upon pastoral landscapes and all system of interrelated mountain landscapes? What are the consequences of seminatural meadows abandoning - regeneration of natural properties or degradation, spatial diversity or unification? These questions expect the solution.

**Land use and land cover change in Olzinelles valley, Montnegre, NE Spain (1924-2006). Linking land abandonment to changes in stream biodiversity**

I. Otero <sup>1</sup>, M. Boada <sup>1,2</sup>, A. Badia <sup>2</sup>, S. Piqueras <sup>1</sup>

<sup>1</sup> Institut de Ciència i Tecnologia Ambientals. Universitat Autònoma de Barcelona  
Edifici Ciències, Torre Àrea 9, 4a planta. 08193 Bellaterra, Barcelona (Spain).  
e-mail: iago.otero@uab.cat

<sup>2</sup> Departament de Geografia, UAB, Edifici B. 08193 Bellaterra, Barcelona (Spain).

**Land use and land cover change in the “new” scientific paradigm**

Changes on land use and on land cover are one of the main components of global change. Land cover change has an important influence on water and energy balance (Turner *et al.*, 1995), and may lead to changes in biodiversity at different spatial and temporal scales. The effects of land use and land cover change and its driving forces interact in a complex network of socioecological relations. In this conception, *nature* and *culture* cannot be considered as aprioristic and separated categories. Different authors have criticised nature/culture separation and excessive specialization of knowledge into unconnected fields, and have proposed new unified views (Capra, 1998; Ángel, 2001; Noguera, 2004). In this holistic framework we may find landscape ecology, a hybrid discipline with a clear motivation to understand and overcome environmental problems (Toledo, 1998). The existence of new global environmental risks questions the domination of scientific method over other forms of knowledge (Funtowicz and Ravetz, 2000), and reveals the importance of taking into account traditional knowledge and oral sources in studies related to sustainability issues.

**Regional evidences of global change-induced alterations of biodiversity**

In Catalonia (NE Spain), different studies have showed global change-induced alterations of biodiversity. Peñuelas and Boada (2003) demonstrated that beech (*Fagus sylvatica*) forest has shifted altitudinally upwards by ca. 70 m at the highest altitudes (1600-1700 m) and that it is being replaced by holm oak (*Quercus ilex*) forest at medium altitudes (800-1400 m), as a consequence of warmer conditions and the cessation of the traditional land management in the Montseny mountains. Peñuelas *et al.* (2002) have provided evidence of altered life cycles for some of the most abundant Mediterranean plants and birds for the period 1952-2000 in Cardedeu, as a consequence of an increase in average annual temperature by 1.4 °C. Stefanescu *et al.* (2004) reported a reduction in number of butterfly species due to urban development and intensification of farmland, and have predicted a loss of diversity in Catalonia in the coming years, according to the most plausible scenarios of climate change.

**Study area and hypothesis**

Olzinelles valley has an extension of 1.130 hectares and is located in Montnegre mountains (province of Barcelona, NE Spain). More than 85% of the area is covered by forests, mainly coppiced cork oak (*Quercus suber*) forest and coppiced holm oak (*Q. ilex*) forest, while only 5% is covered by fields. Timber plantations, such as plane trees (*Platanus* sp.) or stone pines (*Pinus pinea*), occupy 7% of the area. Land tenure is private in all the area and 74% of it is included in the Montnegre-Corredor Natural Park since 1989. Our hypothesis is that rural exodus, land abandonment and cessation of firewood felling have lead to a smaller agrarian area, a larger forest area and a higher forest density. The consequence would be a higher level of basin evapotranspiration, a reduction of Olzinelles stream flow and a change from regular to irregular regime in the last decades. These hydrological changes would be the cause of the disappearance of some aquatic or semiaquatic species of fauna.

**Results**

The analysis of municipality census and parish registers shows that the 179 inhabitants of 1924 have decreased to 27 in 2006, the number of inhabited *masos* (traditional houses of Catalan countryside) has dropped from 24 in 1924 to 10 in 2006 and the number of peasants and shepherds has decreased from 48 in 1924 to 21 in 1970. Through aerial photo interpretation of 1956 and 2002 we have obtained land cover maps of each year and we have superimposed them in a Geographic Information System (GIS) in order to quantify cover transformations. Results show a loss of agrarian cover of 72 hectares an increase in forest cover of 44 hectares. Only a third of the agrarian area of 1956 has been conserved (38 hectares), while almost 60% (67 hectares) has been converted to forest, either by natural afforestation of cork oak and holm oak or by plantation of different timber species as plane trees or stone pines. Moreover, by visual comparison of aerial photographs (1956 and 2002) we have documented an increase in forest density.

Changes in Olzinelles stream flow and regime have been documented by oral sources and by diachronic comparison of photographs. In the last three decades, the flow has decreased and the regime has changed from regular to irregular, with absence of water during summer months. This would be related to the disappearance of Mediterranean barbel (*Barbus meridionalis*), considered as near threatened by the IUCN (Crivelli, 2005), chub (*Squalius cephalus*) and European eel (*Anguilla anguilla*), three fish species that used to be in the stream in the seventies. The disappearance of freshwater white-clawed crayfish (*Austropotamobius pallipes*) is also related to the change in river regime, but is also influenced by the introduction of alien red swamp crayfish (*Procambarus clarkii*). Another species that has disappeared is southwestern water vole (*Arvicola sapidus*), an interesting semiaquatic mammal considered as near threatened by the IUCN (Amori, 1996).

## References

- Amori, G. (1996)** *Arvicola sapidus*. In: IUCN (2006) 2006 IUCN Red List of Threatened Species. Retrieved on 1 February 2007, from [www.iucnredlist.org](http://www.iucnredlist.org).
- Ángel, A. (2001)** *El retorno de Ícaro*. Corporación Universitaria Autónoma de Occidente, Cali.
- Capra, F. (1998)** *La trama de la vida. Una nueva perspectiva de los sistemas vivos*. Anagrama, Barcelona.
- Crivelli, A.J. (2005)** *Barbus meridionalis*. In: IUCN (2006) 2006 IUCN Red List of Threatened Species. Retrieved on 1 February 2007, from [www.iucnredlist.org](http://www.iucnredlist.org).
- Funtowicz, S. & Ravetz, J.R. (2000)** *La ciencia posnormal. Ciencia con la gente*. Icaria, Barcelona.
- Noguera, P. (2004)** *El reencantamiento del mundo*. Programa de las Naciones Unidas para el Medio Ambiente (PNUMA) and Universidad Nacional de Colombia IDEA, Manizales.
- Peñuelas, J. & Boada, M. (2003)** A global change-induced biome shift in Montseny mountains (NE Spain). *Global Change Biology* **9**:131-140.
- Peñuelas, J.; Filella, I. & Comas, P. (2002)** Changed plant and animal life cycles from 1952 to 2000 in the Mediterranean region. *Global Change Biology* **8**: 531-544.
- Toledo, V.M. (1998)** Estudiar lo rural desde una perspectiva interdisciplinaria: el enfoque ecológico-sociológico. E. Valdivia (Ed). *Memorias del V Congreso Latinoamericano de Sociología Rural*. Universidad Autónoma de Chapingo, Mexico D.F., pp. 159-180.
- Turner, B.L.; Skole, D., Sanderson, S., Fischer, G., Fresco, L., Leemans, R. (1995)** *Land-Use and Land-Cover Change Science/Research Plan*. International Human Dimensions Programme on Global Environmental Change and International Geosphere-Biosphere Programme. Retrieved on 20 April 2006, from: <http://www.ihdp.uni-bonn.de/>.
- Stefanescu, C.; Herrando, S. & Páramo, F. (2004)** Butterfly species richness in the north-west Mediterranean Basin: the role of natural and human-induced factors. *Journal of Biogeography* **31**:905-915.

## The main principles of formation and evolution of structure of cultural-historical landscapes of Central Russia.

V.A.Nizovcev

Moscow State University, 119992, Moscow, GSP-2, Leninskie gory, MSU, Faculty of Geography,  
e-mail: [nizov2118@mtu.ru](mailto:nizov2118@mtu.ru)

The formation and development of cultural-historical landscapes are the obligate result of evolution of society and nature, as well as, man and landscapes during their coherent growth. Cultural-historical landscapes are holistic historic-cultural and nature creations. They reflect the history of land use and spiritual development of local (ethnic) community of the finite territory with determined homogeneous natural (landscape) characteristics. The majority of them appertain to the category of relict landscapes, which completed their evolution growth. That means that these are Anthropogenic (AL) and Cultural (CL) landscapes. They have lost anthropogenic management and continue their growth obeying natural processes. These landscapes include elements of morphological structure and natural components, which have been transformed by man, as well as artefacts, sociofacts and mental facts. These facts can be considered as peculiar “biographical chronicle” of activity of population in determinate landscape conditions in determinate historical period. These facts are evidences of material and spiritual cultural of society.

The whole set of such complexes can now be considered as the associative category, because material elements in these complexes are absent or dispensable and historical-cultural associations exist in natural elements. Such natural elements are their carriers. For example, below ground old land soils, cultural layers, saturation of different types artifacts in row of landscape complexes. Such carriers may be also place names, reflected specific land use, mental life in concrete landscape complexes. Landscape-historical complex are the main structural elements of cultural-historical landscapes, which are formed under the influence of natural and man-made factors. Landscape-historical complexes are fixed territorial structure of economical activity in determinate time periods. We can re-found the picture of settlers activity in determinate time periods and reconstruct man-made changes in landscape complexes, accompanied by different types of land use. We can do it according to founded artifacts, below ground old land soils, cultural layers and even due to place names.

The formation of anthropogenic landscapes links completely with transformation of material and spiritual social life. Appropriately the first AL begins to arise simultaneously with conversation of appropriating economy into generating economy. There was such conversation in Central Russia (Neolithic revolution) only in Bronze Age. In this period the soil become the tools of man’s trade. Forming of first AL and CL is a result of developing of agricultural manufacture, developing of arable farming and pasture economy types, and also a consequence of formation of permanent settlements. The first AL and CL were connected to features of settlements distribution on territory. The type of arable farming involves to anthropogenic landscape as a subsystem. This subsystem includes functionally conjunct agricultural technology elements, natural attributes of soil and social elements.

So we can consider that only anthropogenic modification of natural landscapes was only formed at the Mezo-Neolithic stage. Anthropogenic transformed landscape complexes and even man-made landscape complexes have been formed in the Bronze Age. Some of these complexes exist now. Actual anthropogenic and cultural landscapes began to form only in the Iron Age while permanent, long existing settlements and agricultural structure have been organized.

Two main kinds of anthropogenic landscape complexes has formed in Central Russia in the Iron Age. First, these are small settlement anthropogenic landscape complexes (*selischa* and *gorodischa*) with applied permanent miniature arable areas (arable agrosystems on the level of *facia* and *podurochische*). These complexes are located on the

capex and on the areas between river banks and banks of streams. Second, these are pasture anthropogenic landscape complexes (on the level of *podurochische* and *urochische*), located in flood plain and valley-cavin position (pasture *plod* plain meadow-forest). The most extensive anthropogenic landscape complexes with slash and burn agriculture have formed at the same time. Formed land use structure was very stable and optimal for that time. This structure existed for nearly a thousand years in many regions. Today the numerical preserved landscape-historical complexes are the evidences of these cultural landscapes.

The next important stage of formation AL and CL was connected with the Slavonic colonization of the region and with development of arable agriculture by Slavonic settlers (X-XII centuries). There were more than 70 fortified settlements (*gorodischa*) in Moscow region. At the same time the first cultural landscapes of cities (Moscow, Mozshaïsk, Serpuhov, Dmitrov, Volokolamsk, Zvenigorod, Ruza and others) appeared and were developed, as the centers of densely populated region of arable agriculture. Almost all ancient Russian cities are located at the ecotone position at the boundaries of two or more landscapes. There are only five places in the modern Moscow region, where the boundaries of three physico-geographical provinces cross. And all these places have been occupied by ancient Russian cities. These cities are Moscow, Kolomna, Serpuhov, Volokolamsk, Ruza

Diversity and contrast of landscape conditions are determined, in the main, by features of soils and differences of local climate. Moscow cities appeared at the first time on the loamy acclivous valley *zandres* and terraces. So the areas which surrounded of city, were optimal for arable farming features: plain and drained surfaces, clay-sand fruitful soils with advantageous for agriculture air-water regime. These are "warm" places. Usually the soils were ready to use very early in spring. Spreading of arable farming led to localization of permanent places of deep influence on landscape complexes. Unconvertible transformation invaded soils and lithogenous base of landscape complexes, due to development of erosion processes on the slopes. Excavations of ancient grave-mound on slopes near valleys show us that these were made on abandoned arable land with cultural and often with run-off soils. Permanent arable land appeared around settlements, which can be considered anthropogenic landscape complexes of that time.

After that forming of AL were connected with internal colonization of the region, the extensive spread of three-field arable farming and organization of settlement structure on the inerfluves. The specific arable cultural landscapes complexes appeared in that time: e.g. cannabis fields, cabbage crofts and gardens. Arable forests become wide-spread anthropogenic complexes. Cleaning and organization of hayfields and pastures were made after termination of planting for preservation and increasing of fertility of soils. Ancient people knew that cultural features of soil were preserved better under meadow, then under forest. Complicated amelioration procedures were carried out on the flood plain: erection of meanders, draining of depressions near by terraces. Different hayfield and pasture cultural landscapes complexes were formed: e.g. flood plain, lowland and forest types.

The base of modern settlement structure and land use structure has been formed in the majority of Central Russian regions in XIV-XVI centuries. Lea tillage and catch systems with sown three-fields ploughing were wide-spread agriculture practices.

Large areas of arable cultural landscape complexes were formed. Artificial cultural landscape complexes of upland meadow also appeared. The places for such meadows were organized by slush-burning and removing of shrubs and trees. The quantity of settlements was maximal through all the history of region. The agricultural limit was achieved in the existed settlement structure. New types of cultural landscape complexes appeared – artificial ponds on interfluve areas. Monasteries were also very active. Specific monastery cultural landscape complexes appeared. Anthropogenic landscape complexes appeared related to mining where limestone was present. Our investigation has showed that anthropogenic and cultural landscape complexes reached a maximal spread in XVI c. in Central Russia in the Middle Ages.

## Does history really matter? Plant species richness in different fragmented landscapes

S.A.O. Cousins

Department of Botany, Stockholm University, 106 91 Stockholm, Sweden.  
e-mail: cousins@botan.su.se

### Introduction

Several centuries of grassland management has created some of the world's highest plant species richness. Recent land use changes have led to habitat loss and fragmentation which threaten species richness in rural landscapes. To preserve and restore species richness for the future it is necessary to understand how present-day species patterns are affected by historical management. A consequence of the slow response of long-lived species to landscape change is that present species patterns reflect the historical landscape rather than the present. Species might disappear due to an extinction debt even if the contemporary landscape pattern is conserved. However, most studies have been conducted in landscapes that are traditionally managed or otherwise identified as being important for conservation. There is a lack of studies from ordinary commonplace rural landscapes with little semi-natural grassland left.

My question is how important is the past landscape for the present-day plant species richness in rural landscapes with little semi-natural grassland left. To try to answer this I have investigated different common rural landscapes in Sweden and compared the results with the findings of three other studies from Sweden (Lindborg and Eriksson 2004), Estonia (Helm *et al.* 2006) and Belgium (Adriaens *et al.* 2006).

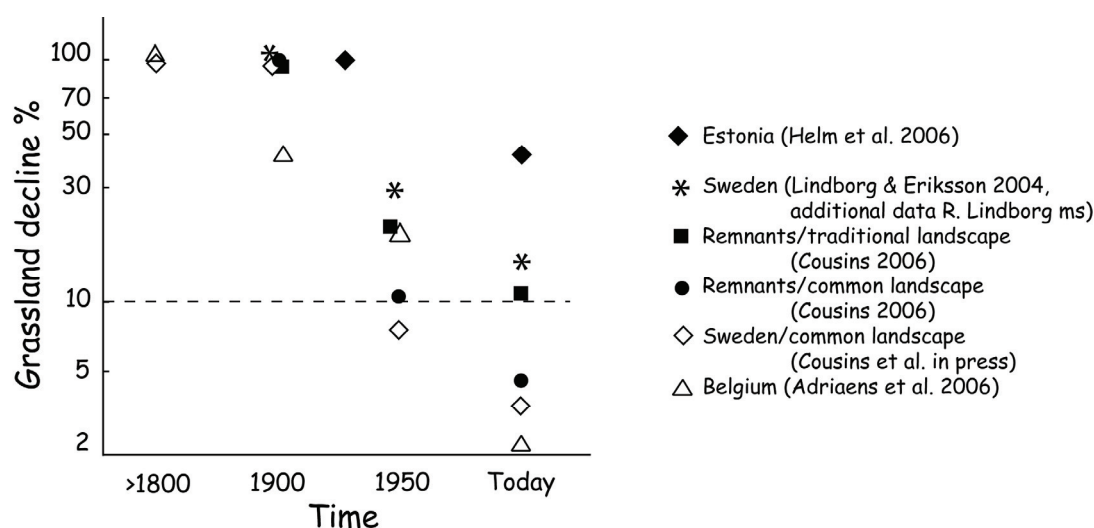
Past and present vegetation patterns were analysed using old cadastral maps, some as early as 17<sup>th</sup> century and aerial photographs. Species richness, density and incidence were investigated in three grassland habitats; continuously grazed semi-natural grasslands, abandoned grasslands and small remnant habitats (midfield islets). 25 different landscapes were used in the first study on grasslands (Cousins *et al.* in press) and two contrasting landscapes for the remnant habitat study, one open modern agricultural landscape and one traditional rural landscape (Cousins 2006). Area and isolation effects was analysed in three time-steps (100 and 50 years ago, and today).

### Results and discussion

There were no effects of grassland connectivity, present or past, to any diversity measure in the study on grazed and abandoned grasslands. Present-day habitat area had strong positive effect on total species richness in both habitats, and a weak relationship to the area 50 years ago for grazed grasslands. Species density was affected by present-day management only. For small remnant habitats area was important for plant incidence in the modern landscape, whereas the connectivity 50 years ago was more important in the traditional rural landscape. Thus, history was not directly important for present-day plant diversity in for the commonplace rural landscapes. In a study from Belgium Adriaens *et al.* (2006) did not find any relationship between species richness and historical area or connectivity in present-day grasslands, while there was a strong effect by historical connectivity in studies from Sweden (Lindborg and Eriksson 2004) and Estonia (Helm *et al.* 2006).

Why are the results so different? Plotting grassland decline in the six types of landscapes show quite different results (Fig 1). The Belgian landscape and the open Swedish agricultural

landscapes have less than 5% grassland left compared to 100 years ago or more, whilst the traditional rural landscapes in Sweden have 11-16% and the Estonian 41% grassland left.



**Figure 1.** The decline in grassland area in five different landscape studies

*So doesn't history matter?*

In landscapes where past connectivity was important, grassland decline had not advanced as much as in landscapes showing no relation to connectivity. Several models predict a non-linear effect of habitat loss – species will become extinct when the amount of remaining habitat falls below a critical threshold (here between 5-10%). To understand and fight threats to plant species diversity in rural landscapes it is necessary to conduct studies not only in “nice” landscapes but also in “ugly” ones. Furthermore, we need to be more explicit with what we mean by fragmentation i.e. how much is left and how long ago did habitat decline start. In the end past grassland management is a prerequisite for grassland species-richness and habitats today so the conclusion is that history matters.

## References

- Adriaens, D.; Honnay, O. & Hermy, M. (2006)** No evidence of a plant extinction debt in highly fragmented calcareous grasslands in Belgium. *Biol. Con.* **133**: 212-224.
- Cousins, S.A.O.; Ohlson, H. & Eriksson, O. (in press)** Effects of historical and present fragmentation on plant species diversity in semi-natural grasslands in Swedish rural landscapes. *Landscape Ecology* DOI 10.1007/s10980-006-9067-1.
- Cousins, S.A.O. (2006)** Plant species richness in midfield islets and road verges - the effect of landscape fragmentation. *Biol. Con.* **127**: 500-509.
- Helm, A.; Hanski, L. & Pärtel, M. (2006)** Slow response of plant species richness to habitat loss and fragmentation. *Ecol. Lett.* **9**: 72-77.
- Lindborg R. & Eriksson O. (2004)** Historical landscape connectivity affects present plant species diversity. *Ecology* **85**: 1840-1845.



## Can we design transitions in agricultural landscape to sustain ecological processes?

J. Baudry<sup>1</sup>, F. Burel<sup>2</sup>, D. Marguerie<sup>3</sup>

<sup>1</sup> INRA (National Institute for Agronomic Research), SAD Paysage, CS 84215, 35042 Rennes Cedex, France

e-mail: jbaudry@rennes.inra.fr

<sup>2</sup> CNRS (National Center for Scientific Research), UMR ECOBIO Campus de Beaulieu, 35042 Rennes Cedex, France

<sup>3</sup> CNRS (National Center for Scientific Research), UMR Archeosciences, Campus de Beaulieu, 35042 Rennes Cedex, France

### Introduction

Agricultural landscapes are changing all the time, with different rates of changes for elements and landscapes. Our assumption is that sound landscape planning must allow landscape changes to adapt to novel functions and, in the meantime must maintain certain structures to sustain ecological, cultural and productive functions.

In some areas, agricultural systems started 3000 years ago. Trajectories of changes have been very different from smooth evolutions to abrupt disruptions in field patterns and land uses. Landscape history produced legacies that help to sustain the resources or diminished potential productivity. Archeology and history research aims at deciphering legacies on the long term, while geography and ecology assess them on a shorter term.

In this presentation we consider that two main types of ecological processes deserve being sustained on the long term: 1) biodiversity maintenance and 2) soil conservation and water control. They all are strongly related to landscape structure over very long periods.

Landscape planning and management should aim at insuring the preservation of those structures to avoid irreversible loss and maintain landscape resilience. This gives room of maneuver for novel usages, field enlargement etc. Comparison across landscapes can provide insights to deciphering those important structures. Drawing from our research in France, we will give examples on possible ways to design landscape transitions.

### Biodiversity management

Biodiversity may be higher in agricultural than in “pristine” landscapes as farming has created novel habitats (meadows, hedgerows) and produces dynamic mosaic. As both land abandonment and intensification (higher inputs of matter and energy) threaten biodiversity, biodiversity conservation requires the maintenance of habitats and of habitat quality. Those habitats must be connected to insure that recolonization takes place in case of local extinction. Beyond these statements, our investigations demonstrate that species have very different behaviours varying from plants that live in small populations on a single point in a wider habitat as a consequence of the same land use for centuries, even up to a thousand years, to insect species that react rapidly to changes in landscape structure even when their habitat is not directly disturbed.

In terms of conservation, this implies that it is necessary to maintain both restricted areas and large landscape structures. A regional scale differentiation between landscapes may achieve those objectives. In the case of hedgerow networks that are the focus of our research, even when field enlargement maintains a network of connected hedgerows there are changes in biodiversity because the microclimatic conditions are changing and because the farming techniques are usually more stressful in large than in small fields.

This illustrates the advances of landscape understanding; local structures and practices are embedded in broader landscape structures and all this hierarchy of pattern drive processes that are essential for biodiversity. The scale dependence responses of organisms (depending of their landscape perception) go along the same lines to promote multi-scale approaches.

Time is another important dimension that articulates archaeological and landscape ecological studies. Time lags in responses of species distribution to landscape changes, as fluctuations of species abundance in landscapes over centuries must be considered in landscape design.

These slow responses can be used when new hedgerows are planted, if connected to old ones acting as sources of species then they can be colonized.

### **Soil and water management**

The strong relationships between field patterns and topography, hence soil and water runoff, is a key figures of landscapes with hedgerows on ancient bedrock. Control of soil erosion and water drainage are two main constraints in landscape design. it may be the first step in landscape design when starting agriculture after land clearance.

Landscape elements implemented to control water flows are strong legacies in landscapes because of soil accumulation and ditches functioning for years which stay active even if filled with earth. These elements are the backbone of landscapes to protect fertility, a major function. In contrast with landscape structures protecting biodiversity, these ones are more spread out in landscapes, also requiring networks of ditches. The control of physical flows can also be performed by structures other than hedgerows like grassy strips.

### **What is flexible?**

The interesting point is that landscapes hold both legacies to be sustained and flexibility. Agricultural landscapes did not develop in a linear manner to attain some kind of maximum quality in the middle of the XXth century and then lose their ecological properties afterwards due to the industrialization of agriculture. These fluctuations are well documented in our study sites. What drives landscapes to unsustainable states is not the fact that they change; it is the way they change. Changes may be fast or slow, we state that their impact is proportional to the desegregation of structures that support functions.

The dismantlement of a network of hedgerows with ditches will have different effects on plants, animals, and water and erosion, according to the change in structure. Breaks in a network of earthen banks may rapidly lead to erosion problems, while effects on biodiversity are nil. Conversely, control of water runoff may be maintained even if many hedgerows are removed as long as the networks they form are connected while many species will disappear because of changes in climatic conditions.

We also find that different landscape structures are required to sustain landscape functions.

## Cultural landscape of the Carpathians and the value of landscape and diversity

J. Oszlányi

Institute of Landscape Ecology SAS, Stefanikova 3, P.O.Box 254, SK Bratislava, Slovakia,  
e-mail: julius.oszlanyi@savba.sk

The Carpathians situated Central and Eastern Europe are the most important mountain arch covering Slovakia, Czech Republic, Poland, Ukraine, Romania and Hungary. In 1400 km long mountain range, the cultural landscape is very diversified as the result of different cultures and ethnicities.

Excellent examples of the very diversified cultural landscape can be found in the regions where two or more ethnicities and cultures used to live or still live together. This is the case of numerous regions in Transylvania/RO where there are the settlements of different ethnicities (Romanians, Hungarians, Germans, Ruthenians) in the same region. In some regions of Slovakia (Slovak, Ruthenians, Germans) used to live together. The way of life, daily work in the fields, meadows and forests, different hierarchy of values and different approach to the ownership has influenced the shape of landscape in the respective cadasters substantially and is still mirroring the pristine and highly adaptable activities of farmers in the nature. This approach has brought very characteristical cultural landscapes with high ecosystem and landscape diversity, well balanced landscape structure which is ecologically stable and is perceived as ideal for this part of Europe.

The situation described above, however, is not present everywhere. In opposite, greatest part of the high-value cultural landscape has been destroyed by the collectivisation of the agriculture during the previous regime. This has been accompanied by creation of large-scale agriculture, i.e. the pristine small-scale fields have been put together and one large field has been created to enable modern agricultural technology and usage of chemicals. The landscape and ecosystem diversity thus has been replaced by monotonous industrialised landscape perceived as non-valuable and ecologically non-stable.

High value cultural landscape with high ecosystem and species diversity are still present and untouched in some parts, especially in higher altitudes of the Carpathians. Here, the collectivisation - of agriculture in its large scale shape was an exemption in previous decades and the traditional form of subsistence agriculture has preserved the landscape in its original form in the majority of the cadasters of mountainous villages. Here, because of the unfavourable climatic, geological and geographical conditions, the cooperative forms had no chance to be prosperous and the subsistence formers have been allowed to continue in old-fashion and small-scale agriculture. The cadasters of the Slovak and Ruthenian villages in the North and East of Slovakia are excellent examples. Villages Liptovská Teplička (region Liptov), Malá Franková and Osturňa (region Zamagurie) and Ruské, Nová Sedlica and others (region Bukovské vrchy) have been studied by ILE SAS researchers within numerous scientific projects. The cadasters of these villages are of high value because of the well preserved diversified landscape, and high species and ecosystem diversity. In most cases, mainly the parts of the cadasters which are in the closest vicinity to the intravilan are the most preserved with precious seminatural and man-made ecosystems and preserving rare or endangered species.

Landscape and species diversity in this part of Europe, however, is now being more and more endangered by impact of new socio – economic conditions.

Agricultural land abandonment causes the natural aforestation and thus loss of traditionally structured landscape with valuable seminatural or man-made ecosystem with rare species occurrence. This more or less intensive process can be observed in all parts of the Carpathians.

This trend has started immediately after the change of regime, i.e. after 1989 and actually was caused by reprivatisation of land (young generation left the villages earlier and found work in the towns or emigrated to different parts of Czechoslovakia or elsewhere, old

**Theme 6: Cultural Landscapes and Landscape Management**  
**6.2 Symposium 20: Landscape diversity and biological diversity cultural landscapes**

farmers and land owners as subsistence farmers had less and less needs to produce in severe and labour-demanding conditions and they have not been administratively forced to utilize each small field do it was the case earlier). The value of these landscapes decreases subsequently in accordance with the subsequent loss of ecosystems diversity. The remote parts of the cadasters are being more and more overgrown by shrubs or they are overgrown by naturally regenerated young forests. This means less and less landscape diversity and in future possible full cover by natural forest ecosystem. However, the value of some chosen landscape is being preserved by administrative interventions to the management of them.

The different sources are used to maintain the fields, meadows and pastures in such cadasters in the original shape. It is necessary that these cultural landscapes, perceived not only by tourists and scientists, but also in general as ideal, are maintained and preserved for future generation as one of the most valuable parts of the national heritage.

The Slovakian part of the Eastern Carpathians has been used as the target region for our studies.

## Terrestrial islands of non-reclaimed industrial deposits: plant species diversity and cultural landscape

P. Kovář

Charles University in Prague, Faculty of Science, Department of Botany, Benátská 2, 128 01  
Prague 2, Czech Republic.  
e-mail: kovar@natur.cuni.cz

### Introduction

The contribution represents an effort to fill a gap between landscape and restoration ecology. It presents the results of a long-term research program conducted as field studies in Central Europe, including in situ experiments on derelict ore/ash slag deposits or deposits of industrial waste materials. It emphasizes the study of spontaneous successional processes related to biodiversity. Implications include suggestions on how to restore the vegetation on these non-natural bodies as parts of the multifunctional landscape.

### Spontaneous biological renaturation and background for management

#### Environmental extremes and industrial ecosystems

Ecology of extremes in nature occurs widely in cultural landscape. We may find such analogies in volcanic detritus, ash deposits from power stations, deserts and mines (Vos & Opdam 1993, Walker & del Moral 2003). The ecological effects of toxicity in degraded and derelict industrial land are obvious in areas contaminated with heavy metals (e.g., van Andel & Aronson 2006).

#### Input windows for colonization and limiting factors

The vegetation cover is incomplete on industrial deposits covered by stands of various successional age (Kovář 1999). This is due to the extreme temperature regime at the substrate surface, as well as to very low pH and high conductance during weathering of the material. However, both relatively stable empty patches and patches originated by extinction of some vegetation components may function as permanent potential input windows for additional coverage of new ecosystem with plant propagules (Kovář 2004).

#### Diversity of organismal groups and their role in succession

##### *Fungi*

The total number of the soil fungi on abandoned industrial sedimentation basins represents 40 taxa, 22 of which belong to the class Ascomycetes and 18 to the class Zygomycetes. Grasses are important rhizosphere agents for arbuscular mycorrhiza distribution and they are also able to facilitate mycorrhization of trees. On the ore-washery substrate in an abandoned sedimentation basin, 31 species of macrofungi were found and on the the ash-slag substrate basin, 11 species.

##### *Algae, lichens and mosses*

A total of 63 algal and cyanoprocaryotal species representing 38 genera were registered on the localities investigated. Dry sedimentation basins of both above mentioned types surprisingly hosts remarkable number of lichens as well as bryophytes. In total, 103 taxa of lichens and 51 taxa of bryophytes were recorded (ore-washery substrate: 99 lichen and 46 bryophyte taxa; ash-slag substrate: 15 lichen and 19 bryophyte taxa).

##### *Herb and woody species*

Ash deposit appears to have a higher species richness. However, further search revealed that concerns only vascular plants which are not always typical of the initial stages of the succession (herbs include 45 species, trees and shrubs 7 species). The abandoned ore deposit has been colonized by 28 herb species and 6 tree and shrub species. However, the second type of substrate is dominated by several distinct vascular plants (*Betula pendula*, *Populus tremula*, *Calamagrostis epigejos*, *Phragmites australis*).

### Genetic diversity of plant populations

Study of demographic parameters of the *Calamagrostis epigejos* grassy polycormons confirmed the initial observations of two adaptive strategies of this plastic invasive grass type on the ash-slag and of phalanx type on the ore-washery substrate (Kovář 1999). Isozyme analysis revealed high genetic variability for habitats of abandoned deposits with stands of low successional age. Selection and decline of the number of genotypes/clones of *C. epigejos* during succession towards tree-dominated stands was recorded on the ore-washery type of substrate (Kovář 2004).

### Disturbance and stress: organismal sensitivity and tolerance

Stress-tolerance (to heavy metals, salinization, microclimatic extremes) implies extremely high concentrations of heavy metals in tissues of the stress-tolerant plants or fungi. Species richness on industrial substrates is created predominantly by more primitive groups of organisms (mainly cryptogams). Changes in the successional trajectories were seen after the fire disturbance of the stand mosaics when most of the tree species were destroyed and the nutrients released supported plant growth.

### Indication of multifunctionality and monitoring of anthropogenic landscapes

The long-term monitoring of abandoned industrial deposits with all the results mentioned above should profit from multiscale links across the hierarchical levels involved (ecology of population, community, ecosystem and landscape); combination of several types of landscape manipulations with their different intensity levels should be derived from adequate levels of indication parameters. From the viewpoint of restoration practice, the process of succession is definitely the cheapest way of reclamation of such a habitat type. However, without man's help the process of succession might be too long and species with ineffective dispersal would have only a small chance to reach a given site (Dobson et al. 1997, van Andel & Aronson 2006).

### References

- Dobson, A.P.; Bradshaw, A.D. & Baker, A.J.M. (1997):** Hopes for the future: restoration ecology and conservation biology. - *Science*, 277: 515-522.
- Kovář, P. (ed.)(1999):** Nature and culture in landscape ecology (Experiences for the 3rd Millennium). The Karolinum Press, Prague.
- Kovář, P. (ed.)(2004):** Natural Recovery of Human-Made Deposits in Landscape (Biotic Interactions and Ore/Ash-Slag Artificial Ecosystems). Academia, Prague.
- Van Andel, J. & Aronson, J. (eds.)(2006):** Restoration ecology. Blackwell Science Ltd., Hong Kong.
- Vos, C.C. & Opdam, P. (eds.)(1993):** Landscape ecology of a stressed environment. Chapman & Hall, London.
- Walker, L.R. & del Moral, R. (2003):** Primary succession and ecosystem rehabilitation. Cambridge Univ. Press, Cambridge.

## Diversity of semi-natural grasslands in a changing rural landscape

L. Halada

Institute of Landscape Ecology SAS, branch Nitra, Akademická 2. P.O.Box 23B, 949 01  
Nitra, Slovakia.  
e-mail: lubos.halada@savba.sk

### Introduction

Semi-natural grasslands represent grasslands that were managed in traditional way for a long time and currently are utilised in low or moderate intensity. The intervention of man is regular (mowing, grazing, fertilisation), but because of low intensity, it does not result in changes of site conditions and species composition.

Semi-natural grasslands have their origin in the neolithic period when man started with animal husbandry. Establishing of pastures and transhumance of domestic animals resulted in new species combinations, not existing before. Current grassland species originated from other habitats: ca 25% species from forests, 20 % from forest clearings, 30 % from naturally forest-free areas. These species of different origins created specific assemblages, unique for each stand type. This development, initiated by man, continued in a process of natural selection and therefore the resulting ecosystems are classified as semi-natural, being composed of native species.

### Values of semi-natural grasslands in a rural landscape

#### Semi-natural grasslands and biodiversity of agricultural landscape

Diversity of species and communities in grasslands is a result of a traditional extensive grassland management interacting with a broad range of site conditions. Grasslands are typical by coexistence of high number of species in a small area resulting in a high biodiversity. Inter-species competition, site conditions (soil and climate in particular) and man intervention (mowing, grazing) represent main factors determining characteristic features of grasslands. Semi-natural grassland is composed of 30 - 70 species of vascular plants and thus it is to the most species-rich habitats in Europe. Nevertheless, even higher than the species diversity of semi-natural grasslands is the diversity of grassland communities. It is unbelievable how many grassland types originated in Europe during the centuries. We know sufficiently only a part of this diversity.

#### Semi-natural grasslands and landscape productivity and stability

Semi-natural grassland contain high number of species, each having a specific life strategy and site requirements. Species preferring actual site conditions are present together with species that can tolerate existing conditions in spite of the fact that their optimum is elsewhere. If conditions are changing, those species present in the community that prefer the new conditions overtake the leading role in the community processes. No other agricultural habitat can react so promptly to environmental changes. Grasslands that are exposed to the repeatedly changing stress conditions (large fluctuations in climate, soil moisture, nutrients availability) belong to the most species-rich ones. The grassland production under stress conditions is not high, but is stable and sustainable. Considerable stability of semi-natural grasslands represents a pillar of stability within the whole agricultural landscape.

#### Semi-natural grasslands and landscape character

The character of rural landscape and its attractiveness are determined by agricultural utilisation. Mountain meadows, Hungarian puszta, Scottish or German heathlands are farmer's products. Semi-natural grasslands represent a real and often a very specific cultural heritage. Part of the history of rural population is stored in species-rich grasslands: from a general coexistence of man and nature, through the way of utilisation of landscape, to the

process of maintaining their long-term productivity also in low-productive sites within an unending cycle of “flowering meadow – hay – domestic animals – fertiliser – flowering meadow”.

### **Recent history of main changes in semi-natural grasslands**

The expansion of grasslands started in the 18<sup>th</sup> and 19<sup>th</sup> centuries due to increasing agricultural production and introduction of new technologies. The first half of the 20<sup>th</sup> century was mainly extensive agriculture with a high number of people employed on the land, minimal influence of land reclamation and by use of grasslands for haymaking and grazing. Grasslands were managed mainly in traditional ways at a low level of mechanization. Usually, this kind of grassland utilisation corresponded well to biodiversity conservation needs. After World War II, intensification of agriculture impacted on grasslands significantly. Drainage of wet meadows, grassland ploughing and their conversion to arable land, and a new phenomenon of intensive grasslands were widespread, resulting in simplification of the agricultural landscape, decline of grassland biodiversity and a significant loss of natural values of grasslands. In the Central and Eastern Europe countries, agriculture intensification was linked to nationalisation of private land and collectivisation of agriculture with significant impacts on the landscape structure and biodiversity. The change in emphasis to environmental functions of agriculture and polarisation of land use (intensification versus abandonment) are the most visible trends in recent decades. Agricultural decline became a reality in mountain areas of Europe. Nowadays, semi-natural grasslands should be considered as rapidly declining ecosystems.

### **How to maintain semi-natural grasslands?**

Protection of cultural landscapes including semi-natural grasslands is a primary goal of nature conservation. The long-term maintenance of species-rich grasslands should be prioritised to the extensification of intensive grasslands. However, the low(er)-intensity grassland management is often not compatible with the requirements of intensive livestock production.

Agro-environmental schemes are result of changes in orientation of agriculture - shift from an emphasis on productivity to a more environment friendly management. They are focused on non-productive functions of agriculture, including nature protection, maintenance of landscape values and scenery through mostly extensive forms of management. Agro-environmental measures are country-specific and thus quite a large diversity of them and their impacts exists. This makes possible to target national or regional particularities of agricultural landscape. It is extremely important to design agro-environmental schemes in a way that allows long-term maintenance of semi-natural grassland in as large territory as possible. Only agriculture can ensure their management in a spatially broad scale.

Natura 2000 network represents the main tool of the European Union for nature protection. Semi-natural grasslands are represented quite well in Annex I. of the Habitats Directive. This annex contains 25 habitats that fully depend on agricultural management and other 23 habitat types that significantly profit from agricultural activities either by enlarging of their area or prolongation of their existence. Semi-natural grasslands of Annex I protected within Natura 2000 sites should be subject to optimal management that is monitored and thus their quality should not be decreased. But also those Annex I. habitats located outside Natura 2000 sites are focused more carefully, what should contribute to their protection.

Support to non-production functions of agro-ecosystems. A mosaic utilisation of landscape based on natural conditions and resulting diversity is useful not only for plants and animals, but man also positively evaluates such a combination. e.g. only 10% of visitors of Austria come only to see Vienna - the rest would like to spend holidays in countryside.



## Managing landscape diversity in Northern Portugal

M.T. Andresen

CIBIO/ICETA. Faculdade de Ciências da Universidade do Porto  
Rua do Campo Alegre 1191, 4150-181 Porto, Portugal.  
e-mail: [mlandres@fc.up.pt](mailto:mlandres@fc.up.pt)

### Introduction

The Northern region of [Portugal](#) is a territory of significant natural and cultural diversity, and is next to the Atlantic. It has 3.7 million inhabitants and an area of 21,278 km<sup>2</sup>. Land use change in the past 20 years has shown a major transformation in the landscape with new landscape patterns emerging. The city/countryside dialogue of today is responsible for new landscape paradigms as well as new life styles. A certain duality is identified between the densely populated region close to the coast and the low density land of the interior. Rivers, mountains, fluvial plains, plateaus are distributed through a landscape where granite and schist geological formations dominate alternatively. A new road network has given rise to new urban patterns and the expansion of metropolitan areas.

The definition of an ecological network represents an opportunity to reinforce the functioning of natural and cultural dynamics as well as for the inclusion of new landscape typologies. Infrastructures are not only responsible for land use change but EU policies such as the Common Agricultural Policy are of significance for the so-called new paradigms. The objective of the paper is to present and discuss a methodology to define an ecological network and the landscape units to make a strategic investment that takes into consideration landscape character and diversity as well as the new paradigms and creates the basis to formulate sustainable management principles to implement sound policies.

### Concept, methodology and results

Ecological networks are understood as basic landscape systems governing the functioning of natural dynamics, with specific aptitudes for human activities and having multiple yet complementary purposes, such as agro-forestry, conservation of natural and cultural heritage, leisure activities and tourism. It is a concept that calls for a correct interpretation of the character of the landscape based on the study of a number of bio-physical and socio-economic components. It is considered to have made its first appearance in the early 1980s within the scope of nature conservation policies. The first initiatives occurred in Holland, Hungary, Denmark, Portugal and the former Czechoslovakia, independently in spite of significant sharing of basic assumptions (Bennett and Wit, 2001, and Sientjes and Roumelioti, 2003 and Andresen, *et al.*, 2005). The concept has widely spread and assumed an operational role in landscape planning practice. The definition of ecological networks is perceived as a tool to guarantee the flow of the ecological processes whilst at the same time contemplating models of sustainable and viable development.

The proposal for an ecological network for Northern Portugal involved developing a 10 year plan of investment that would contribute to the enhancement of the unique assets, both natural and cultural, sustainable management of the region's natural resources, namely water and fertile soil, minimisation of natural hazards impacts through a multiple use model that would include: nature protection, water and biodiversity management, recreation, and cultural/historic resource protection. Agriculture plays a major role in the whole process and the guidelines from the 2<sup>nd</sup> pillar in Common Agriculture Policy have become particular relevant to build opportunities for investment.

As ecological networks know no boundaries, the definition of an ecological network for such a large region needed to take into consideration the immediate surroundings including the Spanish regions of Galicia and Castilia-Leon, the central region of Portugal and the Atlantic ocean. However, the purpose is to define territories for strategic investment so the study area is defined by the administrative boundary of the Northern Region. The ecological network is presented in grey in the figure below and is structured by the river system and includes the five national protected areas (one national park and four natural parks), the nineteen special areas of conservation (Natura 2000), the six special protected areas and two World Heritage sites. Other criteria were taken into consideration for this definition namely the steep territories, plateaus above 700 m, fluvial soils and the coastal areas.

The result is a network of territories that are significant for water management of the region, with low population density and with prevailing agro-ecosystems of high landscape and biodiversity quality. It is a network of environmental and landscape values. However it is recognized that the landscape character of the network contains various dimensions and aptitudes that are functionally complementary and better perceived according to the definition of landscape units.

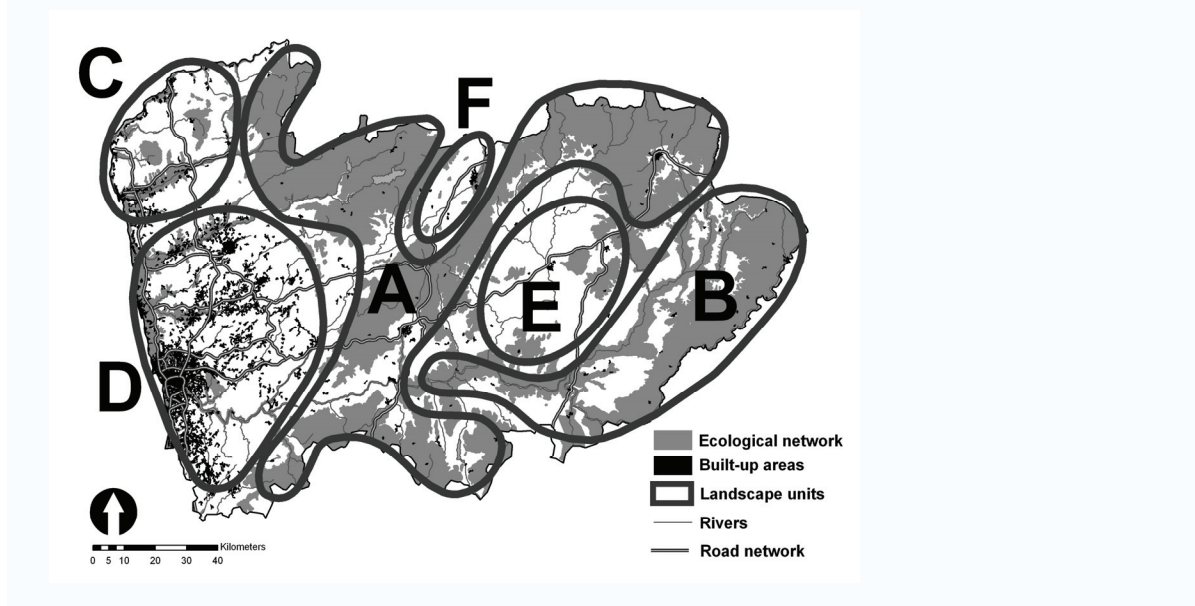


Figure 1 – Ecological network and landscape units of Northern Portugal. A: High Mountain Areas, B: Douro valley, C: Hills and valleys of the northwest, D: Porto Metropolitan Area, E: Mirandela Plateau and F: Chaves plain.

### References

- Andresen, T.,** Curado, M<sup>a</sup> José and Silva, Vilma. (2005) An ecological network for the Oporto Metropolitan Area. In Sustainable Development and Planning, II, Vol 2, edited by Kungolos, A. G., Brebbia, C. A. e Beriatos, E.: 1007-1016
- Bennett and Wit.** (2001) The Development and Application of Ecological Networks: A Review of Proposals, Plans and Programmes, Advice and research for development and Environment, The World Conservation Union (IUCN)
- Rientjes and Roumelioti.** (2003). Support for Ecological Networks in European Nature Conservation: an indicative social map, European Centre for Nature Conservation, Technical report series, Tilburg.

## Adopting the precautionary principle in designing and managing NATURA 2000 – areas

O. Bastian

Saxon Academy of Sciences and Humanities, Working Group on Natural Balance and Regional Characteristics, Neustädter Markt 19 (Blockhaus), D-01097 Dresden, Germany.  
e-mail: Olaf.Bastian@mailbox.tu-dresden.de

### Introduction

The precautionary principle is more and more incorporated into national law and decision-making on natural resource management and biodiversity conservation, also in the coherent European network of protected areas Natura 2000 that shall provide favourable conditions for a long-term survival of species and habitats. Here, the precautionary principle finds expression in coping with scientific uncertainty concerning the number and size of habitats and plant or animal populations necessary for their survival.

After describing principles, structure, implementation and procedures of this rather new instrument of nature conservation, on the example of a Natura 2000 area in the agricultural landscape north of Dresden (Saxony, Germany) chances and problems for biodiversity conservation are outlined. Special attention is paid to the following questions: requirements and actual threats of one of the target species (the butterfly *Maculinea nausithous*), legal means and economic incentives for suitable measures, the management plan, and the role of stakeholders.

### The precautionary principle

Precaution – the ‘precautionary principle’ or ‘precautionary approach’ – is a response to uncertainty. In general, it involves acting to avoid serious or irreversible potential harm, despite lack of scientific certainty as to the likelihood, magnitude, or causation of that harm. In natural resource management and biodiversity conservation the precautionary principle is relevant regarding the efforts to conserve and to use biodiversity sustainably, and in particular to reduce habitat loss, control alien invasive species, prevent over-exploitation of wild species and biological resources, and avert and mitigate the impacts of climate change. The importance of precaution in the context of nature conservation has been recognised through its endorsement by all major biodiversity-related multilateral environmental agreements, as well as policy and legislative instruments at all levels (cp. Cooney, 2004).

### Natura 2000

The 1992 EC Directive on the Conservation of Natural Habitats and of Wild Flora and Fauna (Directive 92/43, the Habitats Directive) aims at the establishment of a suitable network of protected areas for threatened habitats and species. This network shall be comprehensive enough, and it should be distributed in such a manner that the risks of extinction (in the framework of a region) of the habitats and species under protection are minimized. Together with the bird conservation areas (Special Protection Areas, SPAs) established by the 1979 Birds Directive (79/409/EEC), the Special Areas of Conservation (SACs = Fauna-Flora-Habitat Areas / FFH) established by the Habitats Directive is forming the European Natura 2000 network.

### A case study from Saxony: the butterfly Dusky Large Blue (*Maculinea nausithous*)

The SAC area ‘Promnitz und Kleinkuppenlandschaft bei Bärnsdorf’ (Promnitz rivulet and small hilly area near the village of Bärnsdorf)(294 ha) is a varied agricultural landscape with a shallow river valley and distinct granodiorite hills partly covered by coppices. Along the Promnitz rivulet various grassland communities are occurring as well as fallow land, perennial herb communities and small ponds (Bastian & Schrack, 1997). The otter (*Lutra lutra*) and especially the butterfly Dusky Large Blue (*Maculinea nausithous*) are animals of

Community interest, the last-named with one of its most important sites in Germany and Europe. The development cycle of this butterfly is extremely connected with the grassland herb species Great Burnet (*Sanguisorba officinalis*). The female butterflies lay their eggs only into the spherical flowers of the Great Burnet the larvae are feeding on. The older larvae are living then in nests of *Myrmica rubra* ants. For the highly specialised, extremely sensitive and endangered Dusky Large Blue special habitat management measures following the precautionary principle are indispensable, e.g. careful mowing of the meadows with highly adjusted cutting (above 5 cm) to avoid soil wounding and threats to the ants, mosaic-wise, staggered mowing, no pasturing or drainage, fertilization only occasionally with muck, no biocides and no ploughing, no rolling and dragging to avoid soil compaction, coherence (a close pattern of habitats) to link the Dusky Large Blue subpopulations (Stolzenburg, 2001). Although, in general, the farmers are open-minded about nature conservation in this region, some problems arise from these management regulations. The farmers want to mow the meadows earlier in the year (to harvest the young fodder rich in proteins), and they also want to apply higher amounts of fertilizers than allowed (60-70 kg/ha and year instead of only 30 kg). They did not take into account that there is a reasonable nutrient input from the air and from adjacent arable fields as well as from the Promnitz rivulet during floods. The chances of a long-term survival of the butterfly and its habitats are also suffering from the age of the landowners. Mainly several elderly people own the valuable meadows. It can be expected that within the foreseeable future they won't manage the meadows any longer, not to mention their children and grandchildren. Also, the farmers are feeling uncertain, due to the changing agricultural policy of the EU.

### Discussion

It turned out that Natura 2000 could be an effective tool to advance nature conservation, with special regard to the precautionary principle that finds expression in coping with scientific uncertainty concerning the number and size of habitats and plant and animal populations necessary for their survival. To reduce risks of extinction, not only one habitat or population of a type or a species are included into the network of protected areas but a certain percentage of areas (being as large as possible). The comprehensive network of protected areas covering large areas in all EU Member States is a precondition for the long-term survival of endangered species and their habitats. The success of Natura 2000, however, will also depend on how the protection and the necessary management measures can be guaranteed, including in times of shortage of money. To improve the acceptance of Natura 2000, more public relations work is needed as well as financial security for the landowners and land users. However, the scientific investigation (e.g., about population biology and ecology) should also be deepened in order to find the most favourable solutions to manage these areas. The Natura 2000 approach is suitable not only on a national or a European scale but in a worldwide context to maintain global biodiversity in a sustainable manner considering the precautionary principle.

### References

- Bastian, O. & Schrack, M. (eds., 1997)** Die Moritzburger Kleinkuppenlandschaft – einmalig in Mitteleuropa! *Veröff. Mus. Westlausitz Kamenz*, 118 pp.
- Cooney, R. (2004)** The Precautionary Principle in biodiversity conservation and natural resource management: An issues paper for policy-makers, researchers and practitioners. *IUCN*, Gland, Switzerland and Cambridge, UK, 51 pp.
- Stolzenburg, U. (2001)** Zum Vorkommen des Dunklen Wiesenknopf-Ameisenbläulings *Maculinea nausithous* (BERGSTRAESSER, 1779) im Naturraum Westlausitzer Platte. *Veröff. Museum Westlausitz Kamenz* **23**: 89-96.

## The Swiss agri-environmental programme and its effects on selected biodiversity indicators at different scales

P. Jeanneret<sup>1</sup>, S. Aviron<sup>1</sup>, S. Birrer<sup>2</sup>, S. Dreier<sup>1</sup>, F. Herzog<sup>1</sup>, L. Pfiffner<sup>3</sup>, T. Walter<sup>1</sup>

<sup>1</sup>Agroscope Reckenholz-Tänikon Research Station ART, Reckenholzstr. 191, CH-8046 Zurich, Switzerland,

e-mail: philippe.jeanneret@art.admin.ch

<sup>2</sup>Swiss Ornithological Institute, CH-6204 Sempach, Switzerland.

<sup>3</sup>Research Institute of Organic Agriculture, CH-5070 Frick, Switzerland.

### Introduction

In Switzerland, parallel to agri-environmental measures which apply directly to the field management, farmers have to manage at least 7% of their utilised agricultural area (UAA) as ecological compensation areas – ECAs. Major ECAs are extensified grassland (hay and litter meadows), traditional orchards, hedges, wild flower strips. In 2005, farmers practised the ECA scheme all over Switzerland with a total of 119'000 hectares of different types of ECA (11% of the UAA). The introduction of ECAs throughout the agricultural area can be seen as a large scale landscape restoration experiment. We evaluated the effect of the ECA introduction on biodiversity and want to highlight some results about the role of ECAs in promoting biodiversity at habitat and landscape scale.

### Material and methods

First, in three case study areas of about 6 km<sup>2</sup> each, biodiversity indicators (plants, birds, spiders, carabid beetles, grasshoppers and butterflies) were recorded in 60 ECAs and intensively managed fields per case study area and year between 1997 and 2004, as well as the land use dynamic. Second, plants and birds were investigated in ECAs of 56 municipalities of the Swiss plateau. For plants, ecological quality standards were defined with indicator species following a by-law on ecological quality. Bird mapping was restricted to 37 characteristic bird species, for which open and semi-open agricultural landscapes are essential for survival.

At plot level, the species diversities of the biodiversity indicators of ECAs and intensively managed fields were compared. Then, the analysis was conducted at the landscape and regional level to investigate the contribution of ECAs to biodiversity in the agricultural landscape by calculating the habitat specificity (adapted from Wagner and Edwards, 2001). For birds, we tested whether the centres of territories were more frequent in or near ECAs by comparing their actual distribution with a hypothetical random distribution of territories (Herzog *et al.*, 2005). The species were grouped according to their ecological requirements.

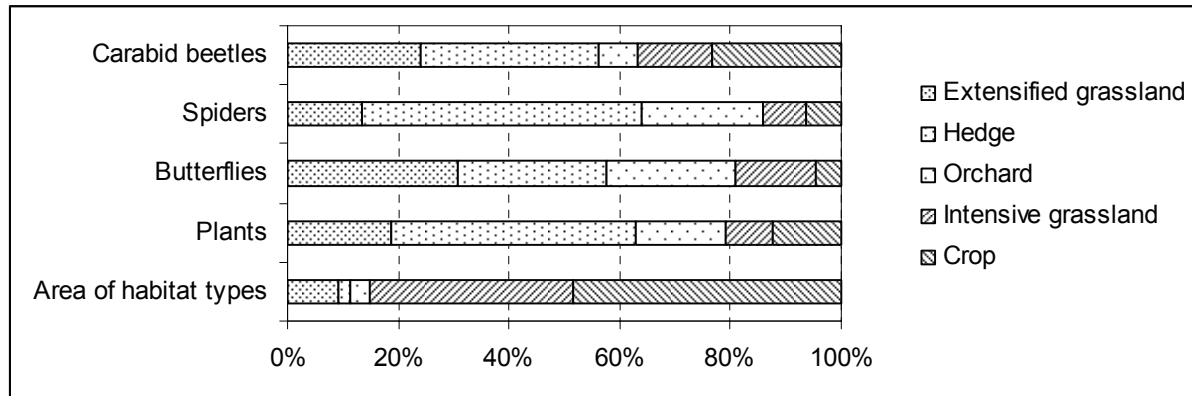
### Results and Discussion

#### Plot level

Results showed that indicator taxa had different reactions to ECAs but ECAs had generally more species or different assemblages as compared to the intensively managed fields (Herzog and Walter, 2005). The most successful ECA types were the hedges and the wild flower strips. On average, 50% of the ECA hedges and almost all flower strips throughout the Swiss plateau fulfilled the requirements of the by-law on ecological quality, in contrast to ECA hay meadows (20%). However, there was a strong variability between biogeographical regions and agricultural production zones (Herzog and Walter, 2005).

#### Landscape level

Based on the case study investigations, the specificity of plants and arthropod species for ECAs and cultivated fields was analysed to estimate the relative contribution of each of the land use types to the regional biodiversity (Figure 1). With less than 20% of the area, ECAs contributed on average about 75% to the overall indicator species specificity at regional level.



**Figure 1.** Relative contribution of ECA grassland, ECA hedge and ECA orchard, and fields to the regional biodiversity measured by the specificity of plants and arthropod species (case study area Nuvilly-Combremont, 2003).

Furthermore, birds preferring open landscapes, namely skylark were significantly less frequent than expected in or near ECAs. On the other hand, the centres of the territories of hedgerow birds, such as the yellowhammer were significantly more frequent in or near ECAs. Wetland birds were also more frequent on or near ECAs, especially on litter meadows.

## Conclusion

The overall result of the assessment on the Swiss Central Plateau is moderately positive. A measurable benefit for biodiversity has been achieved by ecological compensation at plot and landscape level (as partly shown in this short paper). The measures are going in the right direction. However, efforts must be intensified in the lowlands in order to attain species conservation goals, in particular for threatened species. Furthermore, although a negative trend over 25 years could be observed in the upper part of the alpine regions (e.g. butterflies, Hohl, 2006) studies show that ECAs contribute to maintain the highly valuable biodiversity by preserving from reforestation (Herzog and Walter, 2005).

## References

- Herzog, F. & Walter, T. (2005)** Evaluation der Ökomassnahmen – Bereich Biodiversität. *Schriftenreihe der FAL* 56.
- Herzog F., Dreier S., Hofer G., Marfurt C., Schüpbach B., Spiess M. & Walter T. (2005)** Effect of ecological compensation areas on floristic and breeding bird diversity in Swiss agricultural landscapes. *Agriculture, Ecosystems and Environment* 108(3), 189 – 204.
- Hohl, M. (2006)** *Spatial and temporal variation of grasshopper and butterfly communities in differently managed semi-natural grasslands of the Swiss Alps*. Diss. ETH No. 16624. ETH, Zurich.
- Wagner, H. & Edwards, P. (2001)** Quantifying habitat specificity to assess the contribution of a patch to species richness at a landscape scale. *Landscape Ecology* 16: 121-131.

### 6.3 Symposium 21: Mountain Landscapes

#### Landslides, land-use change, and carbon dynamics in the Sierra de Las Minas, Guatemala

C. Restrepo<sup>1</sup>, H. Perotto-Baldiviezo<sup>1,2</sup>, M. Joseph-Haynes<sup>1</sup>, M. Miller<sup>1</sup>, and E. Castellanos<sup>3</sup>

<sup>1</sup>Department of Biology, University of Puerto Rico-Rio Piedras, San Juan, Puerto Rico,  
e-mail: crestre@cnet.upr.edu

<sup>2</sup>Texas A&M University Agricultural Research and Extension Center at Uvalde, TX, USA.

<sup>3</sup>Centro de Estudios Ambientales, Universidad de Guatemala, Guatemala.

#### Introduction

Landslides represent a common feature of tropical mountains, particularly in areas with elevated seismic activity and/or high rainfall. In these mountains, landslides may influence ecosystems in two important ways. First, they may significantly alter land cover and redistribute the organic matter contained both in the vegetation (Restrepo and Vitousek 2003, Restrepo and Alvarez 2006) and soil (Calderon et al. 2006). Second, landslides may influence the rates at which ecosystems reorganize (Walker et al. 1996) and soils develop (Zarin and Johnson 1995a, 1995b) on the recently created substrates. These two sets of observations raise questions about the role of landsliding in carbon budgets of tropical mountainscapes. This study examines the relative contribution of landsliding and human activities to land-cover change, and ultimately to changes in carbon pools and fluxes in the Sierra de Las Minas of Guatemala.

#### Methods

This study centers in the Sierra de Las Minas, a small mountain range (150 – 3,015 masl; 2,500 km<sup>2</sup>) located in eastern Guatemala. The Sierra de Las Minas is found along the Motagua-Polochic Fault, the zone of contact between the North American and Caribbean plates. This region is a source of elevated seismic activity, which together with the formation of storms have induced wide spread slope instability in recent times. The species pool of the Sierra de Las Minas comprises a mixture of species from temperate and tropical regions that have sorted out in response to the diverse climates - a combination of a wide range of elevations and precipitation shadows, geologic substrates, and presumably landsliding.

We focused on two populations of landslides that affected the Sierra de Las Minas in 1976 (the Guatemala 7.6 magnitude earthquake) and 1998 (rainfall associated with Hurricane Mitch). For each year we digitized all landslides and major land-use types observed on the southern flank of the Sierra de Las Minas based on high-resolution imagery that was acquired in 1976 by US surveillance satellites (CORONA, ARGON, and LANYARD), and panchromatic satellite images acquired in 2001 (IRS).

Each land-use type was characterized in terms of the carbon content of above- and below-ground biomass and soil based on unpublished and published figures for Central America. Landslide area was converted into units of carbon in biomass and soil organic matter based on the land-use types in which they occurred.

#### Results

Our data indicates that during the last 24 years 85% of the area (709 x 10<sup>2</sup> ha) did not suffer apparent changes. Of the remaining area, 61 x 10<sup>2</sup> ha of forest was converted to shrublands and agricultural system, and 27 x 10<sup>2</sup> ha of land that appeared as shrublands and

agricultural systems in 1976 had reverted to forest in 2001. The area covered by landslides in 1976 and 1998 was equivalent to 20 ha and 10 ha of land, respectively. In the 24-year period covered by this study land-use change resulted in the loss of 8.1 MgC/ha, whereas landsliding in 5.0 MgC/ha. On the other hand, carbon gains were estimated at 3.8 MgC/ha and 3.46 MgC/ha for land-use change associated with human activities and landsliding, respectively. Carbon losses associated with landsliding, however, may not be so if the carbon enters long-term reservoirs such as colluvial and alluvial deposits a possibility that we discuss. If true, landsliding may contribute to the long-term sequestration of carbon.

### References

- Calderon, N. E. G., A. I. Huerta, G. A. Arteaga, P. V. Krasilnikov, and A. H. Jimenez. 2006.** Soil diversity and properties in mountainous subtropical areas, in Sierra Sur de Oaxaca, Mexico. *Canadian Journal of Soil Science* **86**:61-76.
- Restrepo, C., and N. Alvarez. 2006.** Landslides and their impact on land-cover in the mountains of Mexico and Central America. *Biotropica* **38**:446-457.
- Restrepo, C., and P. Vitousek. 2003.** Landslides significantly alter land cover and the distribution of biomass: An example from the Ninole ridges of Hawai'i. *Plant Ecology* **166**:131-143.
- Walker, L. R., D. J. Zarin, N. Fetcher, R. W. Myster, and A. H. Johnson. 1996.** Ecosystem development and plant succession on landslides in the Caribbean. *Biotropica* **28**:566-576.
- Zarin, D. J., and A. H. Johnson. 1995a.** Base saturation, nutrient cation, and organic matter increases during early pedogenesis on landslide scars in the Luquillo Experimental Forest, Puerto Rico. *Geoderma* **65**:317-330.
- Zarin, D. J., and A. H. Johnson. 1995b.** Nutrient accumulation during primary succession in a montane tropical forest, Puerto Rico. *Soil Science Society of American Journal* **59**:1444-1452.



## **Landscapes, habitats and biodiversity in the Swiss Alps: changes, causes and prospects**

**J. Stöcklin<sup>1</sup>, A. Bosshard<sup>1</sup>, G. Klaus<sup>1</sup>, K. Maurer<sup>1</sup>, M. Fischer<sup>2</sup>**

<sup>1</sup> Botanical Institute, University of Basel, Schönbeinstr. 6. CH-4056 Basel.  
e-mail: juerg.stoecklin@unibas.ch

<sup>2</sup> Institute of Biochemistry and Biology, University of Potsdam, Maulbeerallee 1, D-14469  
Potsdam, Germany.

### **Introduction**

The Alpine landscape is particularly fine-structured, rich in habitats and may be considered as a refuge of biodiversity of the European continent. Several hundreds of plant species exist only in Alpine regions. The landscapes and biodiversity of the Swiss Alps have been co-shaped by centuries of human land use and by three cultural traditions (Romanic, Germanic and Walser). Many new landscape elements and habitats developed from human activity. Altogether, this has significantly enhanced the diversity of the landscape and of the biosphere of the Alps. But in the 20<sup>th</sup> century, this diversity has increasingly come under pressure. Socio-economically motivated land-use changes caused major changes in agricultural practices and are a threat for landscape quality and biodiversity.

Landscape changes and loss of biodiversity in the Alpine region as well as the underlying causes and possible future scenarios have been studied during the past four years in the context of the Swiss National Research Programme NFP 48 «Landscapes and Habitats of the Alps». In a synthesis we summarized the research results and put them in a greater context (Stöcklin et al. 2007). Particularly, we outline how landscapes, habitats and biodiversity in the Swiss Alps have been formed by natural conditions, by changes in agriculture and forestry and by policy of Switzerland. In particular, we summarize the causes and consequences of (a) the large increase of forest area in higher regions of Switzerland, (b) the abandonment or intensification of grassland use, and c) the particularities of federal subsidies to farmers for landscape quality and biodiversity on all levels (habitats, species and genetic diversity). Finally, we present recommendations for state policy, cantons, communities, farmers, societies and NGO's to maintain and improve the rich cultural heritage and biodiversity of the Swiss Alps.

### **Landscapes and Biodiversity: Subject to Changes**

From the mid-20<sup>th</sup> century on, the positive impact of human land use on the diversity of species and landscapes was increasingly reversed into a negative effect. Major causal factors were the mechanization and intensification of agriculture as well as the increasing opening-up of the landscape and the uncontrolled spread of human settlements. Important habitats for animals and plants disappeared, and the landscape became more monotonous. In the grasslands, two opposite developments took place: On the one hand, areas that easily lent themselves to agricultural use were cultivated ever more intensively. Intensification led to a loss of animal and plant species. Since there are plant and animal species that depend on a specific type of agricultural land use, the continuously decreasing diversity of land use, too, means a menace to biodiversity in the Alpine region. On the other hand, steep or badly accessible areas, which did not or not easily lend themselves to mechanical cultivation, were increasingly dismissed from agricultural use or – to save working time – changed into pastures. Unused areas below the timberline will sooner or later be recovered by the forest. In Switzerland, forest areas have grown by 30% to 100% in the previous 150 years. This refers almost exclusively to so-called marginal-yield sites, where the relation between expenses and returns is unfavourable. From a biodiversity protection perspective, this development has to be assessed as negative, since re-forestation affects above all dry meadows and pastures, which are rich in species.

Due to these insights and in view of the high material and immaterial value of the Alpine landscapes and their biodiversity, the question has to be raised whether the future use and shaping of these resources should not be controlled in a more purposive way

### **Scenarios – What will the future bring?**

In four scenarios we explored possibilities of further development of landscapes, habitats, and biodiversity in the Swiss Alps. The focus is on agriculture, since agriculture means by far the greatest direct human impact on the development of landscape, habitats, and biodiversity. At present, Swiss agriculture is compensated by direct payments of about 2.5 billions of Swiss francs annually for its multifunctional services. In contrast to many other influencing variables, these payments can be shaped as to their extent and to the conditions linked to them.

However, by the present agricultural policy of Switzerland, a mixture of product-oriented subsidies (market support), general direct payments, and a small proportion of ecologically motivated direct payments the continuing decrease of the diversity of landscapes and biodiversity cannot be stopped. Still, significantly more negative impacts would be caused by a retreat of agriculture from the mountain area, or by a minimization of requirements linked to payments. Only a scenario suggesting a shift away from product-oriented subsidies and a redirection of a large part of the general direct payments to service-oriented direct payments, indicates a way to reevaluate agriculture and preserve biodiversity.

### **Recommendations for Acting**

The following actions recommended to federal and cantonal governments, agricultural and forestry enterprises, and associations can contribute to the preservation of landscapes, habitats and biodiversity of the Swiss Alps:

- The system of direct payments to the agricultural sector is to be modified insofar as consequently only public, non-marketable services are to be compensated. The present direct payments are largely not linked to services but represent a type of financial return related to area and number of cattle.
- According to the principle of subsidiarity, the allocation of payments should be increasingly delegated to the level of cantons and communities.
- Entrepreneurship, innovativeness, and competitiveness in the sector of agriculture in mountain areas are to be promoted. The consequent shift of general direct payments will strengthen the farmers' entrepreneurial independence in a public market.
- The planned revision of the Swiss forest law will have to prescribe sufficient criteria for safeguarding biodiversity and quality of forests. The biodiversity in forests can be promoted by means of increased use of wood if such use follows certain guidelines.
- Tourism profits from the public services of agriculture. Therefore, it should be considered how tourism could be involved in paying the costs of these services.

The actual development of landscapes, habitats and biodiversity in the Alps is disapproved of by large parts of the Swiss population. The present synthesis of research and derived recommendations indicates ways towards a near-nature cultural landscape worth living in.

### **References**

**Stöcklin, J; Bosshard, A; Klaus, G; Rudmann-Maurer, K. & Fishcer, M. (2007)** Synthesebericht NFP 48: Landnutzung und biologische Vielfalt in den Alpen: Fakten, Perspektive, Empfehlungen. Thematische Synthese zum Forschungsschwerpunkt II "Land- und Forstwirtschaft im alpinen Lebensraum. vdf-Verlag Zürich.

## European mountain zones

M.J. Metzger<sup>1</sup>, R.G.H. Bunce<sup>2</sup>, G. Hofer<sup>3</sup>, T. Wrabka<sup>4</sup>

<sup>1</sup>Wageningen University, P.O. Box 47, 6700 AA Wageningen, The Netherlands,  
e-mail: marc.metzger@wur.nl

<sup>2</sup> Alterra - WUR, P.O. Box 47, 6700 AA Wageningen, The Netherlands

<sup>3</sup> ART Agroscope Reckenholz-Tänikon, Swiss Federal Research Station, Zürich, Switzerland

<sup>4</sup> University of Vienna, Althanstrasse 14, A-1090, Vienna, Austria

Europe has many mountain ranges spanning an environmental gradient from Scandinavia to the Mediterranean. Whilst all mountains share broad characteristics (e.g. in geomorphology, and environmental variability), there are also major contrasts in the landscapes between these mountain ranges, caused by differences in climate, soils, land use, vegetation, species, as well as differences in cultural history.

This paper defines six European mountain zones, based on the statistically derived Environmental Stratification of Europe (Metzger *et al.*, 2005) and appropriate altitude masks (Fig. 1). These are: Northern mountains, Atlantic mountains, Lusitanian mountains, Subsidiary mountains, Alpine mountains and Mediterranean mountains. The differences in the landscape ecology of these six zones have been described using available environmental and ecological datasets (e.g. for climate, land use, vegetation) as well as the literature, providing a comprehensive overview. The GIS dataset of the mountain zones and the supplementary descriptions can be obtained by contacting the corresponding author.

The biogeography of mountain plants has long interested botanists. Discontinuous distributions tell much about the connections between mountains and their distinctive character. Table 1 shows some examples of such species. Not all possible combinations have been included, but only some examples. Especially in the isolated mountains in the Mediterranean region there are many endemics. In some cases the distributions are difficult to determine because of the adjacency of several zones, e.g. in North-Western Spain where Lusitanian, Alpine and Mediterranean occur in close distance.

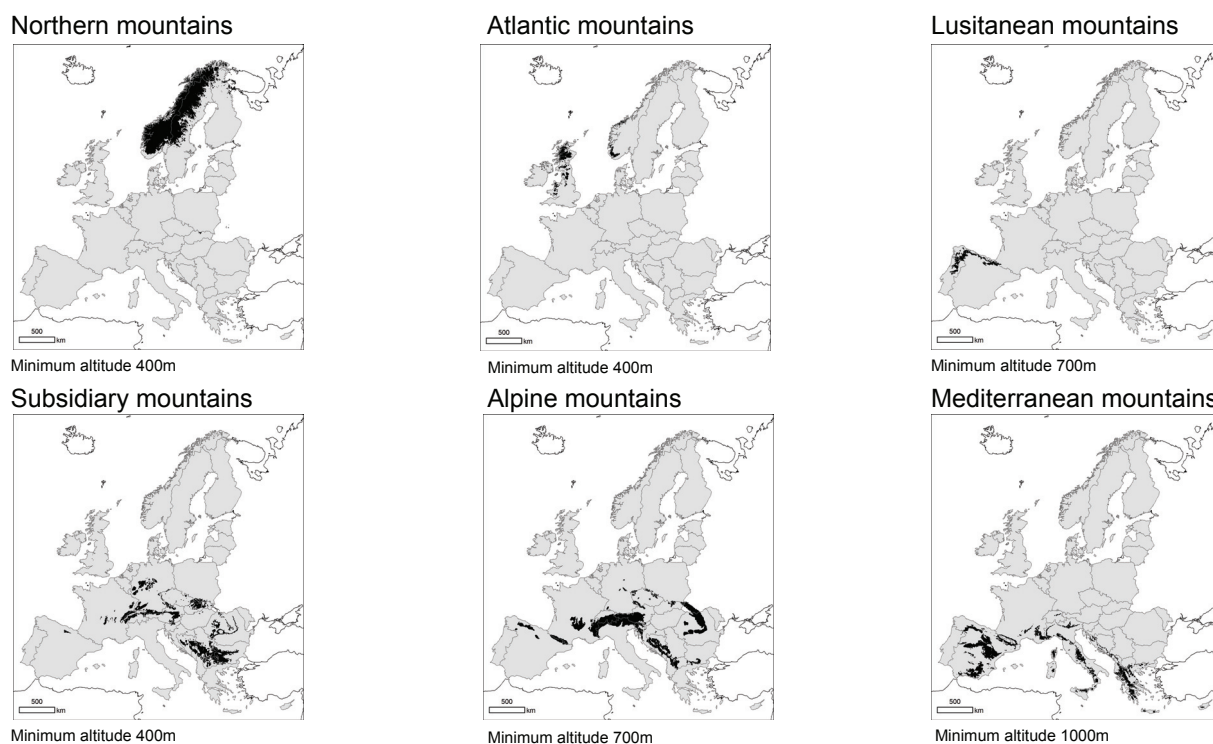
Finally, for each mountain zone a matrix has been constructed of the major environmental pressures on the region, based on Bunce & Petit (2005). Compared to most lowland regions in Europe, mountain landscapes are particularly vulnerable to multiple pressures. The impacts of the pressures are ongoing because disturbances have impacts that last for decades, e.g. Sitka spruce afforestation in Scotland, which mainly took place before the 1990s will dominate the landscape for the next century.

The European mountain zones help in understanding the distinctive differences of the landscape ecology of European mountains. By making the dataset publicly available, we hope to provide a useful stratification for European environmental science as well as European policy. For the latter, it provides a framework to help analyze policy implications, such as land abandonment and marginality caused by factors such as CAP reforms, in these zones.

## References

- Bunce, R.G.H. & Petit, S. (2005) The landscape ecology of the Atlantic Mountains. T. Pinto Correia, R.G.H. Bunce & D.C. Howard (eds) *Landscape Ecology and Management of Atlantic Mountains, Proceedings of the joint APEP and IALE(UK) conference* IALE Publication Series No. 2, pp 1-11.
- Metzger, M.J., Bunce, R.G.H., Jongman, R.H.G., Múcher, C.A. & Watkins, J.W. (2005) A climatic stratification of the environment of Europe *Global Ecology and Biogeography* 14: 549-563.

Theme 6: Cultural Landscapes and Landscape Management  
6.3 Symposium 21: Mountain Landscapes



**Figure 1.** Maps of the European mountains zones. Under each map the altitude mask is given, which was used to define the zones based on the Environmental Stratification of Europe (Metzger *et al.*, 2005).

**Table 1.** Examples of species with different distributions in European mountain zones.

	Northern	Atlantic	Lusitanian	Subsidiary	Alpine	Mediterranean
<i>Caluna vulgaris</i>	X	X	X	X	X	X
<i>Alchemilla alpina</i>	X	X		X	X	
<i>Gentiana verna</i>		X		X	X	X
<i>Saxifraga hypnoides</i>	X	X		X		
<i>Saxifraga aizoides</i>	X	X			X	
<i>Saxifraga rivularis</i>	X	X				
<i>Lloydia serotina</i>		X			X	
<i>Eritricaia nana</i>					X	

**Table 2.** Degree of vulnerability to of the main environmental pressures for the European mountain zones.

	Northern	Atlantic	Lusitanian	Subsidiary	Alpine	Mediterranean
Marginalisation	++	+	++	+	++	++
Abandonment	++	.	+	+	+	+
Climate change	++	.	++	+	++	++
Polarisation intensive and extensive use	+	+	+	++	++	+
Social changes	+	+	+	+	+	+
Urbanisation incl. ski development	+	.	+	+	++	.
Afforestation	.	++	++	.	.	+
Tourism	+	.	.	.	++	.
Eutrophication	.	+	.	+	+	.

++ major threat, + threat, . minimal threat

## Values and threats in Swedish Mountain landscapes – methods to assess landscape characteristics

M. Ihse

Department of Physical Geography and Quaternary Geology, Unit for Ecology, Stockholm University, SE 106 91 Stockholm, Sweden,  
e-mail: margareta.ihse@natgeo.su.se

### Introduction

Mountains can be seen as vertical islands of biological and cultural diversity, sensitive and highly valuable, surrounded by poor environmental and cultural homogeneity. The Swedish mountains are highly valued as one of the largest wilderness areas in Europe. The range runs in a north-south direction for nearly 1000 km, being part of the sub-arctic cap of Europe, which is one of the 200 most important eco-regions of the world.

### Values

Geological and geo-morphological values are often forgotten in the discussion of nature values. They have an intrinsic value, they provide understanding to the deglaciation, they give rise to very small-scale and mosaic vegetation patterns, in characteristic predictive zones due to snow cover, and they have recreational values. The bedrock of the Fennoscandian shield, with acid and nutrition-poor granite and gneisses, is amongst the oldest known on the earth. They are overlaid by much younger folded schists and amphibolites that form most of the mountains, with only small bands of calciferous and nutrition-rich bedrocks. The mountains have a smooth rounded general appearance, denuded through erosion and several glaciations. Characteristic features are accumulation structures such as eskers, fossil deltas, sandurs, and rogen moraine ridges. There are also erosion forms such as U-shaped valleys, fossil beach lines and dry valleys.

Biological characteristics and values are connected to the flora and fauna. The vegetation is dominated by heath communities with dwarf-shrubs and sedges, and large areas have also sloping mires. Meadows with grass and herbs, characteristic of other mountain regions in Europe, are only found here in small areas of favourable conditions. The tree line is formed by the mountain birch. Old virgin coniferous forests are found in the pre-alpine zone. The small scale geomorphology gives rise to a distribution of snow cover, causing a small scale mosaic in zones, from the wind exposed tops with extremely dry dwarf shrub heaths, followed by series of vegetation types to snow-beds in the most protected positions. The vegetative period is very short. Perennial plants dominate, many plants reproduce asexually. The vegetation can be ranked according to vulnerability to trampling; the most sensitive being wet fens and mires, followed by different types of dry heath. Most resistant are meadows and grass heaths of different types. Many birds and carnivores are especially important, e.g. brown bear, grey wolf, arctic fox, lynx, wolverine and all are threatened and rare.

Social – economic values. The Swedish mountains have very high recreation values and there are large areas without settlements and roads. Most of its area is easy assessable for hiking, with well developed works of tracks and huts. There is clean air with long visibility, and clean water to drink from springs and small rivulets. Many large rivers have scenic rapids and waterfalls and are not regulated. Fishing is popular. The main land use today is reindeer herding, started in the 17<sup>th</sup> century. Forestry dominates in areas close to the mountains, changing the landscape and climate with large clear cuts. Agro-pastoral use is restricted today to a few small areas. Mining and hydro-electrical power industry is important. The tourist industry is mainly concentrated in ski resorts, which have developed many years ago, while eco-tourism and adventure tourism is steadily increasing.

## Threats

Mountains are less capable than lowlands to recover from disturbances, as the soil layer is usual thin, the vegetation growth rate is low and the precipitation is heavy. It is easy to cause vegetation damage, which can lead to land degradation and soil erosion. The global threats are climate change and air pollution. A global warming will affect tree lines, species composition, and biomass production; air pollution causes acidification and nitrogen deposition. The local threats come from urbanisation, more intensive land-use from mining, damming for hydro-electric power, windmills for energy purposes, clear-felling for the forest industry, hunting, and more intensive reindeer management and tourism. New roads have fragmented large wilderness areas, whereas the changed management and increased amount of reindeer have exerted a hard pressure on vegetation cover, leading to damage of lichen and dry dwarf shrub heaths and to the onset of soil erosion. Off road driving with motorbikes and snow vehicles makes long lasting tracks, draining sensitive mires and increased amounts of tourist damage by trampling. These changes are of importance for ecosystem function, its resilience and biodiversity, and thus for nature conservation and recreation.

## Methods in science and practice

Remote sensing methods for survey and mapping. *Colour infrared-aerial photographs* have been used for manual interpretation in stereo for mapping vegetation and geomorphology in macro-scale. The methods for data collection were developed after methodological studies. The classification system consists of 25 units and is based on heath, meadow and mire series, with added ecological factors of moisture, physiognomy and hydrology. This method is very quick and accurate; the mapping can be done with 10-15 km<sup>2</sup> per hour with a minimum of field controls, and the assessed accuracy is high (85 %). The photos have also been used to develop methods to detect changes of vegetation and lichen cover in meso-to- micro scale during the last 30 years. Different methods of automatic classification of CIR aerial photos have also been tested for mapping in meso-scale. Until today the survey of tree line has also been field based, but the new digital techniques, with scanned or digital original air photos, converted to ortho-photo and overlaid with high accuracy, will enable high precision mapping and change detection at a micro-scale. Field inventories have to be done for survey and monitoring of floristic composition.

*Medium resolution satellite imageries from Landsat TM* has been used to monitor meso-scale changes in vegetation cover during the last 20 years by supervised classification and masking techniques. *High geometric resolution satellite imageries from Ikonos* has been used for visual interpretation of lichen and vegetation cover changes.

Surveillance and monitoring system in practice has been developed from the described methods and are used for regional and national planning and nature conservation. Geomorphological maps (1:250.000) and vegetation maps (1:100.000) cover the whole mountain range and form together with species inventories the basis for the protection plans for nature conservation and physical planning. Established are several national parks, one bio reserve; identified are several large areas as wilderness areas and many high quality core areas. The National Monitoring system for Landscape in Sweden, NILS, are using the vegetation mapping methods described here, in 5x5 km and 1 km test areas, and a needle point inventory is being tested. This system will also be used in the European Natura 2000 inventory. All the methods for survey and evaluation are based on scientific methods.

## **Assessing the role of transhumance in the sustainability of European mountain environments: the TRANSHUMOUNT project**

**M. Pérez-Soba<sup>1</sup>, R.G.H. Bunce<sup>1</sup>, F. Herzog<sup>2</sup>, A. Gómez Sal<sup>3</sup>, R.H.G. Jongman<sup>1</sup> & I. Austad<sup>4</sup>**

<sup>1</sup> Wageningen University Research Alterra – P.O. Box 47, 6700 AA Wageningen, The Netherlands.

e-mail: marta.perezsoba@wur.nl

<sup>2</sup> Agroscope FAL Reckenholz – Swiss Federal Research Station for Agroecology and Agriculture, Reckenholzstrasse 191, CH-8046 Zurich, Switzerland;

<sup>3</sup> Departamento de Ecología – Universidad de Alcalá, Alcalá de Henares, Madrid, Spain;

<sup>4</sup> Sogn & Fjordane University College (HSF) – Box 133, N-6851 Sogndal, Norway

### **What is transhumance?**

The European mountains and their adjacent regions have significant fluctuations in climate and a very diverse topography which determine seasonal variation in the productivity of their grazing resources. The human answer to these biophysical changes is transhumance, a very ancient livestock practice found in the Neolithic times approximately 8,000 years ago. It consists in the seasonal transfer of herbivores to areas of complementary production i.e. to mountain areas in search of green pastures at the end of spring, and the return to the warmer agricultural land in the valleys and adjacent lowlands in autumn. The distances covered by the livestock strongly vary between countries. One of the most outstanding examples are the Spanish transhumant drove roads (called *cañadas*) that sometimes link zones which are up to 800 km apart (Gómez Sal and Lorente, 2004). Transhumance makes therefore possible to take advantage of the complementary production patterns by means of the mobility of different species and breed of traditional herbivores, which are perfectly adapted to the difficult biophysical conditions. Consequently, transhumance is considered one of the best examples of sustainable, traditional agricultural systems in Europe.

### **What is the role of transhumance in maintaining the very sensitive mountain areas in Europe?**

Mountain and highland areas cover about 30% of the European territory and are the living area for approximately 30 million people, but many more benefit indirectly from their resources. Mountain areas constitute a strategic reservoir of biodiversity, un-fragmented natural areas, cultural and landscape diversity, water resources, tourist assets and local food productions. For many European regions, mountains are central in their cultures probably due to the fact that they cover 50% of the territory, e.g. Switzerland, Austria, Spain, Greece, Italy and Portugal. It is not a coincidence therefore that transhumance has been a common livestock practice in these countries and is recognized to play a key role in shaping their landscapes.

Unfortunately, most of mountain areas in Europe actually experience high pressures. The rapid tempo of globalization, climate change, and abandonment of agricultural practices, mass tourism and urbanization are threatening mountain communities and the resources they depend on, making them particularly sensitive areas that need to be protected.

The 5<sup>th</sup> Framework programme of the EU co-financed the project TRANSHUMOUNT within Key action 2: Global change, climate and biodiversity, Research priority 2.2.1: Ecosystem vulnerability (i) to review the past role of transhumance in different European countries, (ii) to assess the present status and role of transhumance in the European mountain ecosystems and (iii) to identify agricultural policy measures that could ameliorate

potential declines in biodiversity and maintain transhumance under present environmental and socio-economic pressures.

The main messages of the TRANSHUMOUNT project were that (i) the majority of European habitats are not involved anymore in transhumant activities; (ii) the functioning of transhumance is seriously threatened at present by modern pressures such as industrialisation of agriculture, globalisation and modern lifestyle (Herzog et al 2006); and (iii) the status of ten mountain habitats is seriously threatened by the decline in transhumance. These habitats are located in most of the European countries, from Scandinavia to the Mediterranean, and from France to Romania, being examples the mountain flowery meadows and the open Mediterranean forests. These habitats are of high biodiversity and are also important for tourism and the production of traditional foods. This important cultural heritage will be lost irreversibly, unless policy measures are taken to reverse this trend or at least maintain animals in the high mountains.

The project identified the following good and services provided by transhumance to society and nature: (a) transhumance is an integral part of the traditional farming in most European mountains and involved in many high nature value farming systems; (b) in mountain regions, transhumance is central for multifunctional agriculture and sustainable land use management; (c) maintenance of many habitats, species and special breeds which are unique and irreplaceable and have both economic and intrinsic values; (d) contribution to the protection of mountain ecosystems and landscapes from natural hazards (e.g. fire, erosion, avalanches, landslides) by maintaining a stable mosaic of patches that have developed over centuries; and (e) providing employment and income to farmers and therefore contributing to the rural development of the areas and preventing land abandonment.

Finally, the project described policy measures to maintain these systems, including measures already tried or innovative, which were proposed by the scientists and stakeholders participating in the Final Policy Workshop. The core conclusion was that the maintenance of the social fabric is the primary factor to maintain biodiversity. In addition, the preservation of extensive grazing is the principal requirement to solve the biodiversity problems in these situations.

The main product of the project was a scientific book entitled 'Transhumance and Biodiversity in European Mountains', which presents an overview of the current status of transhumance in Europe and forms the basis for understanding its role in biodiversity. The book defines the next stage necessary in policy formulation. It shows that there are wide differences present between countries, with Switzerland being a model on how the systems should be maintained and managed. In addition a range of policy options are presented in a very useful way (<http://www.alterra-research.nl/>), allowing policy makers to assess the impact that a specific policy measure might have on a specific pressure affecting a determined habitat. These policy options are used to be matched to the environmental character and social structure of the mountain area concerned. If adopted, they could enable the target of attaining stability by 2020 to be reached.

## References

- Gómez Sal, A. & Lorente, I. (2004)** The present status and ecological consequences of transhumance in Spain R.G.H. Bunce; M. Pérez-Soba; R.H.G. Jongman; A. Gómze Sal; F. Herzog & I. Austad (Eds). *Transhumance and Biodiversity in European Mountains*. Report of the EU-FP5 project TRANSHUMOUNT (EVK2-CT-2002-80017). IALE publication series nr 1, pp 233-248.
- Herzog, F.; Austad I.; Gómez Sal, A.; Jongman, R.H.G.; Pérez-Soba, M. & Bunce R.G.H. (2006)** Policy options to support transhumance and biodiversity in European mountains. Proceedings of the 13th meeting of the FAO CHIEAM Sub-Network on mountain pastures, 15-17 September 2005, Udine (Italy), pp 43- 48.



## Landscape's diversity in the alpine belt of the Greater Caucasus

E.A. Belonovskaya

Institute of Geography RAN, Staromonetny per. 29, Moscow 119017, Russia;  
e-mail: belena53@mail.ru

One of the main traditional land uses in the Greater Caucasus is cattle breeding on distant pastures. Thus, the alpine belt with its splendid summer pastures plays very important role for the local population. Nevertheless, no special investigation on the ecological situation in the alpine belt was ever pursued. For this reason the maps of the Greater Caucasus are very general and present the alpine belt without any differentiation between plant communities and landscapes. Currently, as a result of field observations of geobotanical and geomorphological elements, the modeling of climatic parameters and the use of remote sensing and GIS-technologies, the diversity of the alpine landscapes of the Greater Caucasus and regularities of their spatial distribution have been revealed (Table 1).

The Greater Caucasus extends southeastward across the Caucasian isthmus, which separates the Black Sea from the Caspian Sea. Traditionally the Greater Caucasus is divided into three regions: the Western, Central and Eastern Caucasus. This paper presents some results of an investigation on the relationship between the spatial heterogeneity of the landscapes and environmental factors (climatic and geomorphologic) in the alpine belt along the ridge. The types of the alpine landscapes correspond to the plant communities that were revealed on the base of the floristic classification

The extraordinary environment of the alpine belt has low temperatures all over the year, low sum of temperature above 10°C (260°), very short vegetative period (1,5-2 months) with night frost occurring throughout the summer, a long period of snow cover (260 days) with communities characterized by absence of phanerophytes and by the low height of the grass layer (of 10 to 15 cm).

The geomorphological factors such as relief forms (with its micro-and nanorelief) and slope orientation and inclination, influence precipitation and solar radiation and through it the air temperature in near ground air layer. All these factors determine the distribution of the alpine landscapes types within the belt, especially locally.

The alpine meadows and heath communities prefer convex relief surfaces of steep diverse slopes and plateaus, modulated by frost weathering and wind reduction. Such sites favor cryogenic activity because the soil can be free of snow during the winter. The cryogenic activity also occurs in critical periods during autumn and spring when the soil is generally uncovered or only temporarily covered by snow. In the Western and Central Caucasus, the amount of precipitation at the same altitude is independent of slope characteristics, but in the Eastern Caucasus in winter time the leeward slopes get precipitation less abundant (by 30-50mm) than the windward ones. The deficit in snow cover explains why the alpine meadows are met mainly on the leeward northern and eastern slopes. These landscapes are characterized by the prevalence of tussock grasses and herbs (especially *Hemikryptophyta caespitosa* of Raunkier's life form types) and lichens (with reindeer moss as the dominant species), as well as by low density of the herb layer (total covering is of 40-50% on average).

Alpine carpet-like meadows or mats – the communities with the prevalence of perennial dicots (especially *Hemikryptophyta rosulata*) occupy varying in size well-moistened depressions on gentle slopes or plains. Communities are characterized by their very low height (5-10 cm) and high density (100%) of the herb layer. During the winter period, they accumulate heavy snow cover which plays the key-role in the development of the communities.

Screes and rock-crevices are associated with special plant groupings.

The limits of the alpine belt are well expressed on the multispectral space images (on the satellite images this belt is in light-brown), and were also confirmed by superposition of the remote sensing and field data. The distribution of screes and rock-crevices are relatively easy identified on topographic maps of a high quality or by aerial photographs.

**Theme 6: Cultural Landscapes and Landscape Management**  
**6.3 Symposium 21: Mountain Landscapes**

Thus, combined application of remote sensing and GIS methods is particularly effective for a complex survey and thematic mapping in the high mountain regions. It also improves the objectivity and precision in the determination of the mountain belt limits, the monitoring of their dynamics and therefore exactness of the environment evaluation in the high mountain regions. This new approach could change the type of studies from laborious and expensive field observations in regions with difficult access into mainly laboratory studies.

**Table 1.** Alpine belt landscapes' diversity of the Greater Caucasus

Regions	Western Caucasus	Central Caucasus	Eastern Caucasus
Altitude (m above sea level)	2500 - 3200	2800 - 3500	2800 - 3500
Mean annual temperature (°C)	-0.4° to -3.1°	-1.1° to -4.6°	-2° to -6.2°
Annual sum of precipitation (mm)	2330-3350	1890-2100	1590
Relative humidity (%)	72-73%	72-73%	76%
bulged steep diverse slopes (alpine meadows)	Anemono speciosae- Campanuletum tridentatae; Nardo stricti- Geranietum gymnocauli;	Anemono speciosae- Campanuletum tridentatae; Polygono vivipari-Kobresietum bellardii; Hedysaro hedysaroidis- Campanuletum collinae	Anemono speciosae- Campanuletum tridentatae; Alchemillo sericeae-Caricetum umbrosae; Potentilletum crantzii
mainly concave and aligned parts of gentle slopes (alpine carpets-like meadows)	Taraxaco confusi-Geranietum gymnocauli; Carici pyrenaicae- Colpodietum pontici	Carici atratae- Anthoxantheum odorati	Gageo fistulosi- Cerastietum cerastoidis; Taraxaco crepidiformis- Colpodietum variegatae
on screes	Myosotido alpestris-Potentilletum gelidae	Alopecuro pontici-Cerastietum alpini	Ranunculetum arachnoidei; Silenetum humile
on rock-crevices	Campanulo saxifragae- Alopecuretum sericei	Gypsophilo tenuifoliae- Saxifragetum juniperifoliae	Saxifrago paniculatae- Campanuletum saxifragae

## Landscape patterns in biogeographical mountain regions: an approach from the natural protected areas of the Catalan Pyrenees.

D. Varga<sup>1</sup>, J. Vila<sup>1</sup>, C. Barriocanal<sup>1</sup>, A. Lertxundi<sup>2</sup>, M. Saez<sup>2</sup>, A. Llausàs<sup>1</sup>, A. Ribas<sup>1</sup>

<sup>1</sup>Institute of the Environment. University of Girona (IMA-UdG), Plaça Ferrater Mora 1, 17071 Girona (Catalonia), Spain  
e-mail: diego.varga@udg.es

<sup>2</sup> Research Group on Statistics, Applied Economics and Health (GRECS), University of Girona. Campus of Montilivi, 17071 Girona, Spain

### Introduction

The Catalan Pyrenees are located in the easternmost part of the Pyrenees mountain range, where it almost meets the Mediterranean Sea. This area has a conjunction of biogeographic regions; up to two principal regions can be found there: Mediterranean and Alpine.

We have quantified and modeled the relationships between distribution and abundance of forest and non-forest habitats by means of the use and the calculation of landscape structure metrics in seven protected natural areas.

These areas are: Aiguestortes National Park (IUCN category: II); Albera Natural Site of National Interest (IUCN Category III); Alt Pirineu Natural Park, Cadi-Moixero Natural Park and Cap de Creus Natural Park (IUCN category: V) and Capcaleres del Ter i Freser Protected Area and Alta Garrotxa Protected Area (IUCN category: VI).

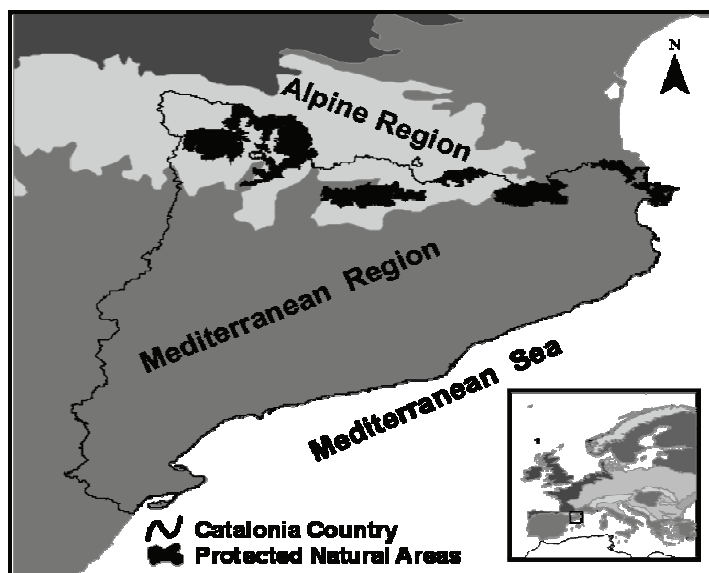


Figure 1. Biogeographic regions and natural protected areas

### Methodology

Principal component analysis (PCA) was used to identify a set of metrics that best describe the characteristics of the landscape units. A Hierarchical cluster analysis (HCA) was used to produce typologies of landscape patterns across both biogeographical regions. We apply finite mixture models. These models assume an underlying partition of the population into  $k$  homogeneous components, where each component has a different risk level, depending on possibly different covariates.

## Results

This study shows the responses of twenty five landscape metrics in two different biogeographic regions and recognizes three behavioral groups. These three clusters can be categorized as two general patterns.

**Table 1.** Cluster analysis and landscape patterns

	Aiguestortes	Alt Pirineu	Cadi Moixero	Ter i Freser	Alta Garrotxa	Albera	Cap de Creus
<b>1987</b>							
Cluster 1	X	X	X				
Cluster 2				X	X	X	
Cluster 3							X
<b>1992</b>							
Cluster 1	X	X					
Cluster 2			X	X	X	X	
Cluster 3							X
<b>1997</b>							
Cluster 1	X	X					
Cluster 2			X	X	X		
Cluster 3						X	X
<b>2002</b>							
Cluster 1	X	X	X				
Cluster 2					X		
Cluster 3				X		X	X

In the Alpine bioregion, a balanced agrarian and forest habitat is observed, and certain landscape heterogeneity is being maintained (Aiguestortes, Alt Pirineu and Cadi Moixero). On the other hand, in the Mediterranean bioregion, a very important reduction and isolation of pasture areas has led to a reduction of landscape heterogeneity, and towards a dominance of the forest habitat (Ter i Freser, Alta Garrotxa, Albera and Cap de Creus).

## Conclusions

Analysis of spatial patterns provides a considerable importance to characterize landscape heterogeneity across Catalan Pyrenees' biogeographic regions and is an essential prelude to the examination of land use and cover dynamic interactions.

These results point to the suggestion that for each biogeographic region there is a unique set of practices of planning, design and management.

## References

- Peña, D. (2002)** *Análisis de datos multivariantes*. McGRAW-HILL, Madrid.
- Swihart, R. & Moore, J. (2004)** *Conserving Biodiversity in Agricultural Landscapes (Model-Based Planning Tools)* Purdue University Press, Indiana.
- Botequilha, A; Miller, A; Ahern, J. & McGarigal, K. (2006)** *Measuring landscapes (A Planner's Handbook)* IslandPress, Washington.

## 6.4 Open Session 21: Fire and land management

### Post-fire tree residual aggregates in boreal forest landscapes: an assessment of spatial patterns using IKONOS imagery

A.H. Perera<sup>1</sup> and T.K. Rimmel<sup>2</sup>

<sup>1</sup>Ontario Forest Research Institute, 1235 Queen St East, Sault Ste. Marie, Ontario Canada.  
e-mail: ajith.perera@ontario.ca

<sup>2</sup>Dept. of Geography, York University, N143A Ross Building, Toronto, Ontario, M3J 1p3  
Canada.

#### Introduction

All forest fires, including stand-replacing boreal fires, leave residuals as a continuum from individual trees to aggregate patches (Eberhart and Woodard, 1987). Given their ecological (e.g., wildlife habitat, seed source, carbon budget) and social (e.g., aesthetic) values, many attempts are made to emulate fire residual patterns during forest harvest plans (Perera and Buse, 2004). An important prerequisite for this forest management practice is knowledge of spatial patterns and causal factors of variability associated with post-fire residuals. However, definition and delineation of residuals in forest fires is typically subjective and value driven, and causal factors are rarely considered. The goals of this study are to (a) objectively assess fire geometry and post-fire residuals occurring within natural fire areas of boreal forests, and (b) propose a series of research hypotheses for the causal factors of boreal post-fire residual aggregates. Further, we will identify a set of criteria that can be used by forest managers in developing designs for post-harvest residual retention to emulate natural forest fires.

#### Methods

We mapped 34 natural (i.e., lightning-caused and unsuppressed) boreal forest fires ranging from 50 ha to over 16,000 ha, using IKONOS imagery. The burned, unburned (residual), and partially burned pixels were mapped at 1 m (panchromatic) spatial resolution and the residual pixels were classified into broad species classes using 4 m spatial resolution multispectral data. First, the residual pixels were analyzed for 1<sup>st</sup> order spatial associations (spatial autocorrelation and correlation with fire geometry). We constructed the spatial geometry of the fire (edge, shape, size) and the residual patches (clusters of unburned pixels inside fire edge and their spatial occurrence) objectively, without using *a priori* knowledge of fire boundary or post-fire residuals. Assessments were conducted along a series of hierarchically coarser spatial resolutions to capture scaling effects among measures including: (1) a pixel's distance from an absolute burned/unburned interface, (2) closest unburned land cover class, (3) areas of contiguous burned/unburned pixel clusters, (4) tallies of cluster heterogeneity within varied moving window sizes, (5) numerous measures of fire and residual geometries, and (6) the hierarchical decomposition of mutual information spectra to characterize spatial patterns (Rimmel and Csillag, 2006). The 2<sup>nd</sup> order spatial associations (correlation with vegetation classes (prior to burning) obtained from Landsat TM imagery; correlation with water bodies and site factors, and their interactions). The 2<sup>nd</sup> order associations were tested as an additive series of hypotheses, with the pre-burn vegetation as the null model.

#### Results

Initial results show that the 'edge' of forest fires is not definitive (Figure 1) – the burned interior:non-burned exterior boundary is not a linear continuum, and depends on the pixel resolution. Also, the boundary is more distinct with certain covert types of unburned exterior. Therefore the fire edge is best defined as an interphase or a transition zone, and the linearity and complexity of 'edge' is scale and context dependent. The clustering of residuals in the fire interior is also not definitive – the cluster size and number of clusters in each size class changes with the degree of contiguity (strength of clusters – or cluster porosity). The spatial occurrence of residuals is correlated with distance from the outermost fire 'edge'. With increasingly coarser representations, the core fire areas become more clearly defined (by measuring cluster presence variability) and the patchiness along the perimeter (or regions with more residuals) is more evident.

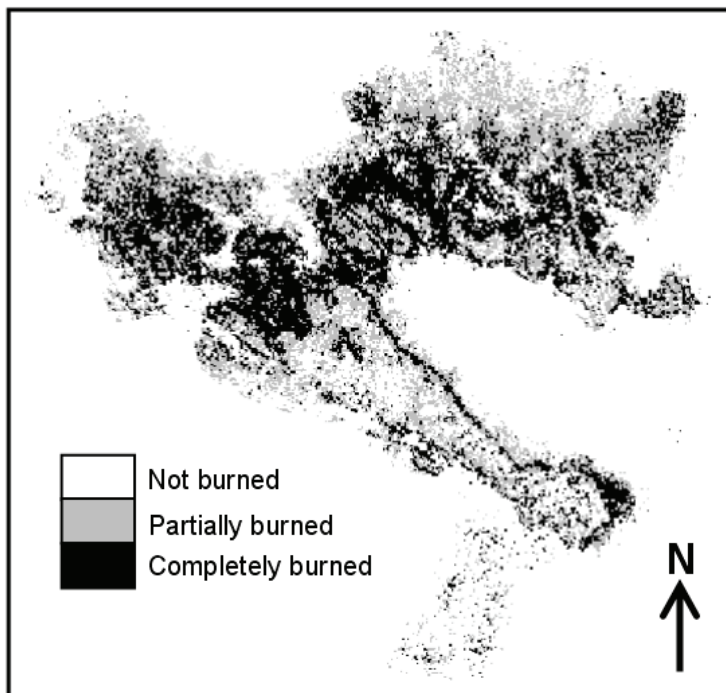


Figure 1. A 410 ha fire in northern Ontario with completely and partially burned pixels identified at 1 m spatial resolution. Residuals and fire exterior (white) are not delineated by distinctive crisp interfaces, but rather appear as irregular and spatially diffused.

## References

- Eberhart, K.E & Woodard P.M. (1987)** Distribution of residual vegetation associated with large fires in Alberta. *Canadian Journal of Forest Research* **17**:1207-1212.
- Perera, A.H. & Buse L.J. (2004)** Emulating natural disturbance in forest management. A.H. Perera, L.J. Buse and M.G. Weber (Eds). *Emulating Natural Forest Landscape Disturbances: Concepts and Applications*. Columbia University Press, New York. pp. 3-7.
- Rommel, T.K. & Csillag, F. (2006)** Mutual information spectra for comparing categorical maps. *International Journal of Remote Sensing* **27**: 1425-1452.

## Fire impact on the northwestern Patagonia grasslands

L. Ghermandi, S. Gonzalez, J. Franzese, M de Torres Curth, P. Parodi.

Laboratorio Ecotono, Centro Regional Universitario Bariloche, Universidad Nacional del Comahue, Calle Quintral 1250, 8400 Bariloche, ARGENTINA.  
e-mail: lghermandi@yahoo.it

### Introduction

Fire can reduce the grasses cover favoring the shrubs encroachment that modifies drastically the community decreasing the grassland productivity and diversity. Fire and grazing are the principal processes that regulate the grasslands dynamics. This ecosystem is fire prone due to the accumulation of fine fuel very inflammable and the occurrence of summer lightning storms. Both successes are modeled by ENSO phenomena. The grasslands of NW Patagonia represent an important natural resource used for the livestock production.

### Study area

The study area is situated in the San Ramón ranch, located 30 km east of Bariloche, NW Patagonia, Argentina (41°03'19"LS-71°01'50"LO). The climate is temperate with probability of frost throughout the year. The annual precipitation is 580 mm, 60% autumn-winter concentrated (May–August) and the mean annual temperature is 7 °C. Frequent and strong W-NW winds increase water stress in the warm season. The landscape is dominated by gently undulated plains and mountains and soils are sandy. The vegetation corresponds to the Phytogeographic Subandean District of Patagonia Province. Due to the landscape heterogeneity, the vegetation is a mosaic of grasslands and shrublands, which are related to the topography and soil. *Stipa speciosa* and *Festuca pallescens* grasslands dominate low and high areas respectively. The native shrubs *Fabiana imbricata*, *Mulinum spinosum*, *Senecio bracteolatus* and *Acaena splendens* are present, scattered in the grasses matrix or forming dense patches. In January 1999, a wildfire burned approximately 15000 ha, more than 60 % of the San Ramón ranch, and quickly spread due to exceptional 1998-1999 drought caused by La Niña phenomenon.

### Material and Methods

#### The shrubs

*Mulinum spinosum* (Apiaceae) is subspherical thorny shrub. Its growths superficially and have dry support structures where air circulate. Its architecture favors the ignition during fires. Its height is up to 90 cm and resprout post-fire. It is not very palatable shrub and rarely forms compact shrublands.

*Senecio bracteolatus* (Asteraceae) is a resprouting not palatable shrub. Measure between 40 y 100 cm of height, is highly branchy and does not form compact shrublands.

*Fabiana imbricata* (Solanaceae) is a seeder, not palatable shrub with persistent seed bank. It is 1,5 – 3 m tall and forms compact shrublands.

*Acaena splendens* (Rosaceae) is ruderal, not palatable and regenerates only by seed. It is 5 – 60 cm tall.

### Objectives

#### 1. Post-fire shrubs encroachment study

We monitored the shrubs cover and recruitment during seven years. We counted and measured the resprouter adults and seedlings. We studied the age of *F. imbricata* shrublands using dendrocronology.

### 2. Post-fire seed bank study

We studied the quantitative and qualitative variation of the seed bank during three years.

### 3. Matrix model of population dynamics of *F. imbricata*

The population and environmental dynamics were described with matrix models coupled in a mega-matrix projecting the population in hypothetical scenarios of different fire frequencies.

## Results and discussion

The fire favors the shrub encroachment in the NW Patagonia. *F. imbricata* (seeder) shows a clear pattern of even-aged patches distribution related to the fire and the topography and recruits only post-disturbance. *M. spinosum* growth higher and faster than *S. bracteolatus* (both resprouter species). *Acaena splendens* (seeder) reached the pre-fire cover seven post-fire years. The shrubs were little represented in the seed bank; with exception of *F. imbricata* of witch seeds are very small. The perennial species form superficial and transient seed bank that suffer high temperature. The climate change suggests the increase of frequency of ENSO phenomena, which in NW Patagonia signifies more coupled fires and rainy springs. The matrix model indicates that this scenario would produce the *F. imbricata* shrub encroachment.

## Conclusions

We consider that it is necessary to include the analysis of satellite images and aerial photographs using GIS tools in further study, to provide information about long term changes in vegetation and fire regime. Our results provide useful information about the ecosystem behaviour, which can be used in Patagonia to improve the grasslands sustainable use.



## Using functional traits to assess bee responses to fire at multiple scales

M. Moretti<sup>1</sup>, B. Pezzatti<sup>1</sup>, F. Zanini<sup>2</sup>, S. Potts<sup>3</sup>, F. de Bello<sup>4</sup>

<sup>1</sup>Swiss Federal Research Institute WSL, Ecosystem boundaries Research Unit, CH-6500 Bellinzona, Switzerland.

e-mail: marco.moretti@wsl.ch

<sup>2</sup>Swiss Federal Institute of Technology Lausanne, Laboratory of ecological systems, CH-1015 Lausanne, Switzerland

<sup>3</sup>Univ. of Reading, Centre for Agri-Environmental Research (CAER), Reading, Berks, UK

<sup>4</sup>Laboratoire d'Ecologie Alpine, CNRS UMR 5553, Université Joseph Fourier, BP 53, 38041 Grenoble Cedex 9, France

### Introduction

There are many concerns about the negative effects of habitat homogenisation on biodiversity (Bengtson 2000). Wildfires are one of the most important disturbance factors affecting forests heterogeneity at small and large scales, creating mosaics of different successional stages and remnants. Heterogeneity allows species with different traits to find more suitable niches for their development. Many studies indicate that some group of species are influenced by low scale heterogeneity while others need a complex landscape at a larger scale (Steffan-Dewenter *et al.*, 2002). Hence, analyses at multiple spatial scales are crucial to detect the importance of this heterogeneity on species assemblages.

In our study we analyze the effect of wildfire mosaics in a forest matrix on the community assemblages and functional traits composition of bees at different spatial scales. Our aims are (i) to understand the extent to which bees' species and trait composition respond to fire changes, and (ii) to assess the spatial effects of different components of fire regime (i.e. frequency and time since the last event) on species and trait composition.

### Methods

The sampling design was based on space-for-time substitution in homogenous former coppice stands of sweet chestnut in Southern Switzerland. We selected 23 sites that covered all fire succession stages, from freshly burnt to unburnt sites. Bees were sampled using 69 window traps between March and September 1997 and identified at species level. For each species we assigned 12 different traits relating to body features, dispersion, nesting, and feeding habits. We then calculated an average for every trait in each plot, by multiplying species' traits by the species abundance (weighted averages *sensu* Ackerly *et al.*, 2002). The effects of habitat mosaic created by fire on species and traits composition were analyzed at multiple scales using different radii from 50 m up to 1000 m. Proportions of areas burnt with different frequency, and time since the last fire were derived from the Wildfire Database of Southern Switzerland and used as explanatory variables in the model. The effects of environmental factors on species and trait composition were tested by means of Redundancy Analysis (RDA) and using a Monte Carlo permutation test ( $P < 0.05$ ; 5000 randomizations) performed with data sets of different spatial resolution.

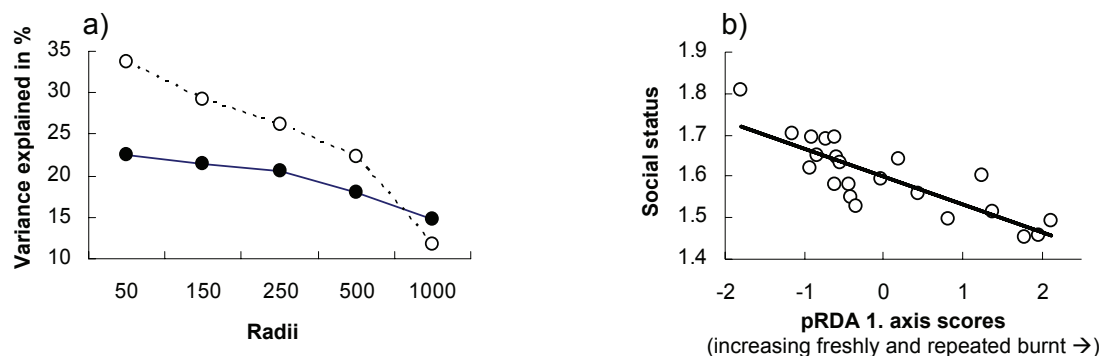
### Results and discussion

Our results showed that fire regime significantly influenced species and trait composition of bees in the study area (Monte-Carlo test,  $P < 0.001$ ) and that the spatial scale is an important factor. In particular, Redundancy Analysis (RDA) revealed that the variation in the species assemblage was mostly affected by the proportion of freshly burnt areas. The functional traits composition was influenced by the same factor but also by the proportion of repeatedly burnt area in the past 30 years. The partial decoupling of species and trait composition response (Fig. 1a) might suggest that repeated fires do not change species composition markedly but determine changes in dominant traits (i.e. the traits were weighted by species abundance). Species, on the other hand react quickly to sudden changes (i.e. freshly fires) and

particularly those which display great mobility. In fact, the combination of freshly and repeated burnt areas positively affected small solitary bees, while large social bees were associated with mature and unburnt areas (Fig. 1b).

The analysis of the effect of fire regime at multiple spatial scales on bee distribution revealed that the most variance in the species assemblage (22.6%) and in the trait composition (33.8%) was found within a radius of 50 m around the trapping sites (Fig. 1a). At this radius, fire regime factors explained up to 1.5-fold better the variation in traits composition than in species assemblage. This difference however decreased at higher scales, showing that the species composition change was less scale dependent than on trait composition (Fig. 1a).

These results confirm the findings of Steffan-Dewenter *et al.* (2002) showing a spatial-scale dependent response of functional group of organisms to spatial heterogeneity and open fields to the novel analyses on the relation of traits with environmental changes.



**Figure 1.** a) Scale-dependent effect of fire regime (i.e. fire frequency and time since last fire) on species (black circles) and traits (white circles) composition; b) Regression of "social status" (higher values = social bees are dominant) with the scores for each study site on the first RDA axis scores in 50 m radius" (higher values = high amount of freshly and repeated burnt areas) ( $r^2 = 0.697$ ,  $P < 0.001$ ).

Overall, the differences between species and trait response to fire regime seem to reflect a functional adaptation to disturbance, which might act as an environmental filter on the distribution and assemblage of the trait values within communities.

The combined analysis of species and trait composition at different spatial scales is an example of a way to monitor communities and generalize results behind localities and disturbance types. Such indicators would provide powerful and promising tools for validating management procedures and controlling ecosystem function.

## References

- Ackerly, D.D.; Knight C.A.; Weiss, S.B.; Barton K. & Starmer, K.P. (2002)** Leaf size, specific leaf area and microhabitat distribution of chaparral woody leaf area and microhabitat distribution of chaparral woody plants: contrasting patterns in species level and community level analyses. *Oecologia* **130**: 449-457.
- Bengtsson, J.; Nilsson, S.G.; Franc, A. & Menozzi, P. (2000)** Biodiversity, disturbance, ecosystem function and management of European forests. *Forest Ecology and Management* **132**: 39-50.
- Steffan-Dewenter, I.; Münzeberg, U.; Bürger, C.; Thies, C. & Tschardtke, T. (2002)** Scale-dependent effect of landscape context on three pollinator guilds. *Ecology* **83**: 1421-1432.

## Do soil or vegetation processes control spatial pattern during succession following recurrent wildfires in Mediterranean shrublands?

M.C. Cobo<sup>1</sup>, H.H. Wagner<sup>2,3</sup>, J.A. Carreira<sup>1</sup>, M.W. Palmer<sup>4</sup>

<sup>1</sup> Departamento de Biología Animal, Biología Vegetal y Ecología, Universidad de Jaén, Paraje Las Lagunillas s/n, Edificio B-3, 23071-Jaén (Spain).

e-mail: mccobo@ujaen.es

<sup>2</sup> WSL Swiss Federal Research Institute, Zürcherstr. 111, 8903 Birmensdorf (Switzerland)

<sup>3</sup> Department of Biology, University of Toronto at Mississauga, 3359 Mississauga Road, Mississauga, ON L5L 1C6 (Canada)

<sup>4</sup> Botany Department, Oklahoma State University, 104 LSE, Stillwater, OK 74078 (USA).

### Introduction

Wildfire creates spatial heterogeneity, with important ecological effects on soil, vegetation and succession. During succession, an increasing biological control creates additional spatial pattern through soil-vegetation and community interactions.

### Objectives

We focus on how differences in fire regime affect the shape and evolution of soil-vegetation spatial pattern and, more specifically, whether 1) particular soil variables drive vegetation pattern formation and 2) certain plant adaptive morpho-biological types (Raunkiaer's life forms) dominate its further development, 3) evaluating the relative importance of intra- versus inter-specific relations.

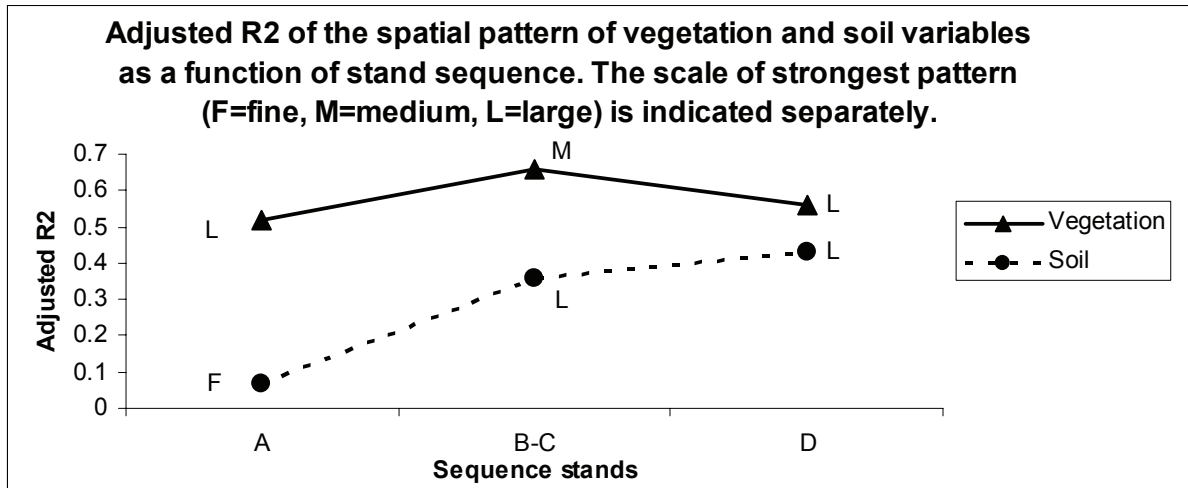
### Methods

In 2000, plant species cover and soil properties were measured along 70 m-long transects located perpendicular to the slope in four, formerly homogeneous, *Pinus pinaster* forest stands. Each stand was burned 0, 1, 2 or 3 times respectively, depending on the extent of three wildfires during 1975-1986 (Carreira *et al.* 1994). We performed variance partitioning (Borcard *et al.* 1992) based on principal coordinates of neighbour matrices (PCNM) (Borcard and Legendre, 2002), complemented by spatial analysis with direct multiscale ordination (MSO) (Wagner, 2004). To account for spatial autocorrelation in species distribution, we performed the classic and spatial version of the variance test (Palmer *et al.* 1995; Wagner, 2003).

### Results and discussion

Variance partitioning with PCNM indicated that soil-driven processes are more important in early succession after a higher frequency of burning, while under lower frequency and older fires, the vegetation dominates in creating spatial structure. Strength and complexity of the patterns followed a similar trend, with a maximum at older stages and larger scales in soil and intermediate stages and scales in vegetation (**Figure 1**). Nitrogen and phosphorus were more associated with vegetation pattern at finer scales under the highest burning frequency, but at larger scales under the lowest frequency. Variance partitioning and MSO suggested these two extremes in burning frequency to be related respectively to an early colonization of the more favorable soil spots in the heterogeneous post-fire substratum, especially for limiting nutrients and moisture ('islands of fertility' hypothesis), and to the late structure of patches of mature vegetation. Spatial pattern in the recently burned extreme responds to shared soil-vegetation processes controlled by soil conditions for plant growth (fine scale: nutrients; large scale: nutrients, moisture) and in the long unburned extreme, to shared soil-vegetation processes controlled by the development of vegetation structure at medium/large

scales. Intermediate successional stages showed fewer shared soil-vegetation patterns. MSO and the variance test showed an overall spatial structure of vegetation dominated by woody species (phanerophyta), first by post-fire seed-regenerated scrubs and later by re-sprouting slow-growing shrubs, whose inter-specific interactions control the development of spatial pattern along this semi-arid fire-related successional sequence.



**Figure 1.** Changes in adjusted R<sup>2</sup> (overall strength) and scale of the strongest spatial pattern (F=fine, M=medium, L=large; indicated separately) in soil and vegetation along a sequence of decreasing number of fires (from stand A to D, 3, 2, 1 and 0 fires) and increasing age since the last fire (from A to D, 14, 19, 25 and >43 years). The overall strength of spatial structure was assessed by the adjusted redundancy statistic  $R^2_{adj}$  of an RDA constrained by all PCNM axes, in order to compare the percent of spatially structured variance along the sequence. The PCNM axes were later divided into three equal groups to compare the relative importance of fine (F), medium (M) and large-scale structures (L). The variation in strength of the pattern along the sequence was especially marked in soil, where it increased from A to reach similar levels and scales than vegetation in B-C-D, suggesting an increasing biological control in pattern formation and the establishment of a soil-vegetation feed-back in late succession (D).

## References

- Borcard, D., Legendre, P., & Drapeau, P. (1992).** Partialling out the spatial component of ecological variation. *Ecology* **73**(3): 1045-1055.
- Borcard, D. & Legendre, P. (2002).** All-scale spatial analysis of ecological data by means of principal coordinates of neighbour matrices. *Ecological Modelling* **153**: 51-68.
- Carreira, J. A., Niell, F.X., & Lajtha, K. (1994).** Soil nitrogen availability and nitrification in Mediterranean shrublands of varying fire history and successional stage. *Biogeochemistry* **26**:189-209.
- Palmer, M.W. & Van der Maarel, E. (1995).** Variance in species richness, species association, and niche limitation. *Oikos* **73**: 203-213.
- Wagner, H. H. (2003).** Spatial covariance in plant communities: integrating ordination, geostatistics, and variance testing. *Ecology* **84**(4): 1045-1057.
- Wagner, H.H. (2004).** Direct multi-scale ordination with canonical correspondence analysis. *Ecology* **85**(2): 342-351.

## Historic and current fire regimes in the Great Xing'an Mountains, northeastern China : Implications for long-term forest management

Y.C. Yuman Hu, R. Bu, Y. Li, H. Chen

Institute of Applied Ecology, Chinese Academy of Sciences, 72 Wenhua Rd. Shenyang  
110016, China.  
e-mail: changyu@iae.ac.cn

### Introduction

Over the last decade, scientists and forest managers have begun to explore emulating natural fire disturbance in managing forest landscape (Cissel et al., 1999; Seymour et al., 2002; Cleland et al., 2004; Nitschke, 2005) because natural fire is a key process in regulating vegetation succession, plant regeneration, and maintaining biodiversity in many forest ecosystems (Gardner et al., 1999; Rollins et al., 2004). Implementation of a management policy of emulating natural fire requires a good understanding of both natural and human influenced fire regimes (Morgan et al., 2001; Li et al., 2005). Natural fire regimes provide baseline information relevant to forest restoration and management, such as timber harvest prescriptions approximating the frequency, intensity, and sizes of past fires (Cissel et al., 1999, Thompson et al. 2006), and current fire regimes may be used to evaluate its departures from historic fire regimes (Hardy et al., 2001). However, few studies have examined long-term changes of the characteristics of fire regime. In this paper, we intend to identify the differences between current and historic fire regimes by examining the long-term changes of fire frequency, fire intensity, fire size, and fire patterns. We will make management recommendations for the Great Xing'an Mountains, Northeastern China in terms of forest harvesting and fuel treatment based on these differences.

### Methods

In this paper, we use a spatially explicit landscape simulation model, LANDIS, to simulate the long-term dynamics of fire characteristics in northeastern China. We simulated two scenarios: historic fire and current fire, and analyzed the changes of fire frequency, fire size, fire severity and spatial pattern of burnt patches.

### Results

Our simulated results show that the fire frequency under the current fire scenario is lower than under the historic fire scenario; the total area burnt is larger with lower fire intensity under the historic fire scenario, and smaller with higher fire intensity under the current fire scenario. We also found most areas were burned by high intensity fires under the current fire scenario, but by low to moderate fires under the historic fire scenario. The burnt patches exhibit a different pattern between the two simulation scenarios. Large patches burnt by high intensity class fires dominate the landscape under the current fire scenario, and under historic fire scenario, the patches burnt by low to moderate fire intensity fires have relatively larger size than those burnt by high intensity fires.

### Conclusions

First, current fire regimes can be characterized as having lower fire frequency, higher fire intensity and higher risks of catastrophic fires compared to historic fire regimes with higher fire frequency, and lower fire intensity. Prescribed burning or coarse woody debris reduction should be incorporated into forest management plans in this region, especially on north-facing slopes. Secondly, current fire patterns in this region are dominated by large,

severely damaged patches. Tree planting may be a better management option on these severely burned areas. Prescribed burning after small area selective cutting, retaining dispersed seed trees, may be a sound forest management alternative in areas except for the severely burned patches.

### References

- Cissel, J.H., Swanson, F.J., Weisberg, P. (1999)** Landscape management using historical fire regimes: Blue river, Oregon. *Ecol. Appl.* 9, 1217-1231.
- Seymour, R.S., White, A.S., deMaynadier, P.G. (2002)** Natural disturbance regimes in northerneastern north America—evaluating silvicultural systems using natural scales and frequencies. *For. Eco. Manage.* 155, 357-367.
- Cleland, D.T., Crow, T.R., Saunders, S.C., Dickman, D.I., Maclean, A.L., Jordan, J.K., Watson, R.L., Sloan, A.M., Brosofske, K.D. (2004)** Characterizing historical and modern fire regimes in Michigan (USA): A landscape ecosystem approach. *Lands. Eco.* 19, 311-325.
- Nitschke, C.R. (2005)** Does forest harvesting emulate fire disturbance? A comparison of effects on selected attributes in coniferous-dominated headwater systems. *For. Eco. Manage.* 214, 305-319.
- Gardner, R.H., Romme, W.H., Turner, M.G. (1999)** Predicting forest fire effects at landscape scale. In 'Spatial modeling of forest landscape change: Approaches and Applications'. (Eds DJ Mladenoff and WL Baker) Cambridge University Press, Cambridge, pp. 163-185.
- Rollins, M.G., Keane, R.E., Parsons R.A. (2004)** Mapping fuels and fire regimes using remote sensing, ecosystem simulation, and gradient modeling. *Ecol. Appl.* 14, 75-95.
- Morgan, P., Hardy, C.C., Swetnam, T.W., Rollins, M.G., Long, D.G. (2001)** Mapping fire regimes across time and space: Understanding coarse and fine-scale fire patterns. *Int. J. Wildland Fire* 10, 329-342.
- Li, C., Barclay, H., Liu, J., Campbell, D. (2005)** Simulation of historical and current fire regimes in central Saskatchewan. *For. Eco. Manage.* 208, 319-329.
- Thompson, J.R., Johnson, K.N., Lennette, M., Spies, T.A., Bettinger, P. (2006)** Historical disturbance regimes as a reference for forest policy in a multiowner province: a simulation experiment. *Can. J. For. Res.* 36, 401-417.
- Hardy, C.C., Schmidt, M., Menakis, J.P., Sampson, R.N. (2001)** Spatial data for national fire planning and fuel management. *Int. J. Wildland Fire* 10, 353-372.

## 6.5 Open Session 22: Landscapes, geology and soils

### Does soil erosion necessarily decrease regional net ecosystem carbon balance? - Lessons from multi-scale analyses of a crop-pasture transition belt in northern China

Q. Gao<sup>1\*</sup>, M. Yu<sup>2</sup>, H.M. Xu, Y.H. Liu, H.K. Jia, X.S. Zhang<sup>1,2</sup>

<sup>1</sup> Laboratory of Integrated Landscape Analysis and Modeling, College of Resources Science and Technology, Beijing Normal University, Beijing 100875, P.R. China.

e-mail: gaoq@bnu.edu.cn

<sup>2</sup> Institute of Botany, Chinese Academy of Sciences, China

We adopted, scaled, and applied a simulation model, TESim (Terrestrial Ecosystem Simulator), to analyze the responses of ecosystem processes and functions in the crop-pasture belt region in northern China (CCPB) to the climatic shift in early 1980s and the impacts of soil erosion on regional net ecosystem carbon balance (NECB). The model at the site scale was scaled to the regional scale by means of simulating three landscapes featuring heavy, moderate, and minimal water erosion, at both the landscape and regional scales, and comparing the simulated net primary productivity (NPP) and water erosion rates at the landscape with those at the regional scales. Simulation with soil erosion gave an average erosion-induced loss of soil organic carbon (ECL) of  $11.0 \pm 2.8 \text{ gC m}^{-2} \text{ a}^{-1}$ , decreased average NPP, RHE and HAV by  $3.3 \pm 0.7$ ,  $14.5 \pm 0.3$ , and  $0.2 \pm 0.0 \text{ gC m}^{-2} \text{ a}^{-1}$  respectively, resulting in a statistically insignificant increase of  $0.4 \pm 3.0 \text{ gC m}^{-2} \text{ a}^{-1}$  in the regional NECB. Long term erosion-induced soil organic carbon loss for the undisturbed ecosystems (grasses, shrubs and forests) was one order of magnitude smaller than the crop ecosystems with irrigation and nitrogen fertilization. The climatic shift with increased temperature and precipitation in early 1980s significantly increased the regional NPP from  $196.0 \pm 20.7$  to  $218.1 \pm 27.3 \text{ gC m}^{-2} \text{ a}^{-1}$  and RHE from  $149.5 \pm 3.0$  to  $161.3 \pm 5.6 \text{ gC m}^{-2} \text{ a}^{-1}$ , but did not significantly alter the regional ECL and NECB. Our analysis showed that the shrubs and grasses in CCPB, because of their adaptation to xeric environments, have higher carbon sink potential than the broadleaf forests in the future drying trend of the regional climate with increasing temperature.

## The structure of East European plain as a geosystem forming factor

I.P. Kotlov, Y.G. Puzachenko

Lomonosov Moscow State University Faculty of Geography, 119899 RF Moscow,  
Leninskiye Gory 1,  
e-mail: ikotlov@gmail.com

Modern geodynamics is an active developing science which uses all the achievements of dynamic systems theory and synergetics. It becomes clear nowadays that geodynamical processes include a wide range of spatial-temporal frequencies commensurable with climatic and biophysical conditions. Latest researches of geodynamic processes in area of various scale faults demonstrate wide range of their biophysical and biochemical activity. Its research – is a task of near future. Modern data accept the concept that the geodynamic state of a specific territory is not constant but an active factor of landscape dynamics and its components, connected with components by positive and negative feedback. The way to develop this research is through relief structure analysis. It reflects the spatial-temporal diversity of interactions between relief and other components. Relief is interpreted as reflection of dynamic processes for certain moment of time. This approach bases on classic Fourier analysis which connects the power of relief-generating process with spatial scale.

Analysis of Fourier spectrum enables the calculations of a fractal dimension of dynamic systems, to prove the existence of quasiharmonic oscillations and to determine quantity of inducing factors (order parameters in terms of synergetic). Then we can explore spatial rules on all hierarchical levels. Every harmonic produces its own set of earth surface forms. Each harmonic has its own energy capacity. That is why within the frames of classic landscape science, we can assess the role of harmonics in spatial hierarchical organization of landscape. Thus, the proposed approach considers relief as the dynamic basis of landscape and explores its conditions not only as the function of denudation and accumulation but also as a function of geodynamic processes acting through geophysical and geochemical variables.

We considered the territory of the East European plain. Initial data is digital elevation model provided by US Geological Survey. The study area is between 40° and 90° north and 20° and 60° east. Its initial projection – latitude/longitude, WGS-84 model. It was transformed to Albers equal area projection with reference longitude 40 degrees east and two transverse parallels – 45 and 65 degrees north. Spatial resolution – 1km<sup>2</sup>.

Spectral analysis was realized for a 2000 x 2000 km square in the center of the image by standard forward Fourier transform. Two projections to X and Y axis were taken into analysis according to Turcotte method (1997). Spectrum power was used in logarithmic scale. As in all similar cases, spectrum power is a function of frequency or wave number. The lower the frequency the higher power logarithm. Parameter of regression line allows to calculate fractal dimension – in our case it is approximately 2.2. This means that the regression line has rather a low slope and the territory is characterized with rather low degree of disjunction and a low diversity of relief forms. Regression residuals prove the hypothesis of quasiharmonic existence. Their frequencies are subordinate to the rule of non-linear oscillator ( $f_i = nf_0$ , where  $n$  is integer). Spectral analysis of residuals reveals that there are no more than three factors determining deviation from fractal process. Statistical reliability of quasiharmonic allows to detach hierarchical levels of relief organization and most probably, the landscape.

Analysis of spatial structure of different hierarchical “waves” helps us to outspread hypothesis of geodynamic forces direction. Each hierarchical level has been restored by inverse Fourier transform. First four of them can be seen on fig. 1. This hierarchy creates basis for researches of all components of landscape and their relations with relief on each hierarchy level. The highest level (820-1024 km) among all structures we can see the following ones with positive sign: 1. Kola peninsula, 2. Timan ridge, 3. Walday – Smolensk-Moscow – Minsk uplands, 4. Podolsk uplands, 5. Ergeny, 6. Bugulminsko-Belebeevskaya

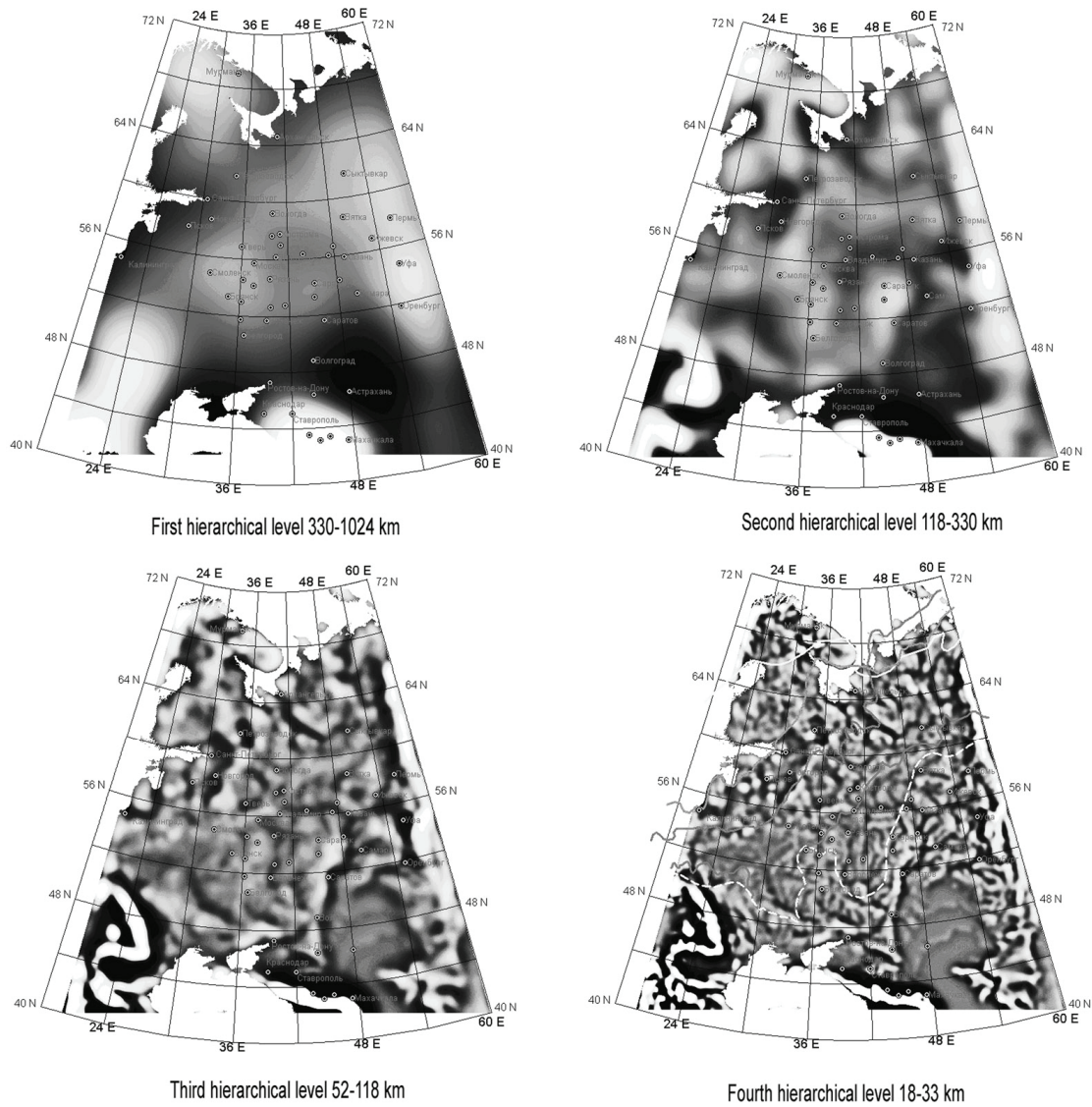


**Theme 6: Cultural Landscapes and Landscape Management**  
**6.5 Open Session 22: Landscapes, geology and soils**

upland. Negative structures on this level – 1. Onega-Baltika zone, 2. Watershed of Volga and Vyatka rivers, 3. Pridnieprovskaya lowland, 4. Pricaspiiskaya lowland.

By the same way we can describe hierarchical levels - 330 to 1024 km, 118 to 330 km, 52 to 118 km, 33 to 52 km and 16 to 33 km. Individual maps show that large-scale structures coincide with uplifting and sinking zones of East European platform. The Middle-scale structures coincide with local zones of tectonic movements, low-scale structures reflect erosion networks, partially influenced with different glaciation zones, which are also seen on maps. The result of the work is detailed information about hierarchical structure of territory, morphological units on each hierarchical level, information about tectonic movements.

The research is made with support of RFBR projects №03-05-64280, №01-05-06012.



**References**

**Turcotte D.L. (1997)** Fractals and chaos in geology and geophysics. Cambridge Univ. Press. 398 p.

## Formation of landscape-geoecological systems in Western Europe

E.P. Romanova

Lomonosov Moscow State University, Faculty of Geography, Leninsky Gory, Moscow,  
119992 Russia,  
e-mail: romanova@kmail.ru

A new landscape-geoecological line of research has been developed in Russian landscape science. Its basic aim is to investigate interrelations and interaction of natural, economic and information subsystems within the boundaries of natural landscapes of various scales. Natural landscapes of Europe have evolved under the interaction of natural components, such as relief, climate, soils, vegetation and runoff. During the last ten thousand years they have experienced the growing and intensive economic development. The response is a complex of natural-anthropogenic processes which have transformed the natural landscape. The effects could be negative if the landscape degrades, or neutral and positive if the landscape preserves its stability and increases its biological productivity. The resulting natural-anthropogenic, or present-day, landscape analyzed in terms of the environmental effects is called Landscape-Geoecological System (LGES). LGES is an integral unit of the spatial analysis of the European region at the scale of 1:5 Mln.

The study included the following stages.

1. A model of natural, natural-anthropogenic and landscape-geoecological systems has been elaborated;
2. A map of the natural landscapes of Europe has been compiled at the scale of 1:5 Mln. It shows 603 landscape units for the European territory outside Russia which are grouped into belts and sectoral associations, zonal types and subtypes of landscapes, classes, subclasses and genera of landscapes. The map shows the extremely complicated structure of the present-day landscapes of Europe, as well as the hierarchy and spatial regularities of natural landscapes distribution;
3. A specialized Geographical Information System (GIS) *Landscapes of Europe* has been elaborated which includes several blocks. The A block, Natural components and landscapes, has 13 parameters which are classification indicators, such as individual number of landscape, its geographical location, geographical belt, subbelt, sector, zone, subzone, class, subclass, genus, type of climate, soil type or subtype, dominant plant associations. The B block describes the systems of economic development (44 groupings). The C block includes the indicators of the Natural-anthropogenic processes subprogram and presents the data on the principal natural and human-induced processes, i.e. water erosion, pollution, soil compaction, acidification, etc. The database of the GIS includes 25,830 indicators;
4. The systems of economic development of landscapes (44 categories) have been identified which transform natural landscape into natural-anthropogenic, or present-day landscape. According to the elaborated systematics and classification of present-day landscapes the map shows *modal landscapes*, which underwent practically no transformation; *derivative landscapes* with transformation of vegetation; and *anthropogenic modification of landscapes* with deep transformation of the natural landscape structure. Particular group of *technogenic* landscapes is for the extreme modification of natural components by urban, industrial and agricultural impacts. The calculations have shown that at present modal landscapes occupy just 15.7 mln ha, or 3.2% of the European territory, derivative landscapes – 25.1 mln.ha (5.2%), anthropogenically modified landscapes – 372 mln. ha (77.8%) and technogenic landscapes – 66 mln.ha (13.8%). These figures prove the predominance of intensively developed landscapes with deep and diverse anthropogenic transformation, particularly within temperate and subtropical geographical belts;
5. The spatial distribution and intensity of natural-anthropogenic processes caused by the economic development have been studied using a number of maps, monographic

**Theme 6: Cultural Landscapes and Landscape Management**  
**6.5 Open Session 22: Landscapes, geology and soils**

and review publications. The information was put into the GIS Landscapes of Europe and represented by a map. It was found out that degradation processes of different type and intensity influence about 401.4 mln.ha, or 83.4% of the total area of Europe. Among the most pronounced processes in landscapes are sheet erosion (263.5 mln. ha or 55%), linear erosion (108 mln. ha or 23%), soil compaction (138 mln. ha or 28.8%), acidification of soils (136.8 mln. ha or 28.5%), dehumification of soils 36 mln.ha (7%), etc. These values vary considerably for particular geographical belts and zones. For example, in the landscapes of temperate belt sheet erosion influences 185.8 mln. ha or 50.1% of the total area while in the subtropical belt 69.5 mln. ha or 74.6%

As a result a map of Landscape-geocological systems of Europe has been compiled showing the groups of landscapes undergoing natural-anthropogenic processes. The preliminary classification of the state of LGES is suggested, from stable functioning to active degradation.

**References:**

**The European Environment. State and outlooks, 2005 (2005)** EEA, Copenhagen.

**Mücher C.A. ed al. (2003)** Identification and Characterisation of Environments and Landscapes in Europe. Alterra-rapport 832. Wageningen,

**Nature and Resources of the World (1998)** *Atlas*. vol. 2, Moscou – Vienna.

**Oldeman L.R.(1992)** Global Extent of Soil Degradation //Bi-Annual report 1991-1992. Wageningen,

**Present-day landscapes of the World (1993)** Map 1: 15 mln. Moscow.

**Романова Э.П. (2004)** Геоэкологическое районирование ландшафтов суши. // География, общество, окружающая среда. Том II, Функционирование и современное состояние ландшафтов, Москва, Изд-во «Городец», с. 352 – 260.

**Romanova E.P. (1998)**.Investigation of the Agronatural potential of the Europe's lands. *IGU Commission "Land use and Land cover change"*. Lisboa, p. 24-25.

**World Map on status of human-induced soil degradation (1990)** Map 1: 15 mln. UNEP/ISRIC, Nairobi.

**World Resources, 2002-2004 (2004)** ([www.wristore.com/wristore](http://www.wristore.com/wristore))

## Geochemical structure and landscape diversity

M.K. Chartko, A.A. Karpichenka, P.V. Zhoomar

Belarusian State University, Nezalezhnasti Av., 4, 220050 Minsk Belarus.

e-mail: chartko@bsu.by

### Introduction

From the point of view of geochemistry landscape diversity is considered as an organizing and structuralizing system for biodiversity realization. The connection with system elements is supported by metabolism.

The chemical element balance in a landscape is one of the most essential factors in securing the functioning maintenance of life support for inhabiting organisms, their populations and associations, because nutrient availability whether in optimal, surplus or deficient levels, has a direct influence on organism physiology. Therefore, information about the geochemical structure of a landscape and its significance for the landscape diversity may serve as a base for the analysis of landscape environment-forming function, both for different ecological assessments and for the solution of different nature conservation problems.

### What is a geochemical structure?

Geochemical structure is a regular lateral and radial distribution of chemical elements within the landscape geochemical system and causes differentiation under the influence of external and internal migratory factors. Geochemical structure consists of radial and lateral structure, which characterize vertical (R-analysis) and horizontal or slope (L-analysis) involving the redistribution of migratory vectors of matter in landscapes.

### Geochemical structures classification

Our work on the geochemical structure classification development is based on the variations of element concentrations and regularities within geochemical catena for the lateral structure and mode of the element accumulation inside different soil layers.

A type of geochemical structure is distinguished by the regularity of both lateral and radial variation of the contents of chemical elements in soils of the catena and characterizes their dispersion and accumulation. A type of geochemical structure for the catena is defined by dominated structures among the elements (element structure, e.g. Ca, Mg etc.). The type identification for radial structures is more complicated. A common type for the whole catena is selected from the set of prevailing radial element structures inside of each elementary geochemical landscape within the catena.

We have selected five type of lateral structures within landscape geochemical profile: *ascended* structure is differed by the increasing of element content within the catena from the top to the bottom; *descended* structure is identified by the reduction of element concentration; *depressive* structure is distinguished by low element concentrations in the middle part of the slope and its growth to the top and to the bottom; *spike* structure, conversely, has high amounts of element concentration in the middle of the slope, which are decreased to the top and to the bottom and *uniform* structure doesn't reveal any significant changes of concentration within the profile.

The leading feature of radial structure identification is a set of regularities of chemical elements distribution by soil layers. There are following types of radial structures: uniform (chemical elements are distributed equally); humic (accumulation has occurred in a humic soil layer); humic-illuvial (accumulation has occurred in humic and illuvial layers); eluvial (elements has concentrated in humic and eluvial layers); eluvioilluvial (both eluvial and illuvial layers concentrate chemical elements) and lessivage structure is differed by the leaching of

elements to the lower layers with gradual concentration growth with the depth, i.e. some bedrocks concentrate elements more than overlying soil layers.

### **Geochemical structures and diversity**

Landscape diversity is determined by geochemical structure type on the one hand and by the domain structure for the whole landscape on the other. In other words the diversity on the level of elementary landscape units is a function of the number of different geochemical structures or their combinations.

In the case of a high number of geochemical structures presented in relatively equal proportion diversity reaches a maximum. If any one structure is intended to dominate and a number of others is extremely small, this type of diversity should be considered as low. Typical diversity is differed by the domination of one or more structures in case of a large amount of others within an elementary landscape.

If landscape diversity is composed of several units with low geochemical structure diversity and each of them is formed by different structures then such type of diversity should be high.

### **Conclusion**

Geochemical structure changes have been reflected in the diversity of soil cover, the vegetation and soil fauna. Geochemical structure is dependent on local conditions migration, accumulation and redistribution of chemical elements. It forms by peculiarities of mineralogical composition of soil and bedrock, associated colloid properties, oxidation, organic matter capacity etc. Each structure reflects all the mentioned factors within a landscape and their changes. These inter-relationships are the information from the basis of landscape diversity.

Geochemical structure of landscapes of Belarus, as other landscapes of taiga zone, is formed by acidic and gley acidic leaching of cationogenic elements including a number of heavy metals (Zn, Pb, Ni, Co, Cd, Hg et al.) from soils of autonomous landscapes, their radial and lateral migration, accumulation on geochemical barriers in humic and illuvial layers of soils and sediment rocks, especially in supra-aquatic geochemically subordinated landscape and bottom sediments of water reservoirs, lakes and rivers.

Low geochemical diversity among lateral structures and typical diversity among radial structures are common to the main part of Belarusian landscapes. High diversity is peculiar to lateral structures of landscapes of alluvial terraces both like to radial structures within marshy landscapes. They may be detected also in morainal lacustrine landscapes.

## 6.6 Posters

### Cultural landscape's temporality vs. durability: village's biographies in Latgale (SE Latvia)

A. Zariņa, I. Liepiņš

University of Latvia, Department of Geography, Alberta 10, LV 1010, Riga, Latvia.  
e-mail: anita.zarina@lu.lv

#### Introduction

Landscapes in biographical perspective are not just a chronological change of land structure. Landscape biographies are about people who have created them and, as Samuels (1979) has pointed "landscapes without authors would be like books without writers".

The paper will seek to answer rather a simple question: what makes one landscape more durable than another in the same cultural region. According to Roberts (2002), there is the fundamental need for continuity in farming life and sustaining soil fertility. Although we will focus on his following statement, that exist linkages, sometimes deliberate and sometimes fortuitous, between the natural environments and human activities and events.

#### Landscape biographies

The paper explores two stories of landscapes at the eastern boundary region of Latvia (Latgale) that for the period of last 150 years has experienced great changes. The region itself is a melting pot of Latvian, Slavonic and Roman Catholic cultures.

#### Case studies

In spring 2006 the historical field marks were mapped in the nearly deserted village Luņi (Eastern Latgale). The village is a garner of the forgotten cultural values. The biography of the village shows that the link of people and place is discontinuous, which consequently makes it to be a change-sensitive landscape, while the cultural landscape of Šultes village (Western Latgale) is more stable. The latter has had very slight land use changes during the last century. It has adapted to political and economic shifts and, conversely to Luņi, has rather benefited from them still maintaining some old lifestyles. The strong linkage among generations that have formed the landscape exists here.

#### Discussion

We can trace roughly all the socio-political history of Latgale through these village's biographies. As well, this study is an example of environmental determinism in practise. While the details show that temporality or durability of cultural landscape is a path dependant in the context of people's belonging to the place and their experience on which their further desires are based.

#### References

- Roberts, B.K. (2002)** Space, place and time: reading the landscape. *Journal of the Scottish Association of Geography Teachers* 31: 39-51.
- Samuels, M.S. (1979)** The biography of landscape. D.W. Meinig (Ed). *The Interpretation of Ordinary Landscapes*. Oxford University Press, New York, pp. 51-88.

**Relationship between socio-economic and natural dynamics in a Protected Natural Area (Parque Regional de la Cuenca Alta del Manzanares, Madrid, Spain)**

**P. Fernández-Sañudo, N. López Estébanez; M.J. Roldán Martín, P. De las Heras**

CIAM (Environmental Research Centre of Madrid) 28791 Soto del Real, Madrid (Spain)  
e-mail: palomafs@bio.ucm.es

**Introduction**

The interrelations between the natural environment and socio-economic development are quite evident in Mediterranean landscapes. However, few studies establish this relationship, and even fewer have dealt with protected natural areas (PNA). We present a study which analyses the relationships between socio-economic and land use parameters in a Regional Park over a 21 years period.

**Methodology**

With the use of aerial photography from 1980 and orthophotography from 2001, we designed vegetation and land use maps for each of these years. Superimposing these maps we obtained a new one representing 6 main types of land uses dynamics and the area affected by each type of change. Furthermore, the analysis of a data matrix, in which we quantified the increase in 63 socio-economic variables in the PNA municipalities over the same time period, by means of multivariate techniques, resulted in a characterisation of 4 main socio-economic dynamics. Finally we analysed a contingency table in which the area affected by the dynamics of each type of change in use is quantified (6 types) in each group of municipalities representing the 4 socio-economic dynamics, by means of a  $\chi^2$  association test. Results show the main statistically significant associations indicating existing relationships between both natural and socio-economic changes.

**Results and discussion**

The 6 types of dynamics of land use changes established are significantly associated with some specific types of socio economic dynamics affecting some groups of municipalities. "No Change" in land cover is the most frequent dynamic in most types of municipalities, whatever their socio-economic evolution may be. "Forest Advance" is associated with those municipalities which have undergone a big increase in density population, a noteworthy change towards tertiary sector activity, and a progressive abandonment of traditional activities (types 1 and 3), and also an increase in incomes and consumption of resources (type 3). In both, the part of their total area included within the PNA presents dynamics of an advance of natural vegetation, regardless of socio economic development. Furthermore, type 3 is also associated with "Generation of New Pastures", and still maintains its original livestock farming activity. The dynamics of "New Croplands" is also associated with municipalities which, in spite of their population increase and an expansion of the tertiary sector, (types 1 and 2), still maintain high natural values associated with their traditional uses. It must be highlighted, however, that types 2 and 3 are not totally exempt from the influence of development in recent years, presenting "Housing Development", the consequence of population growth, the progressive abandonment of agricultural and livestock farming lands, and an increase in developable urban land or the densification of their urban area. Lastly, the municipalities that currently conserve a less complex socio-economic structure and a more rural character (type 4), show the "Tendency towards Shrubland", "Forest Advance" and "No Change" dynamics.

## Relict agricultural ecosystems of the East European Plain

O.N. Trapeznikova

Institute of Environmental Geoscience, Ulanskii per., 13, P.O. Box 145, Moscow, Russia.  
e-mail: dist@geoenv.ru

The aim of the work is to reveal relict features of the up-to-date agricultural landscapes of the East European Plain (within the near Urals taiga zone), to study their spatial pattern, and find main factors of their development and ecological stability. GIS techniques were used to put the maps of different scales and projections into conformity and link statistic data concerning administrative units (which changed from period to period) with agricultural landscapes. Up-to-date agricultural landscapes were studied in details using both statistic data, maps, field observations, and space images.

Slash-and-burn agriculture in the south taiga zone of the Eastern European Plain started since the end of the middle Holocene. Then, in the second half of the first millennium A.D. ancient settled Ugro-Finnic people developed valleys of the upper Kama and its tributaries located further to the north within the middle and south taiga. Their resettlement was a forced reaction on martial nomad cattle-breeders invasion during the Great Migration of People. The new developed area was characterized with rather severe climate and predominantly hard for tillage loam soil. People practiced arable farming with three-field rotation. The new developed areas were completely isolated by taiga forests from the outer world except for the only way by river, where ground wooden castles were built.

Since the end of the first millennium at the west and central parts of forested Europe the agricultural landscape pattern changed many times due to economical, demographical, ecological, and other factors. The comparison of available historical maps of the 18th, 19th centuries, and the first part of the 20th century with up-to-date space images shows that agricultural spatial patterns of different epochs differ very greatly from each other.

But the east of the East European plain (the Kama river basin) is characterized with very constant agricultural landscape pattern. Both the 18th century maps "General'noe mejevanie" and up-to-date space images show us a number of large agricultural ecosystems (hundreds of kilometers long and 200-300 kilometers wide) along river valleys, which developed continuously since the end of the first millennium. These large and complex agricultural ecosystems are called "porechie" that means in Russian a "near-river-area". Up to now it remains the northernmost large agricultural landscapes at the east of the East European Plain. All agricultural ecosystems have similar inner pattern. It is an agricultural landscape pattern, which was formed historically as arable lands surrounding numerous small villages within and near river valleys.

We can name the following nature and social factors for spatial agricultural pattern stability within the taiga zone of East European Plain.

1. Complicated and contrast nature conditions rigidly limiting possibilities of agricultural land use and preventing disturbances of the ecological balance within the area,
2. Initially isolated condition of European northeast agricultural landscapes,
3. Centuries-old extensive agricultural development,
4. Ecological optimum of the spatial agricultural spatial pattern for the taiga zone.

Due to long isolation their agricultural spatial pattern was never essentially disturbed or changed up to the 20th century. Thanks to very strict climatic limitations for field-husbandry these people practiced subsistence farming based on ecological harmony between agricultural, meadow, and forest ecosystems. Ecological balance was kept up for centuries due to free growth of the agricultural ecosystems (porechie) up the river valleys.



## **Drought and Desertification Management in Nigeria; An overview**

**A.I. Ayeni**

Federal Ministry of Environment, Abuja, Nigeria.  
e-mail: aiayeni@yahoo.com

Drought and Desertification are twin environmental hazards that, since the catastrophic Sahelian drought of 1968 – 1973, have forced the international community to look closely at development programmes in the arid and semi – arid areas of the world. Throughout sub-Saharan Africa, Nigeria inclusive, land is a fundamental asset for economic development, food security and poverty reduction. In many parts of the country, particularly for fragile dry land ecosystem, land is becoming increasingly scarce, due to a variety of pressures, including demographic growth. These pressures have resulted in increased competition for land between different groups, such as multiple land uses (farmers, herders etc).

In a country like Nigeria, where majority of the people are dependent on Ecology and natural resources for survival, efforts to combat drought and desertification and conserve the resources must be of high priority to government. This paper reviews the extent, severity and consequences of drought and desertification in Nigeria with particular emphasis on the Northern part of the country. The haphazard manner in which these environmental hazards have been tackled is examined and a systematic approach for the formulation of the national strategy. The paper concluded that the precondition for combating drought and desertification rest on political will and financial commitment, holistic approach and a paradigm shift in planning and management of programmes aimed at controlling desertification for sustainable development.

**Potential of restored landfill sites for biodiversity conservation in the UK and its context to landscape.**

**M.L. Rahman, D. McCollin, J. Ollerton**

The University of Northampton, Landscape and Biodiversity Research Group, School of Applied Sciences, Park Campus, Northampton NN2 7AL, UK.  
e-mail: lutfor.rahman@northampton.ac.uk

Restoration of landfill sites to an acceptable after-use is a fundamental aspect of their post-closure management and also increases opportunities for biodiversity conservation in the UK. Measuring biodiversity is important to an understanding of the ecology of a landscape and for developing rational management strategies aimed at conservation and restoration of biodiversity of that landscape. The goal of the present study is to assess the biodiversity of a variety of taxa on restored landfill sites in the East Midlands region. The taxa to be investigated include plants (bryophytes and vascular plants), vertebrates (small mammals and birds) and invertebrates (molluscs and ground beetles). Standard sampling methods will be chosen for different taxa considering a range of ecofunctional characteristics including geographical distribution, dispersal ability and differing responses to environmental factors. Cross-taxon congruence in biodiversity ( $\alpha$ -diversity and  $\beta$ -diversity) across different taxonomic groups will be investigated to assess the extent to which these groups of organisms can function as surrogates for each other in biodiversity measures. The mechanisms by which landfill sites are interconnected to otherwise isolated natural areas will also be studied since composition of species of a particular landscape depends not only on patch characteristics but more importantly on its context in the land mosaic.

**A framework of land use change and suitability assessment: towards effective land allocation decisions in northern Akwa Ibom State, Nigeria**

**U.J. Ituen**

Department of Geography and Regional Planning, University of Uyo, P.M. B. 1017, Uyo,  
Akwa Ibom State, Nigeria.  
email: uwem\_ituen@yahoo.com

This study represents an attempt to gain understanding of the land use change dynamics as well as the land suitability index of the rural environment of northern Akwa Ibom State, Nigeria. It also sought to use such understanding in land allocation decisions and by so doing, proffer solutions to the age-long rural development problems of the area. To achieve this, a combination of land use change detection and multi criteria evaluation (MCE) techniques were utilized. Consequently, Landsat TM and ETM+ satellite images from 1986 and 2003 respectively were classified and subjected to point-by-point change detection procedure in image analysis environment. On the MCE aspect, seven land and soil characteristics were derived from digital elevation model and existing soil survey data and eventually used in assessing land suitability for wetland rice. The results of change detection analysis revealed that 47% of land has been converted to alternative uses resulting in extensive expansion of existing agricultural lands. Regarding the MCE modeling, about 16% of the land area was rated highly suitable for wetland rice. The different limitations associated with each area were also highlighted in the research. Such information, coupled with the point-by-point land use change results formed the basis for informed land allocation decisions. The study recommends the use of scientific understanding alongside indigenous knowledge for the sustainable use and strategic geographical targeting of land resources.

**Location of ecological borders for a zone of the river landscape between Bassano del Grappa and Tezze sul Brenta. Italy**

**G. Caravello, B. Pivotto**

Università degli Studi di Padova, Dipartimento di Medicina Ambientale e Sanità Pubblica -  
Sede di Igiene, Via Loredan 18 - 35131 Padova;  
e-mail: gianumberto.caravello@unipd.it

The zone of the *Brenta* river, between the two towns of *Bassano del Grappa* and *Tezze sul Brenta* (Vicenza district - Veneto - Italia), is included in the SIC (*Sito di Importanza Comunitaria*) site "IT3260018 - Grave e Zone umide della Brenta". This site has been proposed as biodiversity conservation area inside of the ecological network *Natura 2000*. Often the borders of these areas are traced out on account of economic and urban demands, disregarding the ecological processes.

Historically the *Brenta* river has been a very important trade and transport route, a natural resources supply, a recreational and aesthetical landscape.

Human disturbances, such as the urbanization and the agriculture, have caused the fragmentation of the river landscape and have established a natural gradient varying from the river to the neighbouring rural lands.

In the fragmented landscapes the development of a biodiversity conservation planning should pay attention to the composition and to the spatial structure of the territory because these factors can critically affect life, richness and functions of the local flora and fauna, or the system of ecosystems that forms the river landscape.

By using mathematical-statistic indices proposed by Landscape Ecology an analysis of landscape mosaic of the mentioned river area has been accomplished. By the application of the SED (*Indice di Discontinuità e Contrasto*) index, DDB (*Indice di Biopotenzialità territoriale Trasformata*) index, and the GBA (gliding box algorithm) along transects guidelines taken at regular intervals on the area, gaps between patch types within the landscape has been located.

This analytic approach has permitted to find variation points useful to define new plausible ecological borders.

**Consistency in livestock grazing intensity classification by local experts and a livestock grazing suitability index**

**J. Bemigisha<sup>1</sup>, E.J.M Carranza<sup>1</sup>, V. Retsios<sup>1</sup>, M. McCall<sup>1</sup>, A.K. Skidmore<sup>1</sup>**

<sup>1</sup>International Institute for Geo-Information Science and Earth Observation (ITC),  
Hengelosestraat 99, P.O. Box 6, 7500 AA Enschede, The Netherlands.  
e-mail: bemigisha@itc.nl;

We investigated the extent to which local expert knowledge on livestock grazing distribution relates to grazing suitability index. The aim was to establish how Participatory GIS (PGIS) and spatial data analysis and integration methods such as evidential belief functions (EBFs) and spatial multi-criteria evaluation (SMCE) may reveal the understanding and capacity of local participants to integrate interacting environmental factors. Using a case of mapping livestock grazing distribution in Majella National Park, Italy, we statistically compared a grazing intensity map derived from local rangeland expert knowledge with a grazing suitability index map. The index was developed from a combination of landscape factors that influence livestock grazing distribution in the Majella Park. The grazing intensity map was derived from five different maps produced in a PGIS by local experts working with the Majella Park and integrated using EBFs according to Dempster's rule of combination. Both the grazing intensity map and the grazing suitability index map were based on landscape factors or spatial criteria that were independently considered in the PGIS and the SMCE. The calculated Pearson correlation coefficient between the grazing suitability index and EBF-based grazing intensity map was found to be 0.35 ( $p < 0.01$ ). This implies consistency between grazing intensity classification by local experts, and landscape factors that influence grazing distribution in the study area. The spatial data integration and analysis tools such as EBFs and SMCE, therefore, help to verify the reliability of PGIS products through integration, testing and ensuring consistency of local knowledge in classification and planning. Further investigation is however needed to see if both of these tools may be together directly embedded within PGIS.

## The analysis and evaluation of forest-tundra landscapes of Western Siberia (on example Urengoy gas field area)

D.M. Marinskikh

Tyumen State University, Faculty of Ecology and Geography, Semakova str. 10, Tyumen, 625003, Russia.  
e-mail: marinskikh@utmn.ru

### Introduction

The purpose of study is the research of spatial - temporary landscape patterns and landscape assessment of Urengoy gas field territory. The methods of polysystem landscape analysis and synthesis are used.

### Landscape analysis and evaluation

The major procedure of landscape analysis is landscape classification and mapping. The classification of typological landscape complexes represents their typology on the basis of the most important and common for this level of dimension features of morphological structure. In terrain of field (area about 3000 km<sup>2</sup>) choric spatial units in meso-scale (1:100 000) are mapped: 178 microgeochores and 25 mesogeochores. These spatial units are characterized on the basis of collection of the leading and second signs (geology, relief, physic-geologic and cryogenic processes, properties of a permafrost formations, soil, vegetation etc.) with the help of ArcGIS (Marinskikh, 2003).

The geochores serve as spatial-operational units for extrapolation of landscapes evaluations (functions, value and stability) received on topical level. For the area under study three groups of landscape functions are reviewed: productive economic (eg. tree-resources, bacca-mushroom and hunting); ecological regulation (habitat, climate protection, water protection, water storage, run-off regulation, permafrost-stabilization and erosion-prevention) and social environmental (eg. recreation) (Kozin, 1996).

### Landscape planning and management

The landscapes assessed contain integrated information suitable for landscape planning and management (Bastian et al, 2006). The land use policy map developed includes: elements of ecological network - especially guarded natural landscapes; the most valuable landscapes for traditional management of the native population; valuable historical, cultural and ethnographical landscapes; recreation landscapes; and landscapes with unstable impacts and pollutants (Marinskikh, 2002).

### References

- Marinskikh D.M. (2003)** Landscape ecological analysis of Urengoy oil-gas condensate field. Ph.D. Thesis., Altay State University, Russia, 218 pp. (in Russian).
- Kozin V.V. (1996)** Problem of assessment of ecosystems value and persistence. Kozin V.V & Osipov V.A. (Eds). Environmental management in north-west of Siberia: experience of problem-solving. Tyumen State University Press, Tyumen, pp. 36-48. (in Russian).
- Bastian O., Krönert R., Lipsky Z. (2006)** Landscape diagnosis of different space and time scales – a challenge for landscape planning. *Landscape Ecology* 21: 359-374.
- Marinskikh D.M. (2002)** Landschaftsökologische Analyse, Bewertung und Entwicklung von Planungskategorien für die Landschaften des Urengoy - Erdgasvorkommens (West Sibirien, Russland). In: *Bewertung und Entwicklung der Landschaft*, Dresden, pp. 59-61.

## The factors that affected forest landscape change of the World Heritage Shimogamo Shrine, Kyoto, Japan after the Middle Ages

A. Imanishi, S. Yoshida, J. Imanishi, Y. Morimoto

Kyoto University, Yoshida- Honmachi, Sakyo-ku, Kyoto 606-8501, Japan.  
e-mail: makinoa@kais.kyoto-u.ac.jp

### Introduction and Methods

In Japan, shrine forests are important components of historical, cultural and natural landscapes. The Public tends to believe that they are the remnant of natural vegetation of the region because they have been strictly protected and undisturbed by humans for a long time. Therefore, shrine forests are often set as a goal of natural conservation or rehabilitation while some of researchers have different opinions. Recent studies demonstrate that the forest, once dominated by pine trees, changed to broad-leaved forests from about 100 years ago at large parts of shrine forests from Kanto to Chugoku region (Narumi & Kobayashi 2006). It is assumed that decline of utilization of forest products such as fallen leaves and underbrush is the factor that caused the change. We traced the forest landscape changes after the Middle Ages, in Tadasu Forest, the precinct forest of Shimogamo Shrine that is inscribed on the UNESCO World Cultural Heritage list, and investigated literature to search for the possible factors that caused the changes in the forest landscape.

### Results and Discussions

The present area of Tadasu Forest is about 9.0 ha and is located at the confluence of Kamo and Takano Rivers in Kyoto. Investigating several old pictures, photos and topographic maps, it was estimated that the dominant trees in Tadasu Forest were mainly pines from ca. 1,000 years to 100 years ago. Over the past century, the dominant trees have changed into broad-leaves, mainly ulmaceous species. In 1934, the forest was damaged by a typhoon and after that, *Cinnamomum camphora* was planted. Currently, the forest is dominated by *C. camphora* and ulmaceous trees.

The old diary of a shrine family of about 300 years ago recorded that shrine parishioners utilized the forest; bamboos and dead pines were cut and used, some were sold and underbrush was periodically cut in the autumn. However, several laws that prohibited cutting trees in shrines were enacted ca. 150 years ago when the Meiji Restoration occurred. The present forest was protected and provided off-limits areas.

It was considered that the succession proceeded from pine forest to broad-leaved forest in Tadasu Forest because artificial disturbance was reduced over the past century. In addition, the decrease of natural disturbance might be one of the factors that promoted the vegetation succession in Tadasu Forest because Kyoto has not been damaged by floods since the completion of Kamo river improvement work. In contrast it was recorded that the city was damaged by floods from 5 to 34 times per 100 years until 1938 (Nakajima 1983).

### References

- Narumi, K. & Kobayashi, S. (2006) Landscape changes in the woods around Shinto Shrines since the Early Modern Era. *The historical geography* 48: 1-17. (in Japanese with English abstract)  
Nakajima, C. (1983) Historical review of the floods of the Kamo river in Kyoto (1). *Disaster Prevention Research Institute annuals* 26: 75-92. (in Japanese with English abstract)

**Mountain landscape degradation caused by landslide scars and forest hydrology rehabilitation: Tijuca National Park, SE-Brazil.**

**A.B. Negreiros, A.L. Coelho Netto**

GEOHECO/Geo-Hydroecology Lab., Geography Department, Institute of Geosciences,  
Federal University of Rio de Janeiro, 21941-590, Brazil.  
e-mail: andrebnegreiros@hotmail.com

This study aims to evaluate forest restoration within and around an 18-years old landslide scar (17.888m<sup>2</sup>) and its hydrological responses. The vegetation structure (height-H; diameter at breast height-DBH; basal area and dead trees) was gathered from two transversal sections in the upper portion of the scar; results are summarized in Table 1.

**Table 1** – Structural parameters in the surrounding forested slopes (LSF) and within the studied landslide scar (RB-Right border; IR-Initial revegetation and LF-Left border).

Parameters	Right side			Left side	
	(LSF) Late Secondary Forest	(RB) Border (18 years)	(IR)Initial Revegetation (2 years)	(LB) Border (18 years)	(LSF) Late Secondary Forest
sampling area (m <sup>2</sup> )	500	160	430	250	500
number of trees	198	95	183	82	202
average Height (m)	6,82	4,78	3,94	5,68	5,95
average DBH (cm)	6,44	4,78	3,57	6,14	4,05
Basal area (m <sup>2</sup> /ha)	32,25	14,85	8,80	21,14	28,38
Dead trees (%)	7,73	4,21	4,92	4,88	10,95

Average tree height at right-LSF is gently lower than at left-LSF but at both sites individuals may exceed 20m. Lower values of H and DBH at RB reveal the probable influence of the next bare area which is now under IR; in both sites tree height does not exceed 10m height. On the left border height values may reach up to 10 to 20 m height (12,2% of cases); this also explain the higher DBH (6,14 cm) relative to the adjacent left-LSF (4%) where the frequency of trees above 10m height decreases to 10% in comparison to the right-LSF (15%); also the smallest DBH values(< 5 cm) are more frequent (83%) at left-LSF while at right-LSF this class decreases to 62% in favor to the DBH classes between 5-10 cm (21%) and 10-30 cm (16%). It call attention the relative larger number of dead trees at left-LSF (11%) in comparison to the right-LSF (7,7%). The topsoil of LSF is sandy with a high percentage of aggregates >2 mm; in LB, RB and IR occurs a sandy loam soil of low aggregation. The porosity data are higher at LB and at IR in relation to previous. Hydrological data at the different vegetation domains shows average discharge (Q)/precipitation (P) ratio values (Q/P x 100) as given: 1,67% for LSF; 3,33% for LB; 7,08% for RB and 3,46% for IR. These values are relatively high when compared to results in well-conserved forest areas (<1%). At RB the proximity to a bedrock outcrop increases local overlandflow production. The average erosion rate within the scar is around 98g/m<sup>2</sup>/L for the rainy period 2005-2006. This gives a total amount of 1,05 ton of sediment yield delivered by this landslide scar into the next stream channel. Main results point out that after 18 years there is a possible delayed response of forest degradation particularly in the left LSF as indicated by several dead trees in addition to numerous fallen trees and uprooted fallen trees.



**The significance of soil seed bank for vegetation restoration in abandoned croplands on the hilly-gullied Loess Plateau**

**J. Juying<sup>2</sup>, B. Wenjuan, J. Mitchley**

<sup>1</sup> Institute of Soil and Water Conservation, Northwest A & F University, Yangling 712100, Shaanxi, China;

e-mail: [jjjiao@ms.iswc.ac.cn](mailto:jjjiao@ms.iswc.ac.cn)

<sup>2</sup> Institute of Soil and Water Conservation, Chinese Academy of Sciences and Ministry of Water Resources, Yangling 712100, Shaanxi, China

<sup>3</sup> Imperial College London, Department of Agricultural Sciences, Wye campus, Wye, Ashford, Kent, TN25 5AH, United Kingdom

The aim of this study was to identify the characteristics of soil seed bank, the relationship with standing vegetation, and the potential significance of soil seed bank for vegetation restoration in abandoned croplands on the hilly-gullied Loess Plateau, China. The results of field survey, direct germination and correspondence analysis showed that the soil seed banks density ranged from 900 to 6 467 seeds m<sup>-2</sup> at 0-5 cm depth, 117 to 2 467 seeds m<sup>-2</sup> at 5-10 cm depth, with species richness of 7-14. The early successional species *Artemisia scoparia* dominated in the soil seed bank, but the dominant species of the later successional vegetation stages occurred at very low density in the soil seed bank. The compositional similarity between soil seed bank and standing vegetation was low, with the Sorensen similarity coefficient between the seed bank and the standing vegetation ranging from 0.143 to 0.414. The most important variables discriminating community variation were: soil water content, extractable P, soil seed bank density, and aspect. Soil seed bank alone explained 32.1% of the standing vegetation community variation. These results show that the potential of vegetation restoration from the soil seed bank is limited and that restoration is a slow process. It is recommended to transplant some later successional species such as *Bothriochloa ischaemum*, *Artemisia gmelinii*, *Lespedeza davurica*, *Stipa bungeana* into abandoned croplands to accelerate vegetation succession on the hilly-gullied Loess Plateau.

**Acknowledgments** : We thank the NSFC projects (40571094; 40271074) and the project of Northwest of A & F University 01140301 for funding this research, the assistance of Ansai Ecological Experimental Station of Soil and Water Conservation, CAS.

## What relations between a typical product and its landscapes ? A typology of landscapes on the saint nectaire cheese labels

L. Ménadier

UMR METAFORT (Cemagref, Engref, Enita, Inra), ENITA, F63370 Lempdes, France.  
e-mail : lydie.menadier@laposte.net

### Introduction

In France in the middle of the Massif Central, the saint nectaire cheese area is studied to understand the relations between a typical product and its landscapes. Today, consumers are interested in quality and Nature. Thus, typical farm productions have to prove their specificities (well-defined area, traditional know-how.) and their price. The message is often based on the idea that quality of landscapes reflects the quality of the product (Ricard, 1994). Linked with the system of landscapes (Wieber, 1995) and semiology, this study explains a method to analyse which types of landscapes are associated with the cheese on the labels.

### Method

Around 250 labels of a private collection, all that represent landscapes, have been analysed. First we decided to realise a simple analysis of each label, concerning landscape elements and graphism. Then a multifactor analysis was realised to take into account the diversity of the images thanks to typologies, and to extract values linked to the production of saint nectaire (Menadier 2006).

### Results

The first axis of the classification opposes values attached to Nature or to heritage. The second one is organised between tradition, folklore, symbolism on the one hand and characteristics of the area of production, dynamism and reality on the other hand. Moreover, several types of landscapes related to this cheese have appeared:

- The Cézallier plateau with realistic and modern pictures with villages, pastures, herds.
- Virgin nature or inhabited landscapes tinged with tradition and folklore. The most represented place is the "Chaîne des Puys", a landscape of the area of production.
- More or less realistic mountainous landscapes that look like Dore and Sancy mountains or Cantal one with a diversity of landscape elements.
- Landscapes with Saint-Nectaire village. This connection is wrong because this place has never been in the heart of the area of production.

### Conclusion

This work gives us elements to analyse links and gaps between the materiality of the landscapes of the saint nectaire area and labels. But it was the beginning of an exploratory tool, "the game of labels" was added to this study to access representations of producers and local consumers associated with the production of saint nectaire. Typologies have also been compared with a G.I.S method analysing the "materiality" of landscapes of the area. It will be the object of a thesis which will be centered on the analysis of landscapes and practices of farmers. The aim is to give some tools to producers to help them to evaluate their territorial dynamics. Participatory approaches, will help to conceive advertising messages well related with the area of production on the one hand and with the product itself on the other hand.

### References

- Garanx C. (2005)** Relations pratiques agricoles – caractéristiques du paysage: approche parcellaire et exploitation dans la zone AOC St Nectaire, D.E.S.S « Connaissance et gestions des Terroirs », 75p.

**Theme 6: Cultural Landscapes and Landscape Management**  
**6.6 Posters**

**Menadier L. (2006)** Représentations paysagères et production agricole de qualité : l'image comme outil d'analyse du lien produit-paysage (l'exemple de l'AOC saint-nectaire), Master 1, UBP Clermont Ferrand, 129 p.

**Ricard D. (1994)** Les montagnes fromagères en France, Terroirs, agriculture de qualité et appellations d'origine, Ceramac, Clermont-Ferrand.

**Wieber J.C. Roger A. (dir.) (1995)** Le paysage visible, un concept nécessaire, dans La théorie du paysage en France, 1974 – 1994, Seyssel, Champ Vallon. P 182 – 193.

**Examination of the hydrology-soil-plant relations, in correspondence with climate change and effects of nature conservation measures on the vegetation on the Galgahévíz peaty meadow Hungary**

**M. Vona, Cs. Centeri, A. Barczy, E. Falusi, K. Penksza**

Szent István University, Institute of Environment and Landscape Management, Dept. of Landscape Ecology, 2100-Gödöllő, Páter K. u. 1., Hungary;  
e-mail: Vona.Marton@mkk.szie.hu

The peaty meadow of Galgahévíz is a top priority protected natural land in Hungary. The area is home for more than 30 protected plant species. According to the field experiences in 2002 and 2003 there were negative changes in the vegetation, the number of plants with high water needs decreased significantly. Based on the investigation of the relative ecological figures, the water-need of the present plant association is lower than it was for those plants that lived there few years ago. The present investigations have proved that available water on the meadow has decreased in the last 3-4 years. During my investigations I tried to reveal the reasons of decreasing water sources on the peaty meadow of Galgahévíz. I evaluated the transpiration and precipitation values concerning the 1995, 2002, 2003, 2004, 2005 hydrological years. Transpiration has greatly exceeded the amount of precipitation; there were 160-650 mm/year water deficiency in the examined years. According to my calculations, this water deficiency can be recovered by the precipitation that falls on the watershed of the Sosi Creek, that plays a crucial role in the water supply of the peaty meadow. In 2004 and 2005 positive changes occurred in the structure of the peaty meadow because of the increased water supply thanks to the nature conservancy cutting the grass. However there are signs of climatic changes. Starting in 1952, runoff decreased by 20%, temperature increased by 0.5 °C and precipitation decreased by 5% in the Zagyva watershed. According to the most possible climatic scenario, the Mediterranean character of the climate will increase with a decrease in yearly precipitation and an increase in temperature. The distribution of precipitation will realign in favour of winter. This possible scenario will have an important affect on the hydrological relations of the peaty meadow. The amount of summer transpiration will increase. It will increase the water deficit. The water supply of the Sosi watershed is only capable of bringing the necessary extra water at a lower level. It is important to introduce technical measures for providing the necessary extra water for the long term protection of the peaty meadow and its natural values.

## Long-term wind erosion on sandy soils in northern Germany and its impact on soil heterogeneity and productivity

M. Bach<sup>1</sup>, R. Duttmann<sup>1</sup>

<sup>1</sup> Institute of Geography – Department of Landscape Ecology and Geoinformation Sciences, University of Kiel, Ludewig-Meyn-Str. 14, 24098 Kiel, Germany  
e-mail: bach@geographie.uni-kiel.de

### Introduction

Wind erosion on agricultural soils is a serious problem in sandur plain landscapes in Northwest Germany. Although statewide wind shelter programs have reduced the extent of wind erosion induced damage, wind erosion is still an ongoing process, implying a gradual loss of soil productivity. To date only little is known about the quantity of long-term soil loss due to wind erosion and its impact on the in-field variability of soil property distribution and soil fertility in humid regions.

### Methods

The study area *Goldelund*, part of the Weichselian outwash plain, is situated in Northern Frisia (Schleswig-Holstein) and covers an area of about 18 km<sup>2</sup>. The reasons why this area was chosen to study the role of long-term wind erosion processes on soil heterogeneity are: (1) ideal preconditions for the frequent occurrence of wind erosion, (2) the long and well documented history of sand drift, (3) the study area is one of the official long-term wind erosion monitoring sites in Schleswig-Holstein and (4) a number of studies on drift sands have been carried out here (Iwersen, 1953; Schultz, 1978; Hassenpflug, 1998).

In 3 years 45 samples each were taken from two soil depths (0-15 cm/ 15-30 cm below surface) on a 3 ha site to analyse the following physical and chemical soil properties: soil texture, C<sub>org</sub> and N<sub>total</sub> and P content. The interpolation of the sample data is based on ordinary kriging performed with the statistical software R / GSTAT.

### Results and discussion

The stripwise arrangement of soil property distribution reveals a close relationship with the wind direction prevailing during erosive windstorm events. This is true for the soil texture characteristics such as sand and silt but also for the top soil contents of C<sub>org</sub>, N<sub>total</sub> and P. A comparison of the clay and silt contents of the topsoil shows that the lowest contents of silt and clay can be found in the southwestern parts of the plot. In consideration of the main wind direction causing sand drift, this confirms the assumption of the coarsening effects of wind erosion on soil texture and the evacuation of organic matter and nutrients. The increasing fetch tends to result in increasing mass transports and net soil losses and in decreasing topsoil contents of C<sub>org</sub>, N<sub>total</sub>, silt and clay

### References

- Hassenpflug, W. (1998)** Bodenerosion durch Wind. Richter, G. (Ed.). *Bodenerosion – Analyse und Bilanz eines Umweltproblems*, Wissenschaftliche Buchgesellschaft, Darmstadt, pp. 69-82.
- Iwersen, J. (1953)** Windschutz in Schleswig-Holstein. Aufgezeigt am Beispiel der Schleswigschen Geest. Gottorfer Schriften, Vol. 2, Gottorf. *Australian Journal of Soil and Water Conservation* 7, 30-35.
- Schlutz, A. (1978)** Windschutz auf der nordfriesischen Geest. *Jahrbuch fuer die Schleswigsche Geest* 26, 29-38.

## Structure of a southern taiga landscape in the border zone of the Wurm glaciation

D.N. Kozlov<sup>1</sup>, M.Y. Puzachenko<sup>2</sup>, M.V. Fedyaeva<sup>1</sup>

<sup>1</sup> Lomonosov Moscow State University Faculty of Geography, 119899, Moscow, Leninskiye Gory 1, Russia, e-mail: danilko@nm.ru

<sup>2</sup> A.N. Severtsov Institute of Ecology and Evolution RAS, 119071, Moscow, Leninsky prospect 33, Russia

The purpose of the regional geographical analysis is the description of mechanisms of the formation of spatial structures and conditions of landscapes, their appearance and evolution. The analysis should determine uncertainty areas of logical or formal models. Analysis should also determine the reason of uncertainty - lack of information, inadequate models. A classic example is the existence of two models of the moraine sediments - glacial and marine, and, within the glacial model, uncertainty with regard to the stages and borders of each glacial epoch in time and space. Detection of uncertainty area in current models of structure, genesis, functioning of landscapes is the basis for task-oriented researches.

The involved region (Valdai Hill, Central Forest Biosphere Reserve (CFR established at 1931), 32.75°-33.13° E, 56.38°-56.58° N) is located on the late Wurm glaciations border. There was until now uncertainty concerning the border of the glacier. There are bases to draw it both to the north and to the south from CFR area. There is the same uncertainty with genesis of dust loam cover, of southern taiga ecosystems and of pale sod-podzol soils. Combined use of modern sources of spatial data (DEM, remote sensing data) with traditional field observations (more than 1000 point description of vegetation, soil and sediments) help us decrease uncertainty and to formulate new problems of landscape research. Maps of structure, genesis and functioning of a landscape cover of territory have been constructed.

Spectral analysis of DEM show that pre-quadernary relief is organized by principle of multi scale blocks (3-100 km) which inserted one to another. General border of Wurm glacier was determined by blocks with edges of 66-100 km. Sub-latitude edges of blocks were determined frontal moraine sedimentation of penultimate and last glacial covers. Sub-longitude edges were determined accumulation of medial moraine ridges (1-5 km). Borders between smaller blocks locate erosion network and determine configuration of hierarchical lineament landscape structures. Structures of a relief and sediment of the smaller order (10-1000 m) are defined by features of glacial cover deglaciation. These structures control spatial redistribution of moisture and are characterized by special soil and vegetation types which were decoded on the basis of the remote sensing data with accuracy of 30-70%. Modern natural evolution of geosystems is determined by processes of windfall, development of eluvial and illuvial soil horizons.

The general features of functioning of landscape on the basis of a positive feedback contour was established on the basis of field and remote measurements of energy balance: transpiration of spruce forest increase - temperature decrease - peat-podzol soils forming - spruce trees optimum - transpiration increase. It supports the landscape system in southern taiga mode on general background of zonal mixed forests. Cutting and changing of spruce forests to small-leaved forest will lead to damage of this system and transformation of landscape to the character of the surrounding territories.

Unique features of the CFR nature allow the investigation of questions of fundamental and applied character: formation of structure of a landscape and modern processes of its transformation, identification of geosystem formative factors, a role of territory in regional and global carbon cycle, an estimation of ecological services and optimization of nature management in adjoining territories.

The research is made with support of RFBR projects №03-05-64280, №06-05-64937.

## Landscape structure of slopes along the Yangtze River, China

M. Fujihara<sup>1</sup>, K. Hara<sup>2</sup>, M. Tomita<sup>2</sup>, Y. Zhao<sup>2</sup>, Y. Yang<sup>3</sup>, L. Da<sup>4</sup>

<sup>1</sup> Awaji Landscape Planning & Horticulture Academy/Institute of Natural & Environmental Sciences, University of Hyogo, 954-2 Nojimatokiwa, Awaji-city, Hyogo 656-1726 Japan.  
e-mail: fujihara@awaji.ac.jp

<sup>2</sup> Department of Environmental Information, Tokyo University of Information Sciences, Japan.

<sup>3</sup> Key Lab of Three Gorges Reservoir Region's Eco-Environment (Chongqing University), Ministry of Education, Chongqing / Faculty of Urban Construction and Environmental Engineering, Chongqing University, China.

<sup>4</sup> Department of Environmental Sciences, East China Normal University, China

### Introduction

Landscape patterns are the result of ancient, diverse and complex interactions between ecological and socio-economic systems. These patterns occur both on short- and long-term time scales. Rural landscapes have resulted from agricultural activities with long-term time scale. However, they are drastically deteriorating due to changes in the local and regional economic and social systems. In order to conserve these landscapes, it is necessary to clarify the diversity of land use systems in various regions and the changes in human impact on the landscape structure. The objectives of the present study are to describe the landscape pattern of a watershed and estimate landscape change in short-time scale.

### Study site and Methods

The study area was the middle reach of Yangtze River (the largest river in East Asia), located in central China. The watershed of Yangtze River has a long-term relationship between human impact and landscape. Urbanization has been accelerated in these decades along the River, especially in Chongqing City. The Three Gorge Dam has been completed in the main stream of Yangtze River in 2006. According to the normal water level of 175m, flooded area involves 21 counties (cities and districts) in Hubei Province and Chongqing City, flooding many types of landscape elements. Landscape element type and distribution of each element were recorded before the water level would rise. Species composition and cover-abundance of vascular plants were also recorded in the main forest types. Field surveys were carried out in March and August 2006.

### Results and Discussion

Ten landscape element types were recognized: evergreen broad-leaved forest, deciduous broad-leaved forest, coniferous forest, scrub, grassland, orchard, paddy field, dry arable field, residential area and open water. Arable dry field was the most dominant landscape element type on the slopes. Paddy field was rare along mainstream of Yangtze River. Dense cover of forest was rare due to long-term frequent human impact. Lower part of slopes were covered by arable dry field, this area would disappear due to the rise of water level.

Six species types were categorized in a remnant forest in Chongqing City: *Pinus massoniana* type, *Litsea mollis* type, *Elaeocarpus sylvestris* type, *Castanopsis carlesii* var. *spinosa* type, *Symplocos botryantha* type and *Tricalysia dubia* type. Every type of trees had its own successional niche. This remnant forest is considered to be important as a seed source for the restoration of damaged vegetation in the regional scale.

## The role of sacred space in Japanese landscapes

K. Short, N. Kamagata , K. Hara

Tokyo University of Information Sciences, 1200-2 Yatoh-cho, Wakaba-ku, Chiba, 265-8501  
Japan.

e-mail: kevin.macewen@juno.ocn.ne.jp

Various types of sacred space can be identified as special elements in Japanese landscapes. These include:

- sacred groves surrounding Buddhist temples and Shinto shrines
- sacred waterside habitats such as irrigation ponds, natural springs and waterfalls
- sacred hills and mountains

Sacred spaces are believed to be inhabited by or sacred to spiritual entities. As a result, they are often managed in ways that differ from the surrounding areas. A good example is sacred groves. In both Buddhist and Shinto folk beliefs, the trees surrounding a temple or shrine are considered sacred to the local deity. Cutting of these trees is prohibited or at least strongly discouraged by social sanctions.

In some intensely developed urban and suburban landscapes, sacred groves comprise a significant portion of the remaining forest cover. Even in countryside landscapes, although sacred groves comprise only a small percentage of the overall forest cover, they are often rich in patches of mature evergreen broad-leaved forest, and contain many large, old-growth trees that are not normally found in surrounding non-sacred forest elements such as bamboo grove, coniferous plantation, oak coppice and deciduous broad-leaved woodland.

Sacred elements play a major role in conservation of Japanese landscapes and their associated ecosystems and biodiversity. In Chiba Prefecture, for example, sacred groves surrounding shrines and temples account for 18 of 21 plant communities designated as national or prefectural natural treasures; and 18 of 26 nature protection areas. On a larger scale, the sacred grove of the Kasuga-Taisha Shrine in Nara Prefecture protects 300 hectares (3 sq. km) of very rare old-growth evergreen broad-leaved forest. Felling trees and hunting in this forest has been prohibited since 841, and the entire grove is now part of a UNESCO World Heritage Site.

In many cases, historic sacred irrigation ponds, although they no longer function as such, have been preserved on the initiatives of the local people, and now serve as vital habitat for aquatic plants and animals. Japan is also home to numerous Rei-zan, or 'Spirit Mountains', the slopes of which support large patches of rare native forest communities that have been designated as national natural treasures.

### References

- Chiba Prefecture (2001)** Sacred Groves. *The natural history of Chiba Prefecture 5-4: (Vegetation)* pp. 195-204.
- Gakushukenkyusha, Ltd (2004)** Chinkapins and evergreen oaks. *Trees of Japan 9:* pp. 4-11.



## Is bamboo landscape necessary in Japan? – cultural and ecological examinations

S. Suzuki and N. Nakagoshi

Graduate School for International Development and Cooperation, Hiroshima University,  
1-5-1 Kagamiyama, Higashi-Hiroshima, 739-8529 Japan.  
e-mail: suzusige-univ@hiroshima-u.ac.jp

Recently, bamboo groves have rapidly expanded in Japan, which has become a large problem in rural landscape planning and management. However, bamboo culms and edible shoots were once used in traditional Japanese lives. In this study, we consider the importance of bamboo landscapes in Japan from cultural and ecological viewpoints.

We studied the use of tall bamboo in Japanese life and culture. We calculated the annual expansion rates of bamboo groves in Otaki and Kamakura, eastern Japan, and Takahara, western Japan, and compared these to the annual expansion rates of previously studied regions. We surveyed the number of other species and bamboo culms inside 100-m<sup>2</sup> plots in bamboo groves and in mixed bamboo and broadleaf forests in Takahara. Three tall bamboo species grow in Japan: *Phyllostachys bambusoides* and *P. nigra*, which are known to have grown 800 years ago, and *P. pubescens*, which was introduced in 1736 from China. Bamboo culms, mainly *P. bambusoides*, were traditionally used as building materials and commodities. However, after the 1960's, bamboo culms were replaced with plastic and light metals. *P. pubescens* is used for edible bamboo shoot production, although this production decreased after the 1980's when importation from China increased. Japanese people now use bamboo culms to produce articles of Japanese folk culture. Because new shoots grow up in 2 or 3 months using nutrients stored in rhizomes, bamboo can rapidly invade neighbouring vegetation. Bamboo groves expand about 2.1% per year (in Takahara, investigated between 1996 and 2006) to 4.0% per year (Kamakura, 1988-2000). The invasion by bamboo groves is affected by human use of bamboo groves as well as by physiognomic conditions. Species diversity is reduced with the invasion of bamboo. We found a negative correlation between the number of other species and the number of bamboo culms.

The bamboo landscape is a landscape of invasive plants. The expansion of bamboo groves is facilitated not only by natural conditions but also by human effects. Consequently, bamboo groves are considered a serious problem in the landscape. However, bamboo groves were used traditionally in rural landscapes and Japanese culture, and they appear to be a sustainable resource due to their strong reproductive capabilities. We therefore had better propose to design techniques for the use of bamboo as a biomass resource and to promote landscape planning for bamboo groves, including sustainable management of bamboo resources and clearing non-managed bamboo forest.

## The Characteristics and Function of Dangsang Forests near seashore of South Coast in Korea

J.U. Choi<sup>1</sup>, D.Y. Kim<sup>2</sup>

<sup>1</sup> National Rural Resources Development Institute, NIAST, RDA – 88-2, Seodun-dong, Gwonseon-gu, Suwon, Korea.

e-mail: choiju@rda.go.kr

<sup>2</sup> Department of Landscape Architecture, Sungkyunkwan University – 300, Chunchun-dong, Jangan-gu, Suwon, Korea.

### Introduction

Dangsang forests are the holy place where Dangsang traditional festival is held, and have unique cultural assets of Korea with the history of more than several hundred years. Although many Dangsang forests have been degraded by physical damage and Dangsang festival declined in many villages, lots of villages have maintained Dangsang forests to the present. At present, south and west coast areas are under development in large scale. The problem is that the land reclamation from the sea is generalized in Korea, with little consideration for the value of Dangsang forests near seashore. The objective of this study was to investigate the characteristics of Dangsang forests near seashore of the south coast in Korea, and to seek measures for the conservation of the Dangsang forests.

### Story Content

The geomorphology of Korean Peninsula left limited amount of seashore area along the east coast, whereas there are plenty of seashore areas and islands along the south and west coasts. Those seashores have been eliminated by land reclamation and converted to agricultural fields or resort complex. Although the south coast areas in Jeonla Province are in the process of regional development, lots of coastal villages still have Dangsang forests and utilize them as a windbreak and/or a holy place. Dangsang forests near seashore of Jeonla Province are components of living cultural landscape and an important source of income for local people.

Several cases of Dangsang forest near seashore of the south coast and islands have been investigated. Observations were focused on the scale of Dangsang forests, Dangsang traditional festival, utilization of Dangsang forests and seashore areas, etc.

### References

- Choi, J. U. and D. Y. Kim (2006)** A study on the policy for rural cultural landscapes and for enhancing the value of the rural community groves and Dangsang groves. *Journal of the Korean Institute of Landscape Architecture* **Volume 34(3)**: 41-58.
- Choi, J. U. and D. Y. Kim (2005)** The role of rural community forests including Dangsang forest as a landscape element in Bukha-ri, Korea. *42nd IFLA World Congress presentation of papers*: 33.
- Choi, J. U. and D. Y. Kim (2003)** Effects of rural community forests on local streams as landscape ecological resources in Korea. *6<sup>th</sup> IALE World Congress abstracts*: 30-31
- Forman, R. T. T. (1995)** *Land Mosaics: The ecology of landscape and regions*. Cambridge University Press, Cambridge.

## Landscape management in the mirror of historical land use coherencies

B. Engstová<sup>1</sup>, V. Petříček,<sup>2</sup>

<sup>1</sup>Laboratory of Landscape Ecology, Faculty of Forestry and Environment, Czech University of Agriculture Prague, Nám. Smiřických 1, Kostelec n.Č.l., 28163, Czech Republic;  
e-mail: engstova@knc.czu.cz

<sup>2</sup>Agency for Nature Conservation and Landscape Protection of the Czech Republic,  
Kališnická 4-6, Praha 3, 130 23, Czech Republic

### Introduction

Studies of the land use/land cover changes occupy an important place in contemporary landscape research. The knowledge of historical landscape changes provides us to understand the actual state of the landscape and helps us in landscape planning processes. In that case, moreover, is not important only the type of land use and land cover, but also the historical coherencies.

There are some spectacular types of landscape, where an evolution didn't follow common rules. One of them are military areas. Here, an exploitation of the terrain is much more different as in their surroundings. Two opposite characteristics describe MA: a serious surface disturbance or local soil contamination and a well preserved nature with high biological and landscape value and a good tourist potential.

An actual research in the former Military Area (MA) Ralsko (Czech Republic) is focused on two particularities - the historical land use classifications and the status of the actual vegetation. The history of the area represents an interesting example of strong landscape changes connected immediately to a social-politic and demographical situation.

### History

The landscape of MA Ralsko, originally inhabited mainly by a Germans folk, experienced four big transfers of their inhabitants. First before the World War II., second after the War, third after the founding of the MA in early fifties. Military activities have been then practiced here for forty years. In 1991 the area came under the civil administration again, which led to the fourth big transfer, this time of the Soviet soldiers and theirs families. The strongly disturbed surfaces, at times without any vegetation cover, started spontaneously overgrowth.

### Landscape changes research

The historical land use classifications are studied by a close regard on the ground of the ancient villages, which were displaced and destroyed. Historical land use is studied from ancient maps and aerial photographs. The comparative analysis are made in GIS environment, as well as the projection of the actual vegetation status. The actual vegetation is estimated by creating floristical lists and phytosociological relevés.

### Landscape management

This two points of view, the history and the actual state of the nature, are combined in the aim of finding a suitable sustainable management for the vast grassy or shrubby areas (former battle tank training field and shooting range), originally cultivated rural landscape.

## The roles of isolated trees for biological conservation in human-dominated landscapes

M. Yasuda<sup>1</sup> and F. Koike<sup>1</sup>

<sup>1</sup>Graduate School of Environment and Information Science, Yokohama National University  
79-7 Tokiwadai, Hodogaya, Yokohama, 240-8501 Japan  
E-mail: mic.yasuda@kub.biglobe.ne.jp

### Introduction

Areas of housing and industrials are dramatically increasing in countries around the world. Consequently, the forest vegetation in many regions has been fragmented into a mosaic of patches. The smallest patches are isolated individual trees. Studies of the use of isolated trees by animals are rare except for those in rural landscapes. This study aims to examine the value of isolated trees on ants and other arthropods in a Japanese urban landscape.

### Methods

The study area (2 x 2 km) was set in the centre of Matsudo city of Chiba Prefecture, Japan. We randomly selected 341 trees of 34 species located within the site, and for each tree measured its diameter, distance from the nearest neighbouring tree and the nearest building using a laser range finder (Nikon LASER 400). Land cover within a 50 m radius from each tree was obtained using Arc/GIS. Arboreal ants and other arthropods found on the surface of tree trunks between the height of 50 and 170 cm were sampled by hand collecting and by counting their numbers for two minutes on each tree. In order to detect the effect of host tree properties, the surrounding environment, and urban stresses, analysis of covariance (ANCOVA) was conducted using GLM. Principal components analysis (PCA) was undertaken to investigate arthropod assemblages on various tree species.

### Results

A total of 12,167 individuals of 22 ant species, and 1,579 individuals of 29 arthropod taxa were recorded in this study. Among the various environmental factors and tree properties examined, host tree species was the most significant factor determining both the abundance and number of taxa of ants and other arthropods. The size of the host tree was the next most important factor influencing abundance and the number of taxa of arthropods, excluding ants. All other factors: tree spatial arrangements, surrounding land uses, and distance from nearest buildings and neighbouring trees were not significant. The result of the PCA showed that each of fifteen different tree species supported a different kind of arthropod assemblage.

### Discussion

In order to increase arthropod diversity in urban landscape, it is valuable to select particular tree species, especially those that attract the greatest number of arthropods. Land planners should also consider planting with variety of tree species. In this study, we did not put any greater weight on native tree species; however, it may also be important to consider planting the regional native flora to avoid alien tree species, which could detrimentally affect the local ecosystem.

**The Picos de Europa Mountains, north-west Spain, an inspiration to non-specialist students to study living cultural landscapes**

**N.T. Dykes<sup>1</sup>, H.E. Prince<sup>1</sup>, R.P. Lemmey<sup>1</sup>, R.G.H. Bunce<sup>2</sup>**

<sup>1</sup> St Martins College, Ambleside.LA22 9BB  
e-mail : n.dykes@ucsm.ac.uk

<sup>2</sup> Alterra, PO Box 47, 6700AA Wageningen, The Netherlands.

Since 1990 Outdoor Studies students from St. Martin's College (formerly Charlotte Mason) have surveyed components of the landscape in the Picos de Europa, north-west Spain. The three main aims of the course are: to introduce students to cultural landscapes; to encourage students to engage with disciplined recording of the landscape and to contribute to the knowledge of the area with the ambition that the results would be applicable to local issues.

The group study uses an environmental stratification for teaching the benefits of objective sampling. Field data on landscape features e.g., meadows, woodland and linear features are recorded from samples and converted into population estimates. These projects were often incorporated into a multi-day expedition through the mountains. The students are non-specialists and although at the sample level data is at times, inconsistent, overall it has proved useful to show trends at the regional level. Strong correlations between environmental and field data have been shown, e.g. using the European Survey method described by Bunce et al, 2005. The experience shows that such students can collect meaningful data and learn much from the experience.

In addition, students complete a personal project on one aspect of the mountain environment. These projects are diverse in nature e.g.; using indicator species to monitor meadow management with respect to isolation and classifying building types to monitor cultural change. The last sixteen years have built a formidable bank of information collated in a working document (Toledano, 2003). These projects have been supervised by specialist staff and have been effective in motivating students to learn about their own interests within these mountain landscapes.

These courses have been a peak experience for hundreds of undergraduates from St. Martin's college (Prince, 2005). The students have been inspired by this living cultural landscape and have completed many excellent landscape ecological projects. The educational benefits reach to a wider audience and contribute to the understanding of such landscapes, which is essential for their long term sustainability. Several papers have been published to inform a wider audience, e.g. Bunce *et al*, 1998. A limitation has been the lack of time for documentation of most of the student studies. The development and trials of various methodologies in the group projects have helped inform the design and testing of the European handbook (Bunce *et al*, 2005). Overall, although there have been benefits for the scientific community, the students have not only learned scientific principles but also appreciate and experience living cultural landscapes not found in the UK..

### References

- Toledano, A. (2003)** Abstracts of personal projects from the Picos de Europa, unpublished living document.
- Bunce, R.G.H., Bell, M & Farino, T. (1998)** 'The Environmentally Sensitive Area legislation in the United Kingdom and its potential application to the Picos de Europa Mountains in North-West Spain. *Environmental Conservation*. **23** 219-227
- Bunce, R.G.H. Groom, G. Jongman, R.H.G. & Padoa-Schioppa, E. (2005)** Surveillance and Monitoring of European Habitats. Alterra Rapport.
- Prince, H. (2005)** Graduate pathways: a longitudinal study of Graduates in Outdoor studies in the U.K. *Journal of Adventure Education and Outdoor Learning*. **5** (1) 21-3.

## Semiautomatic delineation of landscape types in the alpine region

E. Szerencsits, B. Schüpbach, H. Conradin, A. Grünig, T. Walter

Research station Agroscope Reckenholz-Tänikon ART – Reckenholzstrasse 191, CH-8046  
Zürich, Switzerland.

e-mail: Erich.Szerencsits@art.admin.ch

### Project concept and structure

A nationwide classification of Swiss landscapes is carried out to provide the administration with a tool to evaluate landscapes by indicators and to develop landscape targets. Preceding workshops were organised by the federal authorities and held together with scientists and cantonal representatives to discuss the targets of the project and the methodological concept. Based on the results, the preparation and analysis of base data were assigned. Subsequent projects with the involvement of cantonal representatives will provide a synthesis of the layers and further, detailed analyses for specific requirements.

### Delineation of landscape units

The authorities showed clear preferences for a polygon based approach to obtain boundaries suited for policy measures and spatial planning. As differences in landscape character are often caused by changes in slope, the main boundary layer of the landscape units was derived by classifying the slope according to soil suitability. Therefore a geoprocessing model was developed including the following steps:

1. According to soil suitability, slope (Swisstopo 2001) was classified binary into twelve classes stored in twelve 25 x 25 meter grids.
2. A focal majority filter was applied to each of the binary slope maps to integrate small geomorphologic elements, e.g. ditches, small terraces and moraines.
3. The raster datasets were converted to polygons.
4. Small islands inside the polygons and small polygons were eliminated.
5. The different slope layers were overlaid with the Geotechnical Map of Switzerland, scale 1:200'000 (BWG and BUWAL 1990).
6. For the delineation of high mountain landscapes, the polygons were split along the contour line touched by forest (Swisstopo 2005).
7. Small polygons and bottle necks of complex polygons were eliminated systematically.

### Classification

In subsequent analyses, the landscape units were separately classified by long term and medium term characteristics. Long term characteristics were determined by orography, topography, geology, and climate. Medium term characteristics were determined by dominant land use systems and land cover mosaics. This was implemented using a GIS based process model and involving additional data sets. The resulting data model provides the opportunity to flexibly combine the different criteria to a landscape classification according to specific requirements.

### References

- BWG and BUWAL (1990)** Simplified Geotechnical Map of Switzerland. GEOSTAT, Swiss Federal Statistical Office, Neuchâtel.
- Swisstopo (2001)** DHM25, digital height model 25 × 25 m. Federal Office of Topography. Berne.
- Swisstopo (2005)** Vector25, digital landscape model. Federal Office of Topography. Berne.

**Methods of landscape indication for the recognition of soil cover from  
multispectrozoal space images**

**S.H. Myshliakou**

Belarusian State University, Nezalezhnasci av. 4, 220050, Minsk, Belarus.  
e-mail: sergey\_myshl@mail.ru

The diversity of soil cover accounts very much for landscape diversity. Recognition of remote sensing images is the leading technology for soil inventories and mapping. Now it is being introduced in Belarus for studies at various spatial scales. This paper describes an application of soil mapping based on land-cover indication from multispectrozoal space images implemented for the basin of the River of Biarezina (tributary to Nioman) in Western Belarus. The main data sources are spectrozoal images of Landsat ETM and TM for different years and seasons.

The special focus of this study was on the application of different recognition characteristics to different landscapes. Basic land-cover units (forests, water surfaces) were detected automatically, while other elements of the landscape (river valleys, agricultural lands and wetlands) were recognised in an interactive mode. The appropriate raster masques have been created for each land-cover unit. Further processing of remote sensing data has been implemented within these masques.

Though colour tone, brightness and objects' structure are the main direct indicators, soil types are mostly recognised by indirect indicators, most important, landforms and vegetation. The automatic soil classification with regard the indicative attributes has been implemented with further interactive editing. The basic technology of this process was supervised classification with spatial signature assessment. The classification rules developed in the course of study have been validated against field data.

Soil cover and vegetation of wetland landscapes are highly dependent on microtopography that determines patterns and dynamics of soil saturation. Criteria for selecting the training areas were well identifiable distinctions in brightness and saturation of images. Some difficulties appear in recognition of alluvial peat soils, because of the image brightness dispersed over a broad range in most bands.

Because arable lands and drained patches are present everywhere in the area and often dominate it, use of landforms and vegetation as indicators is limited. The recognition of these landscapes is based on the processing of near and mid infrared and thermal bands. Except classification, the special wetness index has been used to classify soils in regard of their wetness.

It is noteworthy that indices of wetness and brightness are highly sensitive to seasonal changes. The wetness is always higher on spring images; the soil brightness depends on the type of vegetation and substrate. Therefore, in order to get better and more reliable results, images from different seasons should be used.

The study has been followed by the technology assessment: it was concluded that (1) if compared to panchromatic, multispectrozoal images have good informative capacity; (2) recognition of land-cover units gives robust foundations for soil inventory studies and mapping; (3) the series of remotely sensed images covering long time periods are most helpful for the analysis of landscape dynamics, driving forces and long-term consequences of this dynamics.

## Complementary pedological and palaeoenvironmental examination of the buried soil profile underneath the Lyukas-halom kurgan

Á. Pető<sup>1</sup>, K. Joó<sup>2</sup> and T. Bucsí<sup>2</sup>

<sup>1</sup> Department of Landscape Ecology, Institute of Environmental Management, Szent István University, 2103 – Gödöllő, Páter Károly u. 1., Hungary,  
email: Peto.Akos@mkk.szie.hu

<sup>2</sup> Plant Protection and Soil Conservation Service of Pest County, Gödöllő - 2100, Kotlán S. u. 3., Hungary.

### Introduction

The multidisciplinary excavation of the Lyukas-halom kurgan (Hajdúnánás, Hungary) was lead by the Department of Landscape Ecology from the Szent István University (Gödöllő, Hungary) in 2004. As all burial mounds are under *ex lege* environmental protection in Hungary, it was a special and unique occasion that we could collect all relevant permissions for the excavation. The cross-section wall of the - 5 meters high and approximately 42 meters in diameter wide - kurgan was prepared aiming detailed environmental and archaeological studies.

The buried soil profiles under these 5000 to 6000 years old (B.C.) burial mounds are the messengers of ancient landscape forming factors and soil generation processes (Alexandrovskiy *et al.*, 2001).

### Methodology

The soil profile was sampled for classical pedological, micromorphological examinations as well as for palaeoenvironmental survey. We have utilized the biomorphic analysis, which is a suitable scientific tool for kurgan studies (Golyeva, 2001). Samples for the above mentioned examinations were taken from the top of each genetic horizon in a vertical and horizontal section (Piperno, 1988).

### Results and their discussion

A well-developed ancient soil profile was found buried beneath the enormous formation. By virtue of the on-site macromorphological description and field tests, we could easily outline the genetic horizons. According to the macromorphological examinations, the former, original soil formation belongs to the Chernozem type soils and can be characterized by alike qualities. The parent material, which is pale yellow, loamy, structure-less and shows high carbonate content, is presumably a loess type sediment. The existence of an undisturbed paleosoil and a Chernozem type soil development could have been proven on the basis of both the micromorphological examination and the biomorphic analysis. Results of laboratory analysis of chemical and physical soil qualities confirm the same. The undertaken research pointed out, that aqueous impacts predominated the evolution of the parent material. The former environment was presumably dominated by steppe species and can be imagined as a continental steppe-land. Our objective for the future is to extend our researches regarding the soil evolution and to reveal some questions related to archaeological context

### References

- Alexandrovskiy, A.L.; Plicht, J.; Belinskiy, A.B. & Khokhlova, O.S. (2001) Chronology of soil evolution and climatic changes in the dry steppe zone of the Northern Caucasus, Russia, During the 3rd Millenium BC. *Radiocarbon*, Vol 43, Nr 2B.: 629-635.
- Golyeva, A. A. (2001) Biomorphic analysis as a part of soil morphological investigations. *Catena* 43: 217-230.
- Piperno, D. R. (1988) *Phytolith analysis: An Archeological and Geological Perspective*. Academic Press, Harcourt Brace Jovanovich Publishers, San Diego, p. 268



**Landslide changing landscape in the mountainous rainforest of Rio de Janeiro, Brasil:  
scar recovery dynamic.**

**A.A. Chirol, A.L. Coelho Netto**

GEOHECO/Laboratory of Geo-Hydroecology, Department of Geography, Institute of  
Geosciences, Federal University of Rio de Janeiro, 21941-590, Brazil  
e-mail: achilleschirol@gmail.com

Landslides are erosive phenomena characteristic of steep slopes in mountainous topography of humid regions and are associated to different geo-biophysical factors. Clearings that originate from forest slope landslides promote the destruction of soil-biota system relations so inducing the propagation of border effects to the adjacent forest. In turn, the revegetation process of these clearings involves the readjustment of relations between the succession dynamic and the hydrologic and erosive processes controlled by the morphological aspects of the clearing. In this view, this study proposes to investigate the succession process inside landslides, looking to understand the reinstatement of the system's functionality, and the propagation of border effects to the adjacent forest starting from the following parameters: vegetation structure, litter production and storage, topsoil fauna and chemical spoil properties (C, N, P, K, Ca, Na, Mg, pH and organic matter). Study areas are situated in the Tijuca Forest, Rio de Janeiro, that is a well-preserved Atlantic forest despite intense urban pressure. Three landslides were selected, all with the same age (February 1988), but of different sizes and forms. Landslide 1 is the smallest (0,6 ha) and possesses an elongated form (narrow), landslide 2 is larger than 1 (1,2 ha), but still has an elongated form, and landslide 3 is the largest (1,8 ha) and its form is more circular. Samples were collected at mid-slope, high slope and at the borders of each landslide, as well as in the climax forest that served as a study control. In relation to the structure of vegetation, as was expected, the lesser values for the basal area were found at the interior of landslides, and the smallest were found at mid-slope of landslide 2 (2,40 m<sup>2</sup>/ha). The largest value for the basal area was found at the right border of landslide 1 (61,56 m<sup>2</sup>/ha), while the control area was 28,91 m<sup>2</sup>/ha. Concerning height data, the largest average was at the left border of landslide 3 (7,21m) and the smallest at mid-slope of the same landslide (2,06m), while in the control area it was 4,26m. As per the litter production, the collected data show more border effect at landslide 3 where the proportion of leaves (80,7% at the right border and 79,1% at the left border) is higher than in the control area (66,3%), and the reproductive material is far inferior at the borders (2,1% and 1,8% versus 9,1%). Attention is called by the high proportion of reproductive material at mid-slope of landslide 2 (29,8%), and at the borders of landslide 1 (28,0% and 32,6%), and the low proportion of branches at the interior of landslides 1 and 2 (between 0,7% and 2,8%). Preliminary results obtained in 2001 inside and at the borders of landslide 1 are significantly different than the forested areas: they're smaller for phosphorus and potassium at the left border (P=1,42 ppm; K=9,6 ppm) and for carbon and nitrogen at mid-slope (C=15,1 g/kg; N=1,04 g/kg). In the first case, the values of phosphorus and potassium show a degeneration process caused by border effect propagation while carbon and nitrogen values associated with a low density of oribatid mites indicate perturbances of the decomposing subsystem. The data show the existence of a border effect whose intensity is directly linked to the landslide morphology and less favorable succession conditions at mid-slope, probably associated with hydro-erosive dynamics that might indicate that natural succession is slower than what was expected in these areas.

## Forming of landscape structure on the south of Valday Hill

M.Y. Puzachenko<sup>1</sup>, D.N. Kozlov<sup>2</sup>, E.V.Siunova<sup>1</sup>

<sup>1</sup> A.N. Severtsov Institute of Ecology and Evolution RAS, 119071, Moscow,  
Leninsky prospect 33, Russia,  
e-mail: puzak@orc.ru

<sup>2</sup> Lomonosov Moscow State University Faculty of Geography, 119899, Moscow,  
Leninskiye Gory 1, Russia

The south of Valday Hill (within Tver region borders, coordinates 55° - 57° N и 30°-34° E) is a region of complicated spatial structure of landscapes which is determined by the border of Wurm glaciation maximum stage. There is a relatively high degree of relief, with a diverse geological base, deposits of Saalian and Wurm glaciations and continental climate. Contemporary landscape structure is determined by high level of forest operational damage, historical conditions of land use which are changing during the 20<sup>th</sup> century and nowadays due to withdrawal of fragmented areas from land use.

We demonstrate methods and results of general landscape forming factors (parameters of order) determination, their physical sense and the scale of their influence to each component of landscape. We assess the scale of mutual dependence of landscape components, upon dependent variables of their condition.

Landscape components reflected through spatial variation of numerous properties, determined on digital elevation model (made with topographic map 1:100000), composition of multispectral images Landsat 5, Landsat 7, Geocover (1990 and 2000) and gridded maps of climatic variables with 10 arc minute resolution. We used average long-term variables for each month – precipitation, number of rainy days, average temperature, partial pressure of vapor, relative humidity, duration of sun shining, number of frosty days, wind speed. Detailed descriptions of landscape components were made in 2600 points. Points lay on regular and selective schemes and were GPS-positioned.

Using spectral analysis of DEM the hierarchical levels of relief organization was revealed. Relief at each point was characterized by relative elevation, slope and curvature for each level. Every property of every landscape component is presented via discrete units. Using discriminant analysis for each property spectral bands, vegetation indices and topographical variables were transformed into independent factors. Regression was calculated between factors and property. The property variation in space for each pixel can be described in 40-50% (20-70%) cases. As a result we can create maps of this property and its factors. This method allows the exploration of each component and the whole system.

The general dimension of all properties space does not exceed eight. Four of the landscape forming factors describe 60% of the variation. Each landscape component has properties independent from the whole and determining its autonomous variation. The overall pattern can be expressed by the following items:

1. Spatial structure of landscape is almost strongly fractal. Quasiperiodical component describes less than 5% of variation. Fractality is determined by mechanisms of geologic basis fractioning into blocks under geodynamic forces acceleration.

2. Quaternary sediments and their relief is also fractal and significantly determined by pre-quaternary basis.

3. Strong non-linear interactions can appear between mesoclimate, vegetation, soil, hydrosphere, agriculture and can generate mesoscale fractal structures. This increases dimension of landscape and increases quasiregular input into its structure.

4. Relations between components are determined well on macro level. The determination decreases in lower levels due to non-linear interactions. This means that we can not place more than three (reliably - two) hierarchical levels on one scale.

The research is made with support of RFBR project # 03-05-64280.

**The European Pond Conservation Network (EPCN)**

**A.P. Hull<sup>1</sup>, P. Nicolet<sup>2</sup>, S. Angélibert<sup>3</sup>, J. Biggs<sup>2</sup>, R. Céréghino<sup>4</sup>, B. Oertli<sup>3</sup> and B. Sajaloli<sup>5</sup>**

<sup>1</sup>Ponds Research Unit, Liverpool John Moores University, Clarence Street Building, Clarence Street, Liverpool, L3 5UG, UK.

e-mail: a.p.hull@ljmu.ac.uk

<sup>2</sup>Pond Conservation: The Water Habitats Trust, c/o Oxford Brookes University, BMS, Gypsy Lane, Oxford Oxon OX3 0BP, UK.

<sup>3</sup> Department of Nature Management, University of Applied Sciences of Western Switzerland, 150 route de Presinge, CH-1254 Jussy-Geneva, Switzerland.

<sup>4</sup>Laboratoire d'Ecologie des Hydrosystèmes, Université Paul Sabatier, 118 route de Narbonne, 31062 Toulouse, Cedex 9, France.

<sup>5</sup>Université d'Orléans, France

Ponds are important habitats from both a biodiversity and societal perspective. Despite this, ponds face many threats and receive little protection in Europe. Indeed, they are unlikely to be included as part of the implementation of the Water Framework Directive. However, ponds present many opportunities for freshwater conservation. The characteristics of ponds make them relatively easy to create with maximum biodiversity benefits. Often one of the few wildlife habitats present in intensive land uses, they can also help raise the public awareness of conservation issues, and provide a refuge for aquatic organisms. At the landscape scale, strategically located pond creation schemes may help to maintain and improve the integrity of freshwaters. To address these issues and stimulate collaborative research, the European Pond Conservation Network (EPCN, [www.epcn.org](http://www.epcn.org)) was established in 2004 at the First European Pond Workshop in Geneva. The mission of the network is to *promote the awareness, understanding and conservation of ponds in a changing European landscape*. Specifically the objectives of the network are to:

- exchange information on pond ecology and conservation between researchers, managers and practitioners;
- promote understanding of pond ecology by encouraging the development and coordination of fundamental and applied research;
- raise the profile of ponds and guide national and supra-national policies for their protection;
- promote effective practical pond conservation; and
- disseminate information to the public on the importance, attractiveness and conservation of ponds.

Although still in its infancy, the network includes representatives from most European countries. The next workshop will take place in Spring 2008 in Valencia in Spain and it is hoped that the EPCN will continue to successfully develop its activities over the next few years, and achieve its mission to *promote awareness, understanding and conservation of ponds in a changing European landscape*.

## Chillingham Park, Northumberland: conservation priorities

S.J.G. Hall<sup>1</sup>, R.G.H. Bunce<sup>2</sup>

<sup>1</sup> University of Lincoln, Riseholme Hall, Lincoln LN2 2LG, UK.  
e-mail: sthall@lincoln.ac.uk

<sup>2</sup> Alterra, PO Box 47, 6700 AA Wageningen, The Netherlands.

### Introduction

The management of designated sites often requires active measures which may be in conflict e.g. clearance of scrub from grassland, or laissez faire policies in forest reserves. Chillingham Park in north-east England provides a good example of the necessity of basing decisions on the primary conservation objective of a given site.

The park is a 134 ha early 19<sup>th</sup> century designed landscape imposed upon a late medieval deer park. Veteran trees (oak and other hardwoods) up to 300 years old are present and there are many alders that are considerably older. 80 ha of the park is pasture with scattered trees, the rest is fenced or unfenced plantations and streamside woodland. It is inhabited by the Chillingham Wild White cattle, an ancient breed which numbers 62 with a natural sex ratio and age distribution. Culling and castration are not practised though hay is fed in winter (Hall et al., 2005). The breed has high priority for conservation (Defra, 2006).

For about 40 years the park has also had to support a flock of 300 breeding sheep and about 300 fallow deer have made it their prime habitat. In early 1980, 6 lactating cows died of hypomagnesaemia. A programme of rotational fertilising of the 80 ha of pasture with magnesian limestone (36 tonnes per year applied at a rate of 6 t/ha), plus *ad lib* access to mineral supplement, has operated since then. Thus, each m<sup>2</sup> of the pasture has received a total of 1.17 kg of lime over the last 26 years. Only one lactating cow has died since 1980, nutrition was not implicated. The liming programme has therefore succeeded.

### Vegetation changes 1979-2007

The vegetation of the park has changed. The conservation status of the original infertile grassland has declined. In 1979 complete species lists were made for 101 quadrats (Hall & Bunce 1984, Hall 1988). Here, the species lists made for the innermost 5 x 5 m quadrat are discussed. Thirteen of these were revisited in 2006; corresponding species lists were made.

Quadrats showed a reduction in species diversity (on average, 34.8% of species recorded in 1979 were absent in 2006; range, 9 – 50%). The following species were recorded in 3 or more quadrats in 1979 (in brackets) and were not found in 2006: *Achillea millefolium* (4), *Brachythecium rutabulum* (5), *Carex panicea* (4), *Cirsium palustre* (4), *Conopodium majus* (8), *Galium saxatile* (9), *Lotus corniculatus* (3), *Nardus stricta* (3), *Phleum pratense* (3), *Plagiothecium undulatum* (3), *Poa annua* (6), *Poa trivialis* (6), *Sieglingia decumbens* (4), *Stellaria graminea* (8), *Veronica officinalis* (4), *Vicia sepium* (3). However, the important tree flora has not apparently been harmed

### Conclusion

This outcome is not surprising. The penalty for assuring nutritional security for the cattle has been the loss of vegetational diversity with stress-tolerant species being outcompeted.

### References

- Defra (2006) UK national action plan on farm animal genetic resources. Department for Environment, Food and Rural Affairs, London. Retrieved on 19 January 2007, f
- Hall, S.J.G. (1988) Chillingham Park and its herd of white cattle: relationships between vegetation classes and patterns of range use. *Journal of Applied Ecology* **25**:777-789.
- Hall, S.J.G., Bunce, R.G.H. (1984) Vegetation survey of Chillingham Park, Northumberland. *Transactions of the Natural History Society of Northumbria* **52**: 5-14.
- Hall, S.J.G., Fletcher, J., Gidlow, J., Ingham, B., Shepherd, A., Smith, A., Widdows, A. (2005) Management of the Chillingham Wild White Cattle. *Government Veterinary Journal* **15**: 4-11.



## Theme 7 Assessment of landscape change



## 7.1 Symposium 12: Land abandonment

### Natural expansion of forests on abandoned farmland: effects of changing economy on land use

D. Pettenella

Dipartimento Territorio e Sistemi Agro-Forestali - Università di Padova -Via dell'Università 16  
35020 Legnaro PD – Italy.  
e-mail: davide.pettenella@unipd.it

#### Introduction

Considering the level of profitability, a structural change is taking place in grazing and forest management in the mountain areas of Southern part of the Alps. When looking at the farm products and timber prices and at the production costs over the last 30 years, it appears clear a decreasing level of competitiveness of local producers with respect to foreign markets (Figure 1). In spite of the decision makers and public opinion's general belief, timber production in the Italian mountain areas is not a valuable alternative to the declining role of agriculture. There are some negative impacts of the decreasing profitability of mountain farming and timber production: the traditional integration between pasture management and livestock production as well as the multifunctional nature-oriented forest practices tend to be abandoned. These trends are associated with a shift in the focus of forest policies from mountains to plains, from semi-natural forests based on mixed uneven-aged forests - with long rotation periods, natural regeneration, selective cuttings - to plantations in the Po valley plains.

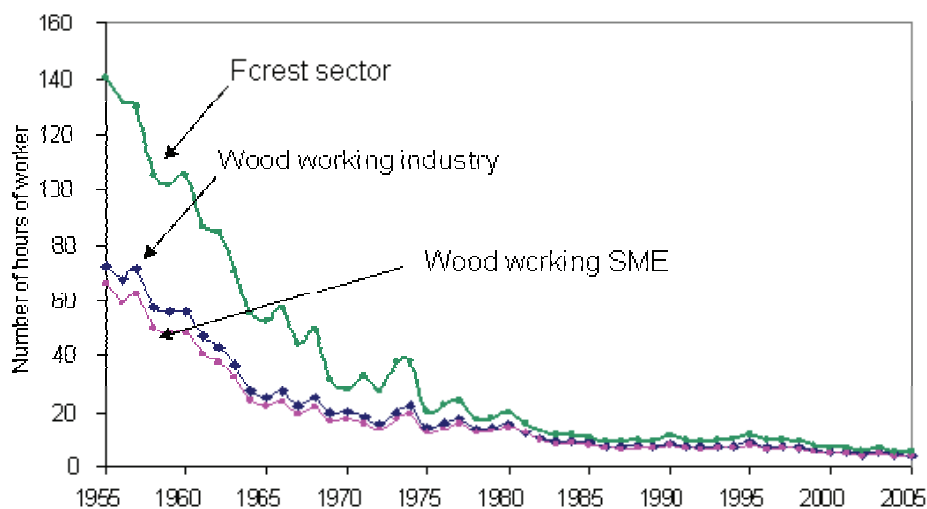


Figure 1. Number of working hours in forest activities that can be covered by selling 1 m<sup>3</sup> of wood (standing tree value) (1955-2005). Source: Ciotti and Pettenella (2005)

The traditional development strategy for the primary sector in mountain areas has therefore to be adapted. The mountain farmland and forests have now to be managed with the priority goals of maintaining a stable and rich environment and a diversified landscape as well as of regulating the water cycle and providing others social public services. Food and timber production are no longer a priority, but a means of reducing the public costs of maintaining the more general environmental and social benefits. Under this evolving perspective, innovative land use practices that can generate new sources of income are mostly welcome. Thus a new role is being played by Non Wood Forest Products and



Services (NWFP &S), such as mushrooms, nuts, forest-based recreational, tourist, educational and sports services.

### NWFP&S marketing development paths

For the NWFP&S suppliers in the Italian Alpine region, it is almost impossible to operate in mass markets. Labor costs, scale economies and supply critical mass are strong competitive factors characterizing foreign suppliers in the mass markets (Collier *et al.*, 2004). In such a situation, two strategies are possible for the Italian mountain producers (Figure 2):

1. to transform mass products or services into specialized NWFP&S, i.e. niche or “cottage” products and services like food or drink specialities, normally with very high added values;
2. to transform mass or niche products or services into complementary products and services, i.e. products that can be sold and used in strict association thanks to the synergies deriving from their joint marketing (a forest museum, associated to some concerts organised in a forest and to restaurants and B&B facilities).

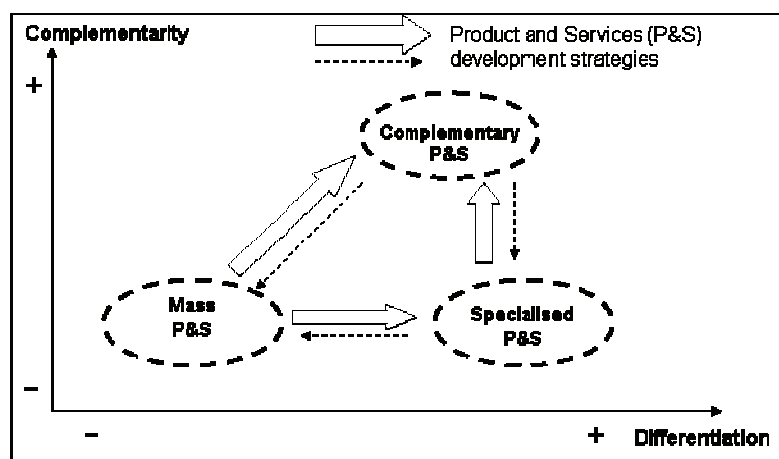


Figure 2. NWFP&S marketing development strategies

### Conclusions

Land managers, by shifting from a timber-based activity to a NWFP&S-based activity, are changing their traditional product-oriented approach into a more customer-oriented one (Font and Tribe, 2000; Mantau *et al.*, 2001). This change has some impacts on the objectives of land use: in developing specialized recreational or sport services like, for example, a forest adventure park or a permanent camping site. The traditional multifunctional forest management systems also tend to be substituted by specialised forms of land use. The final results of this development is a mountain region where forest resources are mostly abandoned or extensively used, accompanied by the random presence of small intensively used restricted locations areas.

### References

- Ciotti, M. & Pettenella, D. (2005) La capacità competitiva delle produzioni di legname nel territorio alpino. *SLM-Istituto Nazionale della Montagna*, 24:14-21.
- Collier, P.; Short, I. & Dorgan, J. (2004) *Markets for non-wood forest products*. COFORD, Dublin.
- Font, X. & Tribe, J. (2000) *Forest tourism and recreation. Case Studies in Environmental Management*. CABI, Wallingford.
- Mantau, U.; Merlo, M.; Sekot, W. & Welcker B. (Eds.) (2001) *Recreational and environmental markets for forest enterprises*, CABI, Wallingford.

## Landscape change in the Western United States: the expansion of Pinyon-Juniper woodlands in Central Nevada

E. Lingua<sup>1</sup>, P. Weisberg<sup>2</sup>, R.B. Pillai<sup>2</sup>

<sup>1</sup> Department AGROSELVITER, University of Turin, Via L. da Vinci, 44, 10095 Grugliasco (TO), Italy.

e-mail: emanuele.lingua@unito.it

<sup>2</sup> Department of Natural Resources and Environmental Sciences, University of Nevada – Reno, Mail Stop 186, 89557 Reno NV, USA.

### Introduction

In the last few decades tree species expansion in formerly open ecosystems has been observed in many ecosystems all over the world (Arno & Gruell 1986; Archer 1994; Hudak & Wessman 1998; Motta & Nola 2001). In the United States a change in fire regime is considered to be among the most influential factors affecting low elevation forest-grassland ecotones (Norman and Taylor 2005). Historically frequent surface fires (typical of a low intensity fire regime) are thought to have limited the extent of woody species until fire control suppression politics were introduced in the late 19th and early 20th centuries (Allen and Breshears 1998, Norman and Taylor 2005). Livestock grazing, by reducing competition of non-woody species and by consuming fine fuel, consequently lowering the fire ignition and spread probability, may have also increased the encroachment of trees in meadow formations (Belsky 1996).

In the western United States a typical example of rapid woodland expansion, driven by the above mentioned factors, has been the encroachment of *Pinus* and *Juniperus* species into sagebrush and other vegetation types of the Great Basin. Since the Euro-American settlement there has been a 10-fold increase in PJ woodland area (from 3 million ha to 30 million ha) throughout the western US (Miller & Tausch 2001). This study aims thus at measuring rates of pinyon-juniper expansion over the past three decades at Simpson Park Range, in central Nevada, USA, analysing at the same time which landscape factors have an influence in determining patterns of expansion and landscape structure changes.

### Methods

The Simpson Park Range is a mountain range located near the geographic centre of the Great Basin in central Nevada, USA. In its southern part a 25 km<sup>2</sup> study area was selected. Historical aerial photographs were used to quantify pinyon-juniper woodland expansion in this area over a 30-year period (1966-1995). Vegetation was classified adopting an object-oriented approach (Pillai et al. 2005); multiple spatial scales from single-tree to ecotone (0.001, 0.025 and 0.4 ha mapping resolution) were analysed through a multi-scale segmentation and classification scheme.

The pattern of expansion has been then analysed in discrete categories of elevation, slope aspect, slope steepness, and hillslope position.

To analyse landscape structure changes over the period, 20 “landscapes” (10 ha) for each elevational zones (lower elevations, moderate elevations, and upper elevations) were randomly extracted. In these 60 resulting samples several landscape metrics were computed for the '66 and '95 tree-level maps.

### Results

Over the 30-year period, an increase in woodland area was registered. Differences in the expansion rate were encountered according to the spatial scales (Table 1). Furthermore the expansion pattern varies according to topographic features and productivity gradients. Expansion rates across all scales have been greatest for valley bottoms, moderate for side and toe slopes, and least for ridgetops. Concerning landscape structure, at lower elevation there is evidence of a more complex patch shape evolution, from a matrix dominated

landscape to a coarse mosaic. At moderate elevations there is a tendency to a coarser mosaic, with patches that become larger, more aggregated and complex. In the upper elevation sites, changes are instead more limited.

**Table 1.** Changes in PJ woodland area at three different spatial scales (period 1966-1995):

Scales	1966	1995	P-J area changes
Tree (20 m <sup>2</sup> )	630.1 ha	837.3 ha	+ 32.9 %
Stand (200 m <sup>2</sup> )	891.0 ha	1127.8 ha	+ 26.6 %
Ecotonal (4000 m <sup>2</sup> )	1847.1 ha	2044.2 ha	+10.7 %

## Discussion

The different rates of pinyon-juniper woodland expansion at the different scales of analysis reveal the presence of an infilling process. Furthermore the expansion is not spatially random, but varies according to landscape gradients of topography and productivity. Rates of infilling have been greatest at lower elevations, while migration of the woodland belt over coarser scales has proceeded in both upslope and downslope directions. Increases in woodland area were several times greater for more mesic sites (Weisberg et al. in press).

The delineation of the rate and main directions of PJ-expansion, identifying which portions of the landscape have become more connected as a result of woodland encroachment, could provide useful information to landscape managers in properly addressing restoration interventions.

## References

- Allen, C.D. & Breshears, D.D. (1998)** Drought-induced shift of a forest-woodland ecotone: rapid landscape response to climate variation. *Proceedings of the National Academy of Sciences of the United States of America* **95**: 14839-14842.
- Archer, S. (1994)** Woody plant encroachment into south-western grasslands and savannas: rates, patterns and proximate causes. M. Vavra, W.A. Laycock & R.D. Pieper (Eds). *Ecological implications of livestock herbivory in the West*. Society for Range Management, Denver, CO. pp 13-68.
- Arno, S.F. & Gruell G.E. (1986)** Douglas-fir encroachment into mountain grassland in Southwestern Montana. *Journal of Range Management* **39**: 272-276.
- Belsky, A.J. (1996)** Viewpoint: western juniper expansion: is it a threat to arid northwestern ecosystems? *Journal of Range Management* **49**: 53-59.
- Hudak, A.T. & Wessman C.A. (1998)** Textural analysis of historical aerial photography to characterize woody plant encroachment in South African savannah. *Remote Sensing of Environment* **66**: 317-330.
- Miller, R.F. & Tausch R. (2001)** The role of fire in juniper and pinyon woodlands: a descriptive analysis. Galley, K.E.M. & Wilson, T.P. (Eds). *The invasive species workshop: the role of fire in the control and spread of invasive species. Fire conference 2000: the first national congress on fire ecology, prevention and management*. Tall Timbers Research Station, Tallahassee, FL. pp 15-30.
- Motta, R. & Nola P. (2001)** Growth trends and dynamics in sub-alpine forest stands in the Varaita valley (Piedmont, Italy) and their relationships with human activities and global change. *Journal of Vegetation Science* **12**: 219-230.
- Norman, S.P. & Taylor, A.H. (2005)** Pine forest expansion along a forest-meadow ecotone in northeastern California, USA. *Forest Ecology and Management* **215**: 51-68.
- Pillai, R.B.; Weisberg, P.J. & Lingua, E. (2005)** Thirty years of woodland expansion in central Nevada Great Basin: a case study of the Simpson Park Range. *Proceedings of the 20<sup>th</sup> Biennial Workshop on Aerial Photography, Videography, and High Resolution Digital Imagery for Resource Assessment*. Weslaco, TX. [CD]
- Weisberg, P.J.; Lingua, E. & Pillai, R.B. (in press)** Spatial patterns of pinyon-juniper woodland expansion in central Nevada, USA. *Range Ecology and Management* In press.

## Land abandonment in Hungary and its effects on birds

J. Verhulst<sup>1</sup>, A. Báldi<sup>2</sup>

<sup>1</sup>Nature Conservation and Plant Ecology Group, Wageningen University. Bornsesteeg 69, 6708 PD Wageningen, The Netherlands.

e-mail Jort.Verhulst@wur.nl

<sup>2</sup>Animal Ecology Research Group, HAS, Hungarian Natural History Museum Ludovika tér 2 Budapest, Hungary, H-1083.

### Introduction

Land abandonment of extensively used farmland is a major threat to biodiversity in central and eastern European countries (Donald *et al.*, 2002; Verhulst *et al.*, 2004). Approximately 15-20% of the Hungarian farmland is affected. Over 50% of the Hungarian important bird areas are affected by land abandonment, which even exceeds the percentage that is affected by intensification (BirdLife, 2000). Large areas were abandoned during the transition in the last decade due to changes such as privatisation. As a result, livestock numbers have dropped over 50%, due to extremely low profitability (FAOSTAT, 2002; European Environmental Agency, 2004). Therefore, grasslands are affected worse than arable land. Accession to the EU is expected to further encourage abandonment, as it has done so in other EU countries (Bignal, 1998).

### Goal

We aimed to assess the effects of land abandonment on farmland birds in Hungary. We monitored breeding birds in abandoned grasslands and vineyards and compared these with extensively and intensively used ones.

### Methods

We used the point count method to determine bird species density. A small part of the huge extensive grassland at Kunpezér (Central-Hungary) was unmanaged for 20 years. Abandoned vineyards at Tokaj (Eastern-Hungary) were unmanaged for at least ten years. Some abandoned vineyards were overgrown with grasses and bushes, others were more heterogeneous and contained small managed parts. The censuses were conducted in 2002.

### Results & discussion

Table 1 shows a selection of species that benefited or suffered from the cessation of management and species that had higher densities on abandoned fields as compared to intensive ones.

In the grasslands, several species benefited from abandonment. Many of them were exclusively found in the abandoned grassland. These are species that generally benefit from wood encroachment which provides them with perches, nesting opportunities etc. The presence of bushes reduced the density of the grassland passerines yellow wagtail *Motacilla flava* and winchat *Saxicola rubetra* but these species preferred abandonment over intensification. On the contrary, skylark *Alauda arvensis* did prefer management, which prevented encroachment by bushes.

Several species rare in managed vineyards occurred in high densities in abandoned ones. Most again were species typical of bushy vegetations. Skylarks were present in former vineyards that were now being grazed and hardly contained bushes. Red-backed shrike *Lanius collurio* and blackbird *Turdus merula* seemed to suffer from intensification, not from abandonment, but song thrush *Turdus philomelos* did seem to suffer from abandonment although to a lesser extend than from intensification. Finally, in the vineyards several species

seemed to suffer from the cessation of management. Partly this was caused by species nesting in buildings and partly by seed-eaters that found their food on sparsely vegetated soils which did not occur in abandoned vineyards.

## Conclusion

Our results show that farmland abandoned for 10-20 years supports rich bird faunas. However, some farmland specialists such as skylark and tree sparrow *Passer montanus* are negatively affected by abandonment already within this short time frame. Even though high densities of some declining farmland birds like corn bunting *Miliaria calandra* and stonechat *Saxicola torquata* are found on abandoned farmlands, we can assume this is only a temporarily situation. As afforestation proceeds, these non-woodland species will further decline and disappear. Therefore, abandonment of extensively used farmland should be prevented in order to maintain the huge farmland bird populations of central and eastern Europe.

**Table 1.** Density of most common bird species per habitat type in individuals per 100 ha. A: Abandoned; E: Extensive; I: Intensive farmland.

	Grasslands	A	E	I	Vineyards	A	E	I
	N	4	23	24		12	22	22
<u>Benefit from abandonment</u>	Stonechat	48	0	0	Skylark	16	1	9
	Red-backed shrike	48	1	0	Stonechat	19	4	4
	Greenfinch	40	0	0	Barred warbler	34	4	0
	Linnet	48	0	0	Corn bunting	40	3	1
	Corn bunting	119	21	9	Yellowhammer	16	6	1
<u>Better than intensification</u>	Yellow wagtail	40	83	9	Red-backed shrike	29	32	12
	Winchat	32	47	19	Blackbird	21	20	3
					Song thrush	11	22	3
<u>Suffer from abandonment</u>	Skylark	8	101	70	Black redstart	3	16	3
					Tree sparrow	5	107	26
					Serin	19	58	32
					Linnet	37	46	81

## References

- Signal, E.M. (1998)** Using an ecological understanding of farmland to reconcile nature conservation requirements, EU agricultural policy and world trade agreements. *Journal of Applied Ecology* **35**: 949-954.
- BirdLife International (2000)** *Important Bird Areas in Europe: Priority Sites for Conservation*, BirdLife International, Cambridge.
- Donald, P.F., Pisano, G., Rayment, M.D. & Pain, D.J. (2002)** The Common Agricultural Policy, EU enlargement and the conservation of Europe's farmland birds. *Agriculture, Ecosystems & Environment* **89**: 167-182.
- European Environmental Agency (2004)** *Agriculture and the environment in the EU accession countries. Implications of applying the EU common agricultural policy*, Environmental issue report no 37, Copenhagen.
- FAOSTAT (2002)** *Database of the UN Food and Agriculture Organization*, FAO, Rome.
- Verhulst, J., Báldi, A. & Kleijn, D. (2004)** Relationship between land-use intensity and species richness and abundance of birds in Hungary. *Agriculture, Ecosystems & Environment* **104**: 465 - 473.

## High resolution modelling of the spatial distribution of land abandonment in Europe under various scenario conditions

K.P. Overmars<sup>1</sup>, M.M. Bakker<sup>1</sup>, P.H. Verburg<sup>1</sup>

<sup>1</sup> Soil Inventory and Land evaluation group (SIL), Wageningen University, PO Box 47, Wageningen, The Netherlands, e-mail: Koen.Overmars@wur.nl

### Introduction and methodology

Land use in Europe will face significant changes in the coming decades due to changes in demography, world economy and changing policies of the European Union (e.g. Bouma et al. 1998). One of the major changes foreseen is the large scale abandonment of agricultural area due to contraction of agriculture. This development has major consequences for the landscape and its functions and therefore for society. In order to make projections of the future land use map and analyze the consequences of land use changes a consortium of modellers developed a chain of models to study land use change in Europe in a comprehensive manner (Klijn et al. 2005, Verburg et al. 2006). This modelling chain includes scenario study, macro-economic modelling, global environmental modelling and high resolution land use modelling. To model succession of the abandoned areas the land use model is complemented with modelling of vegetation growth.

.....The focus of this paper is to study the allocation of land use in general and abandonment of agricultural land in particular for the whole of Europe at 1 km resolution. The allocation of land use changes is projected for a number of scenarios, which are different in their world views and policy options. Land use modelling is carried out with a spatially explicit land use model (Verburg et al. 2002) that allocates land use demands at country level on maps with a 1 km resolution based on biophysical and socio-economic suitability and a set of conversion rules.

### Results and discussion

Table 1 shows the percentage of agricultural abandonment as percentage of all land in the EU27 for four scenarios. The two most extreme cases vary by a factor three. However, these figures can only give a very general picture of the trend in Europe. Detailed results on 1 km resolution show that the locations where agricultural abandonment occurs show a wide spatial variety (an example is in Figure 1). Different spatial policies, for example support to farmers under the LFA (Least Favoured Areas) policy, have a significant impact on the spatial distribution of land abandonment. So, even when the total area of land abandonment is the same, as is the case for the Global Cooperation and Regional Communities scenarios, the impact of land abandonment on landscape functions such as biodiversity and the liveability of rural areas can be different due to the spatial distribution of this abandonment.

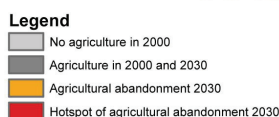
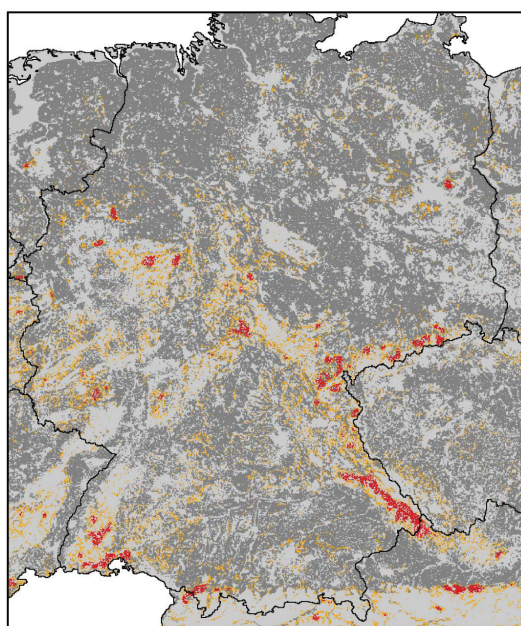
It is important to realise that agricultural land abandonment can occur because of less demand for agricultural land as calculated by the macro-economic model, but can also be caused by shifts of agricultural land to other locations. The paper discusses these various land use conversions in detail.

After agricultural land use is abandoned the land use changed to another set of functions. One of the developments incorporated in the model is succession to natural vegetation. However, abandoned land can also have extensive functions that are either agriculture of nature. These functions are for example horse keeping, hobby farming or land kept as a speculation object. These functions are mainly in area that are denser populated. These effects are incorporated in the model and discussed in this paper.

The presented approach has successfully integrated different scales that are necessary to do a proper land use analysis at European level. Land abandonment is one of the most important land use changes and has a large impact on landscape and society.

**Table 1.** Percentage of agricultural abandonment for four scenarios for the EU 27

Scenario	Agricultural abandonment (% of total land in EU27)
Global Economy	4.32
Continental Markets	1.83
Global Cooperation	5.58
Regional Communities	5.25



**Figure 1.** Hotspots of agricultural abandonment in 2030 for Germany in the Global Economy scenario

## References

- Bouma, J., Varallyay G. & Batjes N.H. (1998)** Principal land use changes anticipated in Europe. *Agriculture, Ecosystems & Environment* **67 (2)**: 103-119.
- Klijn, J.A., Vullings, L.A.E., Berg, M.v.d., van Meijl, H., van Lammeren, R., van Rheenen, T., Veldkamp, A., Verburg, P.H., Westhoek, H., Eickhout, B. & Tabeau, A. (2005)** *The EURURALIS study: technical document*. Alterra-rapport 1196, Alterra, Wageningen.
- Verburg, P.H., Soepboer, W., Veldkamp, A. Limpiada, R. Espaldon, V. & Sharifah Mastura S.A. (2002)** Modeling the Spatial Dynamics of Regional Land Use: the CLUE-S Model. *Environmental Management* **30(3)**: 391-405.
- Verburg, P.H., Schulp, C.J.E., Witte, N. & Veldkamp, A. (2006)** Downscaling of land use change scenarios to assess the dynamics of European landscapes. *Agriculture, Ecosystems & Environment* **114 (1)**: 39-56.

## Successional recovery of the abandoned rice field and its ecological effects in Korea

C.S. Lee

Seoul Women's University, 126 Gongneung 2-dong, Nowon-gu, Seoul, Republic of Korea,  
e-mail: leecs@swu.ac.kr

### Introduction

Rice paddy fields of temperate eastern Asia have generally increased in acreage, to meet rising demand for food. In this region, the flat and gently sloping floodplains beside rivers and streams have been traditionally used for wet rice farming. Recently, however, even in relatively populous countries such as Korea and Japan, abandoned rice paddy fields are not uncommon, particularly in less-productive upland regions. As a result of shifting economies, rural population exodus, and the development of high-yield rice varieties, a substantial number of traditional rice fields are no longer cultivated. Those abandoned rice fields are being restored to their original character through a typical successional process from herbaceous to woody vegetation. In particular, rice fields in the Korean DMZ (Demilitarized Zone), which have been abandoned for more than fifty years after the Korean War, have returned to riparian forest. This study aims 1) to clarify the processes of secondary succession on abandoned rice paddy fields, and 2) to clarify causal factors that led to the Korean DMZ being a hot spot of biodiversity in temperate zone, by comparing landscape structure and biodiversity among areas with different land use intensities.

### Results

The Korean DMZ, which has not been occupied by humans for more than fifty years since the Korean War of 1953, has recovered its natural or close-to-natural landscape. Our analysis of satellite (Landsat™) images revealed a significant conversion from bare ground and early-successional thickets to matured forests. Higher species richness and diversity of birds and mammals, including an IUCN Red List species *Nemorphaedus caudatus* (Amur goral), are an evidence of enhanced biological diversity in the DMZ. Particularly, the recovery of riparian vegetation has encouraged nest-building of such bird species as *Cinclus pallasii* (brown dipper), *Butorides striatus* (striated heron), and *Motacilla cinerea* (grey wagtail). In addition, the presence of *Prionailurus bengalensis* (Bengal cat), as a tertiary consumer, suggest a more complex food web and thus enhanced biological diversity in the DMZ.

Succession in the abandoned rice fields has progressed from herbaceous through to willow towards woody stands, which are dominated by alder. The trajectory resembles the spatial distribution pattern of vegetation that would develop from the water's edge towards the surrounding land in the riparian zone. The vegetation in the final stage was the same as the riparian vegetation, which was established in the Korean DMZ.

In Asian countries, most people live on rice. Therefore, the majority of the floodplains of rivers and streams were transformed into rice fields in the past (Lee et al. 2005). Because rice production was not enough up to the late 20 centuries, abandoned paddy fields appeared rarely (Lee et al. 2002). In recent years, however, owing to socio-economic changes and a continuing movement of people from rural to urban areas (Lee et al. 2002), inaccessible and terraced rice fields are being increasingly abandoned. Those abandoned paddy fields are likely to return to habitats comparable with their original nature through successional process. Such passive restoration could contribute to the recovery of biodiversity lost due to previous intensive use (Young 2000).

### References



**Theme7: Assessment of Landscape Changes**  
**7.1 Symposium 12: Land abandonment**

- Lee, C.S.; You, Y.H. & Robinson, G.R. (2002)** Secondary Succession and Natural Habitat Restoration in Abandoned Rice Fields of Central Korea. *Restoration Ecology* 10(2): 306~314.
- Lee, C.S.; Cho, Y.C.; Shin, H.C.; Moon, J.S.; Lee, B.C. Bae, Y.S.; Byun, H.G. & Yi, H. (2006)** Ecological response of streams in Korea under different management regimes. *Korea Water Resources Association*. 6(3): 131-147.
- Young, T.P. (2000)** Restoration ecology and conservation biology. *Biological Conservation* 92: 73-83.

**Where do all the trees come from?  
Land abandonment and forest regeneration in the Swiss Alps**

**N.E. Zimmermann<sup>1</sup>, J. Bolliger<sup>1</sup>, J. Gehrig-Fasel<sup>1</sup>, M. Gellrich<sup>2</sup>, F. Kienast<sup>1</sup>, G.N. Rutherford<sup>1</sup>**

<sup>1</sup> Swiss Federal Research Institute WSL, Land Use Dynamics, Zuercherstr. 111, CH-8903 Birmensdorf, Switzerland.

e-mail: niklaus.zimmermann@wsl.ch

<sup>2</sup> Swiss Federal Institute of Technology ETH, 8000 Zürich, Switzerland

## **Introduction**

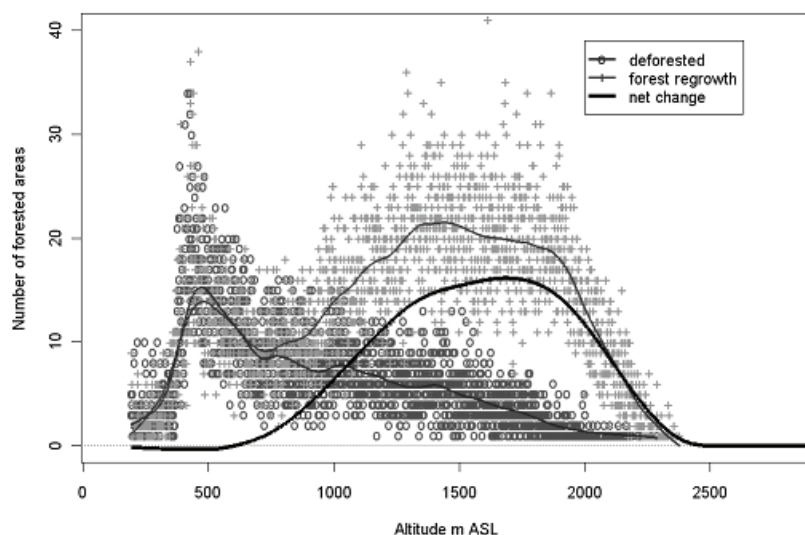
Switzerland is currently undergoing rapid land use changes. Whilst the loss of open land at the cost of sealed surfaces due to urban sprawl and other human alterations of land has been recognised since a while, comparably little attention has been given to the abandonment of agricultural land use and subsequent forest regeneration. Agricultural land abandonment reflects a decline in traditional agricultural practices that can be observed worldwide. In Western Europe particularly mountain regions are affected by such land abandonment (MacDonald et al., 2000). As a consequence, natural forest re-growth is increasingly replacing agricultural and open land in European mountains, a trend that we also observe in Switzerland (Gehrig et al. 2007, Gellrich et al. 2007, Gellrich & Zimmermann 2007; Rutherford et al. 2007).

## **Methods**

We used the repeated land use statistics of Switzerland with reference dates in 1985 and 1997. This data set consists of a 100m point grid across the whole territory of Switzerland distinguishing ca. 70 classes of land use as manually interpreted from high resolution air photos. Several grassland, agricultural and forest types are distinguished, which we recombined prior to our analyses. The reclassified repeated land use statistics were used to identify those plots that had changed from open land (grassland, agricultural) to forest classes within the 12 year interval. We then used a series of bioclimatic, topographic, socio-economic, distance and neighbourhood variables as predictors to explain the difference between those pixels that were abandoned and consequently re-grew to forest and those that remained open. We used OLS and GLM (binomial, multinomial and ordinal) and we calibrated out models at two different spatial scales (100 m grid scale and regional scale).

## **Results**

The analyses revealed no net abandonment at low elevations in Switzerland, where current land use is very intense. On the contrary, we found a considerable net abandonment of land with subsequent forest re-growth mostly between 1000 and 2000 m a.s.l. (Fig.1) Here, the area increase of forest totals to 16 ha daily, which we consider a very rapid land cover change. The major drivers identified by several modelling approaches at the 100 m grid scale can be summarized as follows. Binary land abandonment and transition models generally revealed low deviances explained and prediction accuracies ( $D^2 \sim 0.10$ ; 0.14 when spatial autocorrelation was included; AUC of 0.67 and 0.7, respectively). The major drivers identified to explain land use change were: slope, soil stoniness, distance to forest edges and to roads, and rate of change in population and in the number of farms, number of employees in the primary sector. The low model fit expresses the high stochasticity at the 100 m scale. If land abandonment was split into 5 classes from intensely used through extensively used and bushy open land to open and closed forests, then the individual transition models considerably gained in accuracy, with independently tested AUC values ranging between 0.7



**Figure 1.** Deforestation (light) and Reforestation (dark) in Switzerland between 1985 and 1997 (Gehrig et al. 2007).

predictors. In addition to this term, the number of commuters, the fraction of employees in the II and III sector, as well as the average slope per region significantly contributed to predict land abandonment at this scale.

## Discussion and Conclusions

We conclude that a combination of factors explains land abandonment in mountainous Switzerland. We see the general hypothesis confirmed that land is abandoned where the cultivation costs are high (high elevation, steep) and yield potential is low (cold, stony soils), or where better opportunities for income exist in the near neighbourhood (number of commuters and persons in the II and III sector). However, biophysical factors are more important when we distinguish finer differences in the succession after abandonment. Also, the distance to forest is a very strong predictor of the likelihood that abandonment is followed by forest regeneration, with tree re-growth almost impossible at distances beyond 300 m from a forest edge. The comparably low model performance at the plot level indicates the high degree of stochasticity of the regeneration process after land abandonment. Finally, the strong predictive power of the auto-regressive term indicates that regional differences exist irrespective of the general nature of the land abandonment process.

## References

- Gehrig-Fasel, J.; Guisan, A. & Zimmermann, N.E. (2007) Treeline shifts in the Swiss Alps: Climate Change or Land Abandonment? *Journal of Vegetation Science*, in press.
- Gellrich, M.; Baur, P.; Koch, B. & Zimmermann, N.E. (2007) Agricultural land abandonment and natural forest re-growth in the Swiss mountains: A spatially explicit economic analysis. *Agriculture, Ecosystems and Environment* 118: 93-108.
- Gellrich, M. & Zimmermann, N.E. (2007) Land abandonment in the Swiss mountains: A spatial statistical analysis at the regional scale. *Landscape and Urban Planning* 79: 65-76.
- MacDonald, D.; Crabtree, J.R.; Wiesinger, G.; Dax, T.; Stamou, N.; Fleury, P.; Lazpita, J.G.; Gibon, A. (2000) Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. *Journal of Environmental Management* 59: 47-69.
- Rutherford, G.N.; Guisan, A. & Zimmermann, N.E. (2007) Evaluating sampling strategies and logistic regression methods for modelling complex land cover changes. *Journal of Applied Ecology*, in press.

and 0.83. Here, a range of different predictors best explained these changes, which in turn express different stages of successional transition and differing rates of change.

At the regional scale, land abandonment was analyzed as the fraction of open land abandoned between 1985 and 1997, and this model performed considerably better. Pseudo- $R^2$  reached 0.77 and 0.86, depending on how a spatial autocorrelation term was added to the list of

## Secondary succession: interactions between plants and soil biota

P. Kardol<sup>1</sup>, T.M. Bezemer<sup>1,2,3</sup>, W.H. van der Putten<sup>1,2</sup>

<sup>1</sup> Netherlands Institute of Ecology (NIOO-KNAW), P.O. Box 40. Heteren, the Netherlands.  
e-mail: p.kardol@nioo.knaw.nl

<sup>2</sup> Laboratory of Nematology, Wageningen University and Research Centre, P.O. Boxes 8123, 6700 ES Wageningen, The Netherlands.

<sup>3</sup> Laboratory of Entomology, Wageningen University and Research Centre, P.O. Boxes 8031, 6700 EH Wageningen, The Netherlands.

### Introduction

A major tool for biodiversity conservation in the Netherlands is restoration of former natural ecosystems on abandoned agricultural land. On sandy soils in the Netherlands, policy makers and nature managers aim to (re)create open, low-fertile grasslands. Large areas of former production land (> 100.00 ha) are becoming available for restoration. After agricultural land abandonment, the major abiotic constraint for development of species-rich grasslands is high soil fertility. The majority of restoration projects involved measures to reduce soil fertility, such as grazing, hay making, addition of carbon substrates, or top soil removal. Also the absence of propagules of later-successional 'target' species may be a major constraint in grassland restoration. So far, nature restoration and conservation has made little use of recent studies showing that on smaller spatio-temporal scales, interactions with soil organisms and biotic plant-soil feedbacks can strongly affect plant performance and interactions within and between plants from different succession stages (Kardol et al. 2006, Kardol et al. 2007). Although there is strong potential for interdependence in rate and direction of plant and soil community development in secondary succession after abandonment of agricultural land, little is known about the relationship of plant and soil communities develop at the field scale level and whether manipulation of soil communities can be used as a tool in restoration of species-rich grasslands.

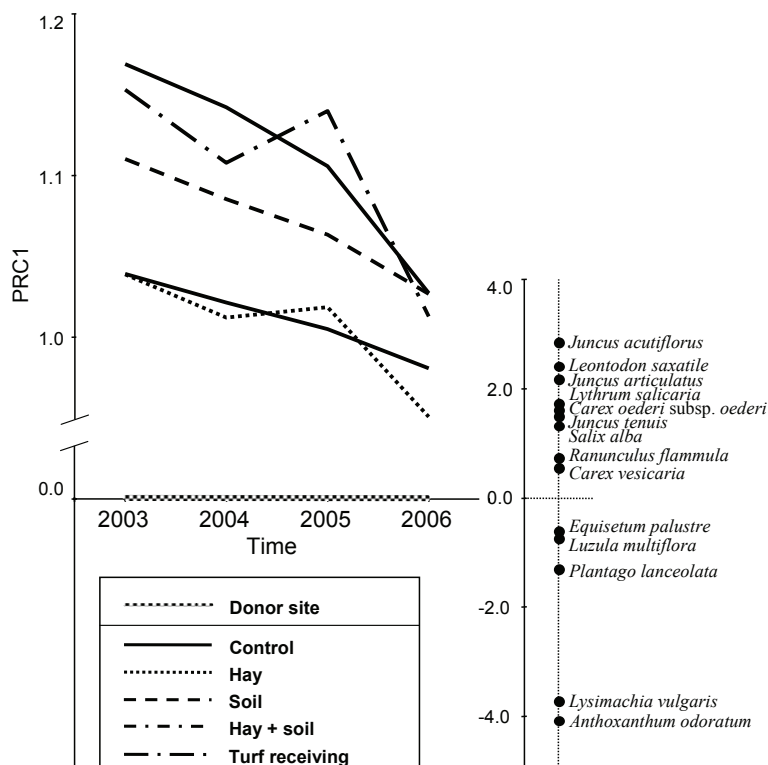
### Chronosequence

In a chronosequence of ex-arable land, we studied above-belowground community succession. In order to determine potential shifts in soil community composition and functioning, we analyzed the taxonomic and feeding group composition of the soil nematode community. Nematode populations can respond relatively fast to land abandonment and their composition has been suggested to be indicative for environmental conditions. We showed that nematode and plant communities did not develop in parallel towards the same reference system (Kardol et al. 2005), which indicates that successful restoration of plant communities does not necessarily imply successful restoration of soil communities. Moreover, in a multi-scale approach, nematodes showed different diversity patterns than soil mites, showing that developments in one group of soil organisms are not indicative of other groups. Successional changes in nematode community composition were characterized by shifts in dominance patterns and were limited by abiotic or biotic site conditions, while successional changes in mite community composition were characterized by a shift in species composition and were limited by dispersal from local species pools.

### Field experiments

We studied the potential of biotic soil manipulations in restoring species-rich grasslands on ex-arable land. First, we tested single and combined effects of soil fertility reduction (by microbial N-immobilization or top soil removal) and sowing mid-successional species. Results show that restoration of species-rich grasslands communities was constrained by

recruitment limitation rather than by soil fertility. Second, in field trial on a top-soil removed ex-arable field, we tested the hypothesis that simultaneous introduction of plant propagules and soil organisms originating from later-successional, species-rich grassland (i.e. the donor site) enhance plant species community development towards the 'target' grassland. We introduced plant propagules and soil organisms by spreading hay and/or soil, or by transplanting turfs. We could not demonstrate that later-successional soil organisms facilitate the establishment of later-successional plant species. Lack of compatibility in abiotic soil conditions between the organic donor site and the mineral receptor site could be the major reason for failure of establishment of later-successional soil organisms. Probably, after land abandonment, introduction of soil or turfs from 'mid-successional' stages may be more effective.



**Figure 1.** Principle Response Curves for hay, soil, hay + soil, and turf receiving treatments for the first RDA axis. The control was taken as the reference treatment and is represented as a horizontal line along the time axis. The vertical 1-D plot is a species weight diagram showing the relative abundance of each species compared to the reference (i.e. the control). A positive score indicates an increase in abundance, while a negative score indicates a decline. For clarity, only species with the best fit to the first ordination axis are shown.

## References

- Kardol, P., Bezemer, T.M., van der Wal, A, & van der Putten, W.H. (2005) Successional trajectories of soil nematode and plant communities in a chronosequence of ex-arable land. *Biological Conservation* **126**: 317-327.
- Kardol, P., Bezemer, T.M., & van der Putten, W.H. (2005) Temporal variation in plant-soil feedback controls succession. *Ecology Letters* **9**: 1080-1088.
- Kardol, P., Cornips, N.C., van Kempen, M.M.L., Bakx-Schotman, J.M.T. & van der Putten, W.H. (2007) Micro-mediated plant-soil feedback in pioneer stages of secondary succession causes long-lasting historical contingency effects in plant community composition. *Ecological Monographs* **77**: xxx-xxx.

## Recent secondary woodlands in a regional sample of Southern-Alpine abandoned landscapes: implications for restoration ecology and silviculture

T. Sitzia<sup>1</sup>, A. Carriero<sup>2</sup>, F. De Natale<sup>3</sup>, P. Gasparini<sup>3</sup>, A. Wolynski<sup>2</sup>, F. Viola<sup>1</sup>

<sup>1</sup> Università degli Studi di Padova, Dipartimento Territorio e Sistemi Agro forestali – Viale dell'Università 16, 35020 Legnaro (PD), Italy,  
e-mail: tommaso.sitzia@unipd.it.

<sup>2</sup> Provincia Autonoma di Trento, Servizio Foreste e Fauna – Via G.B. Trener 3, Trento, Italy.

<sup>3</sup> CRA-ISAFA – Piazza Nicolini 6, 38050 Trento, Italy.

### Introduction

Secondary woodlands are expanding throughout Europe as a result of the abandonment of farmland and the natural or artificial regeneration of forest cover. If properly managed, secondary woodlands can generate significant environmental and livelihood benefits. They can play a key role in biodiversity conservation or loss. In addition, secondary woodlands can represent a land reserve for agriculture and livestock production. Their uncontrolled expansion can lead to the loss of human heritage elements.

### Goal

With this paper we aimed at giving a brief reference of the current status and some management options for recent secondary woodlands based on a regional sample located in the South-Eastern Alps.

### Methods

The study was conducted in the Italian Province of Trento (6207 km<sup>2</sup>). In order to estimate the secondary woodland area, we adopted a two-stages sampling design. In the first stage, 100 cells were randomly selected with replacement in a 4 km regularly spaced grid according to a probability depending on an auxiliary variable; in the second stage, 100 sample points were drawn randomly within each selected cell and used to estimate the total area of the secondary woodlands by comparing the forest – no forest classification on two orthophotos taken in the years 1973 and 1999. Among the 334 points classified as no forest in 1973 and as forest in 1999, 291 (having canopy cover  $\geq 20\%$ , mean height  $\geq 2$  m, surface  $\geq 1000$  m<sup>2</sup> and width  $\geq 10$  m) were surveyed further on the ground, recording ecological, biometrical, management and landscape attributes; to 261 of them we assigned a secondary forest stand category. Where reported, the limits corresponds to 95% confidence.

### Results & discussion

The secondary woodlands covered 2.9 ( $\pm 0.6$ ) % of the entire study area. 80% of the stands developed naturally (mixed 15%, artificial 5%) and they were mostly distributed below 1200 (58%) and between 1600-1800 a.s.l. m (12%); on southern (57%) and moderately steep slopes (60%).

54% of the stands had previous existing trees, mostly spruce and larch. 59% had natural regeneration, but only in 20% it was abundant, its distribution was diffuse (72%), clumped (18%) or marginal (10%) and mainly composed of broadleaved species (ash, hazel, beech, hop hornbeam), spruce and larch.

The biometric indicators assumed values typical of early stages of colonization (Salbitano (1987): basal area  $< 20$  m<sup>2</sup> ha<sup>-1</sup>): the small trees (dbh  $< 10$  cm) had mean density of 2005 ( $\pm 418$ ) ha<sup>-1</sup> and basal area of 4.28 ( $\pm 0.76$ ) m<sup>2</sup> ha<sup>-1</sup>, while those of great trees (dbh  $\geq 10$  cm) were 473 ( $\pm 62$ ) ha<sup>-1</sup> and 13.72 ( $\pm 2.1$ ) m<sup>2</sup> ha<sup>-1</sup> respectively. As for the basal area, the prevalence of unstratified stand structures (one-storied 41%, two-storied 36%, irregular 11%

and stratified 12% stands) provided evidence that the observed standing crops were still in an early colonization stage: this could explain why, while 75% were distant from roads  $\leq$  200 m and rarely interested by phytopathologies, only 30% of the woodlands have been recently logged.

The present landscape context was mostly wooded (68%), while the 89% of previous land uses were grasslands and pastures. 60% showed evidences of the previous land use, especially terraces (36%) and boundaries (20%). Hazel groves, False Acacia and Ailanthus woods, Hop Hornbeam woods, in particular, were more frequent on terraced slopes ( $\chi^2$  test,  $p < 0.01$ ).

The spatial dynamics of the observed succession followed mainly the nucleation model (45%), then the frontal expansion 37% and its variant in the form of the completion of a constrained forest edge (18%).

The secondary forest stand categories were distributed as follows ( $n = 261$ ): mountain and high-mountain secondary Spruce woods (22%), Hazel groves (19%), Alder and other secondary woods on moist soils (11%), mountain and high-mountain secondary Larch woods (8%), Hop Hornbeam woods (6%), False Acacia and Ailanthus woods (6%), subalpine secondary woods with Spruce, Larch and Arolla Pine (6%), Blackthorn and Barberry scrubs (4%), Ash and Ash-Maple woods (4%), secondary woods with Beech (4%), Scots and black pine woods (3%), Birch woods (2%), secondary woods with Oak (1%), secondary scrubs with Mountain Pine (1%), other secondary woods (3%).

The percentage of broadleaved secondary woodlands is much more greater, especially in the regeneration layer, than the provincial one, confirming their strong reduction in favour of conifers due to silviculture since the end of XIX century (Agnoletti, 1998) and the important role of secondary woodlands in restabilising this lost aspect of the landscape. The easy accessibility would permit the logging and frequent management or the conversion to other land uses of many secondary woodlands. Their distribution and composition suggest a frequent colonization of both xerothermic (several categories) and wet habitats (Alder and other secondary woods on moist soils) with a loss of important biodiversity values such as grasslands belonging to *Festuco-Brometalia* and to *Molinietalia*, confirming that land abandon is one of the major threats on plant species included in the provincial red list (Prosser, 2001) and posing worries for animal species living on landscape mosaics in which dry and wet semi-natural grasslands and pastures play an important role (e.g. *Crex crex*). The expansion of secondary Spruce and Larch woods, especially high-mountain and subalpine and adjacent shrublands, can interfere with the habitat mosaics of endangered bird species like *Tetrao tetrix* and *Alectoris graeca*.

The Forest Service applied some management practices like conversion into previous land uses especially in public properties, but an agreement on the possible approaches still lacks. Moreover, also private estates, which are the majority of secondary stands, need attention. The management options and alternatives could be guided with reference to the cited secondary woodlands categories and their recorded attributes, also in other South-Eastern and South-Central Alpine regions.

## References

- Agnoletti, M. (1998)** *Segherie e foreste nel Trentino dal Medioevo ai giorni nostri (Sawmills and forests in Trentino from medieval times to present)*. Museo degli Usi e Costumi della Gente Trentina, San Michele all'Adige, Italy.
- Prosser, F. (2001)** *Lista Rossa della Flora del Trentino. Pteridofite e Fanerogame (Red list of the plants of Trentino. Pteridophytes and Phanerogams)*. Museo Civico, Rovereto, Italy.
- Salbitano, F. (1987)** Vegetazione forestale ed insediamento del bosco in campi abbandonati in un settore delle Prealpi Giulie (Taipana-Udine) (Forest vegetation and woodland development in abandoned fields in a district of the Prealpi Giulie (Taipana-Udine)). *Gortania* **9**: 83-144.

## A landscape level approach to integrate fire risk considerations in forest planning

J.R. González<sup>1</sup>, M. Palahí<sup>1</sup>, T. Pukkala<sup>2</sup>

<sup>1</sup>Centre Tecnològic Forestal de Catalunya. Pujada del seminari s/n, Solsona, Spain,  
e-mail: jr.gonzalez@ctfc.es

<sup>2</sup>University of Joensuu, Faculty of Forestry, P.O. Box 111, FIN-80101 Joensuu, Finland

### Introduction

During recent decades, high income levels and low demographic growth have resulted in an increasing rate of land abandonment in rural areas of Spain. Many activities previously carried out in this region, such as forestry and farming, are no longer profitable, especially in Mediterranean areas. This land abandonment has resulted in an expansion of forest area and an increase in the forest growing stock (Velez, 2002). This new situation has had important consequences in increasing the risk of forest fires as there is a clear relation between fire risk and the spatial arrangement and availability in the fuel forest (Finney and Cohen, 2003; Loehle, 2004).

In this context, landscape forest planning can play an important role in minimizing the risk of forest fires by finding spatially optimal forest landscapes. Since fire spreads in a specifically spatial manner, variables measuring the relative arrangement and connectivity of high/low risk forest stands as well as their total area are a way to measure the overall fire risk and safeness of a forest landscape. In this context, appropriate landscape metrics can make a major contribution (e.g. Palahí et al., 2004). Landscape metrics are variables that measure the sizes, shapes and connectivity of forest patches of a certain kind (McGarical and Marks, 1995). Finding the optimal combination of stand management alternatives to maximize or minimize a landscape metric requires numerical optimization techniques (Pukkala and Kangas, 1993; Palahí et al., 2004).

The present study presents an approach to alter significantly the configuration of different forest landscapes, regarding the spatial distribution of risky and non-risky forest stands. In order to achieve this goal, a stand-level fire risk model (Gonzalez et al., 2006), landscape metrics and heuristic optimisation methods have been combined in order to solve forest management planning problems in which the spatial distribution of fire risk plays an important role.

### A study case

In the following example, six different landscape metrics were analyzed as means to affect the fire risk of the landscape in numerical optimization: Mean fire Resistance (MR); Share Good-Good boundary (G-G); Share of Good-Bad boundary (G-B); Mean Difference (MD); Mean of neighborhood Minima (MMin) and Mean of neighborhood Maxima (MMax).

A planning problem was formulated to test the landscape metrics in an artificial case forest. The planning problem had two objectives, to obtain a target value for the mean fire resistance, and to maximize the value of other landscape metrics at the end of the planning period. The problem was solved using two different heuristics in order to find the optimal solution, Hero (Pukkala and Hangas, 1993) and Tabu Search (Glover and Laguna, 1993), (More information in Gonzalez et al., 2005).

The results obtained from solving the planning problem revealed that the spatial configuration of a forest landscape can be modified through forest management, and this modification can be oriented towards a specific objective using forest planning. For example,



maximize G-B, MD and Mmax, lead to highly fragmented landscapes, and lower connectivity of risky stands if compared to the other three metrics.

### **An observation for future application**

The exact effect that different landscapes configurations have on the resistance of a forest to fire is not clearly known. However, it is assumed that the location and amount of resistant forest stands in a landscape has a major effect on the spread of fire. Also, other important variables can be considered when dealing with the spread of fire across the landscape, such as topography and wind dominance (Rothermel, 1983; Agee, 1993). The inclusion of these variables, gives a new dimension to the planning problem. In this case, the specific allocation of resistant stands at sensitive locations is important in the creation of “natural fuel-breaks”. In the future, when dealing with real forest land, this aspect should be included in the planning problem if these kinds of tools are applied for long-term fire prevention.

### **References**

- Agee, J.K. (1993)** *Fire ecology of pacific northwest forest*. Island Press, Washington, D.C. USA
- Finney, M.A. & Cohen, J.D. (2003)** Expectation and evaluation of fuel management objectives. In: USDA Forest Service Proceedings, RMRS-P 29, pp. 353-366.
- Glover, F. & Laguna, M. (1993)** Tabu search. In: Reeves, C.R. (Ed). *Modern heuristic techniques for combinatorial problems*. John Wiley & Sons, Inc., New York, pp. 70-150.
- González, J.R; Palahí, M & Pukkala, T. (2005)** Integrating fire risk considerations in forest management planning in Spain– a landscape level perspective. *Landscape Ecology* **20 (8)**: 957-970.
- González, J.R.; Palahí, M.; Trasobares, A. & Pukkala, T. (2006)** A fire probability model for forest stands in Catalonia (north-east Spain). *Annals of Forest Science* **63**: 169-176.
- Loehle, C. (2004)** Applying landscape principles to FIRE hazard reduction. *Forest Ecology and Management* **198**: 261-267.
- McGarical, K. & Marks, B.J. (1995)** FRAGSTATS: Spatial pattern analyses program for quantifying landscape structure. USDA Forest Service, PNW, General Technical Report 351. 122pp.
- Palahí, M; Pukkala, T; Pascual, L. & Trasobares, A. (2003)** Examining alternative landscape metrics in ecological forest landscape planning: a case for capercaillie in Catalonia. *Investigaciones Agrarias: Sistemas de Recursos Forestales* **13 (3)**: 527-538.
- Pukkala, T. & Kangas, J. (1993)** A heuristic optimization method for forest planning and decision making. *Scandinavian Journal of Forest Research* **8**: 560-570.
- Rothermel, R.C. (1983)** How to predict the spread and intensity of forest and range fires. USDA Forest Service General Technical Report INT 143. USDA Forest Service Intermountain Rangeland Experimental Station, Ogden, UT.
- Vélez, R. (2002)** Causes of forest fires in the Mediterranean Basin. *EFI Proceedings* **45**: 35-42.

## Forestry and environmental changes of Jebel Ed Dair area Kordofan region, Sudan

N. Dawelbait

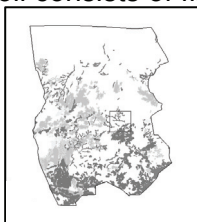
National Center for Research, Sudan, P.O.Box: 10744 Khartoum, Sudan  
e-mail: nagla.dawelbait@gmail.com

### Introduction

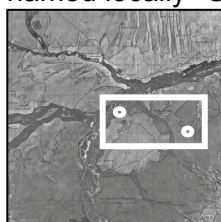
Sudan covers 237,600 thousand ha. More than 50% of the total land area is covered by forests and range lands, with about 121 million head of sheep, camels and cows, Nile, petrol and the mineral resources. Nevertheless the country is considered as one of the world's poorest, the GDP/Capita is only 459 US\$ (UNSTAT, 2003). Famine, 1984, and instability of a civil war in the southern part for 21 years until 2003 (CIA, 2004) then at Darfur region in the western part of the country were noted. Statistical information is often insufficient to evaluate the land use changes. Beside the large variation in the natural vegetation in Sudan it is recognized as an area of environmental deterioration (Agnew and Chappel, 1999). Eklundh and Olsson (2003) indicated that the amount of the vegetation in Sudan and other Sahel region is increasing. The latest estimation for the land cover categories and the change rate in Sudan are reported by Dawelbait *et al* (2006). This paper investigates the changes in Kordofan and examines the tree species in the studied area during the last 30 years.

### Study area

The study area is located in Kordofan region in western Sudan (Figure 1). Two sample points for ground survey were selected one in Khawr Sukhayran and the other in As Sidra village. The interviews were made during the years 2005/2006 with forest officers and local population. The precipitation (100-350 mm/ year) is concentrated in summer months (Hulme, 2001) with longer duration in the south (1985). The soil in the northern part, named locally "Qos", consists of sandy sheets and dunes that are stabilized by vegetation. In the south the soil consists of fine grained silty clay named locally "Gardud".



Source: Dawelbait *et al* 2006  
□ Study area



Source: Forest National Corporation Sudan  
□ Study area    ⊙ selected point for interviews

Figure1.Kordofan forest cover 2000

Figure2.Gebel Ed Dair vegetation map1985

### Vegetation income and land use

The land use is a combination of pastoral grazing and rainfed cultivation. Commonly woody vegetation cover is dominated by plants that tolerate drought periods (Schmidt and Karnieli, 2000). In fact Kitir *Acacia millifera* and Tali *Acacia tortilis* are found in both southern and northern part. Hashab *Acacia senegal* is cultivated in the southern part and in wadies for its important socio-economic value for the gum arabic production and also due to the nitrogen fixation that improve soil fertility. The Hashab tree used to be protected during production years then it is cut down and rotate with crops (Khogali, 1991). Livestock used for food security and alternative income generation at possible crop or gum arabic failure periods. The crop failure refers to rainfall decline (Olsson and Ardo, 2002) and the gum arabic collection failure is due to pest infection or malfunction of local marketing policies (Gamal and Huntsinger, 1993).

### Data processing and methodology

This paper focus on the forest cover in Kordofan region as an element of comparison between vegetation maps 1985 and 2000. The latest is Kordofan forest cover map, based on the results of FAO Africover classification (Figure1), the other one is the vegetation inventory map, based on LANDSAT 5 thematic mapper (MT) (Figure2). The two selected points were compared using GIS, the Africover and the vegetation map legends and the output from the personal interviews (2005/2006) with forest officers and people.

### Results and discussions

Analyses of the land use classification based on the vegetation map of Jebel Ed Dair shows that: in the year 1985 the tree species at the study point selected in Khawr Sukhayran are Kitir and Talih; the vegetation cover in As Sidra is dominated by Kitir and Arad *Albizia amara*. According to the Africover legend codification, the analyses of Kordofan forest cover map, shows that: the vegetation cover in As Sidra area is a combination of rainfed herbaceous and sparse shrubs. This could be interpreted as a land use changing from forest with tree species to other wood land with few shrubs *i.e.* Kitir and Arad are absent, changed or decreased significantly. Also in Khawr Sukhayran the vegetation cover consists of rainfed herbaceous and cereal crops with sparse shrubs. The shrubs could be Kitir or Talih trees but they are "sparse" *i.e.* forest cover change, it is considered as other wooded land (Dawelbait *et al*, 2006). This could be caused by drought period, displacement or shifting cultivation. According to the interviews no Arad species is available in As Sidra area In both studied point areas Oshar *Calotropis procera* is available. Spreading of Oshar usually appears on degraded soils. Presence of other forest species that increases forest cover is reported. This can be explained by the decrease of the wood for energy and the new forest plantation projects for drought, water catchments or gum arabic production (A.Rahim, 2006).

### Conclusions

In both studied points the forest vegetation cover was decreasing and the land is changing. Personal interviews however confirmed partially the vegetation increasing. Although the satellite images are useful for developing countries, periodic inventories and ground trothing is critical for reliable evaluation of land use changes in Sudan.

### References

- A.Rahim (2006)**. Economic analysis of deforestation: the case of the gum arabic belt in Sudan. Wageningen University dissertation. November, 2006.
- CIA (2004)** *World fact book, Sudan*. Downloaded 2004-07-01: [www.cia.gov](http://www.cia.gov)
- Eklundh & Olsson (2003)** In: Herrmann S., Anyamba A. & Tucker C. (2005). Recent trends in vegetation dynamics in the African Sahel and their relationship to climate. [www.sciencedirect.com](http://www.sciencedirect.com)
- FAO (2006)** Estimating forest cover and forest cover change in Sudan, by Dawelbait N. et al, Forest Resources Assessment Working paper 109. . Forest Resources Development Service, Forest Resources Division. FAO, Rome (in Press).
- Gamal A. & Huntsinger L. (1993)** Deterioration of a sustainable agro-silvo-pastoral system in the Sudan: the gum gardens of Kordofan. *Agroforestry systems Journal* 23: 23-38.
- Hulme, M. (2001)** Climatic perspectives on Sahelian desiccation 1973-1998 *Global Environmental Change* 11: 19-29.
- Khogali, M. (1991)** Famine, Desertification and Vulnerable Populations: the Case of Umm Ruwaba District, Kordofan Region; Sudan. *Ambio* 20: 204-206.
- Olsson, L. & Ardö, J. (2002)** Soil carbon sequestration in degraded semi-arid agro ecosystems-perils and potentials. *Ambio* 31: 471-477.
- Schmidt, H. & Karnieli, A. (2000)** Remote sensing of the seasonal variability of vegetation in a semi-arid environment. *Journal of Arid Environments* 45: 43-59.
- UNSTAT (2003)** United Nations Statistics Division: <http://unstats.un.org>

## Effects of land abandonment and restoration on plant species richness in Scandinavian rural landscapes

R. Lindborg

Department of Systems Ecology, Stockholm University, 106 91 Stockholm, Sweden  
e-mail: regina@ecology.su.se

### Introduction

Land use change during the last century has completely altered the traditional rural landscape in Scandinavia. Small-scale farming has been replaced by intensified and specialized agriculture; but an even larger problem is the negative effect of land abandonment on species diversity (Eriksson *et al.*, 2002). In contrast to many other human-dominated environments, semi-natural grasslands (pastures and meadows) in rural landscapes have remarkably high small-scale species richness. A prerequisite for keeping this richness is to continue managing by grazing or mowing. Reduced management of semi-natural grasslands, leading to encroachment of trees and shrubs, is considered to be the main cause of declining biodiversity in agricultural areas (Lindborg and Eriksson, 2004a). As these species rich habitats have decreased both in size and number, the remaining habitats suffer from deterioration and fragmentation.

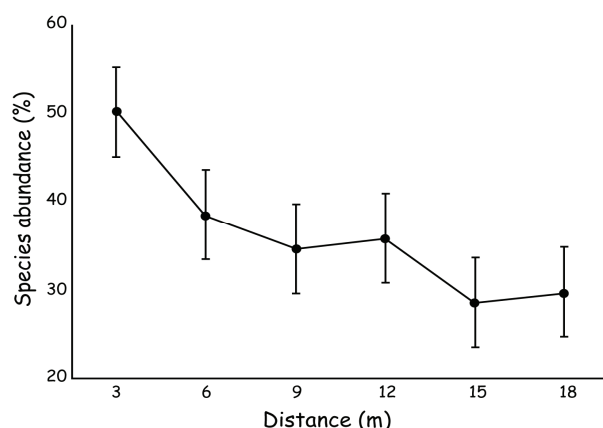
### Restoration

#### *Local perspective*

To counteract the negative effect of abandonment and prevent local species extinctions, restoration of grassland habitats has increased during the last decades. Restoration of abandoned grasslands are often carried out by cutting trees and shrubs, and by the use of fire; followed by reinstating livestock grazing or mowing. It is also common that new grasslands are created on former arable fields. Studies made to evaluate the outcome of grassland restorations suggest that plant species richness increase with time since restoration, and already ten years after restoration the plant community is partly recovered (Tikka *et al.*, 2001; Lindborg and Eriksson, 2004a). However, traditional species composition, including rare short-lived species, takes longer time to restore. A complete clear-cut of trees and shrubs disfavors many grassland species. Thus, leaving a few trees and shrubs to create a mosaic of different successional stages, where a range of more or less grazing-tolerant species may co-occur, will protect plants from heavy grazing and trampling. To increase the establishment of declining grassland species, seed-sowing is frequently discussed as a conservation tool (e.g. Walker *et al.*, 2004). Studies show that artificial seed-sowing may help recreating typical grassland communities and improve local conditions (e.g. Lindborg, 2006)

#### *Landscape perspective*

So far, conservation and restoration efforts have focused on single species-rich grasslands, without considering the effects of the surrounding landscape. To counteract isolation, small remnant habitats, for example road verges, field margins and midfield islets, have been suggested as important for plant species diversity and conservation as they may function as refugias in fragmented landscapes (Smart *et al.*, 2002). Such refugias are also important for restoration success (Cousins and Lindborg, ms), hence they may function as a source for the colonization of grassland species into restored grasslands and former arable fields (Fig.1). A time-lag in response of plant diversity to landscape structure has also been found. When analysing restored semi-natural grasslands in Sweden, species diversity was not related to current grassland connectivity of a restored site, whereas high historical grassland connectivity had a positive effect on present species richness (Lindborg and Eriksson, 2004b).



**Figure 1.** Abundance of grassland species (%) in grazed former arable fields in transects ranging from the refugia into the grazed field.

### Conclusion

Both local and regional processes are important to consider in grassland restoration. In short-term, it is crucial to consider local factors such as light, nutrient levels and management, to succeed in restoration. However, to maintain or build up grassland plant communities in a long-term perspective and to enhance dispersal, it is not enough to focus at local habitat quality only. If both current and historical landscape configuration together with local aspects is considered in restoration planning, maintenance of grassland species diversity at a larger landscape scale may also be enhanced.

### References

- Cousins, S.A.O. & Lindborg, R. (2006)** Midfield islets function as source communities for plant diversification of grazed fields. Submitted ms.
- Eriksson, O., Cousins, S.A.O. & Bruun, H.-H. (2002)** Land-use history and fragmentation of traditionally managed grasslands in Scandinavia. *Journal of Vegetation Science* **13**: 743-748.
- Lindborg, R. (2006)** Recreating grasslands in Swedish rural landscapes - effects of seed sowing and management history. *Biodiversity and Conservation* **15**: 957-969.
- Lindborg, R. & Eriksson, O. (2004a)** Effects of restoration on plant species richness and composition in Scandinavian semi-natural grasslands. *Restoration Ecology* **12**: 318-326.
- Lindborg, R. & Eriksson, O. (2004b)** Historical landscape connectivity affects present plant species diversity. *Ecology* **85**: 1840-1845.
- Smart, S.M., Bunce, R.G.H., Firbank, L.G. & Coward, P. (2002)** Do field boundaries act as refugia for grassland plant species diversity in intensively managed agricultural landscapes in Britain? *Agriculture, Ecosystems and Environment* **91**: 73-87.
- Tikka, P. M., Heikkilä, T., Heiskanen, M. & Kuitunen, M. (2001)** The role of competition and rarity in restoration of a dry grassland in Finland. *Applied Vegetation Science* **4**: 139-146.
- Walker, K.J., Stevens, P.A., Stevens, D.P., Owen Mountford, J., Manchester, S.J. & Pywell, R.F. (2004)** The restoration and re-creation of species-rich lowland grassland on land formerly managed for intensive agriculture in the UK. *Biological Conservation* **119**: 1-18.

## 7.2 Symposium 13: Identification, assessment and management of landscape changes

### In search for explanatory factors of land use change: An interdisciplinary approach in a case study area in Southern Portugal

A.M. van Doorn<sup>1</sup>, M.M. Bakker<sup>2</sup>.

<sup>1</sup> Department of Biophysical and Landscape Planning, Luís Verney College, University of Évora, 7000-671 Évora, Portugal. Current address: Centrum Landschap, Alterra, Wageningen UR, PO Box 47, 6700 AA Wageningen, The Netherlands  
e-mail: anne.doorn@wur.nl

<sup>2</sup> Department of Soil Inventory and Land evaluation, Wageningen UR, 6700 AA Wageningen, The Netherlands.

#### Introduction

One of the main land use trends of the last decades in marginal agricultural areas of Mediterranean Europe is the decline of arable land (Alados et al 2004). Under the influence of economy, policy, social and physical processes that act on global, national and local level, the land use in these areas changes to less intensive uses. In this way former cultivated land converts often to shrub and forest. Such changes are often associated with the increased occurrence of wildfires (Moreira et al 2004), a decline of biodiversity (Gonzalez Bernardez 1989), and a threat to cultural historic values (Pinto Correia 1993). Since a further decline of arable land in these areas is expected (Rounsevell et al 2005) it is desirable to enhance the understanding of the process of land use change regarding arable land.

In this paper we explain the occurrence of land use changes from arable to other land use types in the period 1985-2001 in a local case-study area, by using a set of local biophysical and socio-economic factors. The influence of the individual landowner is integrated by means of a landowner typology, assuming that each type of landowner decides in a different way about his land management.

#### Materials and Methods

A good example of a region where the decline of arable land has been dramatic over the last decades is the municipality of Mértola in the province of the Alentejo in South Portugal. Within this municipality a sample area of 44 square km was chosen. Data on land cover / use were derived from aerial photographs for two years: 1985 and 2000. Four land cover / use categories were distinguished: arable land, forest plantation, montado (agro-silvo-pastoral system, Pinto Correia 1993), and matorral (Mediterranean scrub vegetation).

By comparing the land cover maps of both years, three land use changes that involved the decrease of arable land were identified: 1) Afforestation, 2) Regeneration of the montado and 3) Abandonment, leading to the establishment of *matorral*. These three changes served as the response variable in the statistical analysis. The descriptive variables concerned slope, south exposition, soil quality, distance to infrastructure and landowner type. The latter variable was based on a cluster analysis of data derived from interviews with landowners in the area and concerned four types of landowners: the retired landowner, the active landowner, the diversified landowner and the absentee landowner.

To associate land use changes with socio-economical and biophysical variables a binary logistic regression was carried out. To identify the relative importance of the biophysical and socio-economical variables three models for every land use change were tested: 1) a full model including both biophysical and socio-economical variables, 2) a model including only bio-physical variables and 3) a model including only the socio-economic variables. To assess the descriptive power of the variables, we compared the chi-square values of the three models.

#### Results

The correlation test revealed that the descriptive variables were not correlated to an extent that multi-collinearity problems would arise ( i.e. Pierson  $r < 0.20$ ) The results of the logistic regression for the three land use changes are displayed in Table 1, which shows the chi-square values for the two variable-groups (socio-economical and bio-physical) and the total model. The greater the chi-square value the stronger the land use change is associated with the set of descriptive variables. For each land use change the models including both socio-economic and biophysical descriptive variables have significant chi-square values. This also applies for the models including either the biophysical variables or only the socio-economic variables. This means that the set of descriptive variables describes well the occurrence of the changes in arable land (i.e. the hypothesis that the land use changes occur independently from the biophysical or socio-economical variables can be rejected). Furthermore, the sum of chi-squares of the socio-economic model and the bio-physical model is for each land use change higher than the chi- square of the full model. This indicates an overlap in the descriptive power of the set of bio-physical descriptive variables and the set of socio-economic variables.

**Table 1.** Results logistic regression

	biophysic almodel	socio- econ. model	total model
<b>Afforestation</b>	<b>141**</b>	<b>415**</b>	<b>507**</b>
<b>Regen. of Montado</b>	<b>39**</b>	<b>103**</b>	<b>112**</b>
<b>Abandonment</b>	<b>78**</b>	<b>58**</b>	<b>131**</b>

### Conclusion

The method of combining socio-economical and biophysical data allows for identifying the relative importance of the two groups. By comparing the model performance of three model variants (a model containing all variables; a model containing only the biophysical variables; and a model containing only the socio-economical variables) we can support or reject assumptions on whether the land use change is mainly biophysically driven or that it is more a matter of socio-economical aspects. In our case it turned out that afforestation and the regeneration of the Montado system is mainly related to socio-economical factors, whereby the landowner typology appears to determine whether or not a landowner is willing to respond to policies that favour these land use changes. Land abandonment, on the other hand, is mainly determined by biophysical characteristics, implying that most marginal land is no longer suitable for any use of the land other than extensive management such as hunting.

### References

- Alados CL, Pueyo Y, Barrantes O, Escos J, Giner L, Robles AB (2004)** Variations in landscape patterns and vegetation cover between 1957 and 1994 in a semiarid Mediterranean ecosystem. *Landscape Ecol* **19**: 543-559
- Gonzalez Bernaldez F (1990)** Ecological consequences of the abandonment of traditional land use systems in central Spain. Options Méditerranéenes, Série Séminaires Land abandonment and its role in conservation, Zaragoza, Spain, CIHEAM.
- Moreira F, Ferreira PG, Rego FC, Bunting S (2001)** Landscape changes and breeding bird assemblages in north-western Portugal: the role of fire. *Landscape Ecol* **16**: 175-187
- Pinto Correia T (1993)** Threatened landscape in Alentejo, Portugal: the 'Montado' and other 'agro-silvo-pastoral' systems. *Landscape Urban Plan* **24**: 43-48.
- Rounsevell MDA, F Ewert, et al. (2005)** Future scenarios of European agricultural land use: II. Projecting changes in cropland and grassland. *Agr Ecosyst Environ* **107**: 117-135

## Driving forces of landscape change and their implications for landscape management

A.M. Hersperger, M. Bürgi

Swiss Federal Research Institute WSL, Land Use Dynamics, Zürcherstrasse 111, 8903  
Birmensdorf, Switzerland.  
e-mail: anna.hersperger@wsl.ch

### Introduction

In the past decades, urban sprawl and agricultural intensification have enormously changed the traditional cultural landscapes in periurban areas of Switzerland. These changes were caused by specific driving forces. Many driving forces, such as for example national demographic trends, are beyond the reach of landscape management. Others, however, can be affected by policies and planning interventions. We use an analytical framework identifying five major types of driving forces: political, economical, cultural, technological, and natural driving forces (including driving forces that originate from the spatial configuration) (Bürgi et al. 2004, Schneeberger et al. online available). In order to understand the potential of planning and policy for directing future landscape change we focus this research on political driving forces.

Political driving forces are policies, plans, rules, and regulations on land use, within the governmental context (local to international level). They concern a range of topics including infrastructure, agriculture, forestry, nature protection, and development. The main objectives of this research are (1) to quantify the importance of political driving forces relative to other driving forces for landscape changes from 1930-2000, and (2) to identify the most important political driving forces.

### Study area

The study area includes the five towns Dietikon, Geroldswil, Oetwil a. d. L., Spreitenbach, and Würenlos. It is located approximately 13 km from the centre of Zurich and covers 31.6 km<sup>2</sup> with roughly 42 300 inhabitants (census 2000). In 1930, four of the five towns have been rural villages with only Dietikon having some industry. Since then, the five towns experienced tremendous change in land cover and land use. Only the forest cover remained stable due to the strong legal protection of all forested land in Switzerland. The study area, and the Swiss lowlands in general, has been subject to three main processes of landscape change: urbanization, agricultural intensification, and greening. Urbanization is characterized by an increase in the number of buildings and in transportation infrastructure. Agricultural intensification is characterized by a decline of many elements of the traditional agricultural landscape such as hedgerows and stone walls. An opposite trend, greening, describes the development in which new, ecological valuable landscape elements appear in the agricultural landscape. In all three periods, urbanization was by far the most important trend (accounting for 76% of the changes), followed by agricultural intensification (21% of the changes) and greening (8% of the changes) (Hersperger and Bürgi, in press).

### Method

First, landscape changes were documented based on a map-comparison for the three periods 1930-1956, 1957-1976, and 1977-2000. Then, a list of potentially relevant driving forces was compiled with the help of experts. The landscape changes were subsequently linked with the relevant driving forces. Finally, through aggregation, we were able to determine the importance of individual driving forces, driving forces levels and types (Hersperger and Bürgi, in press).



## Results

Overall, political driving forces contributed 25.7% to the Limmat Valley landscape changes 1930 - 2000. The contribution of political driving forces amounted to about 24% in the first two periods and increased slightly to 28% in the period 1977-2000. Great differences exist among the trends of change. For urbanization, political driving forces remained rather constant at 20% throughout the three periods (20%, 21%, 21%). For greening, political driving forces strongly increased from 19% (1930-1956) to 54% (1957-1976) and 56% (1977-2000). For agricultural intensification, political driving forces increased somewhat from 33% (1930-1956) to 39% (1957-1976) and 45% (1977-2000).

Eighteen political driving forces have been identified as relevant primary drivers for all changes 1930-2000. Of these 18, four are very important, being associated with 78% of the changes. These four are: cantonal transportation and infrastructure policy; local land use planning; national agricultural policy, cantonal agricultural policy. The cantonal and infrastructure policy was primarily affecting urbanization. Its importance was highest in the period 1957-1976. Local land use planning was exclusively associated with urbanization. It was rather unimportant in the period 1930-1956 and peaked in 1957-1976. The national as well as the cantonal agricultural policy were associated with agricultural intensification (rather stable importance throughout the entire study period) and greening (increased importance since 1957-1976).

Looking at the level of the relevant political driving forces, we see the following pattern: For the three periods and the three processes of development combined, regional driving forces were most important (48%), followed by local (30%) and national driving forces (22%). International political forces are not relevant as primary drivers.

## Discussion

Political forces clearly contributed to landscape changes in the past 70 years. However, drivers outside the governmental context (economic, cultural, technological, and natural drivers) were, together, much more important. The result confirm on one hand the skeptisists in their observation that planning and policy has limited impact in guiding land use change. On the other hand, the results point out the large impact of the four most important political driving forces. Most likely, these four most important political driving forces of the past will be crucial drivers in future. It might be a good starting point for land use planners and managers to target these driving forces in order to achieve their goals.

## References

- Bürgi, M.; Hersperger, A.M. & Schneeberger, N. (2004)** Driving forces of landscape change – current and new directions. *Landscape Ecology* 19: 857-868.
- Hersperger, A.M. & Bürgi, M. (In press)** Driving forces of landscape change 1930 – 2000 in the urbanizing Limmat Valley, Zurich Switzerland E. Women; J. Stillwell; A. Brakeman & H.J. Schulte (Eds). *Modeling Land-Use Change*. Springer, London.
- Schneeberger, N.; Bürgi M.; Hersperger A.M.; & Ewald K.C. (Online available).** Driving forces and rates of landscape change as a promising combination for landscape change research - An application on the northern fringe of the Swiss Alps. *Land Use Policy*.

## **Discrepancies in scale between stratified sampling based landscape monitoring and CORINE land cover registration.**

**G. Levin, J. Brandt, M. Olsen, E. Holmes**

Department of Environmental, Social and Spatial Change, Roskilde University, P.O. box 260,  
DK-4000 Roskilde, Denmark.  
e-mail: gplevin@ruc.dk

### **Introduction**

As recent agricultural change profoundly affects landscape patterns, a need to measure changes in agricultural landscapes exists. Important changes are the establishment and removal of small uncultivated and semi-cultural landscape elements, dynamics in field structure as well as extension and abandonment of agricultural land use. These changes are considerable, but generally characterised by small spatial scales. Detailed landscape monitoring like the Danish small biotope programme (SBMP) (Agger and Brandt, 1988; Brandt *et al.*, 2001; Levin *et al.*, 2006) is adequate to measure these changes. However, the SBMP is limited to 32 sample areas, covering < 0.4% of all agricultural land in Denmark, from which it can be difficult to generalise to the national level. The CORINE land cover (CLC) database is a covering land cover registration for 1990 and 2000 embracing all countries in the EU 25. However, the minimum mappable unit is 25 ha, which is too small to capture most changes in Danish agricultural landscapes. This paper aims at analysing relationships and discrepancies in scale between the two databases.

### **Land cover changes between 1990 and 2000**

According to the CLC registration, between 1990 and 2000 only 1.3% of the Danish land area has been subject to change in land cover. Only about 1/3 of all changes involved agricultural land. The major changes involving agricultural land use were agriculture to urban use and agriculture to forest. Changes between different kinds of agricultural land cover accounted for less than 7% of all changes.

In comparison, analyses of land cover changes within 12 sample areas in eastern Denmark show that between 1991 and 2001 more than 15% of the agricultural landscapes were subject to change in land cover. This means that the much lower spatial resolution of CLC limits the registration of most changes in Danish agricultural landscapes.

### **Separating CORINE classes with monitoring data**

For 31 sample areas, Table 1 shows how the three major CLC classes urban, agriculture and forest are characterised by the monitoring data from SBMP. The three classes clearly differ from each other in terms of area in agricultural rotation, area with tree cover and area with urban use.

The same analysis was performed for the three different agricultural classes within CORINE (lowest level), which exist within the 31 sample areas. Furthermore, a larger number of variables from the SBMP monitoring were applied. The analysis showed that the three CLC classes differ highly from each other:

- Non irrigated arable land is characterised by the largest average field size and the highest area percentage of land in rotation.
- Land with complex cultivation patterns is characterised by the highest land cover heterogeneity and the highest density of line elements, such as hedgerows, field divides and water courses.
- Agricultural land use with larger nature areas is characterised by the highest area percentage of land outside rotation and of tree cover

**Table 1.** Characteristics from landscape monitoring data from 1991 for 3 major CORINE land cover classes in 1990 within 31 sample areas in Denmark (average area percentage for CORINE classes calculated for squares of 25ha – 500m X 500m)

CORINE land cover class	% under agricultural rotation	% tree cover	% urban use and built up
Urban	21.6%	0.3%	76.3%
Agriculture	90.7%	2.6%	1.3%
Forest	14.4%	29.1%	0.3%

In spite of the very different scales, this analysis thus points at a clear relationship between the two different datasets. However, with respect to land cover changes between 1990 and 2000 only few relationships between CLC and SBMP could be found. With 12 SBMP sample areas in east Denmark land cover changes were registered for 1991 and 2001. Within these 12 areas no changes in the CLC registration appeared. However, within the two CLC classes, which exist within the 12 areas, following tendencies were observed:

- Non irrigated arable land is characterised by a larger increase in heterogeneity, an increase in mean field size and a larger decrease in land in rotation.
- Agricultural land use with larger nature areas is characterised by a slight fall in mean field size, a larger increase in tree cover and a larger increase in the density of hedgerows and field divides.

## Conclusions

The strength of the CLC registration is that it provides a total coverage for the whole EU. However, the registration is too broad to capture most relevant changes in the Danish agricultural landscape. Still, our analyses show that in spite of very different resolutions, the CLC and the SBMP databases are related to each other. We therefore propose a system, where information from other data sources, e.g. from landscape monitoring, is added to the CLC-database in the form of additional attributes to the existing CLC classes. These attributes or “tessera” specifications, add information on densities and spatial properties of different landscape elements and on indicators for spatial heterogeneity. Such system would hopefully enable the CLC-database to capture more changes in the agricultural landscape, without altering the general CLC classification system.

## References

- Agger, P. & Brandt, J. (1988)** Dynamics of small biotopes in Danish agricultural landscapes. *Landscape Ecology* 1(4): 227-240
- Brandt, J.; Holmes, E. & Agger, P. (2001)** Integrated monitoring on a landscape scale: Lessons from Denmark. G. Groom & T. Reed (Eds). *Strategic landscape monitoring for the Nordic countries – TemaNord series 523*. Nordic Council of Ministers, Copenhagen, pp. 31-41.
- Levin, G.; Brandt, J.; Olsen, M. & Holmes, E. (2006)** *Indikatorer for landskabsændringer – Analyser af komplekse landskabsændringer på baggrund af RUC’s småbiotopundersøgelser [Indicators for landscape changes – analysis of complex landscape changes based on the small biotope monitoring of Roskilde University]*. Rapport i henhold til samarbejdskontrakt mellem Roskilde Universitetscenter og Skov- og Naturstyrelsen. Department of Environmental, Social and Spatial Change, Roskilde Universitetscenter, Roskilde.

**LIFESCAPE - YOUR LANDSCAPE; implementing actions to create functional European landscapes using landscape identity as an inspiration for economic development**

**L. Jones-Walters<sup>1</sup>, R. Maessen<sup>2</sup>, P. Nowicki<sup>1</sup>, Y.R. Waarts<sup>1</sup>**

<sup>1</sup> ECNC-European Centre for Nature Conservation, Tilburg, the Netherlands.  
e-mail: waarts@ecnc.org

<sup>2</sup> Provincie Noord-Brabant, Den Bosch, the Netherlands.

## **Introduction**

The distribution of wildlife and the texture of the landscape are the product of complex interactions. The basic physical qualities of the rock, soil and climate have set the scene, but the detail has been shaped through millennia of human activity, the history of land use and management and its associated impacts. Human activities are themselves driven by economic, social, and environmental forces.

Policies which govern economic, social and environmental decisions, and actions, therefore take on great significance, and provide the basis for achieving 'Sustainable Development'. This concept is an attempt to come to grips with the interaction between economic, social and environmental forces, in a world where our ability to exploit the environment for economic gain is beginning to jeopardise our present and future well-being.

Since our decisions can have far-reaching effects on present and future generations we therefore need to look at how we can engage in regional actions to maintain and improve our contribution to both our local and global environments. There is no doubt that work at the regional level can be a powerful force in steering local agendas for environmental action, whilst providing strong links to national and international programmes.

Our objective should be to create 'functional' landscapes that deliver sustainable development through integration, rather than balance or trade off. This requires that decision makers build environmental and social criteria into the heart of their policies and programmes - so that they can be given equal weight to economic considerations at the beginning of the process. This is what is meant by integration; and contrasts with the more familiar situation, where proposals are drawn up against economic criteria alone and are only weighed against their environmental impact when they are ready to be implemented or put into place.

An essential role will therefore be played by those charged with the design and implementation of policy and programmes for forestry, agriculture, water and recreation. Farming is the major land use in most European regions and farmland therefore provides a major source of opportunity for environmental protection and enhancement. The interregional LIFESCAPE – YOUR LANDSCAPE project was set up specifically to explore, test and describe a viable strategy for the conservation of 'functional' European landscapes, through implementing twenty trans-national actions and sharing the lessons learnt between fourteen partners in five countries.

LIFESCAPE combines "livelihood" and "landscape", the individual benefits and the common good, in one concept. The LIFESCAPE approach is about using our landscape to bring people together to create added value and quality of life. Acknowledging the landscape as a source of identity and inspiration can bring people together from different sectors to join forces in order to preserve and enhance its quality.

The project in its entirety offers a way to deal with worldwide ecological challenges in our own regional context. The activities of the project touch upon many facets of society, from education to practical landscape management, and from spatial planning to farm practices.

## **Programme delivery**

Concrete activities employed in LIFESCAPE are:

- setting up branding processes for products which are produced in combination with the protection of landscapes and its biodiversity;
- school projects in which the children experience the landscape and the influence of human decisions on the landscape;
- the organization of stakeholder involvement in planning decisions;
- schemes are developed and implemented in which the provision of environmental and ecosystem services provide financial benefit throughout the supply chain; and social benefit for local communities for local communities and visitors to the project areas.

## **Outcomes**

Regional identity and social networks – rather than regional borders – are taken the frame of reference. Regional pride, responsibility, and solidarity are the driving forces that need to be mobilized. The gap that still exists between ecology and economy is bridged by strengthening the social fabric of the region.

The perceived historical and natural qualities of our landscape are used as a medium for making new contacts and cooperative actions. Through this medium, a multitude of individuals have been reached including farmers, land owners, entrepreneurs, school children and their parents, teachers, volunteer rangers and local and regional authorities.

Working trans-nationally makes a crucial difference to regional development. International contacts provide opportunities to appreciate different ways of doing things when examining the issues in one's own region, and an incentive to cooperate with stakeholders in the local community through experience of best practice. Dealing with foreign partners helps to bridge institutional borders in our own context; and that is a very important key to innovative, regional development.

LIFESCAPE helps to organise farmers to develop smart business systems that look into the dynamic between financial income, the agricultural practice and the ecological effects.

Through activities such as nature education and branding, consumer awareness of the surrounding landscape is raised, and the local economy benefits through the development of market share.

The LIFESCAPE approach has already achieved political support because of its strong community basis.

## **Conclusion**

By taking an approach that combines a level of 'top-down' leadership and direction with 'bottom-up' planning for project development, a range of exceptional results have been achieved. An element of novelty and creativity has been fostered through the opportunities provided by transnational cooperation and the exchange of knowledge and perspectives this provides.

## Simulating the sociometric analyses of landscape changes in GIS framework: An example of the selected town of Karachi metropolis

S. Qureshi<sup>1</sup>, M.H. Arsalan<sup>2</sup> and R.W. Coles<sup>3</sup>

<sup>1</sup> Department of Geography & Geology, University of Salzburg, Hellbrunnerstrasse 34, A-5020 Salzburg, Austria.

e-mail: salmanhq@gmail.com

<sup>2</sup> Department of Geography, University of Karachi, Karachi 75270, Pakistan,

<sup>3</sup> School of Architecture, University of Central England, Birmingham, United Kingdom.

### Introduction

After the implementation of new devolution plan (NRB-GOP, 2001), last six years have seen significant changes in the mega city of Karachi; both in terms of environment and landscape transition. It is generally been observed that the people belonging to the same living standard have different frames of mind and have different visions towards a common issue; satisfaction level varies from person to person and could be measured at different scales (McCall, 2001). In this paper, satisfaction level of the public has been analysed, which became more effective by the use of the state-of-the-art Geographic Information System (GIS). Visualization techniques made easy to comprehend the situation in past and present; especially the changes in between. Physical data like existing greenery, air quality and noise level have been integrated with the questionnaire data. Results indicate that, for the sustainable development in such a mega city, the public participation in decision-making should be taken into consideration.

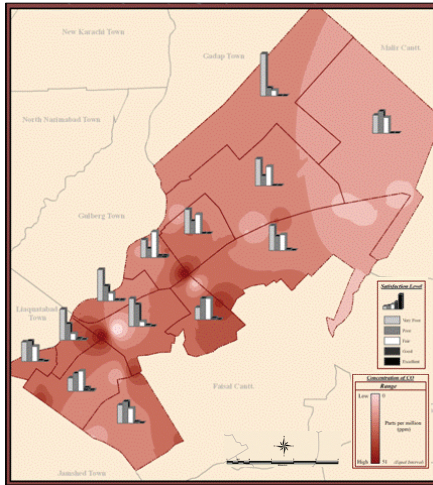
### Material and Methods

In this study, a system approach was used to analyse the situation. Gulshan Iqbal, the biggest town in terms of population (an administrative entity out of 18 towns of Karachi) has been selected as study area. Selected town covers about 53 sq. km area and provides residential land for more than 0.63 million population (GOP, 2000a) of Karachi. After review of development progress reports of the last five years, changes in urban landscape of Karachi were identified as landscape factors. It was observed that major changes have been taken place in transportation network (such as addition in roadway lanes, construction of over head bridges, development of under passes, signalisation at various intersections etc.) and urban green (such as renovation and development of parks and play ground; and plantation at road sideways and medians). Dataset for the public satisfaction have been generated through the interviews of public. Interviews of 130 dwellers have been conducted for the pre-testing of the questionnaire. After some modifications 1041 people had been interviewed; that is one percent of the total population of the selected town. During the questionnaire survey rapid appraisals of land use and development projects have conducted. However, high-resolution satellite image was also used for base mapping and estimation of vegetation cover. For an unbiased appraisal, environmental parameters (such as air pollution, noise levels and solid waste management situation in the area) were also observed to verify the public satisfaction level. Geographical Information System was designed to integrate the multi-scale data on a common platform and to analyse the situation on spatial canvas. Multi-attribute GIS modelling technique (Lo. & Yeung, 2002) was employed to compare the changes in landscape and satisfaction levels of neighbourhood dwellers.

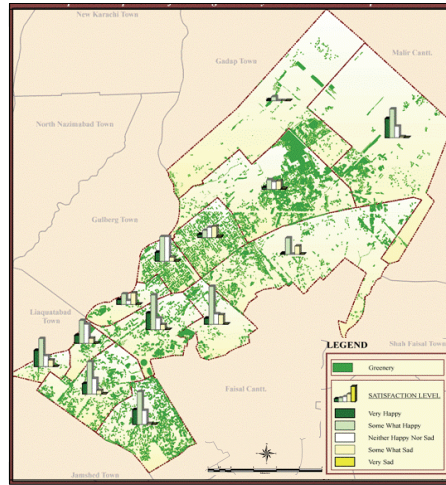
### Results and Discussion

In this paper only two variables have been selected for discussion. Questionnaire data has been integrated with the physical data. In Figure 1, the dispersal of CO has been shown and the satisfaction level of public has been overlaid using charts. A positive correlation can be observed in the public behaviour with the quality of air. Areas with maximum concentration of CO correspond to the negative reflexes of public. Public satisfaction regarding air quality reveals exactly what has been conceived from the physical evaluation of the air quality. More

than fifty percent of the population in all the Union Councils (UCs), sub-division of a town, rated the air quality as “very poor”, rest consider it “poor”.



**Figure 1.** Spatial comparison of air quality and public satisfaction for it



**Figure 2.** Spatial comparison of existing green cover and dweller's perception

From Figure 2, it can be revealed that the common public does not have any clear idea about the importance of the urban green. Only 16.3% respondents are very happy with the existing conditions of the greenery in the roadside locations. It might give a feeling of absolutely worst condition but 33.2% of the respondents replied that they are somewhat happy with the situation. It shows that approximately 50% have the positive feeling about the available greenery in the city especially the roadside locations. 29.4% respondents replied that the condition is very sad and showed unsatisfactory gestures. It depicts that still a lot of awareness is required. Difference in the opinion and ground reality can be observed in few locations but unfortunately lack of awareness – regarding urban green – makes this difference. In fact, few people want to see more roads, buildings and architecture by scarifying the open and green spaces.

### Conclusion

A glance at the statistics of city government shows that most of the areas have been modified significantly during the recent infrastructure development. A deficiency in the effective management in past, have made people to respond aggressively against the authorities. At the same time – during the rapid appraisal of the physical factors in the field – it can easily be observed that the common public is not willing to accept the recent changes. They believe in the discontinuity and instability of this process in the long run by the local government. They believe that it is not the optimum and sustainable utilization of resources. Integration of GIS with sociometric data facilitated the visualization very efficiently. Such multi-attribute GIS models can assist in decision making and spatial planning for the future.

### References

- Government of Pakistan (2000a)** District Census Report of Karachi South, Pakistan Demographic Survey 1998, Federal Bureau of Statistics, Statistics Division, Government of Pakistan, Islamabad
- Lo, C. P. & Yeung, A. K. W. (2002)** Concepts and Techniques of Geographic Information Systems, Prentice Hall, Inc., New Jersey
- McCall, C.H. (2001)** An empirical examination of the Likert scale: Some assumptions, development, and cautions, Presented at the 80th Annual CERA Conference, Embassy Suites Hotel, South Lake Tahoe, CA, USA
- National Reconstruction Bureau, Govt. of Pakistan (2001)**, The Local Government System 2001, Retrieved 1st August 2006, from URL: [http://www.nrb.gov.pk/local\\_government/default.asp](http://www.nrb.gov.pk/local_government/default.asp)

## Management of landscape changes in Slovakia

L. Miklós, Z. Izakovičová

Institute of Landscape Ecology, Slovak Academy of Sciences, Stefanikova 3, 814 99  
Bratislava, Slovak Republic,  
e-mail: Laszlo.miklos@nrsr.sk

### Introduction

In recent times the Slovak landscape has undergone many changes, which have caused new problems. Some examples are as follows: decline in economic activity, changes in agricultural structure, agricultural land abandonment, a decline in the intensity of agricultural production, negative influences of agricultural land abandonment on landscape biodiversity, abundance of synantropic species and an increasing development of agricultural land for industrial and transport construction. There have also been increases in unemployment in rural areas, emigration of people from villages to seek job opportunities and deterioration in social conditions as a result of these processes. On the other hand of urban population to the rural communities as a consequence of preferring better quality of environment. These processes are consequently appearing as well as changes in demographical structure and alterations in life style which are creating a new structure of the Slovak landscape. Many problems have appeared in relation to the accession of the Slovak Republic to the European Union. These new problems are yet to be solved.

### Theoretical-methodical approach

Many of above mentioned specific problems are included as main topics of projects within the 5th and 6th Framework Programs of EU. Let us just mention the questions of negative impacts of agricultural land abandonment on biodiversity (BIOSCENE), correlation between biodiversity and changes of landscape structure (BIOPRESS), the relations between pressures of socio-economic activities on biodiversity, the impact of different life standards, different cultures and religiousness on landscape creation, biodiversity (SOBIO, ALTERNET etc), the production of networks (BIOHAB), and the economic valuation of benefits of ecosystems in agricultural landscape (EVALWET). Since Slovakia is a country with high landscape diversity, the diverse natural, social, cultural and historical potential of this territory caused that all kinds of specific problems resulting from occupying this country by inhabitants appeared. This was one of the reasons, that the Institute of Landscape Ecology of SAS was involved to the solving of many of these EU programs. Based on the experiences the Institute Landscape Ecology SAS developed a methodology of **Integrated Landscape Management**, which is aimed at the assessment and management of landscape changes. The methodology is based on integrated research of the landscape and landscape changes in their three dimensions – environmental, social and economic. ((Miklós & Izakovičová, 1997, Mitchley, et al, 2005, Siebert et al, (2004) Sclocombe (1998 ). The main methodological question is harmonisation of the sources and potential of the landscape in a given region and the demands of society towards the development. Conflicts between resources and demand are a determining factor in the formation of environmental as well as social and economic problems. The model is oriented to solve the conflicts in spatial as well as substantive meanings. It is proposed to develop a landscape-ecological optimum spatial organisation and use of the landscape which will also improve the general quality of life and nature conservation. It will also promote the rational use of and natural resources, landscape-ecological stability and biodiversity of the territory, protection of the landscape based cultural-historical heritage, and therefore the overall protection of the environment.

The basic goals of the integrated landscape management are:

- To identify the landscape-ecological and socio-economic problems of the region



- To provide proposals for minimising these problems (choosing the least evil)
- To foresee possible new problems
- To propose an optimum spatial landscape/land-use structure which is in harmony with the natural and socio-economic conditions of the region

In this respect integrated management can be considered as the main tool for regional sustainable development.

The integrated landscape management consists of the following basic steps:

- Analyses, syntheses, interpretation and evaluation of landscape structure
- Proposals for ecologically optimal spatial organization and land-use
- Proposals for improving the ecological status of „technologies“ used in the landscape
- Application of the regulatory role of landscape-ecological optimal utilisation of the landscape to sectoral plans and documents.
- Proposals for socio-economic measurements
- Proposals for improving the ecological awareness of the inhabitants.

## **Conclusion**

The integrated landscape management method is not a single formula, rather a complex of methods arranged together for a defined region to attain a defined goal. Apart from the scientific content and development, the most important question of integrated landscape management is for its implementation in the legislation and practice of actual planning processes. It is also important in spatial/territorial/physical planning, landscape planning, in integrated management of watersheds as well as in general land-use planning.

## **References**

- Cairns, Jr. J., Crawford, T. V., Salwasser, H. (eds.)**, 1994: Implementing Integrated Environmental Management. Virginia Polytechnic Institute and State University, Blacksburg, VA. In.: SCLOCOMBE, D. S., 1998: Lessons from experience with ecosystem-based management. *Landscape and Urban Planning* 40, p. 31-39.
- Miklós, L., Izakovičová, Z.**, 1997: Landscape as geosystem. Veda Bratislava, 152 pp.
- Mitchley, J., Tzanopoulos, J., Cooper, T.**, 2005: Reconciling conservation of biodiversity with declining agricultural use in the mountains of Europe. In: TAYLOR, L., RYALL, A. (eds.): *Interdisciplinary research and management in mountain areas*. The Banff Centre Canada, p. 61-65.
- Sclocombe, D.S.**, 1998: Lessons from experience with ecosystem-based management. *Landscape and Urban Planning* 40, p. 31-39.
- Siebert, R., Artner, A., Dobrovodská, M., Grotkovská, L., Kortekaas, H.K., Imrichová, Z., Izakovičová, Z., Kenderessy, P., Kränge, O., Midgley, Moyzeová, M., Oszlányi, J., Palarie, T., Skogen, K., Sunyer, C., Szeker, K., Toogood, M., Vadineanu, A., Váľkovcová, Z.**, 2004: Mobilizing the European social research potential in support of biodiversity and ecosystem management. *International Report –Sobio*, 90 pp.
- Szaro, C. R., Sexton, W. T., Malone, Ch. R.**, 1998: The emergence of ecosystem management as a tool for meeting people's needs and sustaining ecosystems. *Landscape and Urban Planning*, 40, p. 1-7.

## **Landscape structure changes related to landscape character assessment and protection**

**Z. Lipský**

Charles University Prague, Faculty of Science, Department of Physical Geography and Geoecology, Albertov 6, Praha 2, CZ-128 43.  
e-mail: lipsky@natur.cuni.cz

### **Introduction**

The concept of landscape character assessment and protection represents one of the most frequent and topical issues in applied landscape ecology at the present both in the Czech Republic and Europe. But landscape is altering all the time and change is therefore an intrinsic factor of the existence and development of any landscape. Accordingly it is not possible to understand landscape character as something static in the practice of nature and landscape protection. This study deals especially with the change in the character of cultural landscape through abandonment.

### **Changes in cultural landscapes**

Landscape changes take place on different time scales (Zonneveld, 1995) and are of different magnitude and extent. Changes in cultural landscapes under dominant influence of the man are driving by society's demands. Anthropogenic processes are (on average) much faster in comparison with most natural processes. These fact is described in the concept of ephemeral landscape (Brassley, 1997) and transitional landscape as a continuous process of flows and changes (Björklund, 1996). We can find many examples of major and dramatic changes in landscape structure and character in the past. Some of them are perceived positively, some of them negatively from the point of view of present landscape character assessment. For example, large fish pond systems originated in Bohemia about 500 years ago changed completely the landscape structure and landscape character and created a specific type of the Czech cultural landscape in some regions. The result of this principal change is highly appreciated and protected now. On the other hand, dramatic changes in landscape structure during socialist collectivisation, especially the major simplification of landscape heterogeneity connected with a strong decrease in biodiversity, are now perceived definitely negatively from a landscape ecological point of view (Lipský, 1995).

### **Present trends in the development of European rural landscapes**

Nowadays the development of the rural landscape in Europe is characterised both by intensification and extensification. We can follow these two contrasting trends since the mid 20th century. In many cases, intensification of land use in one area causes marginalisation in other areas. Equally, the intensification and marginalisation increase the polarisation rate of rural landscapes (Jongman and Bunce, 2000). While intensification has been widely described and analysed and is evaluated negatively by landscape ecologists, biologists, landscape architects and conservationists, the process of extensification has not been evaluated consistently or uniformly.

### **Abandoned lands and new wilderness in cultural landscape**

The origin and successional development of the new wilderness on abandoned land is among characteristic features of the development of the Czech rural landscape during the last 50 years. Various vegetation formations are developing at localities not suitable for large-scale agriculture with heavy mechanisation. Steep slopes and narrow wet alluvial plains along small water bodies represent the most typical examples of this development. At the

present time, a varied mosaic of natural and seminatural communities at different successional stages from initial herbaceous ruderal vegetation and early shrub communities, reed and sedge vegetation to xeric shrubs, alder carrs and alluvial forests is functioning as a key factor increasing biodiversity and ecological stability of the landscape. These localities have become a refuge for many wild plant and animal species forced out from intensively used agricultural lands. Alluvial plains and some valleys have strengthened their significant and irreplaceable functions as important biocorridors in cultural landscape (Lipský, 1995). Table 1 shows an interesting example of two valleys in the Central Bohemia. The valleys were formerly rather intensively used for agricultural production, but in the last 60 years have become marginalised and longely massively abandoned and in 1996 was declared as one of 10 Ramsar Sites in the Czech Republic.

**Table 1.** Changes in landscape character in the valleys of the Libechovka and Psovka streams in the Central Bohemia quantitated by land use changes between 1845-2000 (total length of the valleys 25 km, area 14 sq. km) in %

Land Use Category	1845	1938	2000
Forest and shrub	48	51	70
Grasslands	13	16	15
Arable lands	25	23	3
Total agricultural lands	45	40	18

### Changes in landscape character and dilemma of nature conservation

The process of extensification and abandonment of agricultural land leads undoubtedly to essential changes in landscape character. Succession of shrub and forest communities resulting from abandoning agricultural lands have completely changed landscape features and scenery in some parts of the country. Some specific biotopes depend on long-term human activity in the landscape, like xeric grasslands and their rare species which are endangered by afforestation. These developments and different aspects of the existence of the new wilderness in cultural landscapes are now a matter of discussion among scientists, landscape planners, conservationists and stakeholders with different opinions. Whilst increases in ecological stability of the landscape, improvement of water régime and decrease in water erosion are undisputedly positive features of the development, extinction of biotope and change in landscape character are evaluated as negative. But landscape character and its protection is not possible to be considered as a static process. The present practice of the state in landscape protection, has a serious dilemma: to fight against natural succession and ecological stabilization of the landscape in the name of the protection of some species and habitats or let natural processes take their course?

#### References:

- Björklund, K. (1966)** Transitional Landscape. *Man and Nature Working Paper 83*, Odense University, Odense.
- Brassley, P. (1997)** Agricultural Technology and the Ephemeral Landscape. *Man and Nature Working Paper 94*, Odense University, Odense.
- Jongman, R. H. G. & Bunce, R. G. H. (2000)** Landscape classification, scales and biodiversity in Europe. Ü. Mander & R. H. G. Jongman (eds). *Consequences of Land Use Changes. Advances in Ecological Sciences 5*. WIT Press, Ashurst Lodge, Ashurst, Southampton, pp. 11-38,
- Lipský, Z. (1995)** The changing face of the Czech rural landscape. *Landscape and Urban Planning* 31: 39-45.
- Zonneveld, I. S. (1995)** *Land Ecology*. SPB Academic Publishing, Amsterdam.

## The geoagronomic approach to rural landscapes management: a methodological path to characterize contemporary challenges

D. Rizzo, M. Galli, T. Sabbatini, E. Bonari

Land Lab, Scuola Superiore Sant'Anna – v.S.Cecilia 3, 56127 Pisa, IT.  
e-mail: d.rizzo@sssup.it

### Introduction

Mediterranean rural landscapes are subjected, since the Sixties, to the polarization of agriculture between intensification and abandonment, with an increasing lost of productive function in several marginal areas, partly kept by hobby and part-time farmers (Pinto-Correia & Vos, 2002). Even if rural landscapes are always exposed to change by farming activities, the transformation rate of the Mediterranean ones appears much more higher than in the past, such as to cause concern about the future sustainability of the process.

Thus, the signs of change assume a significance to assess the sustainability of territorial management practices (Galli *et al.*, 2003; Benoît *et al.*, 2006) especially if we consider landscapes as a tangible expression of local knowledge in the use and conservation of resources. This is the case of the terraced landscapes, whose distinctive drainage systems are identified among the more important structuring and managing assets of hilly territories (Baldeschi, 2000; Brancucci *et al.* 2000; Galli *et al.*, 2003; UN, 2005). A novel approach to cope with the arising changes, such those regarding the management priorities, is the geoagronomy (Benoît *et al.*, 2006) that seeks, on one side, to apply and adapt the theories of production agronomy to the landscape components (e.g. the role of farming processes to explain structures and dynamics) and, on the other side, to use the geographical theories to study agronomical features (e.g. allotments and spatial configuration of farming systems).

The aim of this research is twofold: firstly to define a methodological path for the agrarian terraced landscapes characterization, evaluating their reliable conservation conditions through the geo-agronomic approach; secondly, to identify the elements of vulnerability for hillside drainage systems in a Mediterranean environment, in order to provide support for the decision-makers in the coordination of the local management actions. The study area is the SW hillside of the Monte Pisano (62 km<sup>2</sup>, 43°44' N – 10°32' E, Tuscany, Italy) chosen for its convergence between the presence of a historical terraced system and the need, manifested by the local Administrations, to face the management changes occurred during last decays.

### Material and methods

The landscape was “read” as a “system of landmarks”, where each “landmark” was meant as the spatial entity materially resuming the productive farming processes (Rizzo *et al.*, 2006). The identification and the characterization of landmarks were hinged on the geoagronomic approach, applying the wide definition of landscape (*sensu* CoE, 2000) as an interface between a productive-operational perspective of the rural territory (i.e. in terms of agricultural practices) and a perceptive conception of it (i.e. visual survey of traces – either transient and permanent – left by the practices). The research followed three steps: (1) geoagronomic characterization of the key landmarks: land cover, surface drainage works and cultivation condition on the field and their geographical context; (2) landscape state evaluation, through a multicriteria analysis based on results of step one, defining the parameters (structural and operational ones) capable to affect at the territorial scale the propensity to degradation (“fragility”) of the surface drainage works; (3) detailed evaluation of the operational needs for the drainage system conservation, through field surveys and meetings with farmers and agricultural service cooperatives.

### Results and discussions

The results of the first step are relevant to set the main landscape elements in context and then, focus on the quantitative aspect of the key agrarian landmarks. In particular, land cover shows that cultivations extend for 1,813 ha (36% of the study area); this Total Agricultural Surface (TAS) primarily consists of permanent crops (77%, chiefly olive groves), followed by arable land (12%) and other crops (3%); pastures are under 1%, whilst fallow land covers the remaining 7%. Concerning the surface drainage works, 62% of the TAS is terraced *sensu stricto* (held-up by dry-stone walls), and the rest are other kinds of terracing more fitting with the micro-topographic conditions. About the cultivation condition in the fields, abandoned area adds to 21% of TAS. By overlaying these results it is possible to observe that the 85% of olive groves (being them the 95% of the permanent crops) are on terraces s.s. and about one fifth of them are abandoned.

The second determined the relations between the spatial configuration of the above mentioned landmarks and the geographical parameters, allowing the estimation of about 32% with low fragility, 40% intermediate and 28% with a medium-high “fragility”, the latter chiefly regarding areas at high altitude with a great density of dry-stone walls per hectare, made worse by the abandonment. To each level of fragility it is possible to associate different management interventions, ranging from ordinary to extra-ordinary operations.

Finally, the results of the third step were used to prepare a handbook to support the management interventions, coping with the different priorities defined on the fragility maps.

## Conclusions

The definition, application and testing of a methodological path to study the “fragility” of a rural terraced landscape from a geoagronomic viewpoint, led the composition of a knowledge framework which can be used to identify, localize and assess the main management needs. Those needs were neither detectable nor completely understandable using the classical agronomic approaches (i.e. parcel-centred). In terms of landscape conservation, the geoagronomic approach may surely be proposed to support the operative management decisions of such complex systems, consistently with the expectations of the society and the rural policies about the externalities of the agriculture itself (e.g. maintenance of cultural values, landslide prevention, etc.) placing, for instance, the drainage system management within the agro-environmental schemes, as required in the recent developments of the Common Agricultural Policy about the services delivered by the agriculture to the community.

## References

- Baldeschi, P. (2000) *Il Chianti fiorentino, un progetto di tutela del paesaggio*. Laterza, Bari.
- Benoît, M.; Deffontaines J.-P. & Lardon S. (2006) *Acteurs et territoires locaux. Vers une géoagronomie de l'aménagement*. Éd. Inra, Paris.
- Brancucci, G.; Gherzi, A. & Ruggiero, M.E. (2000) *Paesaggi liguri a terrazze: riflessioni per una metodologia di studio*, Alinea Editrice, Firenze.
- CoE – Council of Europe (2000) European Landscape Convention, *European Treaty Series*, 176, retrieved at January 2006, from: <http://conventions.coe.int>
- Galli, M.; Pieroni, P. & Brunori, G. (2003) Un'esperienza di ricerca partecipativa per la valorizzazione degli spazi rurali nel comprensorio del Monte Pisano, *Estimo e territorio*, LXVI : 54-63.
- Pinto-Correia, T. & Vos, W.,(2002) Multifunctionality in Mediterranean landscapes, R. Jongman (Ed). *The new dimensions of European landscapes*, UR Frontis Series, Wageningen, pp. 135-164.
- Rizzo, D.; Sabbatini, T.; Galli, M. & Bonari, E. (2006) *Mediterranean landscapes characterization*. Actes du Colloque International SAGEO, ISBN 2-9526014-1-0. Strasbourg.
- UN – United Nation (2005) *Promotion of Traditional Knowledge A Compilation of UNCCD Documents and Reports from 1997 to 2003*, retrieved at march 2006, from: <http://www.unccd.int/>

## 7.3 Symposium 23: Concepts and methods of landscape change assessment

### Land-cover change and its impact on nutrient export variance

J.D. Wickham<sup>1</sup>, T.G. Wade<sup>1</sup>, K.H. Riitters<sup>2</sup> etc.

<sup>1</sup> U.S. Environmental Protection Agency (E243-05), RTP, NC 27711 USA  
e-mail: wickham.james@epa.gov

<sup>2</sup> Southern Research Station, 3041 Cornwallis Road, Research Triangle Park, NC 27709,  
USA

#### Land-cover composition, change, and nutrient export.

Conversion of natural or semi-natural vegetation to anthropogenic use is widely cited as one of the principal threats to ecosystems worldwide. One consequence of these land-cover conversions is increased input of nutrients into surface waters, which promotes eutrophication, noxious algal blooms, and other problems. Despite the pace of land-cover conversion, there is little information on its affect on nutrient export. The few modeling studies that have addressed the question have had difficulty separating the effect of land-cover change from other factors such as inter-annual variation in precipitation. Part of the reason that modeling studies have had difficulty in distinguishing the effect of land-cover change from other factors is that they have been focused on annual averages (e.g., Vuorenmaa et al. 2002). We hypothesize that the principal effect of land-cover change on nutrient export is increased inter-annual variability. A watershed's annual export of nutrients (e.g., kg/ha/yr) fluctuates more widely as natural vegetation is replaced with agriculture and urban use.

A consequence of increased inter-annual variability is greater difficulty in meeting specified nutrient export goals year after year. For example, Fisher et al. (1998) reported 10 years of total nitrogen (TN) and total phosphorus (TP) for the upper Choptank watershed (Maryland USA). The upper Choptank watershed is approximately 50% agriculture and 50% forest, and land-cover composition has changed little. There was approximately a four-fold range in TN export (3.21 – 11.5 kg/ha/yr) and approximately a three-fold range in TP (0.19 – 0.65 kg/ha/yr). Four of the ten years of TN export and two of the ten years of TP export exceeded management thresholds for the region (Linker et al. 1996).

We compiled a large dataset of TN and TP to quantify the impact of land-cover composition and change on nutrient export variance. The dataset includes about 120 sites and about 1200 observations. Most sites contain estimates of TN and TP for several years. The sites span the conterminous United States and also parts of southern Canada. Data sources include (Reckhow et al. 1980, Smith et al. 1996, Panuska and Lillie 1995, McFarland and Hauck 2001, and Groffman et al. 2004). Land-cover composition for the site (watershed) had to be homogeneous for inclusion in the dataset. The threshold for homogeneity was set to 80%. The four main land-cover classes were: forest, urban, agriculture, and range. Range included shrublands and grasslands and were mainly found in the arid and semi-arid portions of the United States.

The data were fit to three-parameter lognormal distribution by land-cover class and nutrient component. The lognormal models were then used in a Monte Carlo analysis to estimate the variance in nutrient export for mixed land-use watersheds using available land-cover data for the conterminous United States (Vogelmann et al. 2001, Homer et al. 2004). Land-cover change data were also used in a Monte Carlo analysis to quantify the relationship between land-cover change and change in the variance of nutrient export.

Preliminary results indicate that, on average, a 10% loss of forest or range results in a significant increase in TN and TP variance. However, the results were not constant across all watersheds. Much smaller losses produced significant increases in TN and TP variance when the watershed was dominated forest or range. This was consistent with our hypothesis

because watersheds dominated by natural vegetation exhibit little inter-annual variability in nutrient export, and adding even small proportions of anthropogenic land cover (urban, agriculture results in significant increases in TN and TP variance. Conversely, much larger losses of forest and range (i.e., > 10%) were required to significantly increase TN and TP variance in watersheds dominated urban or agriculture. Watersheds dominated by urban and agriculture have characteristically wide TN and TP variance; relatively small losses of the forest or range (i.e., < 10%) that remain do not significantly increase variance.

### **References**

- Alexander, R.B., Slack, J.R., Ludtke, A.S., Fitzgeralds, K.K. & Schertz, T.L. (1996)** Data from selected U.S. Geological Survey national stream water quality monitoring networks. *Water Resources Research* **34**: 2401-2405.
- Fisher T.R., Lee, K.Y., Berndt, H., Benitz, J.A., & Norton, M.M. (1998)** Hydrology and chemistry of the Choptank River basin. *Water, Air, and Soil Pollution* **105**: 387-397.
- Groffman, P.M., Law, N.L., Belt, K.T., Band, L.E., & Fisher, G.T. (2004)** Nitrogen fluxes in urban watershed ecosystems. *Ecosystems* **7**: 393-403.
- Homer, C., Huang, C., Yang, L., Wylie, B., & Coan, M. (2004)** Development of a 2001 National Land-Cover Database for the United States. *Photogrammetric Engineering & Remote Sensing* **70**: 829-840.
- Linker, L.C., Stigall, C.G., Chang, C.H., Donigian, A.S. (1996)** Aquatic accounting: Chesapeake Bay watershed model quantifies nutrient loads. **8**: 48-52
- McFarland, A.M.S. & Hauck, L.M. (2001)** Determining nutrient export coefficients and source loading uncertainty using in-stream monitoring data. *Journal of the American Water Resources Association* **37**: 223236.
- Panuska, J.C. & Lillie, R.A. (1995)** Phosphorus loadings from Wisconsin watersheds: recommended phosphorus export coefficients for agricultural and forested watersheds. *Research Management Findings, Number 38*, Bureau of Research, Wisconsin Department of Natural Resources, Madison, WI, USA.
- Reckhow, K.H., Beaulac, M.N., & Simpson, J.T. (1980)** Modeling Phosphorus Loading and Lake Response Under Uncertainty: a Manual and Compilation of Export Coefficients. **US EPA/440/5-80/011**, U.S. Environmental Protection Agency, Washington, DC.
- Vogelmann, J.E., Howard, S.M., Yang, L., Larson, C.R., Wylie, B.K., & Van Driel, N. (2001)** Completion of the 1990s national land cover data set for the conterminous United States from Landsat Thematic mapper data and ancillary data sources. *Photogrammetric Engineering & Remote Sensing* **67**: 650-662.
- Vuorenmaa, J. Rekolainen, S., Lepositö, A., Kenttämies, K., & Kauppila, P. (2002)** Losses of nitrogen and phosphorus from agricultural and forested areas in Finland during the 1980s and 1990s. *Environmental Monitoring and Assessment* **76**: 213-248.

## Concepts of landscape assessment and landscape security

F. Müller<sup>1</sup>, G. Zurlini<sup>2</sup>, K.B. Jones<sup>3</sup>

<sup>1</sup> Ecology Centre, University of Kiel, Olshausenstrasse 75, D 24118 Kiel, Germany  
e-mail: fmueller@ecology.uni-kiel.de

<sup>2</sup> Dept. of Biological and Environmental Sciences and Technologies, Landscape Ecology Laboratory, University of Lecce, Via per Monteroni, I-73100 Lecce, Italy

<sup>3</sup> U.S. Geological Survey - National Center, Mail Stop 516, 12201 Sunrise Valley Drive, Reston, Virginia 20192-0002, USA

### Introduction

Within this paper some results from the NATO CCMS Pilot Study on the “Use of Landscape Sciences for Environmental Assessment” are presented. While many of the related papers in this symposium focus on the detection of land cover and landscape pattern change, a conceptual framework to represent and compare the dynamics of socio-ecological landscapes at regional scales is described and illustrated by examples from the participating nations of the Pilot Study.

The scope of this Pilot Study was to establish a working group to exchange information about landscape science approaches useful for environmental assessment and to transfer landscape assessment technologies for use in environmental protection and security preservation. Both land use and land cover characterization and the use of landscape indicators are demonstrated for multiple geographic areas in Europe and the continental United States. The pilot study has explored the possibility of quantifying and assessing environmental condition, processes of land degradation, and subsequent impacts on natural and human resources by combining remote sensing, geographic information systems, spatial statistics, and process models with landscape ecology theory.

### Landscape security

The analytical framework has been worked out to assess landscape security which, in an *objective sense*, measures the absence of environmental threats to acquired values at the landscape scale, and which in a *subjective sense*, is related to the absence of fear that such values will be attacked. The respective values at risk are ecosystem services and ecosystem integrity. Therefore, security is strongly related to the concept of sustainability. The proposed strategy of landscape security analysis is basing upon the concepts of hierarchies, self-organization, resilience, fragility and buffer capacity.

These items are embedded in a human-environmental systems model with the following components: due to changes *in land use* structures, the *ecological landscape state* is modified, providing changes in structural and functional items of the affected ecosystems. These modifications take influence on *landscape integrity*, which is defined on the basis of ecosystem theories, i.e. representing the self-organization capacity of the respective landscapes. Those modifications are responsible for changes in the provision of *landscape services*, which potentially affect *human well-being*, thus modifying the *drivers* and motivations of decision makers and leading to a new decision process which (finally) will be responsible for a change of the land use structures again. These components, which are interrelated in a cyclic manner are influenced by several (large-scale) *contextual constraints* which result in the dynamics of the environment (e.g. climate change) as well as technology, politics or culture.

### Landscape security analysis



The sub systems of this model are investigated on the base of landscape ecological methodologies. The conceptual steps in all case study regions have been

- landscape characterization
- land cover change detection
- landscape indication
- landscape modelling and scenario execution
- landscape security assessment
- proposals for an adaptive landscape management.

### **Landscape indication**

A focal methodological step is the derivation of indicators which are able to represent a holistic view on the landscape systems' states. Besides basic indications of the economic and social situation, the representation of ecological integrity plays a major role. It is based on a small number of variables which – as an ensemble – are able to show the environmental state of an ecosystem or a landscape. The selected indicators have been chosen due to their “orientor functions”, which can be used to demonstrate the natural development of structural and functional ecosystem features. The derivation of these indicator sets is described and illustrated by some regional case studies.

### **References**

**Petrosillo, I., Müller, F., Jones, B., Kepner, W., Krauze, K., Li, B., Victorov, S. & G. Zurlini (i.p.):**  
Use of landscape sciences for the assessment of environmental security, Springer Publishers, Dordrecht

## Concepts and methods for interdisciplinary land-cover pattern assessment

K.H. Riitters<sup>1</sup>, J.D. Wickham<sup>2</sup>

<sup>1</sup>US Forest Service, Southern Research Station, 3041 Cornwallis Road, Research Triangle Park, NC 27709, USA.

e-mail: kriitters@fs.fed.us

<sup>2</sup>US Environmental Protection Agency, National Exposure Research Laboratory, E243-05, Research Triangle Park, NC 27711, USA.

### A Motivation for Interdisciplinary Assessments

Landscape pattern is a universal topic in landscape ecology, but most investigators adopt sub-disciplinary perspectives based on the detailed consequences of landscape pattern in their particular circumstances. In Levins' (1966) classic terms, that emphasis on interpreting the meaning of pattern translates to a modeling strategy that maximizes realism and precision, which can only be done at the expense of generality. Generalization or 'scaling up' is often mentioned but has not proven tractable in practice, and in fact, most pattern meta-analyses conclude that more, not less, detail is required before generalizations can be made. This counter-intuitive path through the 'onion' of landscape ecology is reducing the potential for synthesis and therefore is delaying the realization of landscape ecology as an interdisciplinary science. We suggest that the study of landscape pattern and its consequences must be interdisciplinary at first, or it will never be interdisciplinary in the end. Progress requires a Levinsian strategy for landscape pattern assessment that favors realism and generality at the expense of precision.

These considerations affect what the science has to say, or not say, about landscape patterns in the real world. In the field of land-cover pattern assessment, an abundance of data makes it easy to demonstrate that real-world landscapes are experiencing profound changes of pattern over large regions of the globe because of intensifying land use and other environmental changes. At the same time, many landscape ecologists are reluctant to 'over-interpret' those findings because the data and models are not as precise as one would like them to be. This leaves the science of landscape ecology in the somewhat surprising position of knowing a lot but saying little about such profound land-cover pattern changes. If this were astronomy instead of ecology, would we remain silent about an observed change in the chemical composition of a distant planet's atmosphere only because we could not say with much precision how any life forms are affected? When grassland or forest is lost over a large region, must we know with certainty which species dies out first before saying anything at all? After all, it is society and not the individual ecologist that controls regional land-cover patterns, and so it is relevant to ask how much precision *society* requires in a land-cover pattern assessment.

The objective of this conference presentation is to stimulate a discussion of land-cover pattern assessment protocols in support of landscape ecology as a regional, interdisciplinary science. As a point of departure, we note that since society places a value on land-cover patterns *per se*, we may consider land-cover pattern to be an endpoint (*sensu* Graham *et al.*, 1991) and are not bound to think of pattern only as independent variable that affects other things. A regional assessment of the status, causes, and future trends of land-cover patterns directly addresses a real societal concern and requires no further justification. However, that by itself does not lead to an interdisciplinary science; it merely approaches the assessment problem with a different endpoint in mind. Progress towards an interdisciplinary science requires assessment protocols that permit refining interpretations and increasing precision in the contexts of many sub-disciplines, local areas, and circumstances. In contrast to any number of highly focused, disciplinary land-cover pattern assessments, only an

**Theme7: Assessment of Landscape Changes**  
**7.3 Symposium 23: Concepts and methods of landscape change assessment**

interdisciplinary assessment can provide empirical data useful for developing or testing interdisciplinary theories of landscape ecology, which in turn will provide a much better basis for interpreting the results.

Particularly in the forest sector, land-cover pattern assessments must be interdisciplinary in order to address a diverse set of questions about wildlife habitat, recreation experience, water yield, rangeland quality, and other forest amenities in a harmonized way. In this presentation, we illustrate some concepts and methods with examples drawn from forest sector national assessments.

**References**

- Graham, R.L; Hunsaker, C.T; O'Neill, R.V. & Jackson, B.L. (1991)** Ecological risk assessment at the regional scale. *Ecological Applications* **1**: 196-206.
- Levins, R. (1966)** The strategy of model building in population biology. *American Scientist* **54**: 421-431.

## Monitoring landscape spatial patterns: morphological concepts and biodiversity related applications

P. Vogt, M.R. Freire, C. Estreguil

European Commission - DG Joint Research Centre, Institute for Environment and Sustainability, Land Management & Natural Hazards Unit, T.P.261, Via E. Fermi 1, 21020 Ispra (VA), Italy.

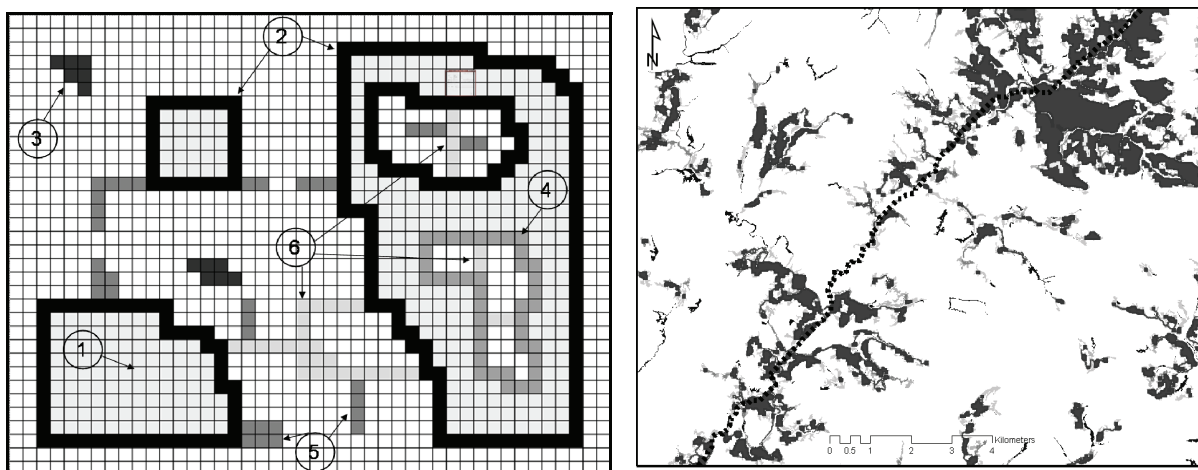
e-mail: **Error! Hyperlink reference not valid.**

### Introduction

A theoretical and application framework for monitoring the state and dynamics of forest spatial pattern is presented. Starting from a binary forest map, forested pixels are classified as “perforated”, “edge”, “patch”, “core”, “connector” and “branch”. These six spatial pattern classes contribute information related to fragmentation and structural connectivity. Fragmentation processes are related to the size and frequency distribution of core forest units, and the proportion and type of edges, perforation and patches. Structural connectivity is addressed with the amount and type of connectors and branches. Spatial pattern information is then analyzed together with movement pathways of an interior forest species to investigate the relation of structural patterns and functional behavior.

### Methods

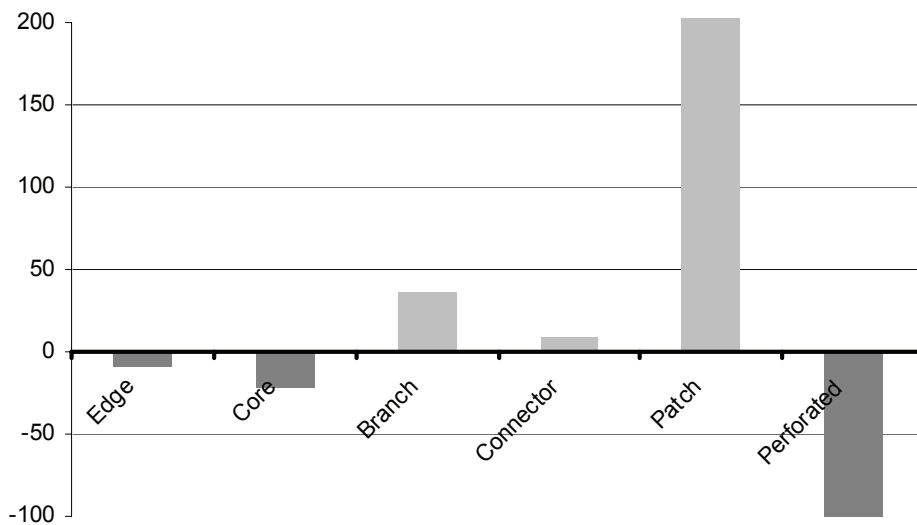
Morphological image processing routines allow for a uniform and automatic classification of binary maps from regional to continental scale. The conceptual ideas are explained in Vogt et al. (2006, 2007) and applied here to a deciduous forest – nonforest map in the Os Ancares-O Courel Natura Site in Galicia, Spain. A probabilistic movement model (Rodriguez Freire & Crecente, 2006) was used to calculate functional connectivity for the nuthatch (*Sitta europaea*) using known relationships between species movement and environmental factors given the spatial location of existing populations. From this model the least cost path was derived and the spatial pattern on it was compared to the patterns in the test site (figure 1).



**Figure 1.** Hypothetical forest showing the six classes core (1), edge (2), patch (3), perforation (4), branch (5), connector (6) (left, see Vogt et al. 2006b) and a subset of the classification result in Galicia with the least cost path overlaid (right).

### Results

The 46% of the least cost path is in forest with the mayor part being along edges (37 %), core (24 %), and branches (22 %). The relative difference of class use along the least cost path with respect to the pattern classes in the entire test site is shown in figure 2. It reveals that patches, branches and connectors are the most preferred patterns. Here, the class patch was found to provide connectivity along stepping stones. The over-proportional use of these classes indicates their importance for the functional connectivity. The class core, and their inner and outer boundaries perforation and edge, contribute less to the least cost path. In summary, these findings indicate that structural patterns provide, at least partially, functional connectivity and this information maybe of interest in the absence of data on the neighborhood matrix.



**Figure 2.** Relative difference of class use along the least cost path with respect to the pattern classes in the entire test site.

Morphological image processing allows for the objective identification and mapping of landscape pattern and structural connectivity features. The geometric nature of the method permits the efficient and unsupervised analysis for a variety of spatial scales and thematic input data. In this paper we illustrated the link between the structural patterns of forest habitat and the functional behavior. The calculation of the species-specific least cost path and its relation to the structural habitat provide valuable information for biodiversity conservation.

## References

- Rodríguez Freire, M. & Crecente, R. (2006)** Application of cost surfaces for mapping connectivity on several scales of a bird species associated with deciduous woodland, the nuthatch *Sitta europaea*. R. Laforteza & G. Sanesi (Eds). *Patterns and processes in forest landscapes, consequences of human management*. Proceedings of the 4th Meeting of IUFRO Working Party 8.01.03, Sept. 26-29, 2006. Locorotondo, Bari, Italy, pp. 513-522.
- Vogt, P.; Riitters, K.; Estreguil, C.; Kozak, J.; Wade, T.G. & Wickham, J.D. (2007)** Mapping Spatial Patterns With Morphological Image Processing. *Landscape Ecology* 22: 171-177  
Online: <http://dx.doi.org/10.1007/s10980-006-9013-2>.
- Vogt, P.; Riitters, K.; Iwanowski, M.; Estreguil, C.; Kozak, J. & Soille, P. (2006)** Mapping Landscape Corridors. *Ecological Indicators*  
Online: <http://dx.doi.org/10.1016/j.ecolind.2006.11.001>.

## Landscape Modelling and Landscape Scenarios – Challenges for Integration of Anthroposphere and Biosphere Processes

R. Seppelt

UFZ Helmholtz Centre for Environmental Research, Permoserstraße 15, Leipzig, Germany,  
e-mail: Ralf.Seppelt@ufz.de

### Introduction

The *ecosystem services* concept - as recently used by the Millennium Assessment, as well as in different other publications (such as Rounevell et al., 2006) - has had a major influence in the last years in landscape science projects. In this contribution the concept is applied, analyzed and demonstrated within different case studies, how far this concept supports solving of environmental management problems and assists in system understanding on a regional scale.

To achieve this, process modelling and simulation is known as a powerful and flexible tool to study, analyze and investigate environmental processes as well as to develop possible management strategies for environmental problems in future centuries. Both increased understanding of environmental systems, as well as management strategies and scenario development are well known methodologies supported by environmental modelling. The presentation focuses on the core questions of the identification of regional impacts due to anthropospheric management especially land use change using ecosystem of landscape services as an integrating concept between anthroposphere and biosphere processes. We focus on the questions of (i) how to specify/assess and *quantify* impacts, (ii) how to cope with *dynamics* of the system and (iii) how to derive *strategies* for managing the system.

### Objective

Spatially explicit ecosystem models allow the calculation of water and matter dynamics in a landscape as functions of spatial localization of habitat structures and matter input, see for instance (Seppelt and Voinov 2002). These process models are capable of providing the information and data of different state variables of a landscape that characterize the abiotic site conditions. Thus these parameters serve as inputs to assess habitat suitability for certain species of traits (Rudner et al. 2007). But also landscape structure – which may be considered dynamically due to land use change – is an important input variable to analyzing habitat suitability (Schröder and Seppelt 2006). *For a general analysis, we aim at assessing ecosystem functions not in a 1-dimensional or separate way.* The aim is to study changes of ecosystem services as a function of landscape structure in an integrative way incorporating the trade-offs and benefits between certain ecosystem functions or services.

### Methodology

We focus on the following ecosystem functions, which can be quantified by certain state variables, or derived from a set of state variables assumed in an ecosystem model of a given site:

- We consider basic ecosystem productivity given by the total rate of net primary production  $NPP(z)$  ( $kg/m^2$ ). This also indirectly represents the retention capability of nutrients (nitrogen) and the uptake of greenhouse gas  $CO_2$ , and has been identified as an important indicator of overall ecosystem services provided by a land use type (Seppelt & Voinov, 2003).

- Nutrient outflow out of a grid cell with horizontal flows of surface and subsurface water:  $N(z)$  (kg/m<sup>2</sup>). This can be interpreted as over consumption of retention capability of the ecosystem.
- Another variable that we would want to take into account is the amount of surface water base flow in the streams,  $QB(z)$  (m<sup>3</sup> per day) calculated as the total of the 50% of the minimal daily flow values. This identifies how land use change affects the hydrologic conditions in the area. In most cases lower base flow is associated with increased vulnerability to drought and peak flooding, which makes it an important characteristic of the landscape and the health of associated ecosystems.
- Finally land use pattern changes may also lead to an increase in suitable habitat for species, but to habitat deterioration for other species with opposing habitat requirements. To investigate the effects of land use changes on different species' habitat suitability and to allow a trade off between management objectives, we applied the concept to analyze multi-species habitat suitability depending on land use patterns (Middle-Spotted Woodpecker, Wood Lark, Red-Backed Shrike). Habitat requirements of Red-Backed Shrike contrast most to those of the other two species with respect to landscape composition and configuration (Holzkämper et al. 2006).

## Results

We showed that an analysis of the dynamic development of certain ecosystem services in a specific region necessitates a fully integrated view, that allows a quantified specification of the functional aspect of ecosystem services including an assessment of the resulting trade-offs: (i) important areas with high retention capabilities were identified and fertilizer maps were set up depending on soil properties. This shows that the interdependency of monetary assessment and ecological tradeoffs is highly nonlinear and complex and offers a useful tool for a systematic analysis of management strategies of ecosystem use. (ii) We investigate where habitat requirements oppose, where they coincide and how a landscape optimized simultaneously for all target species should be characterized. We found that all species would benefit from an increase of deciduous and coniferous forest, a decrease of cropland and grassland in the study area and more heterogeneous land use patterns (smaller patches, more diversity of land use types). However this is only a first step to come to achieve a sound and scientifically based assessment and quantification of ecosystem services.

## References

- Holzkämper, A., A. Lausch, R. Seppelt (2006).** Optimizing landscape configuration to enhance habitat suitability for species with contrasting habitat requirements. *Ecological Modelling*. 198: 277-292
- Rounsevell, M. D. A., I. Reginster, et al. (2006).** "A coherent set of future land use change scenarios for Europe." *Agriculture, Ecosystems and Environment* **114**: 57-68.
- Schröder, B., R. Seppelt (2006).** "Analysis of pattern–process interactions based on landscape models - Overview, general concepts, and methodological issues." *Ecological Modelling* **199**: 505-516.
- Seppelt, R., A. Voinov (2002).** "Optimization methodology for land use patterns using spatially explicit landscape models." *Ecological Modelling* **151**(2-3): 125-142.
- Seppelt, R., A. Voinov (2003).** "Optimization methodology for land use patterns - evaluation based on multiscale habitat pattern comparison." *Ecological Modelling* **168**(3): 217-231.

### Indicators for Multifunctionality Impacts in Landscapes

H. Wiggering<sup>1,2</sup>, C. Dalchow<sup>1</sup>, M. Glemnitz<sup>1</sup>, K. Helming<sup>1</sup>, K. Müller<sup>1,3</sup>, A. Schultz<sup>4</sup>, U. Stachow<sup>1</sup>, P. Zander<sup>1</sup>

<sup>1</sup>Leibniz-Centre for Agricultural Landscape Research (ZALF), Eberswalder Str. 84, D-15374 Müncheberg (DE).

e-mail: wiggering@zalf.de,

<sup>2</sup>University of Potsdam, Institute of Geoecology (DE), <sup>3</sup>Humboldt-University of Berlin, Faculty of Agriculture and Horticulture (DE), <sup>4</sup>University of Applied Science Eberswalde, Faculty of Forestry (DE)

### Multifunctional agriculture and landscape sustainability

Global change, in particular the globalisation of markets, the changing political and economic market conditions as well as employment and structural change have rapidly altered the use of rural areas. Specialisation in production systems and intensification of natural landscape resources exploitation are the consequences of this development. The visible socio-economic and ecological effects of such developments are, for example: the decrease of native plant and animal species, biological degradation and diversity decrease, increasing mono-cultures in plant production and high yielding cattle in livestock production, falling ground water levels and an increasing load on the regional water regime, a greater pollution impact on ecological systems as well as the progressive compaction, erosion, salinisation and desertification of soils. On the other hand, it is observed that in connection with changing political and economic basic conditions the production of non marketable goods including regenerating raw materials for the material and energy utilisation, wind energy and biogas production are important. In addition, landscape conservation and cultural, scenery and educational values of landscapes move increasingly into focus. If one succeeds in developing innovative integrated systems for landscape use which take into account site specific potential and carrying capacity in an optimal way oriented towards the concept of sustainable land development together with the local decision makers, than and by using new science based instruments as well as readily available technologies, new future optims may emerge. The ways there are various, complex and associated with many risks.

Thus, sustainable land use is considered to be intrinsically linked to the concept of multi-functionality. The rationale addresses the interdependence of social, economic, and environmental effects of land use, taking into account commodities and both negative and positive externalities. Land and the rural environment provides a variety of "functions" or "goods and services", covering production, regulation, habitat and information. Multi-functionality therefore is a key feature for implementing sustainable land development.

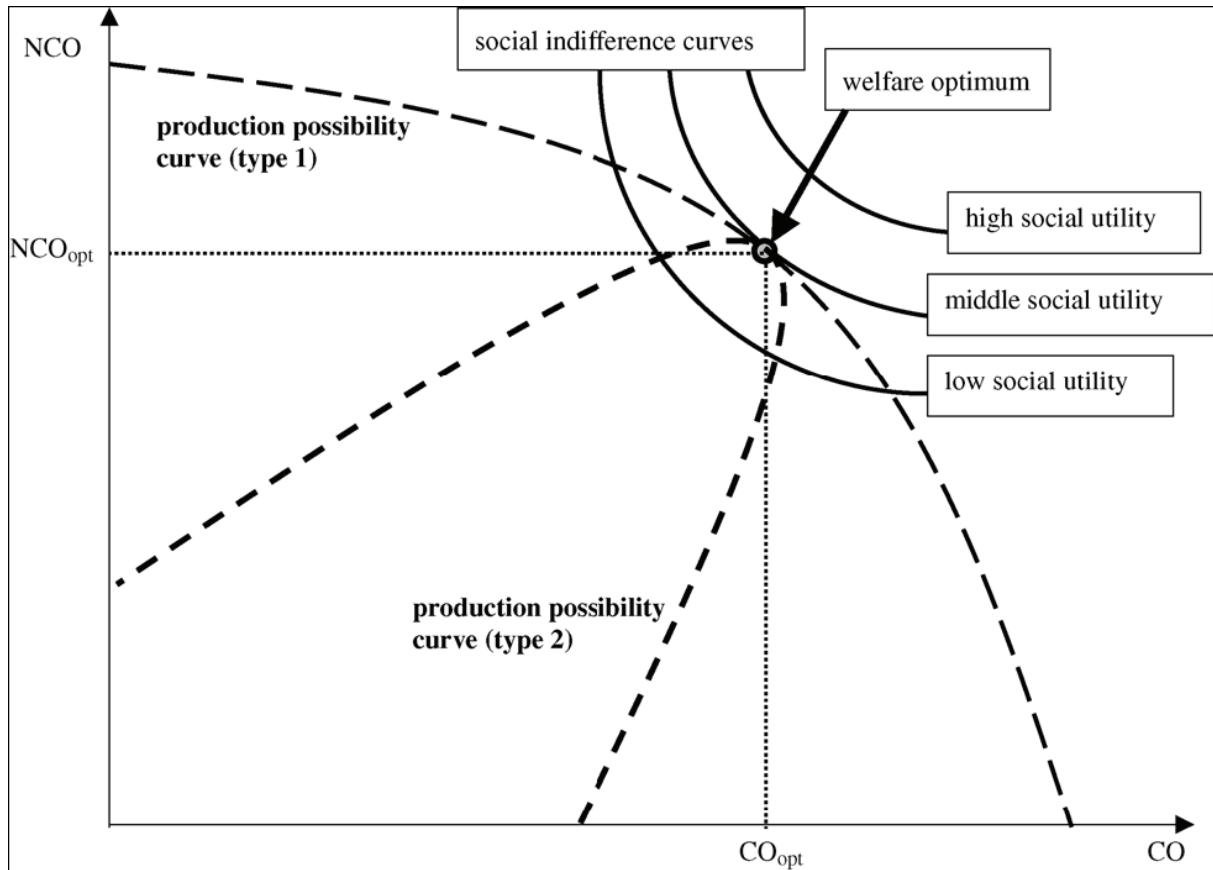
### Indicators for multifunctionality and landscape assessment

In general, indicators to assess sustainable land development often focus on either economic or ecological aspects of landscape use. The concept of multifunctional land use helps to merge these two focuses by emphasising on the rule that economic action is per se accompanied by ecological utility. Commodity Outputs (CO; e.g. yields) are paid for on the market, but Non-Commodity Outputs (NCO; e.g. landscape aesthetics) are considered to be public goods with no market value.

Agricultural production schemes often provided both these outputs, but technical progress under prevailing economic pressures, destroys joint production by the decoupling of commodity from non commodity production. Simultaneously, by public and political awareness of these shortcomings, there is developing a societal demand for some non-commodity outputs from land use. This in turn produces a market potential and a shift towards the realisation of commodity outputs.



An approach is available to merge both types of output by defining an indicator of social utility (Wiggering et al. 2006), where production schemes are considered with respect to social utility of both commodity and non-commodity outputs. Social utility in this sense includes environmental and economic services, as long as society expresses a demand for them. For each combination of parameters a particular combination of conditions (e.g. soil and climate properties of a landscape) a production possibility curve can reflect trade offs between commodity and non-commodity outputs (Fig. 1). On each production possibility curve a welfare optimum can be identified expressing the highest achievable value of social utility, as a trade off between CO and NCO production.



**Figure 1.** Social indifference curves, production possibility curves and welfare optimum. (Source: Wiggering et al., 2006)

Social utility thus allows to assess sustainability of land development in a cross-sectoral approach with respect to multifunctionality. It links socio-economic requirements with landscape potential and thus provides an integration between the demand and supply sides of multifunctional agriculture within the landscape context.

#### References

**Wiggering H, Dalchow C, Glemnitz M, Helming K, Müller K, Schultz A, Stachow U, Zander P. (2006)** Indicators for multifunctional land use: linking socio-economic requirements with landscape potentials. *Ecological Indicators* 6 (1): 238-249.

## **Landscape change assessment: integration of remote sensing, GIS and spatial modelling concepts**

**T. Blaschke, S. Lang, E. Schöpfer, D. Tiede, L. Drăguț**

Z\_GIS Centre for Geoinformatics, Salzburg University – Schillerstr. 30, 5020 Salzburg,  
Austria.  
e-mail: Thomas.Blaschke@sbg.ac.at

### **Motivation and main hypotheses**

In their introductory statement the organisers of Session #23 of the IALE world congress take for granted that assessing land cover and pattern change is a straight-forward task, at least compared to the methodological challenges associated with the dynamics of real socio-ecological landscapes at regional scales. In this paper we challenge the symposium organisers in a way that we highlight the problems related to the assessment of change. Focusing on land cover / land use (LU/LC) change we very discuss the state of the art in remote sensing based LU/LC classification and the recent developments of object-based image analysis (OBIA) which integrate GIS and digital imaging. Most technological challenges can be resolved but methodological challenges remain which require a thorough theoretical foundation. In this respect we finally agree with the session organisers that we need theoretical and operational frameworks to represent and compare landscapes. Two specific aspects covered in this short paper are the multi-scale approach and the integration of the third dimension in landscape change assessment.

### **From pixels to objects – recent progress**

A 'pixel' is a more complicated entity as generally acknowledged. Increasing spatial resolution decreases the effects of 'mixed pixels' only statistically. The traditional method for analysis of Earth observation (EO) data in landscape research is the classification of pixels belonging to the same land cover class being close in spectral feature space. Put different way, one assumes that the classes are relatively pure or at least spectrally separable. However, with GIFOV of 1 km to 30 m, only the broadest land cover classes can be spectrally differentiated. Separability has been improved by the incorporation of spatial information, such as local measures of texture and autocorrelation, but is not assuaged. Spectral separability aside, there is still the scale issue. The pixel-centred view is usually uni-scale in methodology, exploring the pixels of only one scale of imagery and of only one scale within the image.

The multiscale segmentation/object relationship modelling (MSS/ORM) methodology suggested by Burnett and Blaschke (2003) segments information (usually remote sensing images plus any georeferenced information). Generally, an advantage of segmentation to classification of pixels is that the resulting division of space tends to involve fewer and more compact subregions. The multiscale segmentation based approach utilizes scale-dependent information derived from airborne or satellite data or any other continuous data, e.g. digital elevation models. It is designed in such a way that also scaled information can be derived from one single image. Technically, segmentation is not new but only since around the year 2000 the number of applications is increasing number. The main underlying concept is to somehow mimic how a human operator works: to create regions instead of points or pixels as carriers of features which are then introduced into the classification stage. New developments couple segmentation and classification in a cyclic process rather than performing a subsequent linear process (Tiede et al., 2006; Tiede & Hoffmann, 2006). The conceptual idea is that each of these regions corresponds exactly to one object class or building blocks of these, respectively. Furthermore, segmentation algorithms are able to handle multiple data and information sources, thus performing a fusion on feature level.

### **Image objects and landscape change**

Most image data exhibit characteristic texture. This is neglected in common pixel-based classifications, though many authors started to tackle this problem already in the 1970ies. In addition to spectral aspects in images, GIS principally introduces topology as a new dimension to

map the relations between n-dimensional entities. In addition to statistical texture examination we can also describe patterns explicitly using spatial relationships among objects. We speak of objects if we can attach a meaning or a function to the raw information. Generally, the object is regarded to be an aggregation of geometric, thematic and topologic properties. The topologic relations between the pixels the object consists of can be examined once the user has defined his or her objectives, classification scheme and scale of analysis. For a recent overview on image segmentation for landscape classifications we refer to Blaschke et al. (2004). Human vision generally tends to generalize images into homogeneous areas first, and then characterize focal areas more carefully as required. Following this observation, we hypothesize that by creating multiple scales of segmentation and by successively grouping the pixels of an image into homogeneous image objects, a more intuitive and hierarchical partitioning of the image can be achieved. Next to many other approaches the author group of this paper has substantially built on the region-based, local mutual best fitting segmentation approach (Batz & Schäpe, 2000) and other segmentation and class modelling techniques.

The collecting of spatial relationships and semantic descriptions of more complex classes to be addressed brings up the issue of a priori knowledge. For some landscape situations, it has been hypothesized that, for different scenes the similarity of object scales and object characteristics will enable nearly automated and highly accurate classification of land-use. To achieve this, these analysis systems will have to optimize the data collected and the relationship rules applied. The varieties of objects in a near-natural landscape add additional challenges; and likewise the importance of semantic (human) knowledge of each particular scene may play a more important role in these studies. In addition recent landscape change studies go beyond the pure statistical analysis of LU/LC change. They rather focus on spatial arrangements and changes in the patterns, i.e. object transition (Schöpfer & Lang, 2006). However, the location of transition and the object transition itself will play an important role in future research.

#### **Towards tangible multi-dimensional landscape objects**

So far, landscape ecology and especially landscape metrics focussed on the two-dimensional consideration of patches from a bird's eye, i.e. two-dimensional perspective. OBIA concepts are more recently also applied to other continuous, environmental data sets as for example digital elevation models (Dragut & Blaschke, 2006) in an attempt to integrate visually interpretable information and measurable environmental factors. Landscape researchers now have the benefit of working with 'next generation' EO data sets, comprising 1) imaged information of a significantly finer spatial resolution, and 2) multiple scales of data simultaneously. They can contribute analysis methodologies that are better adapted to the self-organized complexity of landscapes.

#### **References**

- Blaschke, T., Burnett, C., Pekkarinen, A. (2004)** New contextual approaches using image segmentation for object-based classification. F. De Meer & S. de Jong (Eds.): *Remote Sensing Image Analysis: Including the spatial domain*. Kluwer Academic Publishers, Dordrecht, pp. 211-236.
- Burnett, C. & Blaschke, T. (2003)** A multi-scale segmentation / object relationship modelling methodology for landscape analysis. *Ecological Modelling* **168**: 233-249.
- Dragut, L. & Blaschke, T. (2006)** Automated classification of landform elements using object-based image analysis. *Geomorphology* **81**: 330-344.
- Schöpfer, E. & S. Lang (2006)** Object fate analysis - a virtual overlay method for the categorisation of object transition and object-based accuracy assessment. *Int. Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* **XXXVI-4/C42**.
- Tiede, D., Lang, S. & Hoffmann, C. (2006)** [Supervised and forest type-specific multi-scale segmentation for a one-level-representation of single trees](#). *Int. Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* **XXXVI-4/C42**.
- Tiede, D. and Hoffmann, C. (2006)** Process oriented object-based algorithms for single tree detection using laser scanning data. *EARSel Workshop on 3D Remote Sensing in Forestry*, Vienna, 151-156.

## Spatial correlograms and landscape metrics as indicators of land use changes

Ü. Mander, E. Uemaa, R. Aunap, A. Kanal, J. Roosaare

University of Tartu, Institute of Geography, Vanemuise 46, 51014 Tartu, Estonia.  
e-mail: mander@ut.ee

### Introduction

The main objectives of this study were: (1) to analyse three map series (from approximately 1900, 1940, and 2000) of selected landscape areas in Estonia concerning their differences in spatial autocorrelation and FRAGSTATS indexes; (2) to find out whether the Moran's I characteristic and landscape indexes respond to the land cover changes; (3) to clarify dynamics of newly introduced characteristic based on spatial correlograms: a half-value distance lag,  $h_{I=0.5}$  – a distance where Moran's I drops below 0.5) in various landscape types; (4) to compare 3 layers in landscapes, the primary layer (represented by soil maps), the secondary layer (represented by natural areas) and the tertiary layer (the man-made land use) based on Moran's I and FRAGSTATS indexes.

### Material and Methods

Thirty-five study areas were selected according to 25 Estonian landscape regions (geosystems that are determined by geomorphologic factors). We studied the spatial autocorrelation (Moran's I) of raster format land use maps from three different time periods (1900, 1940, and 2000) in 35 study areas representing most of the landscape regions in Estonia. Human influence was taken into consideration in compiling a scale of the contrast between 10 land use groups.

Land use data was derived from the Estonian Basic Map (1:10,000) as it was the most accurate map available. The extent of the study areas was set at  $15\text{km} \times 15\text{km} = 225\text{km}^2$ . The original data was in vector format and for analysis it was converted into raster format using 10 m pixel size. We have to use reclassified land use data in order to take into quantitative consideration the qualitative differences in neighbouring land use patches. Land use types were reclassified so that new type numbers could be used as contrast indexes. In case of land use types  $M_i$  and  $M_j$  their difference ( $|i-j|$ ) shows contrast between these types. For example the difference between forest and arable land is the same as orchard and fen. In order to investigate the difference between natural areas (secondary landscape layer) and man-made landscapes (tertiary landscape layer) we masked out the land use types with higher human influence and calculated Moran's I for these maps.

Soil data (representing primary landscape layer) was derived from Estonian Soil Map (1:10,000). Soil map was also converted into raster format using 10 m pixel size. Soil types were similarly to land use reclassified so that the new soil type numbers could be used as contrast indexes.

Following FRAGSTATS indexes were used for analysing landscape metrics: Patch Density (PD), Edge Density (ED), Mean Patch Area Distribution (AREA\_MN), Mean Shape Index (SHAPE\_MN), Contrast Weighted Edge Density (CWED), Contagion (CONTAG), and Percentage of Like Adjacencies (PLADJ). To allow comparison of Moran's I value with FRAGSTATS indexes we introduced a new simple characteristic based on spatial correlograms: a half-value distance lag,  $h_{I=0.5}$  – a distance where Moran's I drops below 0.5 (Aunap et al., 2006; Uemaa et al., 2007).

### Results

No significant change was detected in values of  $h_{l=0.5}$  over time. The analysis of the FRAGSTATS landscape metrics ED, PD, CWED, AREA\_MN, and PLADJ showed significant changes comparing the year 2000 with 1900 and 1940. However, the results showed no significant change in landscape metrics between 1900 and 1940. ED, PD and CWED had higher values in 2000 than in 1900 and 1940. ED, PD, CWED, AREA\_MN and PLADJ metrics also indicated a significant difference between lowlands and heights. The landscape heterogeneity has significantly increased in recent decades.

Analysis of raster format soil maps (1:10,000; 10m pixel size) in the same study areas showed that the Moran's I value decreased rapidly in the case of heights with a very heterogeneous landscape composition, showing low values of  $h_{l=0.5}$  (<100m in all 6 study areas). In uplands and depressions, the spatial autocorrelation also decreased relatively rapidly ( $h_{l=0.5}$  <200m). In most of the plains, coastal lowlands, sea islands and inland paludified lowlands, the values of Moran's I did decrease slowly with increasing lag, being >200m in all but 4 forest and bog areas with complex topographical conditions due to the variety of glacial landforms and peatlands. All landscape metrics studied demonstrated significant correlations with  $h_{l=0.5}$  having Spearman Rank Order Correlation values higher than 0.8. Landscapes with high ED, PD and CWED values have a low autocorrelation: PD, ED and CWED correlated negatively with  $h_{l=0.5}$ . PD, ED and CWED decreased and PLADJ increased with the power-law relationship with increasing  $h_{l=0.5}$ . Spatial autocorrelation is lower in landscapes with complex structure and high contrast. The positive relationship with PLADJ indicates the same.

Comparison of FRAGSTATS indexes with  $h_{l=0.5}$  showed that in the case of soil data all landscape metrics had significant correlations with  $h_{l=0.5}$  and most of them were very strong relationships (Table 1). However, in the case of man-made land use only ED, CWED and PLADJ gave statistically significant correlations with  $h_{l=0.5}$ .

**Table 1.** Spearman Rank Order Correlation between the  $h_{l=0.5}$  and FRAGSTATS metrics in 3 layers of landscapes: soil cover, natural areas and man-made land use. Significant correlation coefficients are in bold;  $p < 0.05$ .

FRAGSTATS landscape metric	$h_{l=0.5}$ (soil)	$h_{l=0.5}$ (natural areas)	$h_{l=0.5}$ (land use)
Patch Density (PD)	<b>-0.82</b>	<b>-0.50</b>	-0.25
Edge Density (ED)	<b>-0.84</b>	-0.21	<b>-0.38</b>
Mean Patch Area Distribution (AREA_MN)	<b>0.82</b>	<b>0.52</b>	0.25
Mean Shape Index (SHAPE_MN)	<b>0.46</b>	0.11	0.06
Contrast Weighted Edge Density (CWED)	<b>-0.89</b>	<b>-0.47</b>	<b>-0.34</b>
Contagion (CONTAG)	<b>0.61</b>	-0.31	0.18
Percentage of Like Adjacencies (PLADJ)	<b>0.86</b>	<b>0.51</b>	<b>0.38</b>

Comparison of soil map layer (primary layer) with the actual land use structure (tertiary layer) allowed us conclude that the human influence simplifies landscape structure in heights and makes it more fragmented in lowlands.

## References

- Aunap, R., Uuemaa, E., Roosaare, J. & Mander, Ü. (2006).** Spatial correlograms and landscape metrics as indicators of land use changes. In: Martin-Duque, J.F., Brebbia, C.A., Emmanouloudis, D., Mander, Ü. (Eds.) *Geo-Environment and Landscape Evolution II*. WIT Press, Southampton, Boston, pp. 305-316.
- Uuemaa, E., Roosaare, J., Kanal, A. & Mander, Ü. (2007).** Spatial correlograms of soil cover as an indicator of landscape heterogeneity. *Ecological Indicators*. In press. doi.org/10.1016/j.ecolind.2006.12.002.

## Landscape monitoring and landscape change

W. Fjellstad, W. Dramstad

Norwegian Forest and Landscape Institute, P.O. Box 115, N-1431 Ås, Norway.  
E-mail: wendy.fjellstad@skogoglandskap.no

This paper presents examples from the Norwegian Monitoring Programme for Agricultural Landscapes. The main data source for the sample-based programme is true colour aerial photography (scale 1:15 000). Maps are constructed from the photographs and the 1 x 1 km sample squares are re-mapped at five-year intervals. Indicators of landscape change are derived from the maps. Various measures of spatial structure are used, describing the content and spatial configuration of the landscape, and expressing trends of change that are relevant for agriculture, biodiversity, cultural heritage and accessibility. This paper presents results from 331 squares that analysed since the monitoring programme began in 1998.

The total amount of change occurring in the monitored area was around 10% (ranging from 8.6% to 11.6% for different counties). Although agriculture was the dominant land type on the monitoring squares (ranging from 32% to 49%), about two thirds of the change occurred in woodland. Most change could be characterised as “swapping”, i.e. loss of a particular land type in one location was accompanied by gain in another location. There was, however, a net loss of agricultural land in all counties. We used the method of Pontius et al. (2004) to identify systematic transitions between categories. This method compares observed changes in the monitored area to that which would be expected if transitions between categories were random. Interestingly, losses of agriculture to roads and built-up areas were very much as would be expected by random processes, in spite of laws and regulations aiming to prevent this type of change. However, the method of Pontius assumes that the loss of area within each category is fixed, and distributes the loss across the other categories in proportion to their occurrence in the landscape. So although the method is useful for detecting systematic transitions amongst the changes that occur, it is difficult to draw conclusions related to the *magnitude* of change until we have a series of time intervals to compare. Many agri-environmental policies aim to counteract negative trends and conserve an existing situation. Related to these aims, a lack of change is to be considered positive. Whilst our results show that changes affect a relatively small proportion of the landscape, they are nevertheless widespread and common in frequency. Table 1 shows the proportion of monitoring squares affected by different types of change.

The significance of changes is difficult to assess, partly because the numbers are small and require that we think in temporal scales of decades rather than years. In addition, some changes affecting only small areas can have large impacts – such as the visual effect of cutting down a row of trees in an open landscape, or the habitat value that is lost when a pond is filled in. Tucker (1999) has emphasised the need for indicators to be easy to interpret, yet we find few measures that are straightforward in this respect. Even where changes can be clearly related to goals, we see that changes that are beneficial in relation to one aim, may be negative for other functions and values. The fact that many changes occur together complicates identification of cause and effect.

For Norway, as for other countries (DGVI Commission 1998), policy aims are often vague. Only a few quantitative goals have been set, such as halving the rate of construction on farmland, ensuring that annual loss of cultural heritage objects is less than 0.5% by 2008, and halting decline in biodiversity by 2010. Other aims, such as preserving the diversity of the agricultural landscape are open to interpretation. Diversity can be measured in different ways and at different scales, and has different relevance in different landscapes. Some elements of this diversity are made more explicit through the requirements that farmers must fulfil to receive subsidies, such as preserving streams, mid-field habitat islands, and stonewalls. Our data shows that negative changes still occur, although we suspect that they would be more common if laws, regulations and subsidies were not in place. While swapping

change dynamics are to be expected in cultural landscapes we cannot expect that new elements have the same values and functions as older elements that disappear. However, without more historical data about rates of change, it is difficult to conclude whether agri-environmental schemes give value for money or not (Kleijn & Sutherland 2003).

Decisions regarding changes in agricultural landscapes are generally made by independent farmers/landowners. A wide array of driving forces may influence these decisions; financial (economy of the farm, other work opportunities in the area), social (neighbours, development of local society), demography (age of landowner, heirs) etc. Of these driving forces, only a few are under direct governmental control (e.g. production subsidies and agri-environmental measures). Although we can comment on specific changes in relation to agri-environmental goals, we have found no clear patterns in the observed changes that shed light on dominant driving forces. One way forward may be to consider capacity to deal with changes, using the concept of resilience in relation to this socio-ecological system (Folke, 2006). In addressing these issues we clearly need a better understanding of factors affecting landowners' decisions.

**Table 1:** Frequency of various types of landscape change recorded in the 3Q monitoring programme. Numbers indicate percent of monitoring squares (N=331).

Landscape change	% of monitoring squares		
	Reduction	No change	Increase
Net change in farmland area <sup>1</sup>	73	7	21
Net change in built-up area on farmland <sup>1</sup>	8	37	54
Net change in unmanaged grassland on farmland <sup>1</sup>	22	12	66
Net change in forest on farmland <sup>1</sup>	22	39	39
Farm ponds	5	91	4
Rows of trees <sup>2</sup>	8	89	3
Overhead power-lines <sup>2</sup>	2	86	11
Stone walls <sup>2</sup>	2	95	3
Streams and ditches <sup>2</sup>	15	67	18
Narrow strips of vegetation between fields <sup>2</sup>	39	38	23
Large mid-field habitat islands	27	48	25
Small mid-field habitat islands	24	46	30
Field size <sup>1</sup>	34	20	46
Net change in bush cover on grassland	33	9	58
Net change in tree cover on grassland	37	1	62
Heterogeneity <sup>3</sup>	25	11	63

<sup>1</sup> Changes in area of less than 500m<sup>2</sup> are included in the category "no change".

<sup>2</sup> Changes in length of less than 5m are included in the category "no change".

<sup>3</sup> Changes in the heterogeneity index of less than 0.005 are counted as "no change".

## References

- DGVI Commission. 1998.** Evaluation of agri-environment programmes. Report VI/7655/98. 9.11.1998 available at <http://ec.europa.eu/agriculture/envir/programs>
- Folke, C. 2006.** Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change* 16, p. 253-267.
- Kleijn, D. & Sutherland, W.J. 2003.** How effective are European agri-environment schemes in conserving and promoting biodiversity? *J. Appl. Ecol.* 40, p. 947-969.
- Pontius, R.G., Shusas, E. & McEachern, M. 2004.** Detecting important categorical land changes while accounting for persistence. *Agric. Ecosyst. Environ.* 101, p. 251-268.
- Tucker, G. 1999.** Measuring the impacts of agriculture on biodiversity. In: F. Brouwer & B. Crabtree, (Ed.) *Environmental Indicators and Agricultural Policy*. pp. 89-104, CAB International, Wallingford, UK.

**Source/sink patterns of disturbance and cross-scale effects as a template for environmental security assessment in a panarchy of social-ecological landscapes**

**N. Zaccarelli<sup>1</sup>, I. Petrosillo<sup>1</sup>, G. Zurlini<sup>1</sup>, K. Riitters<sup>2</sup>**

<sup>1</sup>Dept. of Biological and Environmental Sciences and Technologies, Landscape Ecology Laboratory, University of Lecce, Italy.  
e-mail: giovanni.zurlini@unile.it

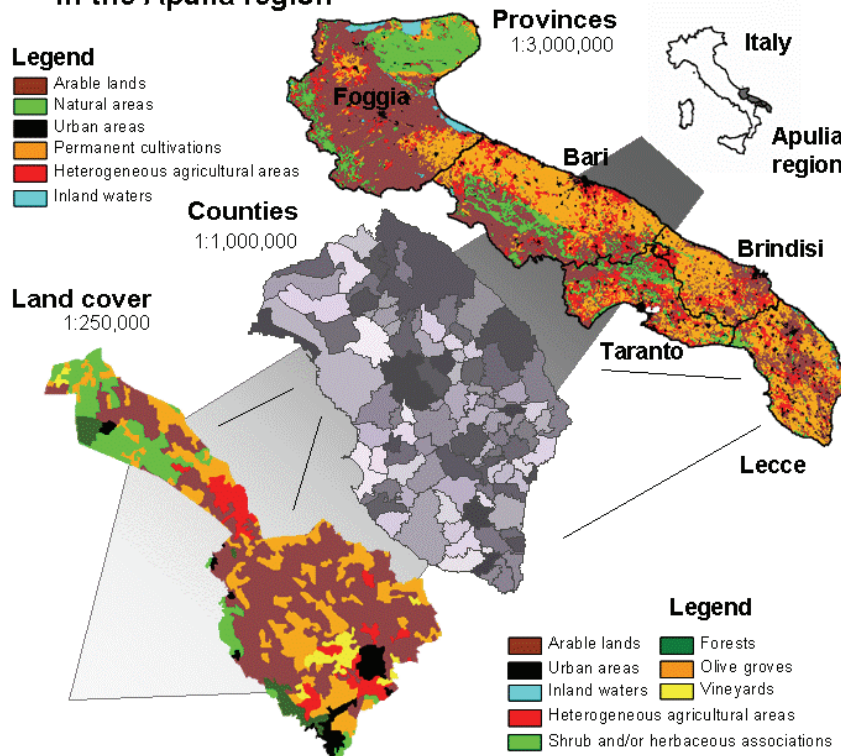
<sup>2</sup>U.S. Dept. of Agriculture, Forest Service, Southern Research Station, 3041 Cornwallis Road, Research Triangle Park, North Carolina 27709, USA.

Land use change is one of the major factors affecting global environmental change and a primary effect of humans on natural systems. Land-use/land-cover changes underlie fragmentation and habitat loss, which are the greatest threats to biodiversity. Since human land use is a major force driving landscape change, landscape dynamics can be better understood in the context of complex adaptive socioeconomic and ecological systems, integrating phenomena across multiple scales of space, time and organizational complexity. In the real geographic world such systems can be better defined as Social-Ecological Landscapes (SELs), taking into account the scales and patterns of human land use as ecosystem disturbances. During the last decades, worldwide losses of biodiversity have occurred at an unprecedented scale and agricultural intensification has been indicated as a major driver of this global change. The effects of land-use intensity on local biodiversity and ecological functioning in SELs depend on spatial scales much larger than a single field or land use. This demands a landscape perspective considering the spatial arrangement of surrounding land-use types at multiple scales. From such perspective, the exchange among land uses of disturbance agents like, for instance, fire, pesticides and fertilizers, pests, diseases, and alien species can be conveniently described by the concept of “source” and “sink” adopted for metapopulation. We describe a framework to characterize and interpret the spatial patterns of disturbances at multiple scales in a panarchy of nested bounded and organized Socio-Ecological Landscapes (SELs) such as region, province, and county, taking into account the scales and spatial patterns of human land use as source/sink disturbance systems. We detect and quantify those scales for three nested jurisdictional levels in a panarchy of SELs in the panarchy, by using a conceptual framework that characterizes multi-scale disturbance patterns exhibited on satellite imagery over a four-year time period in Apulia in South Italy. Multi-scale measurements of the composition (amount) and spatial configuration (clumping) of disturbance identify multi-scale disturbance source/sink trajectories in a pattern metric space which are then examined in relation to the geography of land use across the nested jurisdictional levels in the entire region. We obtain disturbance trajectories at multiple scales for each location (pixel) and we group locations according to broad land use classes for each sub-region in the panarchy to identify spatial scale and geographic regions where disturbance is more or less concentrated in space along the panarchy leading to disturbance sources, or sinks, and cross-scale effects. Disturbance trajectories derived from real landscape patterns of SELs are compared on the same pattern space and interpreted with respect to random, multifractal and hierarchical neutral models to define critical support regions for the assessment and management of disturbances in a panarchy of SELs. This study clarifies the potential roles of natural areas and permanent cultivations (olive groves and vineyards) in buffering landscape dynamics and compensating for disturbances across scales in South Italy. Their function has consequences for regional biodiversity management since their particular interactions in space and time may govern if and how disturbances associated with land use intensification (sources) will trigger changes affecting regional biodiversity. We show that in the real geographic world spatial scale mismatches can occur at particular scale ranges because of cross-scale disparities among land uses for the amount of disturbance and/or spatial accumulation rate of disturbance clumping, leading to more or less exacerbation of contrasting source-sink systems along



certain scale domains. All cross-scale issues can produce both negative and positive effects on the scales above and below their levels. Sources and sinks could be properly arranged by planners and managers in the landscape to match some “desirable” spatial and temporal pattern such that ecological disruptions only occur across a limited range of scales, which would allow persistence of ecological functions operating at unaffected scales. The challenge is then to develop adaptive management strategies with social norms that foster cooperative responses to enhance the benefits and minimize the negative effects. Managers of SELs in the panarchy should be aware of specific scale ranges of disturbance where such effects occur. That knowledge will assist managers and policy makers to value where and how to intervene in the panarchy of SELs to enhance long-term sustainability.

### Nested panarchy of SELs in the Apulia region



### References

- Folke C., T. Hahn, P. Olsson, J. Norberg, 2005.** Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources* 30:441-473.
- Levin S.A., 2006.** Learning to live in a global commons: socioeconomic challenges for a sustainable environment. *Ecol Res* 21:328–333.
- Zurlini G., Riitters K., Zaccarelli N., Petrosillo I., Jones K.B., Rossi L., 2006.** Disturbance patterns in a socioecological system at multiple scales. *Ecological Complexity* 3:119–128.
- Zurlini G., Riitters K., Zaccarelli N., Petrosillo I., 2007.** Patterns of disturbance at multiple scales in real and simulated landscapes. *Landscape Ecology*, DOI 10.1007/s10980-006-9055-5 (available online).

## 7.4 Symposium 24: Land use changes and ecological impacts

### Land Use Based Identification of Agricultural Factors for Improving Sustainable Land Resource Management in Northern Thailand - A Case Study in the Chiang Mai Province

Y. Jiang<sup>1</sup>, D. Schmidt-Vogt<sup>2</sup>, R.P. Schrestha<sup>2</sup>

<sup>1</sup> College of Resources Science and Technology, Beijing Normal University, Beijing, 100875, PR China.

e-mail: jiangy@bnu.edu.cn

<sup>2</sup> School of Environment, Resources and Development, Asian Institute of Technology, P.O. Box 4 Klong Luang, Pathumthani 12120, Thailand

#### Introduction

The rural communities in Northern Thailand traditionally produced food through use of natural resources and practice of a self-sufficient livelihood philosophy (Levis 1984; Trakarnsuphakorn 1997; Nabangchang 2005). Since opening up Thai economy over the past four decades, the agriculture “modernization” oriented towards increasing production through technological breakthrough of the Green Revolution has been promoted. This paper, mainly based on the data from the agricultural sector of the Chiang Mai Province, aims to identify the land use factors benefiting sustainable land resources management in terms of environmental conservation. The discussion, conclusion and extended suggested measures should have some meaning for promoting the sustainable land management in both the Northern Thailand and other Asian developing countries.

#### Methodology

For evaluating the impacts of land use on environment, four parameters, namely use of chemical fertilizer, use of chemical pesticide, land use structure and land use diversity are taken into account. The land use type in agriculture is categorized according to the cultivated products. For comparison of the land use diversity in different periods, the Shannon-Weaver Index has been calculated according to Farina (1998).

The farmers’ properties, income, land tenure and land area of the holdings in agricultural sector have been selected to recognize their influence on the four land use related parameters mentioned above. These analyses are conducted by statistical method, in case that the dataset could satisfy the conditions. Otherwise, qualitative and quantitative comparisons have been carried out.

#### Results

##### Increase in uses of chemical fertilizer and pesticide

In 1963, the number of holdings using chemical fertilizer was 7214, making up only 8% of the total holdings. By 2003, however, about 35% of the total holdings used chemical fertilizer, being nearly eight times the number as in 1963. Meanwhile, the farmland treated with chemical fertilizer reached 149209 ha, and about 48249 ton of chemical fertilizer in total was consumed. The use of chemical pesticide has shown a similar trend. Unfortunately, the use of organic fertilizer has declined in the same period.

##### Change of agricultural land use structure and diversity

A comparison of agricultural land use structure between 1963 and 2003 indicated a significant decrease of rice and an increase in permanent crops. In 1963, rice took 77% of the cultivated land, but in 2003 only 34%. In contrast, percentage of permanent crops rose in the same period from about 9% to 44%. In addition, percentages of field crops and vegetable-herb-flower-ornamental plant slightly increased, and the forest and pasture tended to reduce a little.

The analysis through Shannon-Weaver index has showed an increase tendency in land use diversity in general. In 1963, there were only 16 sorts of crops including vegetables and 12 species of fruit trees cultivated in large scale, but in 2003, there were 28 sorts of crops including vegetables, 13 sorts of flowers and 35 species of fruit trees cultivated.

#### Relationship between land use and application of chemical fertilizer

The permanent crops made the biggest proportion of the total amount used in the year 2003. About 21299 tons of chemical fertilizer has been used for permanent crop, up to 44% of the total amount. The vegetable-herb-flower-ornamental plant was the second most important being 12635 tons and making up 26%. Rice and field crops only the third and fourth places respectively. As for the annual amount used per unit area, the land use type vegetable-herb-flower-ornamental plant was the highest, followed by permanent crops. The amounts of chemical fertilizer used for these two land use types were up to 673 and 329 kg/ha respectively in 2003. In comparison, the amounts for field crop and rice were only 272 and 200 kg/ha respectively. Clearly the former two land use types have played the most important role in raising the use of chemical fertilizer.

#### Impacts of the holding's property on application of chemical fertilizer and pesticide

Among the farmers' properties, the amount of chemical fertilizer used per unit area in large-scale farming is lower than that in small-scale. But large-scale farming might consume more pesticide than the small-scales. A significant negative correlation could be observed between the proportions of the holdings possessing land and the holdings used the fertilizer.

### **Conclusions and discussions**

#### Management of the crop system and land use structure

Diversification of crop systems should be continuously encouraged. But, efforts should also be made to encourage selection and introduction of new strains and varieties of crops and fruits with lower demands for fertilizer and higher resistance against disease and insect pests. In addition, traditional soil improvement treatment, appropriate crop rotation, and other sustainable cultivation technologies should also be encouraged in the management of crop systems.

#### Balancing large-scale and small-scale farming

Balancing the farming scales in agriculture sector should be taken into account in policy decision-making for the future agricultural development. As for land management, special attention should be paid to adopting the measures restraining the use of pesticide in large-scale farming, whereas the use of organic fertilizer and the traditional land improving practices should be especially encouraged among small-scale farming.

#### Insuring land tenure and economic incentives

For policy-making, credit subsidies to the farmers practicing sustainable land management, tax reductions or remissions for inputs used in sustainable agriculture, as well as granting land tenure to community or individuals could be considered. Concerning technology, training, information services, exchange networks and input in rural infrastructure construction should be enhanced, to promote sustainable land resource management.

### **References**

- Levis P. & Levis E. (1984)** *Peoples of the Golden Triangle*. Thames and Hudson, Stuttgart.
- Nabangchang O. (2005)** Demand-driven research on agricultural production technologies: the paradigm shift in the Thai Ministry of Agriculture and cooperatives' principles and approaches. A. Neef (Eds). *Participatory Approaches for Sustainable Land Use in Southeast Asia*. White Lotus, Bangkok, pp. 313-329.
- Trakarnsuphakorn P. (1997)** The wisdom of the Karen in natural resource conservation. D. McCaskill and K. Kampe (Eds). *Development or Domestication? Indigenous Peoples of Southeast Asia*. Silkworm Books, Chiang Mai, pp 205-218.
- Farina D. (1998)** *Principles and methods in landscape ecology*. Chapman & Hall, London.

## Rural landscape changes and its effects on vegetation dynamics in Korea and Japan

J.-E. Kim<sup>1</sup>, S.K. Hong<sup>2</sup>, N. Nakagoshi<sup>1</sup>

<sup>1</sup> Graduate School for International Development and Cooperation, Hiroshima University, 1-5-1 Kagamiyama, Higashi-hiroshima, Hiroshima 739-8529, Japan.

e-mail: [ecokimje@yahoo.co.kr](mailto:ecokimje@yahoo.co.kr)

<sup>2</sup> Institute of Islands culture, Mokpo National University, 61 Dorim-Ri, Cheonggy-Myeon, Muan-Gun, Jeonnam, 534-729, Korea.

### Introduction

Changes of rural landscapes in East Asian countries are important issues in the decreasing biodiversity and the disappearing cultural landscapes due to changes of human management strategies (Nakagoshi and Hong 2001; Kim *et al.*, 2006). To maintain of sustainable development and conservation in rural areas, a study on the landscape ecological process of vegetation dynamics was needed.

### Study areas

Study areas were selected for study in two countries, Korea (Teokdong-ri, TD; Teokseong-ri, TS; Yanghwa-ri, YH) and Japan (Minamikata, MK; Miwa-cho, MW) as having a similar agricultural environments and administrative district over a decade in the rural regions.

### Materials and Methods

Local statistics, vegetation community, plant life-form, and landscape mosaics of both countries were analyzed using quantitative data.

### Results

#### *Local statistics*

Trends in agricultural environment changes, such as decreasing population, mechanization, and decreasing agricultural areas, were similar in both countries. However, the trend of rural forest products such as charcoal production and wild plant collection since the 1990s was found to be different, as Korea showed various increased uses of forest products compared with Japan.

#### *Landscape pattern*

Spatial heterogeneity increased in both countries, whilst it was only statistical significant in Japan. Changes of spatial patterns and vegetation dynamics were clearly shown in Japan. It may be indicated that according to socio-economic changes, consequences of abandoned rural landscapes in Japan are longer and wider than Korea in spatio-temporal scale.

#### *Vegetation analysis*

Theme7: Assessment of Landscape Changes  
7.4 Symposium 24: Land use changes and ecological impacts

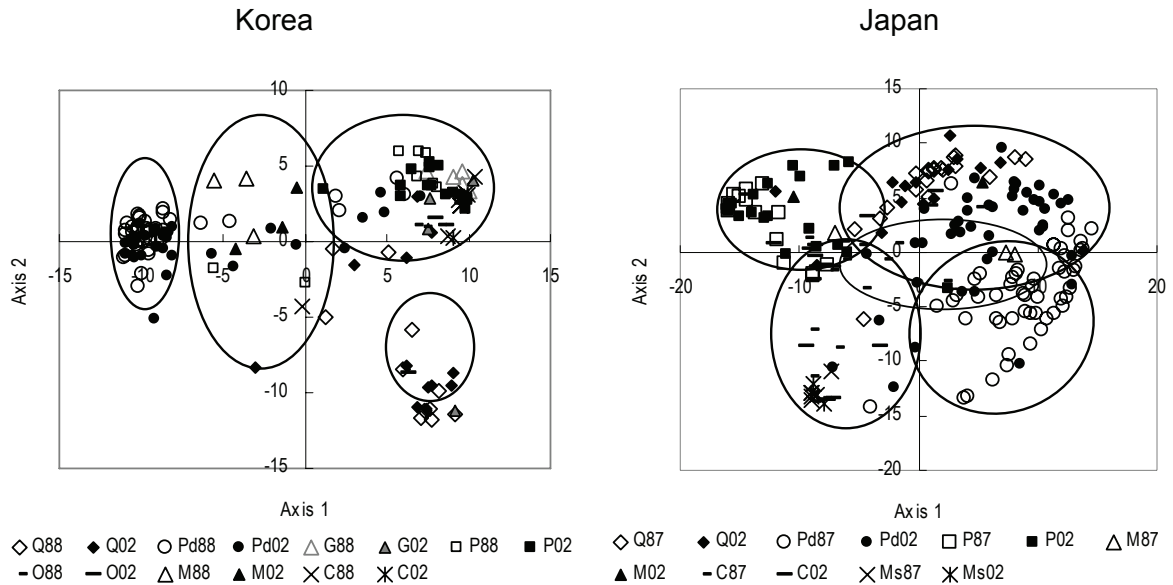


Figure 1. Plot distribution of communities by Principle Component Analysis (PCA) axes 1 and 2. *Quercus* spp. Pd: *Pinus densiflora*, P: Plantation, M: Mixed community, G: *Zoysia japonica*, Ms: *Miscanthus sinensis*, O: Orchard C: Clear cutting with shrub community, 88: The year 1988, 87: The year 1987, 02: The year 2002

Axes of PCA ordination correlated with woody plants and herbaceous layer structures. Vegetation dynamics according to the PCA ordination in Korea was not shown clearly. However, vegetation succession was apparent in Japan from *Pinus densiflora* to *Quercus* spp. Phanerophytes and Chamaephytes in species diversity of given life-form is increased in both countries. Herbaceous species of plant life-form have been related with patch shape of *P. densiflora* in both countries.

## Discussion

Therefore, landscape changes may be shown more obviously and widely in Japan compared with Korea. Moreover, usage of rural forest products since the 1990s has been showed to be more varied and higher regarding human impact in Korea. Vegetation structure of both countries has been changed with altering human impact. In addition, patch structure may be related to vegetation dynamics. Finally, trends of agricultural environment changes are similar in both countries (Hong *et al.*, 1995), whereas the consequences of rural landscape changes with vegetation dynamics is different in both countries.

## References

- Hong, S.-K.; Nakagoshi, N. & Kamada, M. (1995) Human impact on pine-dominated vegetation in rural landscape in Korea and western Japan. *Vegetatio* 116: 161-172.
- Kim, J.-E; Hong, S.-K. & Nakagoshi, N. (2006) Changes in patch mosaics and vegetation structure of rural forested landscape under shifting human impacts in South Korea. *Landscape and Ecological Engineering* 2: 177-195.
- Nakagoshi, N. & Hong, S.-K. (2001) Vegetation and landscape ecology of East Asian 'Satoyama'. *Global Environmental Research* 5: 171-181.

## The analysis of the landscape change of the marginal forestland around urban area A case study of Dadu Mountain in central Taiwan

C-R. Chiou<sup>1</sup>, I-C. Hsueh<sup>2</sup>

<sup>1</sup>School of Forestry and Resource Conservation, National Taiwan University,  
e-mail: esclove@ntu.edu.tw

<sup>2</sup>Graduate Institute of Ecotourism, National University of Tainan

The area of marginal forestland around urban city often decreases because of urbanization. Taichung city is located in the central Taiwan. During the past 30 years, the population has increased from around 5 hundred thousand to more than 1 million, almost doubled that of before. Along with the increase of the surrounding counties, Taichung City has formed a metropolis of a population of more than 2 million.

The study area, Dadu Mountain, lies in the western side of Taichung City, adjacent to Da-Jia River in the north and Dadu River in the south. The total study area is about 12414 ha. The average altitude is 151 m and the highest altitude is 310 m. Rainfall has annual average of 1642 mm. The warmest monthly mean temperature is 28.5 °C and the coldest monthly mean temperature is 16.2 °C. Dadu Mountain located in the margin of rapid developing cities and along with the flat terrain so that the landscape presents a great change for the past 30 years.

The purpose of this study is to investigate the driving force to the landscape change of Dadu Mountain by utilizing the land-use change analysis, road density change analysis and the impact of forest fire. First of all, we acquired three periods of aerial photos which are 1977, 1994 and 2002. Then they are calibrated into orthophoto for delineating the boundary of land-use type. The land-use maps of three periods were established and identified 7 land-use types: forest, woodland, grassland, farmland, development area, graveyards, and barren land. The change analysis of these three land-use demonstrated that the areas of forest and farmland reduced the most during 1977 to 2002. More specifically, the original 2744 ha of forest in 1977 are retained about only 24.6% in 2002, and 41% of farmlands are preserved in 2002 while the original farmlands in 1977 are 5849 ha. On the contrary, the development area expanded the most. 2484 ha in 1977 increased more than double, resulting in 4969 ha in 2002.

In addition, farmland is in the loss of 103 ha annually because of the demand of land areas for the development of built land. There were about 2 thousand ha farmland turned into development area. This result indicated that the change was mainly influenced by the human development. Furthermore, under the effect of forest fire, there were about 66 ha annual loss of forestland which were transformed into other land-use during 1977 to 2002. About half of the forest area in 1977 turned into woodland and grassland in 2002. This concluded that the forest fire is the key factor to the forest change.

In order to further clarify the influenced factor for the farmland change, three periods of road density change were studied to discuss the relation of road density and the reduce of farmland. The result demonstrated that the farmland shifted to development area would definitely raise the road density, especially in the surrounding cities. We can conclude that the reduction of farmlands and the increase of roads have significant correlation. On the other hand, according to the fire recodes between 1991 and 2003, about 120 times of fire events happened, almost centralizing in the zone of grasslands and forests. In addition, 20 satellite images of 2000 to 2003 were employed to interpret the forest fire areas. The frequency of the forest fire was therefore graphed and it obviously revealed the hot spot areas. The result also indicated the areas ever suffering the fire damage during these four years reached to 2107 ha, about 16.97% of the total study area. Consequently, we can

**Theme7: Assessment of Landscape Changes**  
**7.4 Symposium 24: Land use changes and ecological impacts**

notice that the forest fire happens frequently in this area and the disturbed areas were distributed widely.

From the spatial analysis, those fire damaged areas were distributed in grassland and adjacent to graveyards and built lands. Because of the dried temperature in winter of Dadu Mountain and customs to worship ancestors in Chinese New Year by burning paper money as an offering to the dead, this is a peak time when the forest fire happens. This explained the occurrence of forest fire was because of human improper use of the fire.

From the point of view of time axis, the effect of human development and forest fire was serious in the former period (1977-1993). As the developed areas and the expanded scope of fired area, the rate of land use change tended to slow down.

In conclusion, human development and forest fire are the main driving forces for Dadu mountain area to have a server landscape change and maintain only 45.3% of original land use type. However, the change rate was gradually slowing down with the saturation of development.

## Quantifying habitat loss of hygrophytes in regional scale as the base for nature restoration

M. Kamada <sup>1</sup>, E. Harada <sup>2</sup>, M. Ogawa <sup>3</sup>, H. Mitsuhashi <sup>4</sup>

<sup>1</sup> Institute of Technology and Science, Univ. of Tokushima. 2-1 Minami-Josanjima, Tokushima 770-8506, Japan.

e-mail: kamada@ce.tokushima-u.ac.jp

<sup>2</sup> Macro-System Engineering, Univ. of Tokushima. Tokushima 770-8506, Japan

<sup>3</sup> Tokushima Prefectural Museum, Muko-terayama Tokushima 770-8070, Japan

<sup>4</sup> The Museum of Nature and Human Activities, Hyogo. 6 Yayoigaoka, Sanda 669-1546, Japan

### Introduction

The Convention on Biological Diversity was signed at the United Nations Conference on Environment and Development, the so-called "Rio Summit", held in 1992, and the protection of biological diversity and restoration of degraded ecosystems have been accepted as one of the most important environmental issues in Japan. Following this, the National Strategy of Japan on Biological Diversity was drafted in 1995 and revised in 2003 (Biodiversity Center of Japan 2004). The National Strategy strongly supports progress of restoration works, and consequently the Law for the Promotion of Nature Restoration was drafted in 2002 (Ministry of Environment 2004). In the situation, social demand for a conservation of biodiversity and restoration of degraded ecosystems has increased year by year.

The aim of the study involves i) establishing a model for predicting potential habitats of endangered hygrophytes from species-occurrence data and several environmental variables, then ii) evaluating a degree of habitat loss and finding target places for conservation and restoration in regional scale, as a base for establishing regional policy of wetland conservation and restoration, which has been one of the seriously altered ecosystems.

### Objective Region and Data Set

Objective region: Objective region is the entire Tokushima Prefecture, part of Shikoku Island, Japan, and the area is about 4,144km<sup>2</sup>.

Species data: Target hygrophyte species were selected from the Red Data Book (RCB) of Tokushima Prefecture. Hygrophyte species include not only the species growing in water, but also growing around water. Among 689 species listed in the RDB, 75 species were selected. Data on species distribution were collected from the specimen stored in Tokushima Prefectural Museum, as well as the data of a field survey conducted in 2005. Species names and individual localities were recorded into 1km x 1km grids database of GIS.

Environmental variables: Environmental variables used for estimating potential habitat were topographical wetness index (TWI), stream power index (SPI), slope, elevation, precipitation and warmth index.

### Potential Habitat map

Through CCA and cluster analysis, 7 species-groups were found from 75 species. Ranges of environmental variables preferred by each group were identified, and areas where have the same set of preferred environmental variables were extracted from entire region of Tokushima Prefecture. Finally the potential habitat map was produced for each species group.

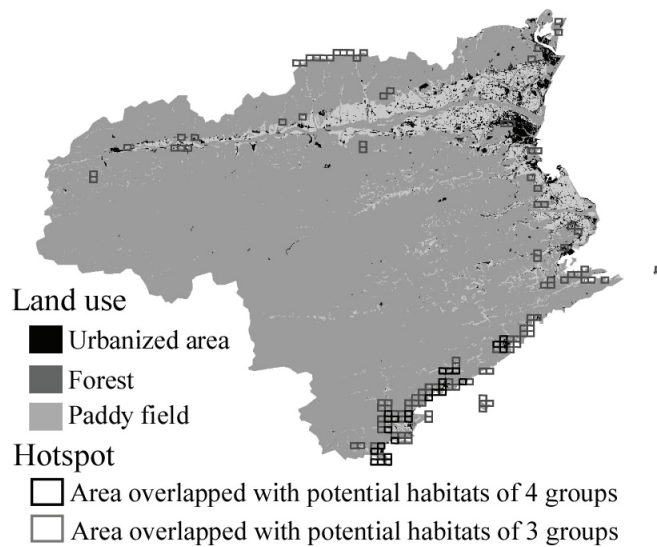
### Application of potential habitat map to establish conservation policy

By overlaying potential habitat maps, the area where involves several endangered hygrophyte groups can be searched; so-called potential "hotspot" area. Then by overlaying the potential habitat map or hotspot map with the land-use map, the area that has a high priority for habitat conservation or restoration can be searched (Fig. 1).



The potential hotspot map shows that southern part of coastal area is important to maintain diversity of endangered hygrophytes. The area has not been urbanized yet, and thus decision makers must pay close attention to the area to conserve habitats before the planning of land development.

The north-eastern of the region, where habitat of group 5 (*Euryale ferox* etc.) is potentially involved, has been overlapped with highly urbanized area. Therefore there should be made an effort to restore the habitat for species-group 5.



**Fig. 1** Map for indicating the area with high priority for conservation and restoration

### Conclusion

Information on the species occurrence is essential to establish conservation policy, but the data have been incomplete in almost all regions. Estimating and mapping potential the habitat is helpful for decision makers to establish conservation strategies and to avoid conflicts between land development and nature conservation.

### References

- Biodiversity Center of Japan (2004)** Laws and Treaties for Nature Conservation. Retrieved from the Web 31/January/2007. [http://www.biodic.go.jp/english/biolaw/law\\_f.html](http://www.biodic.go.jp/english/biolaw/law_f.html)
- Ministry of Environment, Japan (2004)** Law for the Promotion of Nature Restoration. Retrieved from the Web 31/January/2007. [http://www.env.go.jp/nature/saisei/law-saisei/law\\_e.pdf](http://www.env.go.jp/nature/saisei/law-saisei/law_e.pdf)

**Landscape ecological study on water demand and sustainable water resource management in relation to social development of Hiroshima city**

**A. Kikuchi<sup>1</sup>, N. Nakagoshi<sup>1</sup>, Y. Isozaki<sup>1</sup>, T. Nagata<sup>2</sup>**

<sup>1</sup>Graduate School for International Development and Cooperation, Hiroshima University, Kagamiyama, Higashi-hiroshima, 739-8511 Japan,  
e-mail: kikuchi@hiroshima-u.ac.jp

<sup>2</sup>Ministry of Land, Infrastructure and Transport Chugoku Regional Bureau, Haji Dam Management Office, Japan

People that have developed intensive urban land use have also coincidentally developed extensive transportation systems in rural areas (e.g. an infra structure of water supplement system). To consider the new paradigm of Sustainable Water Resource Management, which will deliver the key of ecological services that sustain the life on the region, we have chosen Hiroshima city as is a typical middle size cities in Japan. The water service system in Hiroshima city has grown more that 100 times since its construction in 1898. Since, the people from the cities are directly connected to remote rural areas through a pipe network which create a tight relation between them and nature. In reality, the quality of natural water bodies are easily affected by ecosystem condition as an increase of human activity near water resource areas (e.g. eutrophication), so that it would degrade the water quality that is been supplied to the city. In this point of fact, new partnerships in remote areas (where the water comes from), large scale projects, and cross-cutting activities will be a key to incorporate ecological solutions in water resource sustainability. In this research we focus on the following components of the environmental cause-effect chain: 1) change in decisions of the use of environment, 2) change in land use, and finally 3) change in matter-flow which coincides with the water quality. With these assumptions, it is clear that to disseminate scientific knowledge is the primary importance to support the decision-making process in both, urban and rural areas. From our experience conducted upon Hiroshima, tentative conclusions are as follows, it was possible to accumulate the hydro-ecological data, though it was needed to develop an “ecological cyber infrastructure” as regional ecological data-bank as a resource for “ecoinformatics” e.g. procedures to analyzed the ecological process, and tools to support decisions.

## Cause and consequence of landscape changes of island and coastal area in Korea

S-K. Hong<sup>1</sup>, J-W. Park<sup>2</sup>, and B-S. Ihm<sup>2</sup>

<sup>1</sup>Institute of Island Culture, Mokpo National University, 61 Dorim-Ri, Cheonggy-Myeon, Muan-Gun, Jeonnam, 534-729, Korea  
e-mail: landhong@yahoo.co.kr

<sup>2</sup>Department of Biology, Mokpo National University, 61 Dorim-Ri, Cheonggy-Myeon, Muan-Gun, Jeonnam, 534-729, Korea

### Introduction

In Korea, which boasts the highest population density in the world, and which has continuously pursued economic growth policies, it is inevitable for people to not interfere with the ecosystem. For the most part, these interactions have had a negative effect on the ecosystem. For example, while the reclamation of tideland in coastal areas has led to the damaging of local ecosystems, the destruction of wildlife habitats and the over-capture and excessive gathering of wildlife in coastal areas by humans has brought about a reduction in the number of individual wildlife species; meanwhile, the discharge of environmental pollutants has polluted the coastal ecosystem (KORDI 2002). Although the annual rate of deforestation and felling operations has decreased since the 1990s, the scale of the reclamation projects launched in coastal areas has actually increased (Table 1). In particular, the urbanization of coastal areas has resulted in an increasing amount of such land being incorporated into suburbs.

### Cause of coastal landscape change

Land reclamation projects in the highly productive tideland and mudflat areas, which are home to the majority of the components of the coastal ecosystem, are causing an inordinate amount of damage to these areas. As a result, a new environmental problem has emerged in the form of the seemingly endless increase in the pollution emitted into the air and water environments of urban and coastal areas. One of the main features of the reckless development activities undertaken as part of the projects designed to develop coastal cities carried out in Korea since the 1980's has been the reclamation of mudflats. Such activities have resulted in the reduction of mudflat areas from 280,000 ha in 1987, the equivalent of 2.8% of the nation's total landmass, to 240,000 ha in 1997.

Table 1. Length of shoreline of coastal and island area in South Korea (Km, %)

Region	Total		Terrestrial area		Island area		Types			
	Length	Ratio	Length	Ratio	Length	Ratio	Artificial Coast	Sandy beach	Rocky beach	others
Land Total	11542.4 (100.0)	100.0	6227.5 (100.0)	100.0	5314.9 (100.0)	100.0	1632.1 (14.1)	585.6 (5.1)	980.2 (8.5)	8344.5 (72.3)
*Inchoen	76.5	0.7	61.5	0	15.0	0.3	34.8	0.4	0.1	41.2
Gyeonggi	1171.0	10.1	367.1	5.9	803.9	15.1	252.0	7.9	1.8	909.3
Chungnam	968.7	8.4	763.7	12.	205.0	3.8	235.8	108.4	86.1	538.4
Jeonbuk	444.8	3.9	266.7	3	178.1	3.4	174.0	12.5	0.7	257.6
Jeonnam	5900.7	51.1	2555.3	4.2	3345.	62.9	708.1	109.8	11.8	5071.0
Gyungnam	2042.7	17.7	1406.2	41.	4	12.0	143.3	96.4	589.3	1213.7
*Busan	126.2	1.1	116.6	0	636.5	0.2	32.8	13.3	50.0	30.1
Gyungbuk	332.4	2.9	274.9	22.	9.6	1.1	15.4	112.7	88.1	116.2
Gangwon	216.5	1.9	215.4	6	57.5	0.02	21.1	105.6	80.6	9.2
Jeju	262.9	2.2	200.1	1.9	1	1.2	14.8	18.6	71.7	157.8
				4.4		62.8				
				3.5						
				3.2						

Data: Ministry of Construction and Transportation, 1996; \* metropolitan cities

### Strategy for conservation and development

**Theme7: Assessment of Landscape Changes**  
**7.4 Symposium 24: Land use changes and ecological impacts**

Making use of previous work on coastal ecosystems, this paper attempts to analyze the functional characteristics of coastal ecosystems, and to suggest a natural environment impact assessment inventories which can be used to help conserve and restore tidal flats in Korea (Hong et al. 2007). Furthermore, a comparative analysis of some of the measures which have been proposed with regards to the sustainable management of Korean coastal ecosystems will also be conducted from a socio-ecological standpoint.

**References**

- Hong, S.-K; Koh, C.-H., Harris, R. R., Kim, J.-E., Lee, J.-S. & Ihm, B.-S (2007)** Land use in Korean tidal wetlands: Impacts and Management Strategies. Environmental Management (accepted)
- KORDI (2002)** Studies on inventories and a sustainable use of tidal flats in Korea. Ministry of Marine Affairs and Fisheries. BSPM 16100-1465-3. 885 pp.

**The environmental effects of different land use/land cover in the loess hilly area,  
China**

**L. Chen<sup>1</sup>, B. Fu<sup>1</sup>, J. Gong<sup>1,2</sup>, W. Wei<sup>1</sup>, Z. Huang<sup>1,3</sup>**

<sup>1</sup> State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, P.R. China  
e-mail: chenliding@sohu.com

<sup>2</sup> College of Resource and Environmental Sciences, Lanzhou University, Lanzhou 730000, China

<sup>3</sup> Institute of Ecology, Chinese Academy of Forestry Sciences, Beijing 100085, P.R. China

## **Introduction**

Severe soil and water loss has led to widespread land degradation in China's loess plateau. It has been paid much attention by the Chinese government since the 1950s. In general, soil erosion and land degradation was blamed on strong human activity and a bad water shortage. However the way human and natural factors affect vegetation restoration and soil erosion control is not clear. Although much effort has been made on vegetation restoration to reduce soil and water loss in the loess plateau during the past decades, the efficiency of vegetation restoration was not as satisfactory as had been expected. In the present, a case study of the environmental effects of land use/land covers was studied in the semi-arid loess hilly area, on the western loess plateau. The effect of land use/land cover on soil quality was explored by using an integrated soil quality index based on field soil sampling at a watershed level. The effects of land use/land cover on soil water balance, surface runoff and soil loss were studied by long-term field measurement at plot scale. The following conclusions were reached.

(1) In the semi-arid loess hilly area, land uses have strong effects on soil quality. Vegetation restoration may improve soil quality whilst planting of crops may decrease soil fertility. Among the land use/land cover types investigated, shrubland is the best to improve soil nutrients. Conventional farming systems may cause soil quality decline, whereas other land use/land cover types were intermediate. Generally, the soil quality of land use/land cover are in the following gradient shrubland(*Hippophae rhamnoides* L.) > apricot woodland(*Prunus armeriaca* var. *ansu*) > pine woodland(*Pinus tabulaeformis*) > sparse natural grassland > abandoned > potato farmland in the shaded hill-slopes, and, shrubland (*Caragana microphylla*) > sparse grassland > Alfalfa grassland > abandoned farmland > pine woodland > potato farmland in the with full sun slopes.

(2) Soil water balance was strongly affected by land use/land cover. In most cases, the soil water of all the land use/land cover was close to the state of water deficit, even in the rainy season, and the plant growth was affected badly by water shortage, particularly in the woodlands. In effect, soil water loss occurred during the growing season, and it was not fully replenished from rainfall during the rainy season, although some rainfall occurred in the summer. It was found that soil water at the end of the growing season didn't reach the level at the beginning. This may be due to two reasons. One is that fast growth of vegetation uses much of water, and the second is that much rainfall was lost as surface run-off.

(3) Concerning soil and water loss, it was found that pine woodland induced the largest water loss by surface runoff, followed crops on slopes, alfalfa, semi-natural grassland and shrubland. However, the pine woodland and shrubland are good for soil conservation, and the crops and man-made grasslands produce a high loss compared with the woodland and shrubland. In general, the gradient of soil and water conservation efficiencies was shrubland > semi-natural grassland > pine woodland > man-made grassland (*alfalfa*) > cropland.

## **Conclusions**

**Theme7: Assessment of Landscape Changes**  
**7.4 Symposium 24: Land use changes and ecological impacts**

Based on the above findings, natural vegetation was strongly recommended in the semi-arid loess hilly area when land use conversion was being carried out, then shrub plantation, or finally land closure. As the traditional treatment, tree plantations should be the last to be considered when land use conversion is being carried out. Meanwhile, some measures for improving rainfall conservation are required for improving the regional environment, whilst enhancing the replenish ability of rainfall into soil water.

## Agricultural landscape pattern and its spatial relationship with forestland in the state of Selangor, peninsular Malaysia

S.A. Abdullah<sup>1</sup>, N. Nakagoshi<sup>2</sup>

<sup>1</sup>Institute for Environment and Development (LESTARI), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Darul Ehsan, Malaysia.  
e-mail: saiful\_arif2002@yahoo.com

<sup>2</sup>Graduate School for International Development and Cooperation, Hiroshima University, 1-5-1 Kagamiyama Higashi-Hiroshima City, 739-8529 Japan.  
e-mail: nobu@hiroshima-u.ac.jp

### Introduction

The development of two major agricultural crops in Malaysia in the past decades, oil palm and rubber, has been identified as one of the primary causes of forest loss (Goh, 1982). However, understanding of this relationship is still without quantitative explanatory data, which is vital to improve land development of the agricultural crops. To understand the relationship this study addresses their dynamic changes, patchiness and spatial relationship with forestland in the state of Selangor, Malaysia as a case study.

### Methods

Data sets Three sets of existing digitized (vector version) maps of the study area, representing the years of 1966, 1981 and 1995, were used in this study. In this study forest and, wetland forest and marshland land use categories were referred to as forestland (Abdullah and Nakagoshi, 2006).

### Data analysis

#### *Dynamic changes of oil palm and rubber land uses*

The dynamic changes of these agricultural crops were analyzed in terms of total change (ha) and rate of change (%/year) in two periods: Period 1 (between 1966 and 1981) and Period 2 (between 1981 and 1995). To evaluate how much forestland was converted into these agricultural crops, change detection analysis was conducted using ArcView 3.2, involving the intersection of land use maps of the three years.

#### *Patchiness*

Patchiness of oil palm and rubber was analyzed for the entire study area. Two landscape metrics or indices, number of patches and mean patch size (McGarigal and Marks, 1995), were selected to measure patchiness.

#### *Association Index*

An index, namely Association Index (AI) was defined to quantify the spatial association between the two agriculture lands and forestland.

$$AI, \% = [TL_{fr\_Lui} / TL_{fr}] \times 100$$

where,  $TL_{fr\_Lui}$  = total length of forest perimeter or edge bordered with land use type  $i$  (in this case,  $i$  is either oil palm or rubber) and  $TL_{fr}$  = total perimeter or edge of forest patches.

#### *Entropy*

In this study, entropy of oil palm and rubber was determined to present a general spatial dispersion of these land uses in the time periods studied. To explore the importance of oil palm and rubber dispersion towards areas dominated by large tracts of forestland, the entropy of oil palm and rubber was determined using the landscape type approach.

## Results

During the periods studied oil palm area increased whereas rubber area reduced. Measurement of two landscape metrics (number of patches and mean patch size) revealed that patches of oil palm expanded whereas patches of rubber experienced fragmentation. In Period 2 the total change of forestland into these agricultural crops was higher than that in Period 1. In response, the percent of forestland bordered with these agricultural land uses (measured by the Association Index) generally increased. In Period 2, loss of forestland was mainly associated with the expansion of oil palm whereas in Period 1 it was due to their conversion into rubber plantation. Expansion of oil palm predominantly involved the conversion of wetland forest and marshland. In contrast, conversion into rubber plantation mainly associated with loss of forest land use category. Although the dispersion of oil palm gradually increased, the entropy analysis revealed that its dispersion towards area dominated by large tract of forestland was generally reduced or increased much more slowly in Period 2 than that in Period 1.

## Discussion and conclusion

Rubber and oil palm for decades has been the major human land use in the state of Selangor. However, the most important impact of their development was the loss of natural forest. Over the periods studied oil palm areas dispersed towards forestland. Nevertheless, reduced its expansion towards areas dominated by large tract of forestland suggest that the expansion of oil palm was probably more towards small patches of forestland. This is because small fragmented forests are conducive for human accessibility and easily exposed to various types of development (Forman, 1995).

In this study, using the landscape type approach provides the possibility to produce an actual dispersion pattern of the agricultural crops towards forestland. In conclusion, understanding of the relationship quantitatively can offer other dimension to improve land development of rubber and oil palm for environmental sustainability.

## References

- Abdullah, S.A. & Nakagoshi, N. (2006).** Changes in landscape spatial pattern in the highly developing state of Selangor, peninsular Malaysia. *Landscape and Urban Planning* **77**: 263-275.
- Forman, R.T.T. (1995).** *Land Mosaics: the Ecology of Landscapes and Regions*. Cambridge University Press. Cambridge, UK.
- Goh, K.C. (1982).** Environmental impact of economic development in Peninsular Malaysia: a review. *Applied Geography* **2**: 3-16.
- McGarigal, K. & Marks, B.J. (1995).** *FRAGSTAT. Spatial Analysis Program for Quantifying Landscape Structure*. USDA Forest Service General Technical Report PNW-GTR-351.



## Assessing Impacts of Human Activities on Riparian Wetlands of the Yellow River in He'nan Province Using Remotely Sensed Data

D. Shengyan, L. Guofu

College of Environment & Planning, He'nan University, Kaifeng, 475001, China  
e-mail: syding@henu.edu.cn

Riparian wetlands are regarded as important landscape components for their rich biodiversity, their ecological functions, and their aesthetic values. Proper management of riparian wetlands is therefore at the top of the agenda for many policy makers and landscape planners. A solid base of knowledge regarding riparian wetlands is required for formulating appropriate management policies and implementing them properly. The Yellow River, as the second longest river in China, has supported large human populations for millennia. Intensive exploitation of the Yellow River by humans has thus predictably devastated riparian wetland ecosystems throughout its course. Sustainable management of the Yellow River is therefore imperative. The current body of scientific literature concerning the Yellow River however is inadequate for achieving that. More studies are thus required.

This study assesses changes of human activity along the Yellow River in He'nan Province, and the concomitant changes of the riparian wetland landscape there, in the 1987-2002 period. The study area is located in the northern part of He'nan Province, measuring approximately 4 737.11 km<sup>2</sup>. The wetland landscape elements in the study area were classified into four types: river, pool & lake, paddy field, and beach. Two composite maps, generated using respectively landsat-5 TM images (1987) and landsat-7 ETM images (2002), were used for analysis. A 1:10,000-scale land use map published in 1997 and 1:50,000-scale topographic maps based on aerial photos taken in 1972 were used for geometric rectification and classification accuracy assessment. All image processing was performed using ERDAS IMAGINE software (ERDAS / 8.4). The Shannon-Weaver index (landscape diversity index)  $H$ , the landscape fragmentation index  $FN$ , the patch shape index  $D$ , and centroid coordinates of each patch type were calculated to quantify the landscape changes that occurred in the 1987-2002 period.

Total wetland area declined, by 13.39%, from 1,088.59 km<sup>2</sup> in 1987 to 942.86 km<sup>2</sup> in 2002. Total patch number meanwhile decreased from 19,231 to 9,910. River area shrank considerably during that period. There was a marked decline in beach area and a significant increase in pool & lake area. Paddy field was the largest wetland landscape patch type in this area, both in 1987 and in 2002. Significantly, paddy field area increased slightly while the number of paddy field patches decreased by over 50%, suggesting a consolidation of cultivated patches. The Shannon-Weaver index decreased from 0.9276 to 0.7112, indicating a decline in landscape diversity. The landscape fragmentation index decreased from 0.0159 to 0.0095, showing that the degree of wetland landscape fragmentation was low and falling. Paddy fields became more regular in shape-the patch shape index of paddy fields decreased from 1.4255 to 1.3708. Pools & lakes meanwhile became more irregular in shape-the patch shape index of pools & lakes increased from 1.1267 to 1.3634. The centroid of paddy fields moved 4,962.71m northeastwards. The centroid of pools & lakes moved 6997.74m southwestwards. The river channel became narrower and less branched.

Land-use policies appear to have had a strong impact on the landscape structure of the study area. With the implementation of the household responsibility system in 1978 and the development of the economy, many farmers diversified their production activities, resulting in a diversification of agricultural income sources. In the lower reach of the Yellow River, the relatively abundant water supply and the ease of diverting water from the "hanging river" soon led to an increase of the paddy field and a surge of fishery activities. The rapidly growing economy put an ever growing demand for water supply. Unfortunately, coordinated

**Theme7: Assessment of Landscape Changes**  
**7.4 Symposium 24: Land use changes and ecological impacts**

water resource management system was not established, resulting in great waste of water resources of the Yellow River. Consequently the River dried up, leading to the decline of beaches and constraining the expansion of paddy fields. Dam construction changed the flow dynamics of the River, negatively impacting the riparian wetlands.

## The Urbanised Avian Pondscape: How to Create a Balancing Bird Demand Model?

W-T. Fang

Department of Landscape Architecture, Tunghai University, Taichung 40704, Taiwan  
e-mail: wtfang@thu.edu.tw

Man-made farm ponds are unique geographic features of the Taoyuan Tableland, Taiwan. These small artificial ponds contain many organisms. Usually, attention has focused on the large numbers of birds that use pond fields. It is ecologically significant because one fifth of all the bird species in Taiwan find a home on these ponds. The issue at hand is that these features are disappearing and bring with it the loss of this refuge function. Population growth and inappropriate urban development have led to pond disappearances. This has greatly decreased ponds' water storage capacity in the region, ultimately resulting in ecological degradation. This situation suggests that the ecological functioning of these farm ponds will decline when humans utilize, fill, or drain these ponds for socioeconomic purposes. The mildly sloping gradient of the landscape makes this area suitable for economic exploitation, whereas it is fortunate that this area supports a profusion of avian species.

This study aims at characterizing the diversity of bird species associated with these ponds whose likelihood of survival was assessed along the gradient of land development intensities. Such characterization helps establish decision criteria needed for designating certain ponds for habitat preservation and developing their protection strategies. A holistic model was developed by incorporating logistic regression with error back-propagation into the paradigm of artificial neural networks (ANN). The model considers pond shape, size, neighboring farmlands, and developed areas in calculating parameters pertaining to their respective and interactive influences on avian diversity, among them the Shannon-Wiener diversity index ( $H'$ ). Results indicate that ponds with regular shape or the ones with larger size possess a strong positive correlation with  $H'$ . Farm ponds adjacent to farmland benefited waterside bird diversity. On the other hand, urban development was shown to cause the reduction of farmland and pond numbers, which in turn reduced waterside bird diversity. By running the ANN model with four neurons, the resulting  $H'$  index shows a good-fit prediction of bird diversity against pond size, shape, neighboring farmlands, and neighboring developed areas with a correlation coefficient ( $r$ ) of 0.72, in contrast to the results from a linear regression model ( $r < 0.28$ ).

Analysis of historical pond occurrence to the present showed that ponds with larger size and a long perimeter were less likely to disappear. Smaller ( $< 0.1$  ha) and more curvilinear ponds had a more drastic rate of disappearance. Based on this finding, a logistic regression was constructed to predict pond-loss likelihood in the future and to help identify ponds that should be protected. Overlaying results from ANN and form logistic regression enabled the creation of pond-diversity maps for these simulated scenarios of development intensities with respective to pond-loss trends and the corresponding dynamics of bird diversity.

ANN is one of the tools that can resolve prediction problems, and this ANN property is now well understood. First, the validation results were satisfactory with a four-neuron model, confirming the non-linearity of the relationship among the parameters. The training set ( $r = 0.725537$ ,  $n = 35$ ) and validation set ( $r = 0.722752$ ,  $n = 10$ ) were surprisingly close in meeting the underlying rules embedded in the real values of the true  $H'$ . Second, the pondscape configuration was in fact a very relevant factor in avian diversity. In this study, the pond fractal dimension (MPFD) was the most significant parameter for waterside birds in the non-linear model in comparison to the other factors. The one-row factor elimination approach (FEA) determined that the MPFD is the crucial factor affecting waterside bird diversity. The mean  $H'$  predicted error of the MPFD in the four-neuron simulation model was slight (mean  $H'$  predicted error =  $0.0827 \pm 1.16432E-05$ ,  $n = 45$ ). Rather, the relationship between the values of the MPFD (range = [1, 2]) and waterside bird  $H'$  was negative (tested by a 4-neuron

model, with test samples at a  $\pm 10\%$  range). The precise results and the ANN potential to predict waterside bird H' were significant from the MPFD.

Some of the most significant findings came from the ANN model. The ANN model suggests that small and curvilinear ponds together with urban development associated with landscapes possessing high-density rural populations adversely affect waterside bird diversity. To some extent, increased heterogeneity of microhabitats within these pond units would result in promoting species diversity. For example, drawdown can be beneficial to shorebirds; foliage buildup at the waterfront can be beneficial to waterfowl. There is clearly some mechanism responsible for variations in avian communities across the pond size gradient. According to MacArthur and Wilson (1967), the nature of this mechanism is interesting as the island biogeographic concept predicts that smaller microhabitats should contain fewer species due to the effects of reduced immigration rates. The incidence of area-sensitive species, i.e., waterfowl, is expected to increase as pond size increases. In addition, a larger pond is also more likely to contain at least one individual of a species, especially an uncommon or rare one. Another important finding is that pond shape (i.e., MPFD) within a pondscape might tremendously influence waterside bird diversity. The ANN method provides a good indication of the cumulative influences of other environmental factors: such as %BUILD and %FARM. The cumulative influences were those that resulted from anthropogenic influences, and became statistically significant for waterside bird diversity. The above-mentioned environmental factors were selected from the correlation analysis associated with the linear regression model, and the impact trend of each factor was detected by the ANN testing model. Finally, the impact trends were calculated as the respective sequence of MPFD, %FARM, pond size (PS), and %BUILD.

## Hierarchical theory in the management of fragile subwatersheds --- a case study of Zhifanggou watersheds in hilly gullied Loess Plateau, China

Z.H.Kong<sup>1</sup>, X.S.Zhang<sup>2</sup>

<sup>1</sup>Shanghai Key Laboratory of Urbanization & Ecological Restoration, East China Normal University, Shanghai, China 200062  
e-mail: zhkong@bio.ecnu.edu.cn

<sup>2</sup>Institute of Botany, Chinese Academy of Sciences, Beijing, 100093

### Introduction

Subwatersheds have long been a selected scale for erosion control and economic development in the hilly gullied loess region in China as it is the dominant landscape element in this area. A detailed analysis of natural and social conditions, erosion sensibility, family income, education as well as transportation, in particular, has been carried on in Zhifanggou watershed. Interactions were also studied. Based on its ecological and productive function, this paper defines hierarchical levels as follows: the whole watershed --the slope --villages --households. It was concluded that to realize sustainable development of small watersheds requires that different control and exploration measures be adopted on different hierarchical scales as they exhibit unique spatial heterogeneity, ecologically and economically.

### Results

#### 1. Courtyard economy based on individual household level

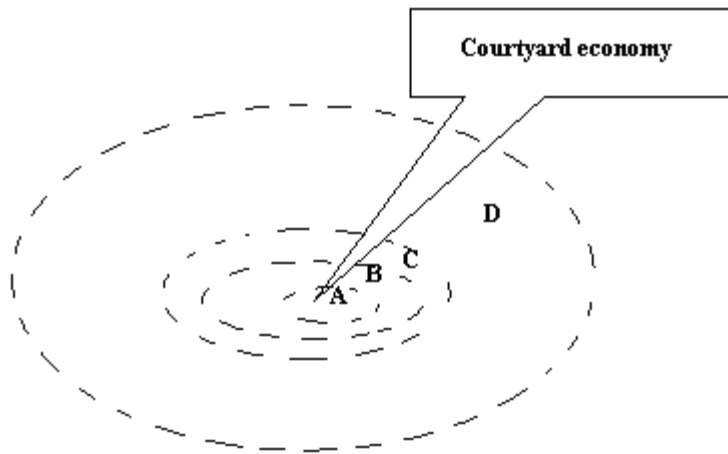
Farmers in the region have a tradition of planting cash crops, breeding stock and initiating other household manufacturing to take advantage of vacant land in the yard or surrounding the house since homes are usually built on plain and fertile land, and always near a water source. Courtyard economy can be an important part of family income.

#### 2. Areas for efficient agricultural production at the village level (Illustration 1)

Due to topography, transportation as well as production condition, discrimination exists at different zones that are within different distances from the villages. Central areas, **A**, **B**, are nearest to the village and the topography here is generally plain and changes slightly, making it more convenient for fertilization and other intensive management activities. The central areas will be the basic farming area for cash crops and trees. **A** also includes courtyard economy. Transitional area, **C**, is outside **A**, **B**, and a little farther from the villages. Slope is the main cultivation land type here. Conservation tillage such as intercropping or rotation of trees, crops and grass should be focused on. The outskirt area, **D**, is the ecological protection area where trees and shrubs will be planted for conservation as well as for firewood purpose.

#### 3. Vegetation restoration and production pattern at slope level

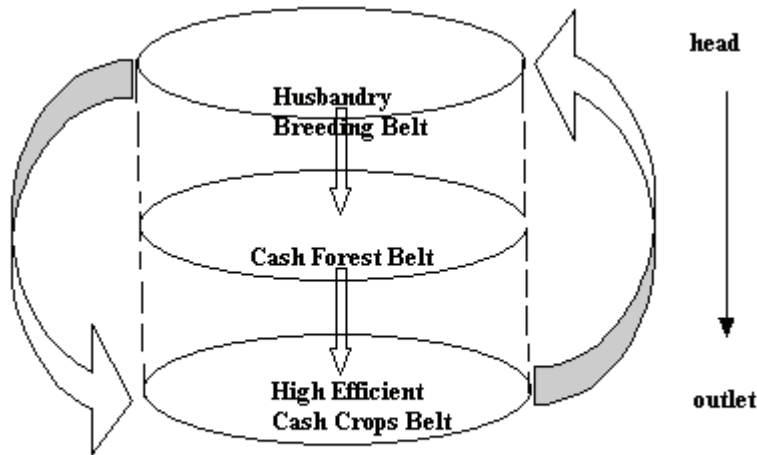
Numerous existing studies show that dramatic differences in natural conditions occur along the slopes, up and down. The top or upper part of a slope is windy, arid and subject to erosion and is generally for soil and water conservation. The middle of a slope where the gradient is gentle with excellent sunshine is for conservation and economic activities. Cash trees would be planted here. To prevent erosion and make full use of resources, legume herbaceous grass and shrubs should be planted at the edge of an orchard. The lower part of a slope with gradual gradient and better soil moisture is mainly composed of terraces. It can be for basic farming. In riverbeds and dam land, an intensive agricultural production system will be formed to achieve a comprehensive development of grain, cash crops and husbandry.



**Illustration 1** Circular stratum pattern  
for high efficient agricultural production

#### 4. Optimized spatial eco-economic pattern of small watersheds (Illustration 2)

Disparity in natural resources and transportation facilities at the head, middle and outlet of the watershed are obvious. Due to source erosion, the head tends to be steeper and has more slope land which is not fit for crop planting and cash forest. There is only one mud-built road leading to the outside world. The topography of the middle section of a watershed tends to be open and gentle. Illumination and water supply is relatively superior and favorable to cash forest planting. The outlet boasts more flat land and more convenient access to water and fertilizer. The most important thing is that it is generally near a wider transportation net. Efficient agricultural production system proves feasible.



**Illustration 2** Optimal spatial pattern  
for high eco-economic development

## 7.5 Open Session 3: Landscape Change Assessment

### Land use changes in politicized maps in an historical perspective: the example of Kohtla-Järve, Estonia

A. Printsman

Institute of Geography, University of Tartu, Vanemuise 46, 51014 Tartu, Estonia;  
Centre for Landscape and Culture, Tallinn University, Uus-Sadama 5, 10120 Tallinn, Estonia.  
e-mail: anu.printsman@ut.ee

#### Introduction

Mapping itself is a political act: it often lays a claim onto the piece of land in question. Cosgrove's (1999) observation that "mapping is deceptively simple activity" is especially true when dealing with historical perspective. Maps as representations have always "projective power" or ulterior motives. This should be kept in mind above all in Eastern European countries such as Estonia that have witnessed many rulers during the course of history who have shaped the landscape and land use as well as produced maps.

#### History of mapping in Estonia

Modern Estonia's first exact maps concerning land use come from the end of 17<sup>th</sup> century. The mapping of land use was necessary to get an overview of resources for the war-torn Sweden that Estonia was part of. These amazingly precise cadastral maps together with detailed descriptions are still partly preserved today.

However, the new ruler, Russia, did not initiate mapping works in Estonia during the whole 18<sup>th</sup> century. In czarist Russia the Baltic states enjoyed special conditions involving continuation of feudalism by Baltic Germans. Estonian peasants had no need for maps and manor owners could copy the adequate original maps in Stockholm, Sweden.

The 19<sup>th</sup> century witnessed several agricultural reforms so new maps were necessary. For example, encumbrances from peasants were now calculated not on income but resources, i.e. area and quality of land. During the 19<sup>th</sup> century also land amelioration and land consolidation was started by landlords at first opposed by peasants, but after the abolition of serfdom, when it became possible to buy private property even formerly reluctant peasants became interested in improving the quality and profitability of land. In the conditions of the industrial revolution agricultural innovation finally spread through the countryside. Two large-scale mapping projects were carried out in 1855-1859 and 1893-1913.

During the 20<sup>th</sup> century Estonia first belonged to czarist Russia, then gained independence, was occupied by Germans and Russians several times during the Second World War finally ending up in the Soviet Union and regained its independence officially in 1991 (see Palang *et al.*, 2006). Each of the socio-economic (trans)formations saw new mapping exercises.

#### Consequences for the user

When studying historical land use one has to pay attention to several inconsistencies.

(1) Not all of the land is covered by one mapping exercise. With mapping in 1893-1913 first sheets of maps were from north-eastern part of Estonia but south-eastern part remained unmapped. This also ends up in the situation where industrial elements were recorded on one map sheet but not to the other, e.g. railway lines. "Time-leaps" are too long to reflect rapidly developing/developed areas.

(2) The usage of different projections and measurements (scale and resolution) units from arm-lengths, fathoms and versts giving unreasonable scales in kilometres. In historical

cadastral maps the ratio between real space and maps has been presented as graphic line scale. The preciseness of mapping itself and its outcome is also questionable. Some sheets of the maps in the end of 19<sup>th</sup> century were photographically reduced to receive the needed scale, thus content of the map sheets varies greatly depended upon whether it was mapped in end size or not. Today's land cover maps, e.g. CORINE are using grids with cell size too large for Estonian landscape diversity.

(3) The knowledge of different languages used on maps originating from different time periods: Latin and Cyrillic alphabets representing local Estonian and Baltic German names and descriptive specifications.

(4) Changes in land use classifications and class definitions combined with personal interpretation of models of reality in GIS terms. Is forest just a forest? or is it divided into deciduous and coniferous woods? or is the coniferous forest subdivided into spruce or pine stands? Combination of already attainable official statistics (since the 19<sup>th</sup> century) with contemporary maps gives strange results: e.g. the island of Saaremaa had share of forests 5% according to statistics but on the maps it is 42% (Raet *et al.*, 2004). Some of the land use classes have disappeared, e.g. "Buschland" depending on agricultural innovations. Besides the questions of the truthfulness of represented reality, reality may not be changed but the depiction of it has in the means of cartographic representation, e.g. colour schemes, fuzziness of borders etc. (e.g. contemporary maps do not show winter tracks).

(5) With large scale maps, problems with ownership politics appear. Time sequences can be hard to draw: with the owner changes also toponymics may change. Furthermore place names "travel" and street names are often subjected to changes in political order. Still, these specific and technical maps provide exclusive materials for those interested in the history of a given place.

(6) When dealing with maps produced under a totalitarian regime a whole new set of discrepancies emerge. Some maps in Soviet Union had "imaginative scope and projective power" of mapped objects not actually there yet. Thus, the metaphor for maps as "frozen moments in time" is not always true for such planned economies. Additionally, distortion and intentional lying, i.e. omitting "important" objects causes problems, as are also accessibility of maps in form of confidentiality and availability.

### Example: Kohtla-Järve, Estonia

All these problems were encountered when dealing with land use changes in Kohtla-Järve, Estonia. Kohtla-Järve is a town formed in 1946 under the Soviet regime in north-eastern Estonia because of its oil shale deposits. The politics and inconsistencies and contingencies of land use maps will be illustrated in the presentation demonstrating different contexts and coming in the end to the conclusion that maps still have value as products of their era and that land use has been changed, although politics revolves around and inside of mapping.

### References

- Cosgrove, D. (1999)** Introduction: mapping meaning. D. Cosgrove (ed.) *Mappings*. Reaktion Books, London, pp. 1-13.
- Palang, H.; Printsmann, A.; Konkoly Gyuró, É.; Urbanc, M.; Skowronek E. & Woloszyn W. (2006)** The forgotten rural landscapes of Central and Eastern Europe. *Landscape Ecology* **21** (3): 347-357.
- Raet, J.; Sepp, K.; Külvik M. & Meikar T. (2004)** *Metsa ja avamaastiku territoriaalse vahekorra kujunemise analüüs viimastel sajanditel [Analysis of the development of forest and open landscape ratio during last centuries]*. Manuscript in the Institute of Environmental Protection at Estonian University of Life Sciences, Tartu, Estonia.



**Geo-hydroecological responses to historical and present day land use changes in the Middle Paraíba do Sul river valley: challenges for a sustainable landscape (\*)**

**A.L. Coelho Netto, A.S. Avelar**

<sup>1</sup> GEOHECO/Laboratory of Geo-Hydroecology: integrated research on Geomorphology, Hydrology and Geoecology/Landscape Ecology, Department of Geography, Institute of Geosciences at Federal University of Rio de Janeiro, Rio de Janeiro, CEP 21941-590, Brazil ; e-mail: ananetto@acd.ufrj.br

**Introduction**

The landscape mosaic at Middle Paraíba do Sul river basin (55,400 km<sup>2</sup>) has been submitted to land use changes since the mid-XVIII century when the original Atlantic rainforest was substituted by coffee plantations. In the early XX century this use was substituted by cattle grazing and grasslands spread throughout the hilly lowlands. In the mid-XX century industrialization and urban growth expanded. Currently the hilly lowlands show a degraded rural landscape marked by intense gully erosion and landslides. Since 2000 this unstable landscape has been submitted to a new economic cycle based on *Eucalyptus* plantations to attend the world cellulose and carbon markets. This paper focuses on the geo-hydroecological responses to these land use changes as a contribution to provide a basis for landscape rehabilitation and to prevent landscape degradation.

**Previous landscape history over geological time**

The regional landscape comprises high grade metamorphic rocks of Pre-Cambrian age trending NE-SW: orthogneisses; metasedimentary rocks and granitoid rocks. The Cretaceous-Paleogene tectonic was caused by the rift system of SE Brazil that created the present physiography marked by the mountain ranges parallel to the coast and the hilly convex-concave lowlands with wide, gentle inclined valley bottoms. The studied basins (of *Bananal*, *Barreiro de Baixo* and *Sesmarias* rivers) drain northeasterly as the reverse of the Atlantic faulting scarp (called *Serra da Bocaina*). The underlying bedrock presents a series of sub-vertical and ruptile faults and two main regional sub-vertical joint settings striking NE-SW and NW-SE. These inherited structures have been influencing the recent landscape evolution particularly related to the expansion of the channel network (gullying) as shown by Coelho Netto (1999, 2003). Paleoenvironmental studies in the Bananal basin indicate the entry of the Atlantic rainforest between 9,000 and 8,000 years BP replacing savannah-like vegetation as a response to the global warming during the Pleistocene-Holocene transition (10,000 years BP). This environmental change was followed by a period of landscape instability (under high erosion rates) lasting from 10,000 to 8,000 years BP; these sediment supply to the main channels led to an aggradation cycle (depositional rate=1.485 m<sup>3</sup>/ km/ year). Then landscape stability prevailed until the forest substitution by coffee plantations which re-started a new phase of landscape instability; since then the sediment rate along the present floodplain has reached 3.737 m<sup>3</sup>/ km/ y.

**Geo-hydroecological responses to human induced land use changes:**

Geo-hydroecological studies on forest slopes demonstrate the important role played by the litter-topsoil zone in controlling high infiltration capacity and very low discontinuous intra-litterflow production: < 1% of rainfall above 20 mm/day (Coelho Netto, 1987). In small mountainous catchments (<5 km<sup>2</sup>) around 20% of the annual rainfall is partially intercepted by the forest canopy and only 30% of the annual total converge into the channel as stormflow. So on average 50% of the annual precipitation remains stored in the soil and is gradually recycled to the atmosphere by evapotranspiration. In addition, soil reinforcement by

roots increase slope stability; therefore landslides studied cases are mostly common on degraded forest slopes.

#### From forest to coffee plantations

Despite the presence of a cohesive soil mantle in these hilly lowlands, the exposure of bare soil between the lines of coffee trees along the hillslopes provided lower infiltration rates and increased overlandflow production; the lost tree-root strength increases soil erodibility leading to high erosion rates. Higher sediment yields converging into the river system intensifies bed incision and exposes groundwater seepages at the base of thick alluvial fills. Under critical discharges, seepage erosion has led to the expansion of the channel network (gullying) throughout the low-order tributary valleys.

#### From coffee to cattle grazing

Cattle grazing has favoured the gullying processes in response to significant changes on hillslope hydrology and mechanics of erosion. Grass-roots and the network of channels constructed by "Saúva" ants increased infiltration rates due to higher hydraulic conductivity ( $K_s$ ) within the dense root zone of 30 cm thick ( $K_{s/10\text{ cm}} = 1.26 \times 10^{-4}$  cm/sec;  $K_{s/30\text{ cm}} = 3.52 \times 10^{-5}$ ;  $K_{s/60\text{ cm}} = 4.45 \times 10^{-5}$ ). Thus pipeflow can be generated whenever the topsoil reaches a near saturation condition to feed a temporary saturated zone at the base of the permeable, non-cohesive and thick Quaternary deposits. Regressive channel incision into this sediment fills followed the tributary valley axis due to groundwater exfiltration and seepage erosion; new gully tips have progressed towards the upper unchanneled valleys. When gully incision reaches the underlying saprolite it may cause the exfiltration of joint-controlled artesian flows and accelerate gully retreat; as the gully reaches the steep slopes nearby the hillslope divides it may trigger landslides. This last condition increases the sediment yield delivered to the regional channel network to feed the current aggradation cycle.

#### From cattle to the introduction of *Eucaliptus*

An initial study indicates that net precipitation below the tree canopy is higher than gross precipitation and also that high infiltration capacity avoid overlandflow generation. So it is an infiltration environment as it is discussed in the present paper.

\* Funding by: CNPq and FAPERJ.

#### **References**

- Coelho Netto, A.L. (1987)** Overlandflow production in a tropical rainforest catchment: the role of litter cover. *CATENA*, vol. 14: 213-231.
- Coelho Netto, A.L. (1999)** Catastrophic Landscape Evolution in a Humid Region (SE Brazil): inheritances from tectonic, climatic and land use induced changes. *Supplementi di Geografia Fisica e Dinamica Quaternária, Supp. III, Tomo 3*: 21-48.
- Coelho Netto, A.L. (2003)** Evolution of headwater zones in the Mid-Paraíba do Sul river valley (SP/RJ): structurally controlled channel formation and network growth. *Revista Brasileira de Geomorfologia*, 4 (2):118-167.

## Long-term changes within China's densely populated rural landscapes

E.C. Ellis

Department of Geography & Environmental Systems University of Maryland, Baltimore  
County, 1000 Hilltop Circle, Baltimore, MD 21250, USA  
e-mail: ece@umbc.edu.

### Introduction

Densely populated agricultural villages cover more than 2 million square kilometres across China. The ecology of these ancient anthropogenic landscapes has been transformed over the past fifty years by unprecedented changes in population density and technology, without a significant change in their total area. Though changes in land use by hundreds of millions of rural households would be expected to have global environmental consequences, these fine-scale changes are not well measured or well understood because they are a challenge to measure by conventional, coarser-resolution systems for measuring land use change (>25 m; Ellis *et al.*, 2006).

### Methods

We used a regional sampling and upscaling system to estimate long-term ecological changes, circa 1945 to 2002, across China's densely populated agricultural regions based on high-resolution landscape change measurements made at five field sites across China (Ellis, 2004). Landscape samples (25 ha) were mapped by direct interpretation and intensive field validation of ecologically distinct landscape features (ecotopes) in historical aerial photographs (circa 1945) and IKONOS satellite imagery (2002) using a standardized fine-scale ecotope mapping system (Ellis *et al.*, 2006). Regional changes and their uncertainties were estimated by upscaling landscape sample data using a statistically robust uncertainty analysis system combining bootstrapping and Monte Carlo simulation with regional optimization based on regional land cover, population and terrain data.

### Results & Discussion

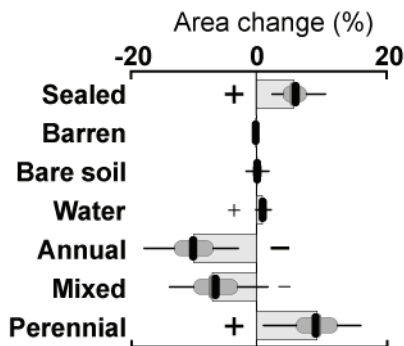
As expected, impervious surface areas increased substantially over time as a result of housing and road construction ("Sealed" in Figure 1). Still, this increase was unexpectedly large, representing an area similar in magnitude to the total current extent of all of China's cities put together. Though this might seem an overestimate, this result is entirely reasonable when considering the current distribution of China's population and the much lower density of its rural settlements. Even more surprisingly, cover by closed canopy woody vegetation and trees also increased significantly over time in these same areas, by approximately 10%, driven by tree planting and regrowth around new buildings, the introduction of perennial agriculture and improved forestry, and the abandonment of annual crop cultivation ("Perennial" cover in Figure 1).

The impacts of these fine-scale changes in landscape structure on climate, biogeochemistry and biodiversity are poorly understood and may be entirely different from those observed at larger scales, with urban heat islands replaced by "rural heat mosaics" and forests replaced by carefully tended orchards and small stands of one to a few trees, with the environmental impacts of these strongly moderated by local patterns of housing and road construction, agriculture, forestry and abandoned lands.

### Conclusions

Theme7: Assessment of Landscape Changes  
7.5 Open Session 3: Landscape Change Assessment

Our observations of significant long-term changes in landscape structure across China's village landscapes demonstrate that fine-scale changes within anthropogenic landscapes have the potential to contribute substantially and in unforeseen ways to global changes in biogeochemistry, biodiversity and climate. In conventional global and even regional-scale observations and models, China's village regions are represented far more simply than in our study, either as cultivated land alone or as crops mixed with trees and shrubs in hilly areas or with builtup surfaces and/or water in plain regions. As a result, China's village regions appear, erroneously, to have changed little in the recent decades for which regional estimates from conventional remote sensing are available. Landscape sampling and regional upscaling methodologies, such as ours, can enable the coupling of relatively precise local observations with regional data and models, yielding more accurate assessments of the regional and global impacts of land use changes within and across the densely populated landscapes of the world. These assessments, and their use in mediating the negative consequences of land use change, will be increasingly important as human populations increase and expand in the years ahead.



**Figure 1.** Changes in land cover across China's village regions, 1945 to 2002. Bars indicate median changed area as percent of total regional area, including their uncertainty.

### References

- Ellis, E.C. (2004)** Long-term ecological changes in the densely populated rural landscapes of China. R.S. DeFries, G.P. Asner, R.A. Houghton (Eds.). *Ecosystems and Land Use Change*. American Geophysical Union, Washington, DC, pp. 303-320.
- Ellis, E.C., Wang, H., Xiao, H.S., Peng, K., Liu, X.P., Li, S.C., Ouyang, H., Cheng, X., Yang, L.Z., (2006)** Measuring long-term ecological changes in densely populated landscapes using current and historical high resolution imagery. *Remote Sensing of Environment* **100**: 457-473.

## **A Review of Methods Used to Visualise Landscape Change Patterns**

**E.A. Moylan**

School of Geosciences, University of Sydney, Sydney, 2006, Australia,  
e-mail: emoy4644@mail.usyd.edu.au

### **Introduction**

New methods of visualising spatio-temporal datasets have been developed at a time when the assessment of landscape change pattern (LCP) is becoming more widespread and complex. Recent massive increases in computing speed, power, and sophistication has seen an improvement in the capacity to analyse the complexities of spatio-temporal datasets. However, as new methods are introduced it is important to understand not only their advantages, but also their limitations in relation to LCP assessment.

This paper reviews methods used to visualise LCP by comparing five different approaches; a single index, index series, map series, interactive spatio-temporal cube, and interactive mapping software with temporal functionality. The ability of each method to identify, analysis, and communicate LCP was examined. Matters raised as a result of the research, and discussed in this paper, include: the role of temporal cognition, the question of appropriate metadata formats, the varying impact of dataset uncertainty, the relationship between dataset exploration capabilities and processing levels, and the need to combine methods to improve analysis capacity.

### **Extracting Landscape Change Patterns from the dataset**

Landscape change features used in pattern analysis can include: the number of changes in the landscape, the location of change, the timing of the changes, the rate of change, and the type of changes. The ability to examine these features is influenced by the visualisation methods incorporated into the tools that are used to extract the patterns from the dataset.

The single index is a metric that represents the rate at which changes occur. It is calculated based on the number of changes over the period, providing a single quantitative figure. An index series uses intervals to divide a study period. For each interval a value is calculated (e.g. percentage of land use type). The index series provides a numerical visualisation of change over time. A map series is created using queries to extract information from the dataset at selected time points. The resulting maps are sequenced to illustrate changes in the landscapes spatial structure. An interactive spatio-temporal cube is accessed using computer software. Using time as the 3<sup>rd</sup> dimension the dataset can be investigated through queries. Mapping software with temporal functionality (such as TimeMap©) allows the dataset to be explored in both in a spatio-temporal environment.

### **Temporal Cognition in a spatial context**

The use of geovisualisation methods to analysis LCP raised some interesting questions relating to the analysis of spatio-temporal patterns. A fundamental problem with spatio-temporal datasets is that it is not possible to view all data simultaneously. Temporal cognition in the spatial sciences has been examined (MacEachren 1995), however emphasis has been placed on the identification of event locations and/or the change in spatial extent, as opposed to the rate or spatio-temporal patterns of change. The role of temporal cognition and furthermore, spatio-temporal cognition, in the analysis of the spatio-temporal patterns in the landscape change context has not been widely discussed and requires further exploration. It is not clear how humans interpret and understand spatio-temporal patterns.

### Metadata requirements

The provision of metadata to improve conceptualisation and interpretation in a geovisualisation environment is recommended by Nakaoji, Takashima et al (2001). In terms of spatio-temporal cognition the provision of metadata (e.g. temporal interval values) in the visualisation of LCP appears to be of prime importance, especially for those techniques that use interactive tools.

### Impact of Uncertainty

Uncertainty is an example of metadata that proved difficult to visualise. Although uncertainty in the dataset was identified, its representation was problematic. The significance of uncertainty was shown to vary depending on the visualisation methods used in analysis. The development of ways to visualise uncertainty in spatio-temporal datasets could improve an understanding of its impact on LCP analysis.

### Relationship between Data Processing and Pattern Exploration

Differences in the patterns created using each visualisation method revealed a relationship between dataset processing and pattern exploration, where an increase in the level of dataset processing reflected a decrease in the capacity to explore the patterns. The relationship between the two represents a balance between examining trends through generalisation and the freedom to explore data in its raw form. The results of this study suggest that increasing the capacity to explore spatiotemporal datasets, using low processing levels, corresponds to an improved understanding of the spatio-temporal patterns and the factors that influence them. These findings support the contention that powerful visualisation is not only useful, but necessary when both spatial and temporal components must be accounted for (MacEachren 1995).

### Combining Methods

When analysing LCP there was an advantage in viewing spatio-temporal patterns from multiple perspectives. The ability to view animation, in conjunction with the 2½D interactive geovisualisation and graphs showing the rate of change was found to significantly enhance the analyse LCP. The investigation of pattern using multiple perspectives can incorporate exploratory methods that are unstructured. Complex questions can be posed, examined comprehensively, and then further investigated. These observations agree with the suggestion that communications using geovisualisation should not be limited to a single technique (Slocum, Jiang et al. 2001).

Keywords: Spatio-temporal datasets, landscape change patterns, visualisation.

### References

- MacEachren, A. M. (1995)** *How Maps Work*. New York, The Guilford Press.
- Nakaoji, K; A. Takashima, et al. (2001)** *Cognitive Effects of Animated Visualization in Exploratory Visual Data Analysis*. *Proceedings of Information Visualisation 2001*, IEEE Computer Society, pp.77-84, London, UK, July,.
- Slocum, T. A., B. Jiang, et al. (2001)** Cognitive and usability issues in geovisualization. *Cartography and Geographic Information Science* **28**(1): 61-75.

## Landscape assessment of the Lower Dyje River area on the basis of individual natural landscape units as a possible source for sustainable management

H. Skokanova

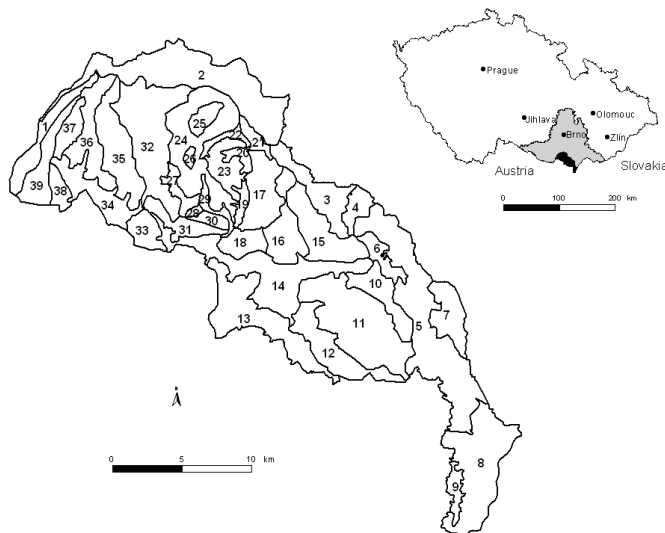
Research Institute Silva Taroucy for landscape and ornament gardening, Lidicka 25/27,  
60600 Brno, Czech Republic,  
e-mail: hskokan@email.cz

### Introduction

The Lower Dyje River area is a part of South Moravia, Czech Republic; one of the core settlements in the Czech Republic. It has been largely changed by human activities for centuries. On the other hand, unique biotopes, such as vast floodplain forests (the largest of their kind in Central Europe) and populations of exothermic flora (reaching from Pannonicum), have developed here. Thanks to these exceptional conditions (exothermic biota and geology) a landscape-protected area (LPA), called Palava, was established in the part of the study area, which appears on the UNESCO list of biosphere reserves. This LPA together with another unique historical landscape of Lednice-Valtice area and floodplain forests was in 2003 grouped into the UNESCO biosphere reserve (BR) called Lower Morava.

### Landscape assessment

There are several steps in the landscape assessment of the study area. Firstly, the natural conditions were assessed. This assessment resulted in creation of 39 individual natural landscape units (see Figure 1). Secondly, land use changes during last hundred years were researched with the emphasis on the driving forces of these changes. Finally, environmental risks, such as wind and water erosion, air and water pollution, old ecological burdens and mining sites, were assessed, and landscape-stabilizing components were determined. As a result of the assessment, management of the study area was proposed with the emphasis on the rules of sustainability.



**Figure 1.** Natural landscape units of the study area

### Land use changes

Land use changes were researched in three periods – end of the 19<sup>th</sup> Century, 1970s/1990s and present (2004). It can be said that main driving forces were socio-economic ones, mainly changes in political system in 1948 and 1989 together with changes

in economy. These changes influenced mainly categories of forests and shrubs, water areas, arable land, meadows and pastures and permanent cultures (see Table 1). Very important driving force was also transfer of German and Croatian population after the war, causing increase in swamps and barren.

**Table 1.** Land use changes in the study area (in %) in the period 1890-2004

category\year	1890	75/92	2004	1890- 75/92	75/92- 2004	1890- 2004
swamps	0,1	1,2	0,2	1,1	-1,0	0,1
barren	4,1	4,5	2,3	0,4	-2,2	-1,8
forests and shrubs	29,7	29,1	27,8	-0,6	-1,3	-1,9
meadows and pastures	12,2	8,1	8,4	-4,1	0,3	-3,8
arable land	40,7	41,0	34,7	0,3	-6,3	-6,0
permanent cultures	3,7	5,6	10,2	1,9	4,6	6,5
water areas	2,8	3,6	9,9	0,8	6,3	7,1
gardens	1,2	2,1	2,3	0,9	0,2	1,1
built areas	0,9	1,3	2,1	0,3	0,8	1,2

### Environmental risks and landscape-stabilizing components

Two major environmental risks occur in the study area: the first one is wind and water erosion threatening mainly large blocks of arable land without any erosion-control systems, the second one is water pollution of main rivers and water reservoirs.

Special protected areas, NATURA 2000 sites, Ramsaar sites and elements of Territorial System of Ecological Stability represent landscape-stabilizing components. As a synthetic criterion a coefficient of ecological stability was calculated.

### Management

The Lower Dyje River area is a multifunctional region, where major activity is agriculture. However, very important are also nature/landscape protection and tourism. Because of its status – LPA and BR, it is important that all these activities follow the rules of sustainability.

### References

- Doležal, P.; Podhrázká, J. & Novotný, I. (2005)** *Problematic study "Wind erosion in South Moravia region and suggestion of its solution"*. Agroprojekt PSO, Brno (in Czech).
- Havlíček, T.; Navrátilová, M.; Veselá, O.; Novotný, P.; Sedlák, Z.; Glos, J.; Jelínek, B.; Kocián, J.; Kolářová, D.; Tvrdoňová, M.; Beneš, M.; Hartl, P.; Velecká, V. & Zimová., E. (2004)** *Conception of nature protection of South Moravia Region*. Retrieved on 10<sup>th</sup> June 2005, from: <http://koncepce1.fontes.cz/page.php?etapy> (in Czech).
- Collective (2005)** *Plan of management of the Protected Landscape Area Palava for the period 2006-2015*. Správa ochrany přírody, Praha (in Czech).
- Skokanová, H. (2006)** *Landscape assessment of the Lower Dyje River Area*. Geografický ústav PŘF MU, Brno (dissertation, in Czech).
- Skokanová, H. (2006)** Land use changes in the Lower Dyje River Area in the period 1890-2004. I. Baláž, I. Jakab (Eds). *Zborník zo VII. vedeckej konferencie doktorandov a mladých vedeckých pracovníkov*. FPV UKF, Nitra. CD-ROM (in Czech).
- Skokanová, H. (2007)** Assessment of human activities in the Lower Dyje River Area (Environmental risks and stabilizing components of the landscape of the Lower Dyje River Area). Herber, V. (Ed). *Fyzickogeografický sborník 4. Fyzická geografie – teorie a aplikace: příspěvky z 23. konference Fyzickogeografické sekce České geografické společnosti konané 14. a 15. února 2006 v Brně*. MU Brno (in press, in Czech).



## **Analysing the long term impact of landscape change on landscape structure and landscape functions in the national park region Saxon Switzerland**

**M. Neubert, U. Walz**

Leibniz Institute of Ecological and Regional Development (IOER), Weberplatz 1, D-01217  
Dresden, Germany,  
e-mail: m.neubert@ioer.de; u.walz@ioer.de

### **Introduction and investigation area**

Important tasks of today's landscape ecology are to monitor and assess natural resources, to examine impacts and effects of human intervention and – last but not least – to observe the state of the environment over long time periods. We focused on spatial analyses as well as indicators for the description of the environmental effects of land use changes concerning landscape structure and selected landscape functions.

The study is exemplified by the national park region Saxon Switzerland (398 km<sup>2</sup>), which consists of a national park (93.5 km<sup>2</sup>) and a surrounding landscape conservation area (287.5 km<sup>2</sup>). The region is situated in the east of the Federal Republic of Germany, south-east within the Free State of Saxony. Only some kilometres upstream the Elbe river from the state capital Dresden the area is bordering the Czech Republic in the south. The landscape unique in Central Europe represents the German part of the Elbe Sandstone Mountains which extend to Bohemia with a corresponding national park and landscape conservation area. The landscape of the region is characterised by forest and rock areas, including mesas, sandstone rock towers and u-shaped gorges, which are predominantly free of settlements, plateaus, which provide favourable conditions for agricultural use but also include most of the settlements, and canyons like the Elbe river valley with its scarps and vertical rock walls.

### **Analysing landscape change**

The investigation is based on the analysis of historical maps from the last 200 years. The land use data of five time states was digitised and processed with a sufficient accuracy using a Geographic Information System (GIS). For the classification of all datasets the CORINE Land Cover nomenclature was used. It was adopted by additional classes in some cases (up to five levels instead of three). Up to 22 different polygon and line classes could be mapped at each point of time. The resulting digital land use database was used for the further GIS-based spatial analysis of landscape change, e.g. land use statistics, land use stability (number of land use changes), development of road and field path network or spatial changes of single land use classes. As a further result indicators for the description of the most important changes were developed (Neubert and Walz, 2006).

### **Effects of landscape change on landscape structure**

The structural changes of the landscape were quantified by means of structural indices (landscape metrics). For the calculations of landscape metrics on class and landscape level ArcGIS 9.1 and the ArcGIS extension V-LATE 1.1 (LARG, 2005) were used. Self-developed calculation routines were applied for analyses based on 250 m grid cells, which are particularly suitable for spatial comparison over time periods, because the reference areas remain unchanged. The resulting values confirm trends of landscape development from the previous change analysis. Most of the developments are continuous in the period 1780 to 1940 and converse afterwards. This tendency can be found in all landscape metrics calculations of the investigation area. Reasons for this development can particularly be found in the following phase of farming collectivisation and reallocation of land in the GDR time. The aim was the homogeneous cultivation of both heterogeneous and extreme sites. The field path network was strongly decreased, and thus, a lot of land use boundaries were eliminated. In addition hedges, tree rows and bosks were removed and flowing waters

became canalised and piped. These actions exerted a far-reaching influence on the structure and with that on the character of the landscape.

Furthermore, using a correlation analysis of the calculations based on grid cells the most significant landscape metrics were selected from the extensive overall set of structure measures. *Mean Patch Size*, *Patch Size Standard Deviation*, *Mean Patch Edge*, *Mean Perimeter-Area Ratio*, *Mean Fractal Dimension*, *Mean Shape Index* and *Dominance* turned out to be weakly correlated, while *Mesh*, *Proportion*, *Shannons' Diversity* and *Evenness indices* have a high relevance despite high correlation. Those metrics can therefore be considered as indicators of landscape structure development (Tröger, 2006; Neubert & Walz, 2006).

### **Impacts on landscape functions**

For the further analyses the extensive land use database of different time states was used to model how these land use changes affect selected functions or potentials of landscapes. The effects of land use changes on the suitability of the landscape for a nature-oriented recreation, the impacts on soil erosion as well as on groundwater regeneration were examined. Another part of the case study focused on the correlations between land use change and biodiversity. An additional cross-border study has shown impressive results for the increase of landscape fragmentation in the Saxon-Bohemian Switzerland. The results of this analyses show that there have been negative impacts taken place to all of the functions analysed and a loss of landscape functionality could be shown. For example, the soil erosion of agricultural land has increased as a result of changed field structures, mainly the increase of erosion effective slope length due to the elimination of erosion barriers, like hedges, tree rows or field paths.

### **Conclusions**

The information gathered by such analyses is helpful for the management of protected areas which are oftentimes tourist regions relying on their natural conditions. The resulting database of changes between historic and present landscape state contains quantitative-statistical information, which can be used for example for a continuous monitoring with comparable measure values. A set of indicators of landscape change is proposed to determine trends in landscape development and their consequences. Thus, problems of the impact of land use change can be counteracted in future. Furthermore, the results can be used to manage the changes of land use spatially in detail. Doing so, sensitive areas (e.g. for ground water recharge or as habitats) can be protected in a more efficient way.

For a more detailed description of project results and further publications see the project website under <http://www.ioer.de/sistemaparc>.

### **References**

- LARG (Landscape and Resource Management Research Group) (2005)** V-LATE - Vector-based Landscape Analysis Tools Extension. 31.01.2007, <http://www.geo.sbg.ac.at/larg/vlate.htm>
- Neubert, M. & Walz, U. (2006)** Indikatoren zur Beschreibung von Landschaftsveränderungen – am Beispiel der Nationalparkregion Sächsische Schweiz. J. Strobl, T. Blaschke & G. Griesebner (Eds.): *Angewandte Geoinformatik 2006*. Wichmann Verlag, Heidelberg, pp. 504-509
- Tröger, M. (2006)** *Analyse der Entwicklung der Flächennutzungsstruktur der Nationalparkregion Sächsische Schweiz unter Einsatz von Landschaftsstrukturmaßen*. Diploma thesis, TU Dresden: 150 p. (unpublished)

## Encouraging virtuous landscape change in cultural landscapes

P.H. Selman

Department of Landscape, Western Bank, University of Sheffield, Sheffield S10 2TN, UK.  
e-mail: p.selman@shef.ac.uk

### Introduction

Cultural landscapes are widely valued and often serve as exemplars of sustainability. They may display high accumulation of natural capital arising from centuries of relatively low intensity management, and may possess distinctiveness deriving from a well attuned interplay between natural systems and socio-economic practices. Yet drivers of change – external and often global in nature – are eroding cultural landscapes and, arguably, replacing them with less sustainable ones. If distinctive cultural landscapes are to be reproduced in the future, new drivers capable of accumulating natural and social capital are required. It is suggested that their sustainability comprises three key qualities:

- multifunctionality – the simultaneous, interactive and synergistic interplay of regulation, carrier, production and information functions
- virtuosity – where an endogenous dynamic generates reciprocity between place qualities and entrepreneurial opportunities
- place consciousness – the attachments of people to place, including time-depth, pride, care and an awareness of local landscape inter-relationships.

Current trends are for a loss of character and natural capital due to 'vicious circles' comprising, for example, land degradation and declining skill banks. The sustainability literature suggests a need to promote 'virtuous circles' which respect and reinforce natural, social, cultural and economic capitals, creating a 'landscape premium' where the ecological-physical environment generates opportunities for economic and social entrepreneurship, encouraging investment in practices which enhance distinctiveness.

### Emerging Landscape Drivers

New social and economic drivers are available and, whilst they will not necessarily reproduce traditional vernacular scenery, they can generate sustainable and distinctive landscapes representative of vibrant cultures. Key opportunities (Table 1) are:

re-embedding short production chains – perhaps the most familiar option is to promote smaller scale farming and woodland management units which rely less on chemical and mechanical inputs and more on quality and traceability associated with place-distinctiveness. Yet, it is unclear whether the production of organic food, regional speciality foodstuffs or premium timber will necessarily produce multi-scaled, distinctive and associative landscapes. Current markets are insufficient to guarantee survival of wholesale cultural landscapes, and subsidies are still needed, but there is scope to grow demand through product certification, landscape representation and marketing.

renewable energy production for local and national consumers – a key user of landscape resources is renewable energy, based on the climatic and hydrologic properties of an area. This continues a use of landscapes which is as old as human settlement. After a long period of carbon and uranium based energy production where landscape properties were merely incidental, energy production – often associated with harvesting wind or biomass for community use or to be fed into a national grid – is again producing distinctive landscapes.

consumption values for residence, leisure and amenity – the growing demand for rural residency has injected new money and knowledges into many areas. Whilst this may result in detraditionalisation of customs and practices, it may bring new energies and funds to maintain physical and social capital. New micro-landscapes emerge – for example, farms are

**Theme7: Assessment of Landscape Changes**  
**7.5 Open Session 3: Landscape Change Assessment**

manicured into country residences and paddocks, whilst leisure and tourism produce land uses such as golf driving ranges, stables and health farms.

environmental service function areas and networks – following centuries of land improvement, the need to respond to climate change, flood management and biodiversity loss is leading to proposals for large-scale landscape transformation and re-wilding. This is occurring both as multifunctional *areas* and infrastructural *networks*, and the relative absence of an economic driver in such situations is partly compensated through the patronage of environmental NGOs, whilst green infrastructure can receive considerable input from developers.

**Table 1.** Potential future drivers of cultural landscapes

<b>driver</b>	<b>natural capital (examples)</b>	<b>social capital (examples)</b>	<b>landscape effect (examples)</b>	<b>knowledge resources (examples)</b>	<b>mobilisers (examples)</b>
<i>short production chain primary land use</i>	semi-natural pasture and woods	settlements, traditional skills	managed pasture, boundaries, copses	skills training, business support	customers willing to pay premium
<i>renewable energy production</i>	wind, water, biomass coppice	active-adopters, available technology	large land-take, visual change	matching users to appropriate technologies	government policies and energy obligations
<i>residence, leisure, amenity</i>	scenery, topography, affordances	ownership change, 'third sector'	grazing regimes, site maintenance	'newcomer' expertise/volunteering	private and cooperative ventures
<i>environmental service spaces and networks</i>	ecological and hydrological potential	landowners, stakeholding interests	water regimes, habitat connectivity	social learning, environmental expertise	NGO patronage, spatial planning

**What we need to know**

The widespread continuation of traditional cultural landscapes is clearly threatened, and new opportunities need to be found of coupling place qualities to social and economic entrepreneurship. In this context an 'axiom' for the self-sustaining and self-reinforcing rural sustainable landscape might be: "give it structure, water and time and nature will take care of it; give it meaning, value and time and people will take care of it". However, the most viable emergent drivers currently have a 'heretic' quality about them and have been subject to disparaging comments, many of which are based on rhetoric. We now need robust evidence about the properties and detailed landscape consequences of emergent, sustainable drivers. Planning virtuous landscape change will require new systems models and datasets to target intervention and evaluate long-term sustainability. This paper considers some case studies as a way of exploring the types of evidence and theory needed for sustainable landscape planning.

## The FORE-SCE model: projecting land use change using a scenario-based modelling technique

T.L. Sohl<sup>1</sup>, K.L. Saylor<sup>2</sup>

<sup>1</sup> Science Applications International Corporation, contractor to U.S. Geological Survey (USGS) Center for Earth Resources Observation and Science, 47914 252<sup>nd</sup> Street, Sioux Falls, SD 57198 USA  
e-mail: sohl@usgs.gov.

<sup>2</sup> USGS Center for Earth Resources Observation and Science, 47914 252<sup>nd</sup> Street, Sioux Falls, SD 57198 USA

### Introduction

An understanding of potential future scenarios of land use and land cover change is essential to mitigate the potentially negative consequences of change on regional carbon dynamics, climate change, hydrology, and biodiversity. The FOREcasting SCEnarios of change (FORE-SCE) model was developed to create high-resolution land cover projections under multiple scenarios for large geographic regions. Parts of the FORE-SCE model are parameterized with historical land cover change information. The U.S. Land Cover Trends project (Loveland et al., 2002) analyzes contemporary (1973-2000) land cover change in the conterminous United States, and provides the necessary information to build the FORE-SCE model, including historic rates of change, a breakdown of thematic categories of change, and key components of landscape pattern.

### Basic model structure

FORE-SCE incorporates Land Cover Trends data with a theoretical, statistical, and deterministic modelling technique in order to project future land cover change under multiple plausible scenarios. The basic structure of FORE-SCE is loosely based on the CLUE-S model (Verburg et al., 2002). Future land cover proportions are derived from external scenario development, based on variations of projected Land Cover Trends results. Existing land cover data from the 1992 National Land Cover Data set (NLCD) (Vogelmann et al., 2001) are used in conjunction with an array of ancillary spatial data sets to derive relationships between the ancillary variables and individual land cover classes. Baseline probability surfaces are constructed for each individual land cover class. A final probability surface is constructed based on the baseline probability surface, existing land cover type, and the types of typical land cover change for a given region as measured by the Land Cover Trends project. Protected areas are either excluded or receive special treatment. "Seed" pixels are planted on the final probability surface, and change polygons are grown around each seed to a size that is typical for the region. Seeds are planted and change polygons grown until land cover proportions match those specified in each scenario.

### Model Applications

#### United States Great Plains

The initial application of FORE-SCE was for a large (~2,750,000 km<sup>2</sup>) region covering most of the Great Plains of the United States. FORE-SCE development in the Great Plains focused on baseline model construction, and on methods of incorporating historical Land Cover Trends data. Three scenarios of 1992-2020 land cover change were mapped: one was an extrapolation of Land Cover Trends results, and two scenarios were run that represented favorable and unfavorable biophysical and socioeconomic conditions, respectively, for agriculture in the study area. These scenarios have been analyzed to assess the potential effects of future land use on climate and climate variability in the Great Plains.

### Southeastern United States

The FORE-SCE model has since been applied to 1992-2020 land cover change in the southeastern United States. Land Cover Trends results have documented an extremely dynamic timber industry in this region. Given the potential implications of forest stand age for carbon and climate studies, FORE-SCE was augmented to simulate the dynamics of forest cutting and regrowth. Forest stand age for 1992 was initially established from Forest Inventory and Analysis (FIA) data from the U.S. Department of Agriculture-Forest Service (Miles et al., 2001). Iterative yearly model runs were performed, and stand age was tracked through each iteration. Information on the typical forest cutting cycle for the region, along with patch characteristics from the Land Cover Trends project, were used to simulate typical forest cutting cycles, with cut forest patches grown to typical sizes on lands of suitable cutting age. Three scenarios were run for the southeastern United States: one was an extrapolation of Land Cover Trends results, and two scenarios were run that represented favorable and unfavorable biophysical and socioeconomic conditions, respectively, for forest plantations in the study area.

### **Future model development**

New applications of FORE-SCE are planned for the Mid-Atlantic and Southern California regions in the United States. We plan to enhance different parts of FORE-SCE with every subsequent application. Mid-Atlantic work will focus on strengthening high-resolution urban dynamic modelling. Current FORE-SCE applications have used scenario sets related to existing land cover change studies, and have thus focused on the spatial allocation of change rather than on the change scenarios themselves. Future work in Southern California will focus on the establishment of quantitative relationships between various biophysical and socioeconomic drivers of change and projected future proportions of land cover.

Work performed under USGS contract **03CRCN0001**.

### **References**

- Loveland, T.R., Sohl, T.L., Stehman, S.V., Gallant, A.L., Saylor, K.L., & Napton, C.E. (2002).** A strategy for estimating the rates of recent United States land cover changes. *Photogrammetric Engineering and Remote Sensing* **68**: 1091-1099.
- Miles, P. D., Brand, G. J., Alerich, C. L., Bednar, L. F., Woudenberg, S. W., Glover, J. F., Ezzell, E. N. (2001).** The forest inventory and analysis database: database description and users manual version 1.0. Gen. Tech. Rep. NC-218. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 130 p.
- Verburg, P.H., Soepboer, W., Veldkamp, A., Limpiada, R., & Espaldon, V. (2002).** Modelling the spatial dynamics of regional land use: The CLUE-S Model. *Environmental Management* **30** : 391-405.
- Vogelmann, J.E., Howard, S.M., Yang, L., Larson, C.R., Wylie, B.K., & Van Driel, N. (2001).** Completion of the 1990s National Land Cover Data set for the conterminous United States from Landsat thematic mapper data and ancillary data sources. *Photogrammetric Engineering and Remote Sensing* **67**: 650-662.

## 7.6 Open Session 16: Changing land and map measurement

### Measuring urban concentration and land-use diversity in maps of simulated future land use

E. Koomen<sup>1</sup> and J. Ritsema van Eck<sup>2</sup>

<sup>1</sup> Faculty of Economics and Business Administration/SPINlab, Vrije Universiteit Amsterdam, De Boelelaan 1105, 1081 HV Amsterdam, the Netherlands, email: ekoomen@feweb.vu.nl

<sup>2</sup> Netherlands Institute for Spatial Research, Postbus 30314, 2500 GH The Hague

#### Introduction

Future land use is an important theme in the preparation and evaluation of spatial planning reports. These studies typically look several decades ahead and describe the outlook of the future by means of a set of scenarios with different socio-economic conditions. Land-use models are commonly used to indicate possible future land-use patterns according to the scenario conditions. In order to help policy-makers and researchers interpret, compare and evaluate different scenario simulations quantitative measures are needed that objectively describe the resulting maps. Functional indicators should: relate to specific (policy) themes, be intuitively understandable for policymakers, capture the essence of simulation results and discriminate between different simulation outcomes.

This paper presents two sets of functional indicators that were implemented and tested for the assessment of spatial aspects of future land-use configurations as simulated by a land-use model. The indicators were applied in a Dutch case study and relate to two important themes in spatial planning: compact urbanisation and land-use diversity. The indicators are applied to simulations based on two scenarios for land-use development in the Netherlands up to 2030. A full account of this research is provided in Ritsema van Eck & Koomen (2007).

#### Urban concentration

An initial impression of the urbanisation patterns at hand is provided by a number of general composition indices and a visual presentation of the pixel-based density increase over time. By using this combination of composition and configuration indicators at various scales we can quantify the extent to which the urban growth differs between the scenarios and furthermore typify which simulated urban patterns are closest to the spatial planning objective of concentrated, compact urbanisation.

Subsequently we focus on metrics describing concentrations formed by a set of contiguous urban areas as these are most closely related to the spatial policies aimed at preserving the alternation of relatively large urban areas surrounded by sizeable non-urban (open) spaces that we want to evaluate. This focus on individual urban constellations is similar to the approach ecologists take when studying landscape patterns. Crucial in their description of changes in the landscape is the distinction of individual 'patches' that consist of a single landscape type. From their extensive work we select a limited number of indicators relating to patch-size distribution and shape complexity (Table 1).

#### Land-use diversity

Measures for diversity of land use in a raster cell can be derived from equivalent indices in ecology that for example measure biodiversity. A distinction can be made between distributional measures, which indicate the number of species and the distribution of individuals over those species, and measures of variation, which measure the size and importance of the differences between the species present. Although it would be useful to have indices which combine both aspects, measuring both the distribution of individuals over

the species and the degree to which these species differ from one another, at present such an index does not seem to be available (Baumgärtner, 2002). For measuring land-use diversity the first aspect, the distribution (of land over different functions) is crucial. Therefore we will only discuss the distributional measures. There are four basic measures in general use; it can be shown that these four are all equivalent to special cases of the so called Renyi diversity profile (Magurran, 1988). Because of its intuitively appealing interpretation we select Simpsons Diversity Index for this application (Table 1).

**Table 1.** Indicator values resulting from application to a land-use simulation study.

	current use	land scenario 1	scenario 2
<b>urban concentration</b>			
Total built-up area [ha]	491,710	693,253	610,420
Urbanisation degree [%]	12	17	15
Number of urban areas	1381	1414	1209
Average urban area size [ha]	227	330	338
Std.Dev. of urban area size	817	2203	1328
Average circularity ratio	0.27	0.21	0.24
<b>land-use diversity</b>			
Average Diversity index	0.38	0.41	0.37
Std.Dev. of Diversity index	0.21	0.23	0.21

## Discussion

The presented set of indicators allows for a critical comparison of the urban patterns in the two opposing scenarios. Single indicators capture individual aspects of urbanisation like magnitude (through general composition indices), spatial pattern (pixel-based urban density), concentration (patch size distribution) and compactness (average urban area circularity). It is, however, the combined use of these indicators that offers a more complete overview on projected urban developments. A high average degree of compactness is for example not necessarily preferable from a spatial-policy perspective, if this compactness is associated with a large number of small, compact urban areas as this may pose a serious risk to open space fragmentation.

The diversity maps are also useful in the sense that they add depth to the maps of dominant land use that are normally used to present the simulation results of land-use change models. They show clearly that the some other agricultural areas will be more diverse in land use, especially in a free-market oriented scenario where agriculture suffers from fierce international competition and many planning restriction on land use are lifted. They also indicate that land use in the city will become less mixed and help pinpoint locations with potential for multi-functional land-use developments.

## References

- Baumgärtner, S. (2002)** *Measuring the diversity of what? And for what purpose? A conceptual comparison of ecological and economic measures of biodiversity*, Interdisciplinary Institute for Environmental Economics, Heidelberg.
- Magurran, A. E. (1988)** *Ecological diversity and its measurement*, Princeton university press.
- Ritsema van Eck, J. & Koomen, E. (2007)**, Characterising urban concentration and land-use diversity in simulations of future land use, *Annals of regional Science* (forthcoming).



## Map comparison to assess the prediction of vegetation response to El Niño in Southern Africa

R.G. Pontius Jr<sup>1</sup>, O. Thontteh<sup>2</sup>, H. Chen<sup>1</sup>

<sup>1</sup> Clark University, 950 Main Street, Worcester MA 01610, USA.  
e-mail: rpontius@clarku.edu

<sup>2</sup> Regional Center for Training in Aerospace Surveys, PMB 5545 Ile-Ife, Osun State, Nigeria.

### Introduction

This paper presents novel statistical methods that are useful to compare maps that share a real variable. This multiple-resolution method can be applied to a variety of continuous variables that are important to landscape ecologists, for example: slope, temperature, precipitation, biomass, population density, nutrient concentration, etc. We illustrate the technique by comparing a map of predicted vegetation deviation to a map of observed vegetation deviation during the 2003 El Niño event. It is important to understand the accuracy of predictions for vegetation response to El Niño, especially in Southern Africa where El Niño causes severe drought and hence famine. The method compares the output from a prediction model to both: 1) a null model that predicts that the vegetation in the 2003 growing season is equal to the historic long term average, and 2) a uniform model that predicts that the vegetation deficit in the 2003 growing season is spatially allocated uniformly across the landscape.

### Methods

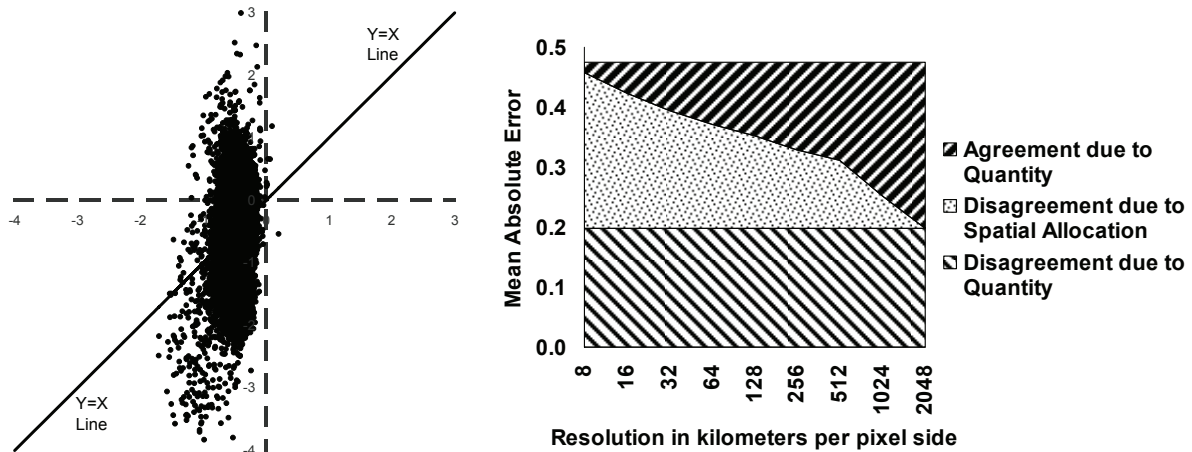
#### Data

Pontius et al. (in press) show the data, which consist of two raster maps: a reference map of observed vegetation deviation and a comparison map of predicted vegetation deviation. Both maps show the same variable, which is the z-score that expresses the deviation in Normalized Difference Vegetation Index (NDVI) during the 2003 growing season compared to the previous 18-year average. Values that are less than zero indicate that the NDVI in 2003 is less than normal, while values that are greater than zero indicate that the NDVI in 2003 is greater than normal. The left side of figure 1 shows the scatter plot of the predicted z-scores on the dashed vertical axis versus the observed z-scores on the dashed horizontal axis, where each point on the plot is a pixel that is 8 kilometres on a side. If the two maps agreed perfectly, then the points would lie on the Y=X line. The cluster shows that most of the values are negative in both maps, therefore the model accurately predicted that 2003 was a lower than normal NDVI year. The centre of the cluster is below the Y=X line, which indicates that the model predicted that 2003 would have lower NDVI than it actually did. The predicted map shows more variation than the observed map, which reflects the fact that the spatial allocation of the predicted z-scores is not perfect. In fact, if all of the predicted values were to be uniformly equal to the average predicted value, then the points would be closer to the Y=X line. The purpose of the proposed statistical analysis is to quantify the information that we can see in the maps and in the scatter plot. It performs this by computing components of agreement and disagreement due to quantity and spatial allocation at multiple resolutions as described next.

#### Mathematics

Equations 1-4 define up to four components of information consisting of two components of disagreement and two components of agreement. The foundation of the analysis is the mean absolute error; therefore this analysis is consistent with the case for a categorical variable (Pontius et al. 2004). The mathematical notation to define the possible components for each resolution is:  $n$  = index for a particular pixel,  $N_r$  = number of pixels at resolution  $r$ ,  $X_{rn}$  = value of pixel  $n$  at resolution  $r$  in the reference map,  $Y_{rn}$  = value of pixel  $n$  at resolution  $r$  in the comparison map, and  $W_{rn}$  = weight of pixel  $n$  at resolution  $r$  in reference map.

$\text{Disagreement due to quantity} = \frac{\sum_{n=1}^{Nr} (W_{rn} \times \{Y_{rn} - X_{rn}\})}{\sum_{n=1}^{Nr} W_{rn}}$	equation 1
$\text{Disagreement due to spatial allocation} = \frac{\sum_{n=1}^{Nr} (W_{rn} \times  Y_{rn} - X_{rn} )}{\sum_{n=1}^{Nr} W_{rn}} - \frac{\sum_{n=1}^{Nr} (W_{rn} \times \{Y_{rn} - X_{rn}\})}{\sum_{n=1}^{Nr} W_{rn}}$	equation 2
$\text{Agreement due to spatial allocation} = \frac{\sum_{n=1}^{Nr} (W_{rn} \times  \bar{Y} - X_{rn} )}{\sum_{n=1}^{Nr} W_{rn}} - \frac{\sum_{n=1}^{Nr} (W_{rn} \times  Y_{rn} - X_{rn} )}{\sum_{n=1}^{Nr} W_{rn}}$ <p style="text-align: center;">= 0    else</p>	if positive  equation 3
$\text{Agreement due to quantity} = \frac{\sum_{n=1}^{Nr} (W_{rn} \times  0 - X_{rn} )}{\sum_{n=1}^{Nr} W_{rn}} - \frac{\sum_{n=1}^{Nr} (W_{rn} \times  \bar{Y} - X_{rn} )}{\sum_{n=1}^{Nr} W_{rn}}$ <p style="text-align: center;">= 0    else</p>	if positive  equation 4



**Figure 1.** Scatter plot on the left showing predicted versus observed z-scores and stacked budget on the right showing components of disagreement and agreement.

### Results and conclusions

The stacked budget on the right side of figure 1 quantifies the information that is visible in the maps and in the scatter plot. The component of disagreement due to quantity reflects that the predicted z-scores are 0.2 less on average than the observed z-scores. The component of disagreement due to location shows how much worse than perfect the prediction is in terms of spatial allocation. This error of spatial allocation shrinks as resolution becomes coarser. The zero component of agreement due location indicates that a uniform spatial allocation would be more accurate than the predicted spatial allocation. The agreement due to quantity indicates that the prediction is more accurate than a null model that predicts zero for every pixel. The budget quantifies the manner in which the prediction succeeds and fails.

### References

- Pontius Jr, R.G.; Huffaker, D. & Denman, K. (2004)** Useful techniques of validation for spatially-explicit land change models. *Ecological Modeling* **179(4)**: 445-461.
- Pontius Jr, R.G.; Thontteh, O. & Chen, H. (in press)** Useful techniques of validation for spatially-explicit land change models. *Ecological and Environmental Statistics* available at [www.clarku.edu/~rpontius](http://www.clarku.edu/~rpontius).

## Improvements in the use of the Relative Operating Characteristic (ROC)

B. Parmentier, R.G. Pontius Jr

Clark University, 950 Main Street, Worcester MA 01610, USA.  
e-mail: bparmentier@clarku.edu.

### Introduction

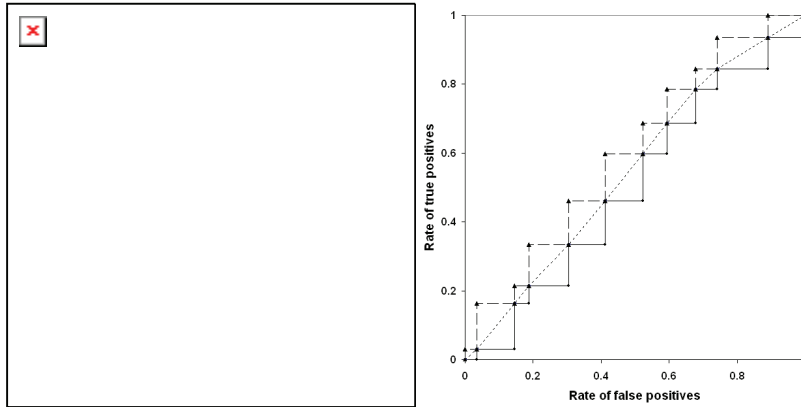
The Relative Operating Characteristic (ROC) and its related Area Under the Curve (AUC) statistic is used increasingly in a variety of fields: psychology to assess medical test (Swets 1998), in remote sensing to assess soft classification, in land use and land cover change (LUCC) modelling to assess predictions (Pontius 2001) and in ecology to assess species distribution (Fielding 1995). It is used in Geographic Information Science to compare a Boolean map and a rank map. In the case of LUCC modelling, the rank map frequently is a suitability map representing the propensity of change, while the boolean map represents the areas that have changed. There are several problems in the current use of the ROC for map comparison. For example, the current use requires the modeller to make a decision on the number of thresholds. Further, the focus on the Area Under the Curve (AUC) as the sole measure of the strength of the association fails to reap the full information contained in the curve. We offer four new improvements in the use of the ROC. First, we provide an estimate of the uncertainty of the ROC curve and its AUC. Second, we introduce a method to determine the number and values of the thresholds. Third, we express the information of the ROC in the form of a map in order to facilitate visualization. Fourth, we present an important concept that is useful to interpret the shape of the ROC curve. For this study, we use data from the Plum Island Ecosystems study area in Northeastern Massachusetts, USA.

### Methods

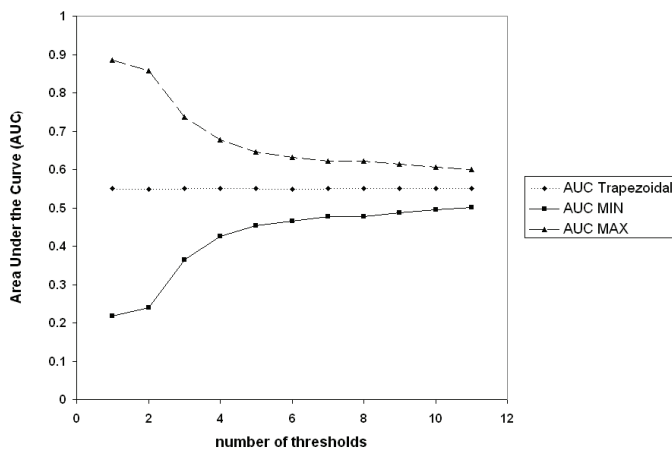
For each threshold, we can calculate the rate of true positive and false positive. These are plotted on Fig. 1a. The diagonal represent the random baseline. The Trapezoidal AUC is obtained by joining the successive threshold by diagonal lines while the AUCMIN and AUC MAX by joining the successive threshold points by linear and vertical lines. The upper curve corresponds to the upper bounds and the lower curve to the lower bounds around the thresholds. This is illustrated on Figure 1b where the lower bounds appear in continuous line and the upper bounds in dashed lines. For each curve, we can calculate an AUC. The uncertainty or precision is defined as the difference between the AUC MAX and AUC MIN. We use the desired precision or minimum uncertainty to determine the number of threshold. The modeller decides on the desired precision and the algorithm runs and adds successively a threshold until the desired precision is reached. The upper and lower bounds define a rectangle of uncertainty. The position of successive thresholds is calculated using this rectangle of uncertainty and its thresholds. At each step, the rectangle with the highest uncertainty is chosen for the next threshold. The new threshold is defined at midpoint between the thresholds defining the rectangle. The ROC map represents the proportion of true positive within each bin. Bins with high proportion will exhibit high values on the ROC map. The more similar the ROC map is to the rank map the more, the model is performing well.

The shape of the ROC is of particular interest. In the case of strong association between the Boolean map and the rank map, we expect start of the ROC curve to lie very near and parallel to the Y-axis while the end to lie parallel to the line  $Y=1$ . In some cases, the curve dips below the random baseline or is close to it. This is the case on Figure 1a. This means that the model is not performing better than a random one. Further, if two ranking maps have the same AUC but different shape, with one closer to the line Y-axis near the origin, we will prefer that one. The shape is therefore additional information to consider when assessing the quality of a model.

**Theme7: Assessment of Landscape Changes**  
**7.6 Open Session 16: Changing land and map measurement**



**Figure 1.** a. Random baseline and thresholds points b. range of uncertainty: the dashed line represents the AUCMAX, the dotted line corresponds to the AUC Trapezoidal, while the solid line corresponds to AUCMIN. The desired uncertainty is 0.10.



**Figure 2.** Range in the AUC decreases as the number of thresholds increases. Note the convergence of AUCMIN and AUCMAX as the number of thresholds increases.

**Results**

We obtained 11 thresholds for a desired precision of 0.10 for the AUC, Figure 1, illustrates the interval or range of uncertainty for the ROC curve. Figure 2 shows the convergence of the AUCMIN and AUC MAX as the number of threshold increases. It also illustrates the reduction of the range of uncertainty for the AUC as the number of threshold increases. The rectangles of uncertainty are also visible on Figure 1. They are defined by the upper and lower bounds. In conclusion, only 11 thresholds were necessary to attain the desired precision.

**References**

- Pontius, R. G., and Schneider, L. C. (2001).** "Land-cover change model validation by an ROC method for the Ipswich watershed, Massachusetts, USA." *Agriculture, Ecosystems and Environment* 85: 239-248.
- Swets, J. A., (1988).** "Measuring the Accuracy of Diagnostic Systems." *Science* (240): 1285-1293.
- Fielding, A. H., Bell, J. F. (1997),** A review of methods for the assessment of prediction errors in conservation presence/absence models. *Environmental Conservation* 24 (1): 38–49

## A state-space representation for measuring urban change

A. Hagen-Zanker

Urban Planning Group, Eindhoven University of Technology, PO Box 513, Vertigo Building,  
Eindhoven, 5600 MB, The Netherlands;  
e-mail: a.h.hagen.zanker@tue.nl

### Introduction

Descriptive models of urban patterns are, by large, based on static situations i.e. single moments in time. They may present us with surprising regularities in space and time, such as the rank size distribution of city populations (Ioannides & Overman, 2003), the cluster size distributions of urban areas (Benguigui et al, 2006) and fractal relations in urban form (Batty & Longley 1996). Furthermore there are many metrics of spatial clustering and diffusion (e.g. Verburg et al. 2004). Patterns are recognized, but due to the static nature the relation with processes is unclear and understanding of causal relations remains low.

Explanatory models of urban areas, by contrast are typically based on the dynamic interactions between actors and their relative geographic position. Such relations can include for instance network effects and benefits of scale or negative externalities that lead to buffers, segregation and diffusion. Modern computing makes it possible to simulate virtual cities which are composed of many small elements and relatively simple interaction rules, for instance by Cellular Automata (White & Engelen 1993) or Agent Based Modelling (Parker et al. 2003). Although the results of these explanatory models are promising and they find applications in urban planning practice, they lack empirical support. Lambin et al. (2001) even identify a number of myths (popular but false assumptions).

This paper explores a descriptive model of urban change that may offer empirical support for the kind of hypotheses that underlie the dynamic exploratory models. The model is based on transitions in state-space. As a proof of concept it is applied to classify urban change in the Netherlands.

### Methods

On the basis of different attributes a location on the map is linked to a location in state-space. Over the course of time the characteristics of a location change and therefore the location in state-space changes. The transitions in state-space characterize the spatial dynamics of a region.

In a categorical raster map every location (cell) is primarily defined by its category. However, the geographic relation between locations implies further attributes that need to be derived. In this application we characterize the state-space of a location by two attributes; the fraction of urban area within a radius of 2 km and 7.5 km. Both attributes are categorized in 4 bins, yielding in total 16 categories to characterize urban form. The categorization is made on the basis of 500m resolution land use maps of 1989 and 1996. Next the transitions that take place are tabulated for 40 separate (NUTS3) regions. Thus the changes in each region are summarized by a 16\*16 transition matrix. This matrix is normalized and contains proportions of transitions for each class of urban form in the initial map. The difference between transition tables is calculated on a (matrix) cell-by-cell basis, according to the following equation:

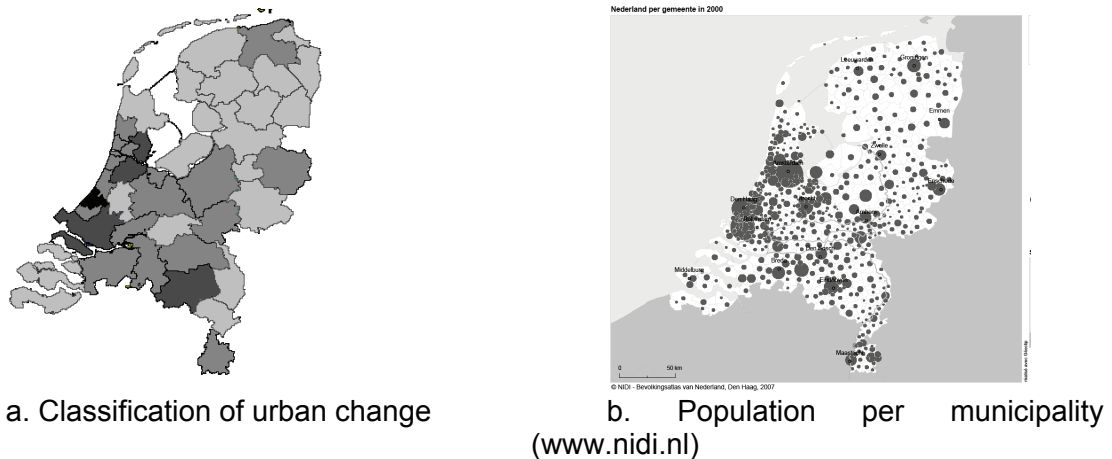
$$d(A,B) = \frac{\sum_{i,j} (|A_{i,j} - B_{i,j}| * w_{i,A,B})}{\sum_i w_{i,A,B}}$$

Where  $d(A,B)$  is the difference in urban change between regions A and B.  $A_{i,j}$  is the proportion of cells originally in class  $i$  in region A that changed state to class  $j$ . The weight  $w_{i,A,B}$  is included to account for regions that initially do not contain a cell in class  $i$  at all. If region A or B does not contain class  $i$  initially, then the weight 0, otherwise it is 1.

Finally, a nearest-neighbour algorithm finds clusters according to the regional similarity in urban change patterns.

## Results

The classification of urban change creates a pattern that correlates to urban form in the Netherlands, for instance as measured by the distribution of population per municipality (Figure 1). Although not surprising, it is an indication that the state-space approach is robust and gives confidence in further research towards the description and classification of patterns of urban change.



**Figure 1.** The classification of urban change correlates with the spatial distribution of population in the Netherlands.

## References

- Batty, M., & Longley, P. A. (1996). *Fractal cities*. London and San Diego: Academic press.
- Benguigui, L., Blumenfeld-Lieberthal, E., & Czamanski, D. (2006). The dynamics of the Tel Aviv morphology. *Environment and Planning B: Planning and Design*, 33(2), 269 – 284.
- Ioannides, Y. M., & Overman, H. G. (2003). Zipf's law for cities: an empirical examination. *Regional Science and Urban Economics*, 33(2), 127-137.
- Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., Coomes, O. T., Dirzo, R., Fischer, G., Folke, C., George, P. S., Homewood, K., Imbernon, J., Leemans, R., Li, X., Moran, E. F., Mortimore, M., Ramakrishnan, P. S., Richards, J. F., Skanes, H., Steffen, W., Stone, G. D., Svedin, U., Veldkamp, T. A., Vogel, C., & Xu, J. (2001). The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change*, 11(4), 261-269.
- Parker, D. C., Manson, S. M., Janssen, M. A., Hoffmann, M. J., & Deadman, P. (2003). Multi-agent systems for the simulation of land-use and land-cover change: A review. *Annals of the Association of American Geographers*, 93(2), 314-337.
- Verburg, P. H., de Nijs, T. C. M., Ritsema van Eck, J., Visser, H., & de Jong, K. (2004). A method to analyse neighbourhood characteristics of land use patterns. *Computers, Environment and Urban Systems*, 28(6), 667-690.
- White, R., & Engelen, G. (1993). Cellular-automata and fractal urban Form: a cellular modeling approach to the evolution of urban land-use patterns. *Environment and Planning A*, 25(8), 1175-1199.

## 7.7 Posters

### Modelling and simulation of landscape changes

**E. Pauditsova, K. Pavlickova**

Comenius University in Bratislava, Faculty of Natural Sciences, Department of Landscape Ecology; Mlynska dolina B2, 842 15, Bratislava, The Slovak Republic.  
e-mail: epaudits@fns.uniba.sk

#### Introduction

The contribution is dealing with an evaluation of landscape changes in a selected territory – a part of the Myjava Hills in the Slovak Republic. The attractiveness of this region is caused by the solitary cottager's type of settlement, which evolved due to specific natural as well as historical conditions. The Myjava Hills were settled during the Neolithic Age, and more intensively from the 12<sup>th</sup> century. The settlement of this area peaked at the end of the 18<sup>th</sup> century (Stankoviansky, 2003). The landscape utilisation was significantly influenced by the process of collectivisation in the 1950's. The changes in land use in this territory were determined on the basis of comparing quantitative indicators such as the number and area of landscape elements in the individual observed periods (18<sup>th</sup> and 21<sup>st</sup> centuries).

#### Methodology

The methodological procedure leading to detection of differences between the current and historic landscape structures in the territory consists of the following steps (Pauditsova, 2003): 1 – scanning a historic map; 2 – retrieval and selection of reference points; 3 – taking the coordinates of reference points in the field by GPS; 4 – preparation of a so-called reference map containing the reference points; 5 – realisation of a polynomial transformation; 6 – preparing the vector map layer of the historic landscape structure; 7 – preparing the vector map layer of the current landscape structure; 8 – comparing quantitative indicators of landscape in the individual observed periods; 9 – creation of the model land use landscape in the future.

#### Results

Information on the structure of landscape in a given period was gained through correct adaptation of historic maps. Changes in the functional utilisation of territory were evaluated by mutual comparison of the current and historic landscape structures. The occurrence of single landscape elements was compared and the mosaic of the landscape was investigated. Particularly, the development of agriculture, forestation, deforestation, the settlement growth and the investment activities associated with it contributed to changes in the extent and arrangement of landscape elements in the territory. A detailed comparison of the occurrence of single types of the functional utilisation of the territory during the past and also at present, represents a basis for study of the landscape structure in the future.

This abstract was supported by Science grant Agency (VEGA) No. 1/2340/05.

#### References

- Pauditsova, E. (2003)** Old maps – a basis for the observation of transformations in the landscape structure L. Jelecek, P. Chromy, H. Janu, J. Miskovsky & L. Uhlirova (Eds). *Dealing with diversity. VS Praha*, Prague, pp. 276-279.
- Stankoviansky, M. (2003)** *Geomorphic Response to Environmental Changes in the Territory of the Myjava Hill Land*. Comenius University Press, Bratislava.

### Land-use change detection in arid environments in South-East Spain

**M. Piquer-Rodriguez<sup>1,2</sup>, R. Zurita-Milla<sup>2</sup>, J. Cabello-Pinar<sup>1</sup>, D. Alcaraz-Segura<sup>1</sup>, J. Crompvoets<sup>2</sup> and R.G.H. Bunce<sup>3</sup>**

<sup>1</sup>Department of Plant Biology and Ecology. University of Almeria. La Canada S.Urbano.  
04120 Almeria. Spain.

e-mail: jcabello@ual.es

<sup>2</sup>Centre for Geo-Information. Wageningen University and Research Centre. P.O. Box 47.  
6700 AA. Wageningen. The Netherlands.

<sup>3</sup>ALTERRA. Wageningen University and Research Centre. P.O. Box 47. 6700 AA.  
Wageningen. The Netherlands

Anthropogenic Land-Use (LU) activities are changing rapidly and are affecting at high rates the natural ecosystems of south east of Spain. Biodiversity is being lost, natural resources are becoming depleted and ecosystem services are declining. Here, we present the application of a Markovian Cellular Automata model (CAM) to spatially locate Land-Use Changes (LUC) in the Almería province to detect natural areas threaten by human activity.

A LU projection was done at a provincial and ecosystem level from 1991-1999 to 2007. Validation of the model projection was carried out in 2005 using field data. Accuracy results were suitable for the purpose of the analysis, although when comparing the LU projection with a null model, the CAM showed a high stability in LUC. The reliability of land-use projections was interpolated for the whole province by indicator kriging. Dynamic areas with major changes showed low accuracy values due to either the quality of the inputs, or because suitability maps do not take into account the spatial amount of LUC.

The main LU forces of change detected were firstly, urban development for tourism, greenhouses and thirdly, other types of agricultural development. The first two, caused the highest proportion of vegetation loss in the semi-arid plains regional ecosystem zone. This system contains most of the LUC of the province for the studied period. Five main areas of the province where the most dynamic: Campo de Dalías, Campos de Níjar, Tabernas-Sorbas Corridor, the Almanzora river basin and the Chirivel Watercourse. The landscape equilibrium state was also calculated and showed that provincial natural vegetation would be reduced to such a state that it would be isolated in protected areas by 2034 if current management policies do not change. There is therefore an urgent requirement for conservation planning outside protected areas.



## Landscape change of non-forest areas of Tuchola Pinewoods (northern Poland)

T. Giętkowski

Institute of Geography, Kazimierz Wielki University, Bydgoszcz, Poland.  
e-mail: tomgie@ukw.edu.pl

Deforestation, as a result of intensive industrial development, was one of the main directions of landscape change in Poland in the 19th century. The process was not spatially homogenous. It was significantly less intensive in regions located far from rivers and railways which were the ways of wood transportation. The region presented here is an example of this kind. At the end of the 19th century, a production-oriented forestry model was developed, based on intensive production of monospecific, coniferous forests. That model was also implemented by the Prussians in Tuchola Pinewoods. Since then, directions of landscape transitions have changed and afforestation has become a primary process.

The Tuchola Pinewoods region is situated in northern Poland and covers an area of 3700 km<sup>2</sup>. It is characterized by the occurrence of 290 non-forested areas with an average size of about 388 ha, which occupy 30% of the surface. They are distributed irregularly. The largest are located in the central part of the region and smaller ones, with more complex shapes, at the edges.

The poster presents a first examination of results referring to the detection of land cover change, and was based on the Legbałd test area (9.2 x 5.6 km). For realization of this task, historical maps from 1878, 1936, 1954, 1979 (all in scale 1:25 000) and aerial photos from 1996 (1:26 000) were used. First of all, these materials were rectified to one coordinate system, and then land cover parcels and other elements (rivers, settlements) were vectorized in ArcGIS ESRI software. In addition, in order to detect the relationship of different factors other thematic layers such as a Digital Elevation Model, a soil map and a statistical census data were prepared. After rasterization of the vector data, landscape matrices were calculated using Fragstats. The intensity and direction of change (transition matrix, Markov chain) were established in LandCell, a computer program created by the author.

There were two most important directions of landscape change. Firstly, the results show significant decrease of non-forest areas from 55% in 1878 to 33% in 1996. The analysis of land cover transition matrix indicated that between 1878 and 1936 the rate of change was the highest and took place on 30% of the total area. This situation was caused by nationalization and transformation of land property structure. It happened on almost 34% of area of cultivated lands directly transformed into the forest. These areas were located mostly on the sandy plane with a deep level of ground water, where crop yields were low. The second problem is connected with wetlands, the most valuable habitats in the region. As a consequence of constructing drainage systems, wetlands have dried out and become transformed to meadows or to a lesser degree, crops. From forty-seven patches of wetlands at the beginning, only four remain today with the total area of 7 ha.

In the last decade the rate of landscape change has declined. The transition occurred only in small areas, designed mostly for afforestation because of poor soil conditions. Moreover, financial support from the European Union connected to afforestation programs, slows down this process. At the same time the structure of the employment has changed. The majority of the population now works in non-agricultural sectors (services, agrotourism). This may be a final stage for determining optimal location of a forest boundary or spatial arrangement of rural landscapes.

**Monitoring local scale *Land Use and Land Cover Change* processes. The case of  
Ridaura sessile oak forestland (Natural Park of Montseny, NE Spain)**

**F.J. Gómez, M. Boada, S. Sánchez**

Institute of Environmental Science and Technology. Autonomous University of Barcelona.  
Campus de Bellaterra, Edifici C Torre 5 Planta 4, Cerdanyola del Vallès. Barcelona, Spain.  
e-mail: franciscojavier.gomez@uab.es

Changes in forest cover can indicate Global Change processes in terms of land use and land cover change. The analysis of these processes requires the integration of ecological and social criteria so as to unravel landscape dynamics complexity. For this reason, hybrid methodologies are basic tools to interpret environmental changes.

The Montseny Mountain, declared a Natural Park in 1977 and a UNESCO Biosphere Reserve in 1978, present outstanding socio-environmental elements for Global Change monitoring. Firstly, the presence of three biogeographical regions determines the appearance of ecotonic borders between several chorological elements which are especially sensitive to environmental changes. Secondly, socio-economical and historical changes associated with energy consumption and primary sector activities have occurred during the second half of the 20<sup>th</sup> century.

The study area is the Ridaura sessile oak (*Quercus petraea*) forest, an Atlantic influenced zone that is an example of ecotonic border transition from the Mediterranean to the Eurosiberian region. It is also a traditional Catalan countryside unit with primary sector activities linked to a household.

The methodology used in this study is based on *LUCC models* and it includes diachronic and synchronic analysis. The diachronic study analyzes changes in agrarian and forestland surface and those that have occurred in the floristic composition of cold-temperate forestland in the last 50 years. It integrates documental sources of information (cartography analyzed with GIS and botanical checklists) as well as oral sources of information that have taken an outstanding role for reconstructing the environmental history and track the changes taking place. Interviews were also held with social actors, such as actual and former landowners, forest workers and merchants, and Natural Park land managers. The synchronic study monitors sessile oak and holm oak (*Quercus ilex*) dynamics in experimental plots measuring ecological variables, such as size, age and mortality of adult trees and recruitment.

**Landscape change trajectory analysis in the assessment of ecosystem space-time properties and dynamics: case study from south-western Finland**

**N.Käyhkö<sup>1</sup>, H. Skånes<sup>2</sup>**

<sup>1</sup> Department of Geography, University of Turku, 20014 Turku, Finland, email:  
[niina.kayhko@utu.fi](mailto:niina.kayhko@utu.fi)

<sup>2</sup> Department of Physical Geography and Quaternary Geology, Stockholm University, 106 91  
Stockholm, Sweden

Landscape Change Trajectory Analysis (LCTA) can be used to analyse landscape dynamics and to dissect evidences of the major driving forces of landscape change. The emphasis of the change analysis is on the retrospective relationship between the present-day and the past landscape patterns with the aim of identifying the relevant spatio-temporal processes in the landscape. We have tested the use of LCTA approach in the analysis and assessment of ecosystem space-time properties and dynamics within a protected oak forest site in south-western Finland to improve the conservation planning and practise of this key ecosystem. Oak woodlands and forest biotopes represent valuable habitats in the hemiboreal landscapes of Finland and are characterised by dynamics due to nature-human interactions over centuries.

The study covered a time span of ca. 300 years and consisted of the following phases. Firstly, spatial analysis and visualisation was done in GIS of selected structural patterns of the present-day oak forests derived from existing forest inventory. Secondly, space-time indicators of forest cover stability and continuity, land use trajectories and boundary dynamics were derived from the spatio-temporal database, which consisted of land cover and land use information from 1690 to 1998. Thirdly, edaphic site conditions, indicated by the wetness, slope and aspect characteristics, were analysed within the current oaks forests. Finally, forest structural and tree species composition were combined with the site-specific edaphic and change dynamics information in GIS. This database was spatially analysed to assess the space-time properties of the oaks forests and to reorganise and cluster the forest patches based on their similarities and differences in the present characteristics and past trajectories of development. The spatio-temporal analysis was based on the applications of cartographic space-time models and statistical and overlay techniques in GIS.

**Demographic Change – Opportunities and Risks for a Sustainable Landscape Development: Case Studies in the Eastern Federal States, Germany.**

**M. Moorfeld<sup>1</sup>, S. Heiland**

Berlin University of Technology, Department of Landscape Architecture and Environmental Planning – Straße des 17. Juni 145, Germany- 10623 Berlin.  
e-mail: maria.moorfeld@tu-berlin.de

Demographic change and its various effects are broadly discussed in public. This change is sometimes characterised by population decrease. Aging, heterogeneity and internationalisation is not just a German but also a European phenomenon which has been known since the seventies and eighties of the last century. Causes of demographic change are decreasing birth rates, an increased life expectancy and migration movements. Especially migration from economically weaker towards stronger regions probably extremely effect land-use und landscape structures.

The presented study supported by the German foundation “*Deutsche Bundesstiftung Umwelt*” focuses on these effects in rural areas of Eastern Germany. It particularly considers and analyses land-use patterns, landscape structures and stakeholders such as farmers, administrations and planners.

A range of studies have examined the spatial effects of demographic change but they mainly regard urban areas. Only a few studies have more thoroughly investigated the consequences of demographic change on nature and environmental protection. However, they use scenario-techniques, literature reviews and theoretically based inquiries. Empirical studies on this topic have yet to be carried out.

In order to obtain empirical based knowledge about demographic change as a driving force of landscape development, it is indispensable to conduct case studies in regions such as Eastern Germany with a major population decrease and aging. Theories or hypotheses regarding this topic can then be derived. The other, above-named criteria heterogeneity and internationalisation have especially influenced urban areas in the Western parts of Germany. They are not as important for the Eastern rural areas and therefore neglected.

Important driving forces of current landscape change and analysis of landscape development were carried out in the chosen case study areas, especially in the time period 1990-2006), as part of the main objectives. Moreover the study investigates interconnections or interfaces between demographic and landscape change and discusses current concepts in spatial planning disciplines and strategies as well as the necessary action.

The case-study areas will be chosen by different criteria: a strong population decrease, an increase in older people caused by significant migration movement and decreasing birth rates, different landscape formations (e.g. lowlands, low mountain ranges) and data availability.

With an interdisciplinary approach using methods from social (e.g. interviews) and spatial science (e.g. analysis of historical maps; as well as GIS-data and aerial views or satellite data) there is the prospect of finding solutions to current problems which may will also emerge in other European regions with still increasing or constant populations. For this reason it is important to define potential developments at an early stage in order to have the possibility of developing suitable policies regarding the criteria of sustainability (e.g. enlargement of protected areas and biodynamic agriculture).

## Social-Economic Indicators as a Tool of Landscape Use Changes Evaluation

B. Barkova<sup>1</sup>, K. Pavlickova<sup>2</sup>

<sup>1</sup> Dpt. of Landscape Ecology, Faculty of Natural Sciences, Comenius University in Bratislava, Mlynska Dolina B-2, 842 15 Bratislava, Slovak Republic.  
e-mail: bhudecova@fns.uniba.sk

### Introduction

As one of the most important factors, which influence development and changes of landscape, social-economic conditions of society should be considered. The final result of this process is reflected in the structure and function of landscape. In our research we try to refer to the interrelation between changing social-economic conditions and their influence on landscape in a case study. The locality is situated in a central part of Slovakia, on the boundary of three national parks and was chosen as a test area. It contains specific historical developments connected with contrasting land use changes. Presently it belongs to intensively and dynamic developed centres of tourism. This development was initiated by social changes after the 1989 year and assign paradoxes, especially in the interrelation between so called "selective and "realization" assumption of the territory.

### Method of evaluation

The methodology is based on an analysis of statistical data, which are characterized as "hard data." Statistics give us an exact opinion of social-economic conditions of society. We focused on demographic characteristics, specifically the changes in number of the population and on the structure of accommodation facilities. For better data comparability there were base indexes calculated for each data value file in order to see changes compared to initial status of the monitored datum. For better development deducibility trend lines were added. We also evaluated the change rate of the data values which were: absolute increase and growth index.

### Results

The phenomenon typical of this area is a high number of temporary present inhabitants. This appears to create a barrier in creating a local community, capable of creating and using internal resources for development of the village. The number of accommodation facilities is growing faster than the number of beds, which defines a new trend – a switch from large hotel complexes built mostly till 1989 to smaller facilities. The demand regards mainly facilities of above standard apartment type and individual recreational houses.

*This abstract was supported by Science Grant Agency (VEGA) No. 1/2340/05.*

### References

- Škrinárová, Ľ., at al. (2002) *Donovaly – space between heaven and the earth*. Harmony, B. Bystrica, 111 p.
- Šmelko, Š. (1995) *Statistic methods in forestry*. Zvolen ES TU, 276 p.
- Tomeček, O. (2003) Beginning of timbering and colliery settlements in Donovaly. *Acta Historica, Neosolensia* No 6: p. 5-11.
- Jančura, P. & Pavlík, J. et al. (2005) *Landscape-ecological research: case study Donovaly – Phare Project No.2002/00.610-13-652 Planning of urbanistic and rural development of centre of tourism*. B.Bystrica, L.Mikuláš, 29 p.

## The landscape ecological analysis for environmental impact assessment of oil-and-gas production and transport: experience from north-west of Siberia, Russia

V.V. Kozin <sup>1</sup>, D.M. Marinskikh <sup>1</sup>, A.V. Marshinin <sup>1</sup>, I.R. Idrisov <sup>2</sup>

<sup>1</sup> Tyumen State University, Faculty of Ecology and Geography, Semakova street, 10, Tyumen, 625003, Russia.

e-mail: d\_marinskikh@mail.ru

<sup>2</sup> ZAO "NPC "SibGeo", Nemtsova street, 22, Tyumen, 625002, Russia.

### Introduction

The structure of landscapes of Western Siberia in forest-tundra of Nadym-Pur-Taz interfluvial plain is explored. The landscapes classification, mapping and evaluation of the territory for environmental impact assessment (EIA) of oil-and-gas field and pipeline is carried out (Idrisov et al, 2006).

### The landscape classification and mapping

The major procedure of landscape analysis is landscape classification and mapping (Mikheev et al, 1996). The classification of landscape complexes represents their typology on the basis of the most important and common for this level of dimension features of morphological structure. Depending on the bioclimatic and geomorphologic exponents occupied the following stock of landscapes are revealed: the fifth sea plain, fourth lake-alluvial plain, flood-plains etc. Within stocks of landscapes in scale 1:50000 19 types of mesogeochores and 138 types of microgeochores have been mapped and included into the composition of 9 series and 5 cycles of geosystems development. These landscape complexes were characterized on the basis of collection of the leading and second signs (geology, relief, soil, vegetation etc.) with the help of ArcGIS 9.1.

### The landscape evaluation

The evaluation of a landscape is based on the concepts of landscape functions (De Groot, 1992). The landscapes of the territory carry out nature resource functions (tree-resource, bacca-mushroom, hunting, ren-pascual etc) and nature protection functions (habitat, climate protecting, water protecting, water storage, runoff regulative, permafrost-stabilizing etc) (Kozin & Osipov, 1996). Thus, in landscape assessment nature protection and resource value of multifunctional landscapes is taken into consideration. Moreover, for EIA of oil-and-gas field and pipeline the assessment of landscapes stability is of great importance. Integral assessment of ecological characteristics (landscape functions, nature protection and resource value, stability) is the base for environmental constraints map.

### References

- Mikheev V.S., Kozin V.V., Shekhovtsov A.I. (1996)** General principle of geoecological mapping. *Ecological mapping of Siberia*. Publishing House SB RAS, Novosibirsk, pp. 20-58. (in Russian).
- De Groot R.S. (1992)** *Functions of Nature: evaluation of nature in environmental planning, management and decision-making*. Wolters Noordhoff BV, Groningen, 345 pp.
- Kozin V.V. & Osipov V.A. (1996)** (Eds). *Environmental management in north-west of Siberia: experience of problem-solving*. Tyumen University Press, Tyumen, pp. 15-28. (in Russian).
- Idrisov I.R., Kozin V.V., Marshinin A.V., Marinskikh D.M. (2006)** Geo-informational supplying of environmental audit of oil-and-gas production enterprises (on example of Vyngapur oil field). *Problems of regional ecology*. 3, pp. 88-95. (in Russian).

**Landscape changes and management goals: the case of Terres de l'Ebre, NE Spain.**

**J Lascurain, S Imola**

SGM s.l. Pau Claris 167. Barcelona. 08037-Spain.

e-mail: info@sgm.es

In a study funded by the Departament de Política Territorial de la Generalitat de Catalunya with the aim to delimit areas to be protected from urban development, a survey of landscape change was undertaken. The area of study is 3,243 Km<sup>2</sup> with important bird and faunal areas and includes the Ebro river delta (295 Km<sup>2</sup>), mountain ranges with wild goat populations and birds of prey (1,029 km<sup>2</sup>), and plain areas mainly with permanent olive groves on alluvial fans, tectonic depressions and the Ebro basin (1.918 Km<sup>2</sup>).

In the Ebro delta the reed bed area was digitized from aerial images from 1971 and the Landscape vegetation map of Ebre delta was done between 1974 and 1975. In the inland area, two areas were studied: one of 1,312 Km<sup>2</sup> and inside it, another of 286 Km<sup>2</sup>. In those areas we worked with the flights of 1956, 1974, 1996 and 2004. Dispersed random survey of 4ha/25Km<sup>2</sup> and 1ha/Km<sup>2</sup> was conducted on each sector. To assess the accuracy of the survey on the less represented habitats, the entire forest in random squares of 25ha/Km<sup>2</sup> was digitized in the 286Km<sup>2</sup> sector.

The landscape vegetation map overestimated reed and rush communities (*Phragmites*) only in a 5.51 % because it not included the small open-water areas inside. The comparison between 1971-74 and 1996 shows a reed bed area loss mainly to rice fields of 58,76%. The interior reed bed area (100m from perimeter) loss has been of 95%. This change is possibly related to the loss of threatened breeding birds as great bittern (*Botaurus stellaris*), marsh harrier (*Circus aeruginosus*) and bearded tit (*Panurus biarmicus*).

The loss of olive grove area ranges between 54 and 69%. The coalescence of trees and shrubs is not only related to an increase in fire occurrence and burned areas, but with the impact of fire on old growth forest and range reduction on residual species as *Pinus nigra*. The level of impact due to loss of habitat on faunal groups (partridges, thrushes, little owl, rabbits, Bonelli's eagle) is still unknown.

Those results triggered different research needs and management proposals:

- The need to know how the (non linear) process of afforestation of abandoned olive groves works, and the role of the relative topographical position of Aleppo pine (*Pinus halepensis*).
- On which phase of afforestation is better to intervene in order to keep habitat quality with minimum effort?
- How to measure the habitat quality of olive groves and its relationship with key and endangered species?
- Which are the criteria to select the olive grove areas to protect? (aggregation; distance to nests of Bonelli's eagle,..).
- Where are and how to re-install reed beds, and how restore endangered species?
- The role of consistent criteria on drawing precise delimitations of protected areas.

## Historical landscape of Šumava in the light of palaeobotanic and antique maps' evidence

K. Křováková, V. Brůna

Geoinformatic Laboratory UJEP, Dělnická 21, 434 01 Most, Czech Republic,  
e-mail: cariad@geolab.cz

### Introduction

Studying the landscape is an interdisciplinary task requiring various data sources which are often not easy to integrate. Research concerning the changes of vegetation could serve as a good example - the intention is to integrate outputs of palaeobotany and historical geography, namely the pollen profiles and antique maps, in order to receive a picture of the past vegetation in the studied area (the Šumava Mts. in Southern Bohemia). The first conclusions are given here.

### Method

For the confrontation the pollen profiles analysed by Svobodová (2004) and the 2<sup>nd</sup> Military Survey maps dated to the middle of 19<sup>th</sup> Century were chosen; on the military map the area within 1 km circle around the profile was vectorised in the GIS environment and converted into land-cover categories. From the pollen diagrams the values of arboreal pollen (AP) percentage and number of taxons were drawn and together with the land-cover values pictured in the graph.

The expected correlations (AP-forest area, number of taxons-length of boundaries) were observed at all sites except Malá niva (the reason is being checked); correlation wood taxons-forest area was not found; we take it that many of the trees may belong to the wetland class (possibly *Betula nana* and *Pinus rotundata*).

Beside this „quantitative“ analysis also a rather „qualitative“ approach was used as well - the parallels between taxons and antique sources were discussed (e.g. *Melampyrum* sp. and its relation to the fire management of the area).

### Conclusion

The problems were mostly caused by uncertainties when handling the pollen diagram, namely the precise dating and a question of spatial representativeness of the pollen data. We considered that the research would inevitably involve these questions and aim at statistical analyses of parallels between pollen data and historical landscape. The first steps will be based on precision and amplification of both data types; the pollen data will be converted from the point to the polygon through interpolation and modelling and the correlations will be searched for.

The aim is now to enhance the information gained from antique map by the pollen evidence, i.e. plant species found on the site and the pollen data by a spatial context, whereas the method can be tested on the antique maps.

### References

**Svobodová, H. (2004):** Migrace klimaxových dřevin na Šumavu v holocénu (Migration of klimax wood species to Šumava during the Holocene). *Bulletin Slovenskej botanickej spoločnosti*, Bratislava, Suppl. 11, pp. 207-216



## Landscape transformations: comparing land cover maps to understand trends and changes

M.C. Mariani, M. Gherardi, G.Vianello, M. Speranza

Department of Agro-Environmental Sciences and Technologies Viale Fanin 44, I-40127  
Bologna (Italy)  
e-mail: maria.speranza@unibo.it

We present here a case study on land-use/land cover changes concerning the territory of Borgo Tossignano (Emilia-Romagna region, Italy) The territory in question, extending over 2900 ha between 100 m and 500 m a.s.l., is of particular interest because of its location close both to the plain and to the mountain belt. This implicates the contemporary presence of different patterns of landscape dynamics in a territory of relatively small dimensions.

By means of a Geographic Information System we analysed the modifications of land-use/land cover changes over the period 1955-1976-1994-2003, using four geo-referenced land-use maps at 1:25.000 scale. Nine land use categories were distinguished: urban areas, sown areas with cultivated trees, herbaceous crops, orchards and vineyards, shrublands, woodlands, barren soils and non cultivated areas, water bodies, wetlands. Land-use transformations were classified as: persistence, urban persistence, intensification, urban intensification, extensification, exceptionality, natural dynamics, abandonment.

The different dynamics considered are reciprocally quite balanced over the period 1955-1976, where persistence (30% of the territory), intensification (22%), abandonment (21%) and natural dynamics (9%) are the most important dynamic tendencies. Subsequently (1976-1994 and 1994-2003) the landscape is primarily characterised by persistence (53% and 55% of the territory in the two periods, respectively), followed by intensification (20% and 16%) and abandonment (10% and 16%), while extensification (9% and 4%) and natural dynamics (5% and 6%) play a less important role. Persistence concerns anthropized areas (herbaceous crops, orchards and vineyards) as well as more natural areas (barren soils and non cultivated areas, shrublands, woodlands). Intensification maintains more or less the same quantitative importance over the whole period. This phenomenon prevalently concerns the transformation of areas belonging to different categories of land use (cultivated and non cultivated) into orchards and vineyards. Abandonment is the third dynamic tendency in order of quantitative importance; it concerns many categories of land use and is not easy to set within a prevailing trend. Intensification as well as abandonment are accompanied by "swap" phenomena, widely distributed throughout the territory

Two opposite landscapes (anthropic and semi-natural) co-exist in the studied territory, as in many European countries (Romero-Calcerrada and Perry, 2004; Falucci *et al.*, 2006; Mottet *et al.*, 2006). "Swap" phenomena cause space-temporal variability in the anthropic landscape deriving from intensification as well as in the semi-natural landscape deriving from abandonment.

### References

- Falucci, A. ; Maiorano, L. & Boitani, L. (2006) Changes in land-use/land-cover patterns in Italy and their implications for biodiversity conservation. *Landscape Ecology*, published on line.
- Mottet, A.; Ladet, S.; Coqué, N. & Gibon, A. (2006) Agricultural land-use changes and its drivers in mountain landscape: a case study in the Pyrenees. *Agriculture Ecosystems & Environment* **114**: 296-310.
- Romero-Calcerrada, R. & Perry, G.L.V. (2004) The role of land abandonment in landscape dynamics in the SPA 'Encinares del río Alberche Y Cofio, Central Spain, 1984-1999. *Landscape and Urban Planning* **66**: 217-232.

## Kurgans: Specific values of the Holocene landscape history of the Carpathian Basin

A. Barczy<sup>1</sup>, V. Grónás

Dept. of Landscape Ecology, Szent István University, Gödöllő, Hungary,  
e-mail: barczy.attila@mkk.szie.hu

The burial mounds, living mounds, guarding and border mounds organized into the group named “*kurgan*” are under environmental protection in Hungary since 1996. *Kurgans* are one of the oldest memories of history in civilization of Hungary. Besides the fact that they are important elements from the archeological point of view, in many cases they reserve valuable remaining parts of one-time loess steppes. Studying the buried soils and the paleoecological aspects can provide novel data for the better understanding of the ancient environment, flora and the soil formation process that took place long ago. This is a current problem, because the history of the development of the Hungarian sodic steppe lands, the afforestation of the Carpathian Basin or the lack of forests in the Holocene, the natural or anthropogenic formation of sodic soils are still unclear questions.

Examination of soils could be one of the most important methods to solve this problem. The statement of Dokucsajev that „Soil is the mirror of the landscape” stands for paleosoils, too. Their buried soils and the examinations on the body and surroundings of these mounds may contribute with new data for the recognition of the ancient environment, vegetation and soil formation processes of the past and present.

In the course of our *kurgan* researches besides analysis of the buried soils, the morphology, structure and age of the mound, our data were completed with mineralogical and geochemical examinations. To learn further about the original environment and morphogenesis of the mound we used paleoecological methods, too.

Recently there are only a few thousand *kurgans* left on the territory of Hungary from those many ten thousand that were originally found in the Carpathian Basin formerly. For our researches we designated representative *kurgans* from the north to the south on the Hungarian Great Plains, from which 6 were studied in the last few years.

Our aim is to describe the stratigraphy of the mounds and to provide data for the palaeoecological knowledge about the wider surroundings of the *kurgans*. Their surface is usually covered with Chernozem soil, and the soil that is buried under the mound is Chernozem type, too. In some cases we could detect the traces of water influenced soil properties and the influence of high salt content, but the loess ridges underneath the *kurgans* (that they were usually built upon) provided dry environment for soil generation. Instead of closed forest vegetation, a loess-steppe or semi-shaded steppe can be imagined as the former environment of the mounds. These vegetational patterns were presumably mosaically surrounded by water and salt affected areas.

We prove that during this period, 5000 to 6000 thousand B.C. on the basis of the radiocarbon dating – in contrast to some previous projects –forests were not current in the inner area of the Great Plain, but was similar to the present-day, with a mosaic of wet and sodic landscape proportioned with steppes being typical.

With the help of these tests we could confirm the results of those examinations, which provided data for the Holocene morphogenesis of the Carpathian Basin. We can prove that the ancient flora and fauna reflects the genetical processes of the soils developed under a longer period and the environmental condition of the soil formation, too.

The current publication was created within the frame of the Hungarian and Russian intergovernmental scientific and technological cooperation and with the support provided by the Research and Technological Innovation Fund and the Ministerstvo nauki i tekhnicheskoy politiki Rossiiskoi Federacii (Ministry of Science and Technical Policy, Russian Federation). This project was supported by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences.

## Tools supporting sustainable management of landscape changes: Examples of good practice from the Slovak Republic

M. Kozova<sup>1</sup>, P. Misikova<sup>2</sup>, A. Krsakova<sup>3</sup>, Z. Izakovicova<sup>4</sup>, P. Jancura<sup>5</sup>, E. Stanková<sup>1</sup>

<sup>1</sup> Comenius University in Bratislava, Faculty of Natural Sciences, Mlynska dolina B-2, 842 15 Bratislava 4, SK,

e-mail: kozova@fns.uniba.sk

<sup>2</sup> Ministry of the Environment of the Slovak Republic, Nam. L. Stura 1, 812 35 Bratislava, SK

<sup>3</sup> Slovak Environment Agency, Centre for Environmental Education and Promotion, Tajovskeho 28, 975 90 Banska Bystrica, SK <sup>4</sup> Institute of Landscape Ecology Slovak Academy of Sciences, Stefanikova 3, 814 99 Bratislava 1, SK <sup>5</sup> Technical University in Zvolen, Faculty of Ecology and Environmental Sciences, Masarykova 24, Zvolen, SK

### Introduction and methodology

There is a long history in the landscape-ecological research and education in Slovakia. New tools for protection, management, planning and formation of landscape have been elaborated or are currently under preparation. On the basis of analysis of legislation, programmes, economic and other tools (research, education, participation etc.), strong and weak points and their synergistic effects have been evaluated. Selected case studies of good practice on the local and regional levels demonstrate examples of possible ways for reinforcing/improving these tools.

### Results

An overview and analysis of relevant tools applicable for sustainable landscape management are introduced. We report examples of results from interdisciplinary research, programmes and projects, guidelines and regulations dealing with the landscape management changes supporting sustainable landscape management developed by the Slovak researchers and decision-makers. Several examples of good practice are presented. They are based on the participatory processes dealing with synergies between landscape planning, nature protection and territorial planning: (a) Landscape Plan and Landscape Character Assessment (the High Tatras – Biosphere Reserve, affected in November 2004 by severe windstorm); (b) Territorial System of Ecological Stability (Trnava district – typical mono-functional agricultural landscape with low ecological stability); (c) NATURA 2000 as a tool for protected areas management (National Park Mala Fatra – area with major prevalence of private ownership); (d) Local Agenda 21 (active villages participating in international programmes on Local Agenda 21; examples: Municipality recreation park in Dunajská Lužná, Implementation of sustainable development strategy in Sucha nad Parnou); (e) Programme of Village Renewal (School of Village Renewal, Village of the Year Award – examples). The objectives of the Programme of the European Landscape Convention Implementation in Slovakia are presented. The programme reflected integrative management principles and represents an umbrella for protection, planning, formation and management of landscapes.

### Discussion and conclusion

We discuss how scientific knowledge and participatory approaches can support integration of sustainable principles to management of landscape changes. On the evaluation of relevant tools we identified major driving forces for sustainable management of landscape: (1) integrative approaches to management of landscape changes (2) participatory form of governance and integration of different interests of “stakeholders” into decision-making processes; (3) sustainable development studies based on the newest scientific knowledge and dissemination of good practice, (4) sustainable local economy development; (5) sustainable tourism; and (6) public awareness of landscape values.

## Models of landscape change based on the entropy of transition matrices of land uses and landscape mosaics

M.J. Roldán Martín<sup>1</sup>; J. Gimeno<sup>2</sup>; V. Valverde<sup>2</sup>; P. Martín de Agar<sup>2</sup> & C. L. de Pablo<sup>2</sup>

1 CIAM Environmental Research Centre of Madrid "Fernando González Bernáldez". c/ San Sebastián 71. 28791, Soto del Real, Madrid (Spain)

e-mail: mariajose.roldan@madrid.org

2 Department of Ecology. Complutense University. c/ José Antonio Novais 2, 28040 Madrid (Spain)

### Introduction

Changes in land uses and in their spatial structure involve modifications in the interactions occurring among them and in consequence modify the functioning of the landscape. Landscapes are organized according to landscape mosaics. These mosaics are the spatial pattern of land uses including their boundaries. They integrate both the composition of land uses and the spatial disposition of their patches as well as the interactions across the boundaries among them. Changes in the composition or in the configuration of land uses, and hence in boundaries, involve modifications in the spatial patterns that constitute the mosaics of the landscape.

### Methodology

Transition and origin matrices between land uses and between landscape mosaics, were built, based respectively on land use maps and on landscape mosaic maps from 1946 to 1999 (Roldán Martín *et al.*, 2003 and 2006). Each element of the transition matrix is the proportion of the land use, or mosaic,  $i$  in the time  $t_1$  that becomes the land use, or the mosaic,  $j$  in the time  $t_2$ . Each element of the origin matrix is the proportion of the land use, or mosaic,  $i$  in the time  $t_2$  that comes from land use, or the mosaic,  $j$  in the time  $t_1$ . Both types of matrices were studied using conditional entropy parameters (Pielou, 1977; de Pablo *et al.*, 1988).

### Results and discussion

Four general models of change have been identified: 1) an random model, in which any change is equally probable; this indicates that the territory is used in an indiscriminate way; 2) a conservative model: the system of uses of the landscape is maintained, probably because it is socially or economically well adjusted; 3) a model of landscape diversity increase: the loss of socioeconomic viability of some dominant land use or mosaic involves its substitution for other less dominant ones, increasing the diversity of the landscape; 4) a model of landscape diversity decrease: the surface of some of the land uses or mosaics is increased due to a given use of the territory results more advantageous from the socioeconomic point of view.

### References

- De Pablo C.L., Martín de Agar P., Gómez Sal A. & Pineda F.D. (1988) Descriptive capacity and indicative value of territorial variables in ecological cartography. *Landscape Ecology* 1: 203-211.
- Pielou E.C. (1977) *Mathematical Ecology*. Wiley, London.
- Roldán Martín, M.J.; Martín de Agar, P. & de Pablo, C.L. (2003) Landscape mosaics. Recognition and changes over time: a methodological approach. Mader, Ü & Antrop, M. (Eds.) *Multifunctional landscapes Vol. III Continuity and change*, WIT Press. Southampton, pp. 55-77.
- Roldán Martín, M.J.; de Pablo, C.L. & Martín de Agar, P. (2006) Landscapes changes over time: comparison of land uses, boundaries and mosaics. *Landscape Ecology* 21: 1075-1088.

### Future climate change impacts on the boreal forest in northwestern ontario.

T.R.A. Muñoz-Márquez<sup>1</sup>, R. Suffling<sup>2</sup>, P.J. Deadman<sup>2</sup>, D. Scott<sup>2</sup>, A. Perera<sup>3</sup>.

<sup>1</sup> Colegio de Postgraduados, Campus Córdoba, Km. 348 Carretera Federal Córdoba-Ver. Apdo. Postal 143 C.P. 94500, Córdoba, Veracruz, México.

e-mail: arturom@colpos.mx

<sup>2</sup> Faculty of Environmental Studies, University of Waterloo, Canada

<sup>3</sup> Landscape Ecology Laboratory, Ontario Forest Research Institute. Canada.

A large body of research has documented evidence of climate change impact already occurring on different systems on earth (MET 2005), so future impacts can be expected. This work investigated how climate change affects landscape change, and how to use this understanding in the analysis of land-use and landscape planning and management to adapt to climate change impacts. This paper shows results in examining timber availability under climate change in the Dog River Matawin forest, a  $\approx 8 \times 10^4$  ha boreal forest in Ontario Canada, which is currently under harvesting. It is part of a bigger research, which examined how climate change might impact a managed forest in terms of timber availability, and the regional community that relies on it for its survival (Muñoz-Márquez 2005).

The main hypothesis was that Boreal forest in north western Ontario will change in the short term (i.e. 60 years) in species, composition and will produce less available timber as a result of human-induced climate change as modeled by different General Circulation Models plus harvesting, compared to a baseline climate.

The Boreal Forest Landscape Dynamic Simulator (BFOLDS) fire model (Perera *et al.* 2003) was used to simulate landscape change under different climate change scenarios (CCSRNIES A21, CGCM2 A22), which were then compared to simulations under a baseline climate scenario (1961-1990). The studied period covered 60 years to analyze impacts in the medium term in the landscape change.

Some of the main results were: (1) there will be a shortage in timber availability under all scenarios including the baseline. The impacts of climate change will cause a deficit in timber availability much earlier under a warmer scenario with respect to the baseline. The combined impact of climate change and harvesting could diminish timber availability up to 35% compared to the baseline by year 2040 under the CCSRNIES A21 scenario mainly due to an increase in fires.

There are important economic, social and environmental implications of the results of this study, namely a future forest that would be young and would supply much less timber.

#### References

**MET (2005).** Avoiding dangerous climate change. Conference outcomes [Online] <http://www.stabilisation2005.com/outcomes.html> (verified December 27, 2004).

**Muñoz-Márquez, T.R.A. (2005).** Future climate change impacts on the boreal forest in northwestern ontario. Implications for the forestry sector and the local community. Unpublished Ph.D. Thesis. School of Planning, Faculty of Environmental Studies, University of Waterloo.

**Perera, A.H., D.J.B. Baldwin, D.G. Yemshanov, F. Schneckeburger, K. Weaver, and D. Boychuk (2003).** Predicting the potential for old growth forests by spatial simulation of landscape aging patterns. *Forestry Chronicle* 79:621-631.

## **The landscape history of Godmanchester (Québec, Canada), two centuries of a shifting relationship between anthropic and biophysical factors**

**G. Domon<sup>1</sup> and A. Bouchard<sup>2</sup>**

<sup>1</sup> Department of Landscape and Environmental Design, University of Montreal, C.P. 6128, Succ. Centre-Ville, H3C 3J7, Montréal, Canada.

email : gerald.domon@umontreal.ca

<sup>2</sup> Plant Science Research Institute and Department of Biological Sciences, University of Montreal, 4101 Est rue Sherbrooke, H1X 2B2, Montréal, Canada

### **Introduction**

Taking into consideration ecological aspects in land management requires an understanding of the processes and dynamics that create landscapes. Based on the research of a multidisciplinary team this paper proposes to reconstruct the landscape of Godmanchester (Quebec, Canada) from the pre-colonial period (1785) to today (2005).

### **Methods**

The methods can be categorized into three groups. First, the study of 19<sup>th</sup> century transformations was based on two principal methods: (1) wood sales recorded in notary deeds allowed us to determine the quantities, the prices and the tree species involved in 19<sup>th</sup> century transactions; (2) nominative and cumulative data from the Canadian censuses were used for studying the spatial-temporal dynamics of land occupancy. Secondly, the analysis and the treatment of information from aerial photographs form the basis of the reconstruction of the land use dynamics for the 20<sup>th</sup> century. Finally, the current characteristics of the study area were documented and analyzed according to two main avenues. Regarding the distribution and composition of the vegetation, detailed inventories of the woodlots and the hedgerows were made. As for the data on socio-economic characteristics of the study area, they come from cluster analyses of census data, from interviews with residents and from various transactions made between 1958 and 1997.

### **Results**

Seven periods were identified: (1) the pre-colonial period, (2) the first settlements, (3) the first agricultural developments, (4) the maximum development of agricultural activities, (5) the concentration of agricultural activities, (6) the intensification of agricultural activities, (7) the importance of new amenities. The results allowed us to identify three sets of fundamental factors that are necessary for understanding the landscape changes, the geomorphological characteristics, the socio-economic demands, and the technological transformations. The results also highlight the key elements and the perspectives that are appropriate to their comprehension, in order to be able to direct the future evolution of the landscapes. This requires that transformations be analyzed from mid-term to long term perspectives, that the consequences of the changes, as well as the opportunities that they generate are well understood, and that relationships be drawn between the biophysical, anthropic and technological factors responsible for these transformations.

### **Conclusion**

This paper concludes with the idea that the creation of landscapes occurs through actions brought about by social demands and by the adjustment of technologies according to the biophysical characteristics of the territories.

## Challenges faced when predicting landscape change

J.A. Hepinstall<sup>1</sup>, M. Alberti<sup>2</sup>

<sup>1</sup>School of Forestry and Natural Resources, University of Georgia, Athens GA, USA,  
e-mail: jhepinstall@warnell.uga.edu,

<sup>2</sup>Urban Ecology Research Laboratory, University of Washington, Seattle WA, USA.

### Introduction

Predicting likely future landscape change is essential to informing our planning process and supporting conservation efforts. We have developed an integrated modelling framework of landscape change that links models of urban development, land cover change, and bird species richness to explore potential futures for the region given current trajectories.

### Methods

We combined the output from an economic development model (UrbanSim) and measures of the composition and spatial pattern of development, land cover change between 1991-95 and 1995-99, and biophysical elements at three spatial scales to develop multinomial logit models of land cover change (LCCMs). Land cover is predicted 25 years into the future at 4 year intervals for individual 30m pixels. We validate our models by comparing 2003 predictions with observed 2002 data. The LCCM output is combined with development variables from UrbanSim as input into predictive models of bird diversity generated from 5 years of extensive field studies across the urban and land use gradients.

In this poster we focus on several interesting modelling problems that were encountered during the process of developing the LCCM and bird diversity models ranging from non-stationarity of input data and varying strength of drivers of landscape change across the urban gradient to methodological artefacts derived from using Monte Carlo methods to choose which pixels transition. Non-stationarity in driving forces of land cover change and their interactions may vary substantially from one place to another and over time. Current modeling approaches assume stationarity and fail to explicitly address one of the major challenges in representing realistically the evolution of the landscape (Wagner and Fortin 2005). Additionally, land cover change is a complex process and depends in principle on an infinite number of other processes and thus it is difficult to simultaneously measure all covariates that affect the land-cover change.

### Findings

We provide specific examples from our study system of problems we encountered and the methods that we are using to address them as well as how these different approaches affect predicted land cover change and bird species richness. Specifically, segmenting the study area into relatively homogeneous zones of intensity of current development (urban, transition, exurban) were used to address non-stationarity. Results indicate that segmenting our study landscape helped both to fit more precise models and to predict observed future land cover with higher accuracy. Additionally, several options for incorporating spatial configuration of neighbouring pixels simultaneously when estimating the model and predicting land cover transitions have been identified include: using wavelets to determine processes operating simultaneously at multiple scales; incorporating neighboring information while building a model for transition probabilities; and introducing a latent process that varying over space and time. The latent process is an abstraction of the underlying unmeasured processes that drive land cover change.

### References

Wagner, H.H. & Fortin, M.J. (2005) Spatial analysis of landscapes: concepts and statistics. *Ecology* **86**: 1975-1987.

**Land cover changes in the catchment basin of the Yangtze River, China: a case study of Wanzhou and Kaixian regions using satellite remote sensing**

**M. Tomita<sup>1</sup>, Y. Zhao<sup>1</sup>, K. Hara<sup>1</sup>, M. Fujihara<sup>2</sup>, L. Da<sup>3</sup>, Y. Yang<sup>4</sup>**

<sup>1</sup> Faculty of Information Sciences, Tokyo University of Information Sciences, 1200-2 Yatocho, Wakaba-ku, Chiba 265-8501, Japan.

e-mail: tomita@rsch.tuis.ac.jp

<sup>2</sup> Awaji Landscape Planning & Horticulture Academy/Institute of Natural & Environmental Sciences, University of Hyogo, Japan.

<sup>3</sup> Department of Environmental Sciences, East China Normal University, East China Normal University, China

<sup>4</sup>Key Lab of Three Gorges Reservoir Region's Eco-Environment (Chongqing University) , Ministry of Education, Chongqing / Faculty of Urban Construction and Environmental Engineering, Chongqing University, China.

### **Introduction**

Changes in regional land cover affect biodiversity, hydrology, and biogeochemical cycles in local watershed and landscape structures. Rapid changes in land cover have occurred in many regions of the Yangtze River catchment basin since the 1990's, particularly due to construction of the Three Gorges Dam. Although this dam will provide economic benefits in terms of flood control and hydroelectric power, there is concern over the potential loss of vegetation and the effect on landscape structure. In this study, satellite remote sensing is used for land cover classification and analysis of land cover changes in Wanzhou and Kaixian, which are part of the Yangtze River catchment basin.

### **Methods**

Field datasets for image classification and accuracy assessment were collected throughout the study area in August 2006 using a GPS. Four Landsat images of the study area were acquired between 1988 and 2000. The earlier images (June 1988 for Wanzhou and June 1988 for Kaixian) were from the Thematic Mapper (TM) sensor, and later images (July 2000 for Wanzhou and May 2000 for Kaixian) were from the Landsat Enhanced Thematic Mapper Plus (ETM+) sensor. Supervised classification of the 1988 and 2000 images was performed using maximum likelihood classification (MLC) by reference to ground truth data. Accuracy of the image classification was assessed based on ground truth data not used in developing the classification, and also known features such as open waters, urban areas and rock outcrops identified in the image. Land cover conversion analysis was performed by comparing land cover classification in 1988 and 2000 for each pixel, and was summarized separately for the two study areas.

### **Results and Discussion**

Land cover was classified into the following categories: forest, scrub, agricultural land (including both irrigated rice paddies and dry farmland), urban area, bare land and open water. The images classified by MLC showed drastic changes in land cover in both study areas between 1988 and 2000. Large areas of agricultural land, for example, were seen to have disappeared, particularly near the urban area. Also, not only loss of vegetation but also other changes in landscape structure were detected by the two Landsat data sets in this study. Our results illustrate the importance of considering landscape structures when formulating ecologically sustainable development.



## **A Quantitative Analysis of Landscape Pattern Change in Menglun, Xishuangbanna**

**W.J. Liu, Y.X.Ma , H.B. Hu, H.M.Li**

Xishuangbann Tropical Botanical Garden, Chinese Academy of Sciences, – 88 Xuefu Road,  
Kunming, Yunnan, China.  
e-mail: liuwj62@yahoo.com.cn

### **Introduction**

Menglun Township in Xishuangbanna is located in the tropical rain forest region of Southern Yunnan, China. Biodiversity is high in Menglun, and it is representative of other areas within Xishuangbanna because they have similar environment conditions, ethnic culture and economy development.

### **Method**

The changes in landscape spatial pattern between 1988 and 2003 were analyzed using Landsat TM/ETM images and the program FRAGSTATS. Landscape diversity, patch characteristics, and the spatial distribution attributes of different landscape elements were analyzed quantitatively and their changes over time were compared. Most indices are presented for the landscape and class level to show the overall characteristics of the landscape.

### **Result**

The area of rubber plantation exceeded the forested area and became the largest land cover category in 2003. This resulted in a more even distribution of the major landscape elements, and thus there was an increase in the landscape diversity and evenness indices. The forested areas are fragmented, increased the number of the patches from 368 to 441, and reduced the mean patch sizes from 44 km<sup>2</sup> to 21 km<sup>2</sup>. The shape of the largest patch was simplified, and as a result, the core area (with edge depth of 20 m) of forested area decreased and became functionally isolated. The spatial context of other landscape elements also changed. With the exception of rubber plantations, most of the other landscape elements have fewer chances to intersperse with each other. In conclusion, the major factor influencing these changes has been the spread of rubber plantations. If this trend continues, we can expect further deterioration of the regional environment. Rational land-use planning is needed to prevent the further fragmentation of forested area and preserve the functional connection between forest patches based on landscape ecology theory.

**Identifying potential abandonment of agricultural through change in landscape structure: a case study in Castelo de Vide, Portugal**

**C.I.F. Santos<sup>1</sup>; T.M. Teixeira<sup>1</sup>; I.L. Ramos<sup>2</sup>**

<sup>1</sup> National Agrarian Station, Department of Experimental Statistic, Economic and Agronomic Sociologies, Oeiras, Portugal.

e-mail: carlasantos22@hotmail.com

<sup>2</sup> CESUR - Technical University of Lisbon, Av. Rovisco Pais, 1049-001 Lisbon, Portugal.

Agricultural abandonment is changing rural landscapes. It is most commonly the culmination of a marginalization process and its causes can be found at various levels, such as social, economical and political, but also due to biophysical farmland constraints (e.g. soils, slopes). On one hand, it can be seen as a process of adjustment to a changing society and social demands, or an opportunity for renaturalization, on the other. It is threatening present landscape functions, notably ecological processes or even aesthetic quality. In this context it becomes relevant to monitor changes and to identify ongoing processes in time. Therefore the objective of this poster is to present the approach pursued to set a basis for the implementation of a landscape monitoring system at local scale that is focused on identifying marginalization processes leading to agricultural abandonment through its impact on landscape structure.

The methodological approach applied to the case study of Castelo de Vide municipality in Portugal is presented in the poster. Different sampling strategies were tested using a Land Cover Map. Random stratified sampling was identified as the most adequate for a sample unit of 25 ha square and sampling rate of 1,25% (10 sampling squares). The strata were built based on the integration of biophysical data (soils, slopes and pulverization). In order to identify the most suitable set of indicators capable of monitoring agricultural abandonment through landscape structure, historical aerial photographs (1968, 1980, 1995 and 2005) were used for the sampling squares to test a group of nine indicators proposed in literature (e.g.: Piorr, 2003; Romero-Calcerrada and Perry, 2004): SHDI, patch density, edge density, percentage of occupational class, contagion, density of linear elements, number of cultural elements, number of patches and total area of the class. The three vector maps for each date, resulting from the photo-interpretation aided by the observation of historical land use and land cover maps (punctual, linear and land use classes) allowed the calculation of the landscape indicators for the ten sampling units and to which four other were added later where actual agricultural abandonment is present. These aim at testing which indicators would have been most capable in the past of identify ongoing marginalization processes.

Even though it is recognized that there is no historical parallel for the future, this methodological approach may contribute to identify an initial set of indicators that seems better adapted to this landscape. Since the construction of a monitoring system to a specific landscape is an interactive process where all components will need to be adjusted throughout time, allowing evaluating and comparing the system's response to ongoing changes, also initially chosen indicators will only be able to prove their suitability in the future.

**References**

- Piorr, H.P. (2003)** Environmental policy, agri-environmental indicators and landscape indicators. *Journal of Agriculture, Ecosystems and Environment* **98**: 17–33.
- Romero-Calcerrada, R. & Perry, G. L. W. (2004)** The role of land abandonment in landscape dynamics in the SPA "Encinares del río Alberche y Cofio, Central Spain, 1984-1999. *Journal of Landscape and Urban Planning* **66**: 217-232.

## Different changes and methods to evaluate developments in cultural and mining landscapes

**M. Mulkova, R. Sedlarikova**

Department of Physical Geography and Geocology, Faculty of Science, University of Ostrava, Chittussiho 10, 71000 - Slezska Ostrava, Czech Republic,  
email: Monika.Mulkova@osu.cz

The Karvina Region is situated in the north-eastern part of the Czech Republic. About 50% of the region belongs to Ostravsko-karvinsky mining district, where deep mining of black coal has been in progress since the end of 19<sup>th</sup> century. Now the black coal is exploited only in the Karvina part of Ostravsko-karvinsky mining district. In the Karvina region there is the development of the cultural landscapes with mostly agricultural use, as well as the development of landscapes which are intensively influenced by deep mining.

The different landscape development calls for different methods to evaluate the landscape changes. Two localities, Poolsi and Lazy, were chosen as model areas. Poolsi locality presents cultural landscape with agricultural use. Mining area Lazy however represents an anthropogenic landscape transformed by mining activity. The aerial photos from different years were used as the source data. The archive aerial photos from the years 1947 and 1971 were provided from Military geographical and hydrometeorological institution in Dobruška and orthophotos from the year 2003 were acquired from the firm GEODIS Brno. The land cover was visually interpreted from the geometric corrected photos in the ArcGIS software.

The development of the areas affected by mining activity differs from the development of the landscape, which was not influenced by exploitation of minerals. Because of that the multitemporal analyses methodology should be to optimize to these areas with different objectives of development type by the selection of suitable evaluative metrics in relation to landscape character. For the quantitative evaluation of landscape changes in the area of interest the following landscape metrics were used: coefficient of anthropogenic impact on the landscape, coefficient of ecology stability, development index and total landscape change index. Since the coefficient of anthropogenic impact on the landscape gives biased data in mining landscape development evaluation, the authors have defined the coefficient of mining transformation of the landscape. The coefficient of mining transformation of the landscape includes the degree of the real anthropogenic impact on the landscape owing to mining.

The poster displays the land cover and the values of landscape metrics in the years: 1947, 1971 and 2003 in Lazy and Poolsi localities. The differences are shown for the predicative ability of indexes for mining landscape and cultural landscape.

Historical survey of spatio-temporal transformation in the landscape is an important source of information for the study of territorial differentiation changes and their intensity, character and reasons. It is a base for investigation of processes going to particular changes, objective knowledge of impact on landscape and the understanding of their relative interaction. Interception of landscape structure condition in the past, the evaluation of landscape characteristics and knowledge obtained from monitoring the landscape development is possible in the application of projects involved in optimization of landscape reclamation and in the field of landscape protection and management.

## Visualising changes in agricultural landscapes

D. Auclair, S. Griffon

INRA, UMR AMAP, Montpellier, F-34000 France.

e-mail: auclair@cirad.fr

Environmental and agricultural policies must co-evolve to ensure their effective contribution to conservation and sustainability in agriculture as well as contributions of agriculture to sustainable development of society at large. Assessing the strengths and weaknesses of new policies and innovations prior to their introduction, i.e., 'ex-ante integrated assessment', is vital to target policy development for sustainable development. An integrated computerized framework has been developed by a European research consortium ("SEAMLESS" project, European Commission, DG Research, contract n° 010036-2, Van Ittersum *et al.*, 2006) to compare alternative agricultural and environmental policy options. It enables assessment of key indicators through quantitative models, and qualitative procedures to simulate the impact of biophysical, economic and behavioural changes. It uses innovative software architecture that allows linkage of individual knowledge sources (models, databases, indicators) to assess indicators at the full range of scales, from global to the field scale.

One important aspect of cultural landscapes concerns the perception by the public of landscape elements and changes in the landscape. This is addressed here through a model component within the SEAMLESS integrated framework specifically targeted at visualising changes in the landscape. A prototype of a 3-D visualisation tool for representing the model outputs intended for landscape exploration and for assessment of the visual characteristics and perception has been developed.

The input data required for such visualisation concerns terrain data (Digital Terrain Model), land cover (present land cover, and land cover resulting from the outputs of the field- and farm-scale models), and a library of detailed textures and vegetation models. For each simulation, representing one "run" or "scenario", SLE ("Seamless Landscape Explorer") processes the input data to build a "virtual scene", which is saved in a "project file".

Such files can be used to visualize a scene previously calculated by the "landmodeler", for example from different viewpoints, or to produce a film by navigating within the scene. Satellite or aerial imagery or generated textures can be draped over the Terrain, and the building process then assembles the 3D landscape model, and displays it in the viewer.

An example of virtual landscapes based on a site in the French Midi-Pyrénées region is presented here, to illustrate potential land-use changes between agriculture, forestry, and agroforestry.

### References

Van Ittersum, M.; Ewert, F.; Alkan Olsson, J.; Andersen, E.; Bezlepkina, I.; Brouwer, F.; Donatelli, M.; Flichman, G.; Heckeley, T.; Olsson, L.; Lansink, A.O.; Rizzoli, A.; Van der Wal, T. & Wery J. (2006) Integrated assessment of agricultural and environmental policies – towards a computerized framework for the EU (SEAMLESS-IF). In: A. Voinov, A.J. Jakeman & A.E. Rizzoli (eds). *Proceedings of the iEMSS Third Biennial Meeting: "Summit on Environmental Modelling and Software"*. International Environmental Modelling and Software Society, Burlington, USA, July 2006. [http://www.iemss.org/iemss2006/papers/s10/280\\_vanIttersum\\_1.pdf](http://www.iemss.org/iemss2006/papers/s10/280_vanIttersum_1.pdf).

**Land use change in rural areas of Belarus  
affected by Chernobyl accident: twenty-year monitoring**

**V.M. Yatsukhno**

Belarusian State University, Landscape Ecology Lab,  
Nezalezhnasti Av., 4, 220050 Minsk Belarus.  
e-mail: yatsukhno@bsu.by

The areas affected by the Chernobyl radioactive fallout are generally rural landscapes. There are more than 1.8 million hectares of agricultural land in Belarus (which is about 20% of its total area) were affected by  $^{137}\text{Cs}$  contamination. Its activity is more than  $37 \text{ kBq/m}^3$ . As a result of high density of contamination 0,3 million hectares of agricultural land was withdrawn from economic use, 53 state collective farms were closed and almost 140 thousand people from 470 settlements have been resettled. Since the 20 years from Chernobyl 66 thousand houses and flats, including 239 settlements with infrastructure and services have been constructed for resettled population within clean areas (Yatsukhno and Kozlovskaya, 1998). Since the accident 14.6 thousand hectares of originally closed land have been turned back into the agricultural activity. Nowadays the agribusiness is conducted on 1.1 mln. hectares of lands, contaminated by  $^{137}\text{Cs}$  with a density from 1 to  $40 \text{ Ci/km}^2$  (0.65 mln. hectares of them are arable land and 0.45 mln. hectares are forage lands). Numerous increasing restrictions of the radionuclide's content in foods and raw materials and protective measures, have allowed the reduction of volumes of production with the above-normal content of radionuclides in comparison with the first year after the accident. The problem has occurred mainly for agricultural enterprises and private farms with predominatly of sandy, sandy loam and peat soils, which are characterized by high transfer factors for  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$ .

Most radiological unsafe lands unsuitable for the food production were included in the Polesye radioecological reservation. It was founded in 1988 inside of the Belarusian 30-km zone of Chernobyl station covering  $2155 \text{ km}^2$  (An information..., 2004).

The contemporary state of ecosystems and economic infrastructure of the evacuation zone and reservation is characterized by processes of degradation of former agricultural land, land reclamation systems, roads, cut over bogs (20 Years..., 2006).

In the long term following the Chernobyl accident, remediation measures and regular countermeasures remain efficient and justified mainly in rural landscapes, especially, radical improvement of pastures and grasslands as well as draining of wet peaty areas has very effective. However, the highly contaminated Chernobyl exclusion zone is a globally unique area for radioecological research in otherwise former natural and rural situations.

#### **References**

- Yatsukhno, V; Kozlovskaya, L. (1998)** The Ecological Impact of the Chernobyl Catastrophe On Sustainable Development In Belarus. U.M. Graute, B. Müller & W. Ergbouth (Eds) *Sustainable Development fro Central and Eastern Europe*. Springer, Berlin Heidelberg, pp. 255-266.
- An Information Needs Assessment of the Chernobyl-affected Population in the Republic of Belarus (2004)**. Report. T. Boesch (Editor). Unipack, Minsk.
- 20 Years After The Chernobyl Catastrophe. The Consequences in the Republic of Belarus and Their Overcoming (2006)**. National Report. V.E. Shevchuk & V.L. Gurachevsky (Eds). Committee on the Problems of the Consequences of the Catastrophe at the Chernobyl NPP under the Belarusian Council of Ministers, Minsk.

## Landscape effects of growing biomass crops on farmland bird populations in England

P.E. Bellamy<sup>1</sup>, R. Sage<sup>2</sup> and R.D. Swetnam<sup>1</sup>

<sup>1</sup> NERC Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, UK  
e-mail: pbe@ceh.ac.uk

<sup>2</sup>The Game Conservancy Trust, Fordingbridge, Hampshire, SP6 1EF, UK.

### Introduction

The growing of biomass crops for energy production as heat and electricity is a recent development in the UK. To stimulate the growth of biomass crops in England, an establishment grant was introduced. Also, increasing amounts of electricity must be produced using renewable sources under the Renewables Obligation. This poster aims to scale up the limited information available for birds in these crops to give a qualitative assessment of the landscape effects around power stations.

### Results

There are ten projects in England which are using or planning to use Biomass crops for energy production (Lindegaard 2006). For landscape units of 40 km radius around each power station, the distance eligible for planting grants, the amount of biomass crops needed would occupy from 0.3 to 7.3 % of available agricultural land. Miscanthus will be grown to fuel seven of the power plants at which it will occupy 0.1 to 2.8% (mean =1.0%) of surrounding agricultural land. Short-Rotation Coppice willow (SRC) will be grown to supply five power plants and is expected to replace a mean of 0.86% of agricultural land (range 0.47-1.39%).

Some important farmland species may be displaced by biomass crops. Others will also use biomass crops, some times at higher densities. SRC also attracts common woodland species which are also found in field boundaries, and warblers not normally found on farmland. Total densities of breeding birds in SRC are 2-3 times higher than both arable and grassland and it also enhances bird numbers in adjacent hedges and fields (Sage *et al.* 2006). This is largely due to higher food availability from the abundant insects in SRC. Although less is known about Miscanthus, the birds found are mainly those also found in other arable crops, at higher breeding densities than in wheat. The area of farmland occupied by biomass crops is small, but the differences between biomass crops and other farmland crops are large and it is thought that they may have a significant effect on farmland bird populations

### Conclusions

Although the anticipated amounts of biomass crops are relatively small at the landscape scale, SRC will have both positive and negative effects beyond the crop boundaries. Miscanthus is thought to have a similar but smaller effect. Biomass crops may significantly enhance bird diversity and numbers but will also displace a small number of sensitive farmland species.

### References

Lindegaard, K. (2006) Bioenergy contracts. *Farmers weekly* 28/07/2006 pp. 36-37.

Sage, R.; Cunningham, M. & Boatman, N. (2006) Birds in willow short-rotation coppice compared to other arable crops in central England and a review of bird census data from energy crops in the UK. *Ibis* 148:184-197.

**Theme 8: Global Change impacts**  
**8.1 Symposium 14: Effects of climate change on fragmented landscapes**

## Theme 8: Global change impacts



**Theme 8: Global Change impacts**  
**8.1 Symposium 14: Effects of climate change on fragmented landscapes**

## 8.1 Symposium 14: Effects of climate change on fragmented landscapes

### Introduction to the symposium theme: Climate change in fragmented landscapes; can we develop spatial adaptation strategies?

**J. Verboom, C.C. Vos, P. Schippers**

Alterra, Wageningen University and Research Centre, P.O. Box 47, 6700 AA Wageningen,  
The Netherlands.  
e-mail: Jana.verboom@wur.nl

#### Introduction

The Intergovernmental Panel for Climate Change (IPCC) concluded that by increasing the concentration of greenhouse gasses, man has a discernible influence on climate, and this is expected to be a long-term phenomenon affecting the environment in the forthcoming decades or even centuries. Since climate is a key driving force for ecological processes, climate change is likely to exert considerable impact on ecosystems. Since nature policy worldwide is often based upon policy plans which do not take climate change into account, it is questionable whether current biodiversity conservation goals can be achieved with the current efforts. There is therefore a need for a new, climate-proof, nature policy.

Climate change already has a large impact on ecosystems and these effects will be amplified in the coming century. Temperature rise already has effects on the distribution of species. Some species are expanding their range polewards and to higher elevations, while species adapted to cooler conditions are declining. The occurrence of weather extremes will enlarge population fluctuations, which may lead to extinctions. Ecosystems will be subject to increased disturbances, caused by direct climatic impacts (e.g. flooding) and by shifting species composition and changed species interactions (e.g. phenological mismatches).

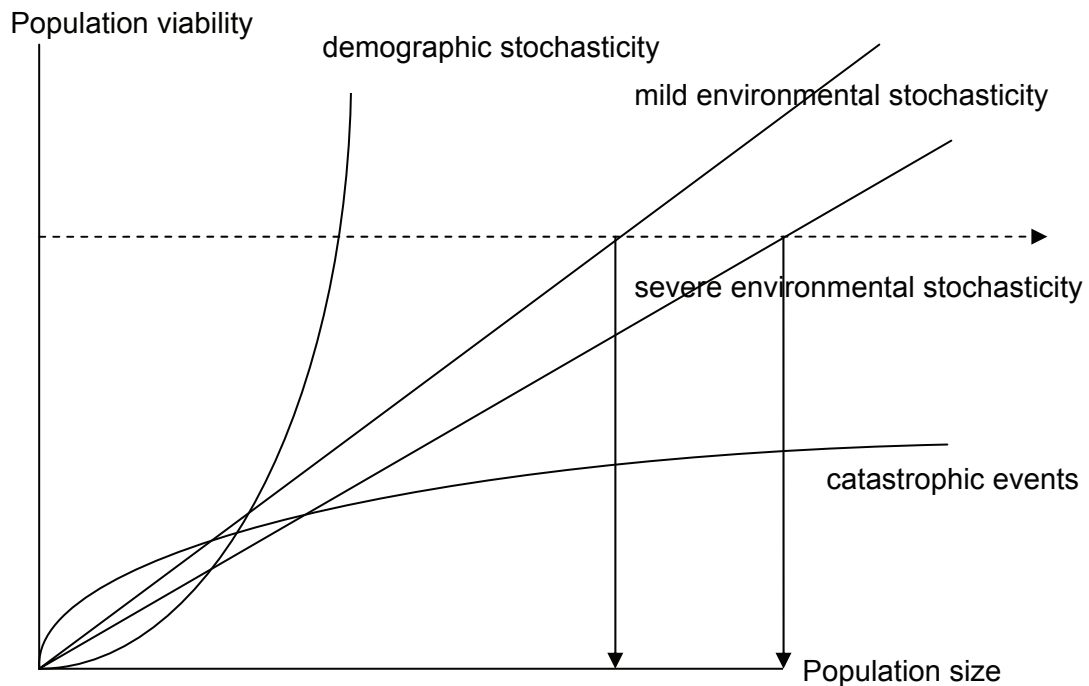
Landscape ecology can contribute to the knowledge of these dynamics in space and time, and spatial planning of nature conservation areas can lead to effective adaptation strategies. We cannot stop climate change, but we may be able to enhance the ability of landscapes to cope with it. Central focus of the symposium is: How can landscapes best be adapted to improve resilience of ecosystems to the effects of climate change? What might be effective adaptation strategies to cope with partly unknown risks? How can the landscape, land use and spatial configuration of ecosystems (ecological networks, robust corridors, multifunctional landscape buffers, protection of strategic ecosystem refugia, etc.) contribute to the resilience to climate change? The different contributions focus on different aspects.

#### Climate change in fragmented landscapes: metapopulations in a changing world

Climate change will lead – and is leading already - to range shifts. But what happens if the habitat of species and ecosystems occurs in small, isolated patches? Will the species be able to track the changing conditions? Will they adapt? Or will they become trapped on their islands that are no longer suitable, and perish? Dispersal limitation will most probably lead to unoccupied suitable habitat at the frontier of the shifting range, especially in species with limited dispersal abilities and fragmented habitat. On the other hand, time lags ('extinction debt', Tilman *et al.*, 1994) will lead to the opposite: occupied habitat that is no longer suitable for long term survival. Even in the centre of their distribution range populations are not safe; Increased environmental variation will increase population fluctuations. More environmental stochasticity means higher extinction rates (see Fig. 1) leading to shifts in the colonization/extinction balance.

#### Towards new assessment tools

In the Netherlands, spatial planning for biodiversity is based upon the methodology described by Vos *et al.* (2001) and Verboom *et al.* (2001) combining ecologically scaled landscape indices and key patch standards. But this methodology does not take into account climate change and has to be adapted to new insights. At least three steps have to be taken: (1) a new system of eco-environmental profiles has to be developed; (2) standards for minimum viable populations must be corrected for increased environmental variation (see Fig. 1); (3) a dynamic view of the landscape must be adopted instead of a static approach.



**Figure 1.** Population viability is known to increase with population size; the form of the relationship depends upon the importance of demographic stochasticity, environmental stochasticity, and catastrophes. If due to climate change the level of environmental stochasticity rises, as is predicted, population viabilities will drop and larger populations will be needed to achieve the same viability. Therefore, standards for minimum area requirements will have to be changed.

#### References

- Tilman, D.; May, R.M., Lehman, C.L. & Nowak, M.A. (1994) Habitat destruction and the extinction debt. *Nature* **371**, 65 – 66.
- Verboom, J.; Foppen, R.; Chardon, P.; Opdam, P. & Luttikhuisen, P. (2001) Introducing the key patch approach for habitat networks with persistent populations: an example for marshland birds. *Biological Conservation* **100**: 89-101.
- Vos, C. C.; Verboom, J.; Opdam, P.F.M. & Ter Braak, C. J. F. (2001) Toward Ecologically Scaled Landscape Indices. *The American Naturalist*, **157**: 24–41.

## **Adapting the landscape to climate change: linking ecosystem networks.**

**C.C. Vos, J. Verboom**

Alterra, Landscape Centre, P.O. box 47, 6700 AA Wageningen, the Netherlands.  
e-mail: [claire.vos@wur.nl](mailto:claire.vos@wur.nl)

### **Introduction**

Adaptation strategies to improve resilience of ecosystems to the effects of climate change should be focussed on a landscape scale and not on single reserves. The processes of range shifts and increased population fluctuations, caused by climate change, will interact with habitat fragmentation and human-induced land use changes. Landscape ecology can contribute to the knowledge of these dynamics and the development of effective adaptation strategies.

### **Adaptation strategies**

Whether species will be able to follow their suitable climate space depends both on species and landscape characteristics. Such a response might be prevented or inhibited by habitat fragmentation (Opdam and Wascher, 2004). In human dominated landscapes, natural or semi-natural ecosystems have become fragmented and are embedded in unsuitable landscape, with low permeability. Populations of species that are restricted to these remnants of suitable habitat often show characteristics of a metapopulation structure. The persistence and dynamics of these metapopulations are determined by the spatial cohesion of the habitat networks in such landscapes. At a larger scale, the species range can be conceptualized as a spatial configuration of habitat networks varying in size, density, quality and in the type of landscape in which they are embedded.

When climate change results in a potential pole ward expansion of the suitable climate space, species can only respond by colonizing unoccupied parts of existing networks, or would be able to 'jump' to neighbouring networks. A prerequisite is that distances between patches can be crossed with enough probability. That requires that source habitat patches are producing sufficient dispersing individuals, whereas distances must be within the dispersal capacity of species and not impassable because of physical barriers. Hence, adaptation of terrestrial ecosystems to climate change requires a sufficient degree of spatial cohesion within and between ecological networks over large spatial scales. We designed landscape adaptation strategies and indicated search areas where adaptation measures are needed to improve the climate change robustness of ecosystems.

### Linking ecological networks

When the suitable climate envelop shifts because of climate change, some habitat will no longer be suitable at the contracting side of a species range, while habitat patches become suitable at the expanding range side. Habitat networks and single patches that are within a suitable climate zone but that have no overlap with the previous suitable climate zone are not climate proof. The distance is too large for the species to be colonized from the already suitable and occupied habitat networks. However adaptation measures that connect this network to the nearest already climate proof network, would turn it into a climate proof network. There are several measures that contribute to the linking of ecological networks, e.g. enlarging existing habitat patches, creating new habitat patches, creating robust corridors, improving matrix permeability or mitigate barrier effects (Opdam *et al.*, 2003; Vos *et al.*, 2007).

### Increase expanding potential

Also the size of populations in the overlap zone, the part of the network that is suitable in successive climatic time frames, is an important prerequisite for climate robustness. The larger the overlap between consecutive climate zones, the larger the growing potential from which habitat patches that have become suitable can be colonized. A second adaptation strategy is therefore to increase suitable habitat in the overlap zone. Indeed, populations in the overlap zone are the sources from which new suitable habitat are to be colonized. In this respect the speed of the colonizing process in relation to the speed of shifting climate envelope space, determines whether species will be able to keep up with climate change. Thus mitigation measures which slow the process of climate change are also a very important adaptation measure.

#### Protect climate refugia

Finally an important strategy is to put extra conservation effort in the protection of species in parts of their range that are not influenced by climate change. These regions form stable 'climate refugia', and might function as important source areas from which species can expand when climatic conditions become again more favourable.

#### **The role of the Natura 2000 network**

Under European conservation policy the Natura 2000 network has been launched to protect biodiversity. It is a physical network through which key habitats, key species and prime conditions for their long term preservation are legally protected. At the same time, it is a coordinating mechanism through which the partners can develop and implement cooperative actions. However, the planning of the Natura 2000 network is based on a static view on the distributions of habitats and populations, and does not imply the impact of climate change. An urgent question to be answered is to what extent and where the spatial cohesion of the Natura 2000 network will make it climate change proof, and where bottlenecks in the network prevent adaptation of species ranges to shifting climate space.

#### **References**

- Opdam, P.; Verboom, J. & Pouwels, R. (2003).** Landscape cohesion: an index for the conservation potential of landscapes for biodiversity. *Landscape ecology* **18**: 113-126.
- Opdam, P. & Wascher D. (2004)** Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. *Biological Conservation* **117**: 285-297.
- Vos, C.C.; Opdam, P.; Steingröver, E.G. & Reijnen, R. (in press)** Transferring ecological knowledge to landscape planning: a design method for robust corridors. J. Wu & R. Hobbs (Eds). Chapter 13. *Key Topics in Landscape Ecology Book* Cambridge University Press, Cambridge.

## **Adaptation strategies for climate change: what have we got now and how can they be improved?**

**J. Piper**

School of the Built Environment, Oxford Brookes University, Oxford OX3 0BP, U.K.  
email: [jake.piper@brookes.ac.uk](mailto:jake.piper@brookes.ac.uk)

### **Introduction**

Whilst there can be no clear consensus, despite the worldwide research effort, on the speed and extent of climate change, and the array of likely impacts at any specific date in the next 100 years, there is increasing agreement about the nature and direction of change, and the inevitable impacts for biodiversity: habitats, species, ecosystems. Three lines of action are being pursued: mitigation (reduction of greenhouse gases via carbon reduction in the atmosphere), adaptation to climate change, and various forms of technological advance, across many sectors. Strategies for such measures are much discussed; such a strategy might consist of a vision, a set of objectives, a set of indicators and targets, policies for the achievement of the targets and measures or instruments to implement policy, then provision for monitoring and auditing of results in due course. Within the EU, in the case of biodiversity and climate change the vision is provided, for example, by the EU's aim to halt biodiversity loss by 2010, whilst objectives and policies are set out in the Communication on Biodiversity (EC, 2006) with its four priority policy areas (biodiversity in the EU, the EU and global biodiversity, biodiversity and climate change and the knowledge base) and ten priority objectives, which include: addressing the most important habitats and species; actions in the wider countryside and making regional development more compatible with nature, in addition to effective international governance and reducing negative impacts of international trade. Who are the key players in starting to make progress towards achieving these aims? Government policy alone will not suffice. Other major contributions must come from: 1. spatial planners at all levels (national, regional, local as well as sectoral planners such as transport planners); 2. ecologists and ecological modellers who work to expand the knowledge base; 3. communicators and educators disseminating the information and then also from institutions, companies and households awake to the issues and prepared to contribute to the changes which must be made.

### **Nature of impacts**

Likely impacts upon biodiversity are increasingly well understood, using scenarios of climate change resulting from socio-economic scenarios based on carbon by our growing populations and economies. For European biodiversity the picture is one in which those species which can, move either "uphill" or "northwards", in order to regain their preferred climate space. Those that move slowly or cannot move must either evolve (but the time is not there), be translocated, or may face extinction.

### **Development of awareness and policy**

Climate change is not fast, though extreme events may make it appear so. However, it is hard to describe the pace of governmental and EU policy change as other than slow. From recognition of the growing problem (at different times in different countries, but in the UK awareness was rising in universities in the 1980s), through an exploration of likely impacts and the creation of means of modelling and scenarios of change in the light, partly, of mitigation possibilities, it is perhaps only since 2000 that the need for a "climate change adaptation strategy" for biodiversity has been recognised. The European Commission is now finalising a Green Paper on Adaptation, to be published for a one-year consultation in June 2007. It will be followed by a White Paper and, eventually, legislation.

### Style, structure and content of a strategy

T

here is a good deal of agreement on the sorts of measures that are now needed: whilst designated sites face considerable challenges in the retention of their “conservation objectives”, they are still a major plank in the strategy. However, the role of the wider countryside, as a source of resources and niches, is also recognised. The three themes of coherence, connectivity and resilience (approximately mapping onto protected sites, wider countryside and ecosystem function) are seen as the way forward. The many other values of biodiversity with natural environments are recognised (health, leisure, well-being, etc.) and the incorporation of these concepts into government thinking is very actively promoted (BirdLife, undated).

What is also recognised is the range of other pressures upon biodiversity: pressures from population and economic growth, from fragmentation of habitats as infrastructure is extended, pressures from new presences in the environment (whether they be chemical substances, alien/exotic species, or perhaps mobile phone radiation). In addition, we are now aware that actions to mitigate climate change (e.g. by switching to carbon-neutral energy sources) or to adapt to climate change (e.g. city densification and loss of brownfield sites) may also lead to adverse impacts upon biodiversity (Wiesenthal *et al.*, 2006), so within a spatial planning framework with appropriate (longer) time horizons, assessment of interactions and cumulative effects is essential.

### What else do we need?

Climate change has reached the top of the political agenda over the past year. Consequences for biodiversity are discussed in the media but it is not guaranteed that this will be a priority for national governments. To help push the process forward we need further developments. These include wider recognition of the seriousness of the position we are in by all elements in society; some information on values of biodiversity and potential costs of loss (e.g. the cost of alternative means of pollination); awareness of interactions with mitigation and adaptation in other sectors is needed. From scientists we need better baseline data, together with tools such as models, maps and scenarios so that the policy community can provide full information to policy makers. Monitoring of changes, auditing of initiatives and projects must be improved for good guidance. The necessary resources include funding (e.g. for purchase or safeguarding of future sites) as well as skills in modelling, GIS, communication and negotiation, etc. Partnerships across sectors and boundaries, and community based partnerships, should help, and more effective *ex ante* assessment of projects and plans via EIA, SEA and Appropriate Assessment in tandem with the plans required under the Water Framework Directive.

### References

- BirdLife International (undated)** Well-being through wildlife in the EU Brussels: BirdLife
- European Commission (2006)** Communication on Biodiversity
- Piper, J.M; Wilson, E.B; Weston, J; Thompson S. & Glasson J. (2006)** Spatial planning for biodiversity in our changing climate. *English Nature Research Report 677* Peterborough: English Nature. Available at <http://www.english-nature.org.uk/pubs/publication/PDF/RIN677.pdf>
- Wiesenthal, T, Mourelatou, A, Petersen, J-E and Taylor, P. (2006)** How much bioenergy can Europe produce without harming the environment? *EEA Report 7/2006*. Brussels: OPOCE

## Can we mitigate climate change effects on biodiversity at treeline ecotones?

T. Dirnböck<sup>1</sup>, S. Dullinger<sup>2</sup>, J. Peterseil<sup>1</sup>

<sup>1</sup> Umweltbundesamt, Spittelauer Lände 5, A-1090 Vienna, Austria.  
e-mail: thomas.dirnboeck@umweltbundesamt.at

<sup>2</sup> VINCA – Vienna Institute for Nature Conservation & Analyses, Giessergasse 6/7, A-1090 Vienna, Austria

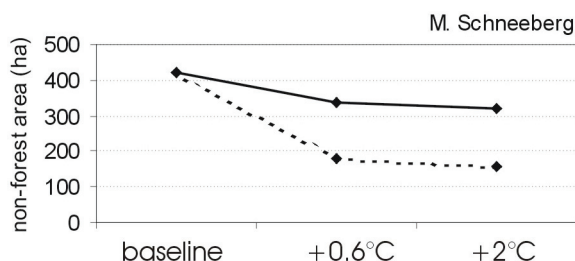
### Introduction

Mountain biodiversity is particularly sensitive to climate change which drives single species and the treeline as a whole upward (Grabherr et al. 1994, Tinner & Kaltenrieder 2005). Due to the limited altitude and conic shape of mountains this necessarily implies habitat reduction, often combined with fragmentation. A typical feature of many high mountain floras is their relatively high degree of endemism. As a consequence, regional extinctions often imply a loss to global biodiversity.

Land use has shaped treeline ecotones for centuries in many mountains of the world. Natural treelines were lowered in order to increase the grazing area for livestock. In Europe however, the economic development of the last century has led to a decrease in alpine farming intensity and many high mountain summer farms have become abandoned. As a consequence, reforestation of former pastures is a widespread phenomenon with great impact on habitat diversity and quality at the treeline ecotone. It is likely that the future use of alpine summer farms will have a profound effect on climate change driven vegetation dynamics in European high mountain ecosystems. The knowledge about the interplay of climate and land use change with regard to alpine biodiversity is nevertheless only rudimentary. This study used two complementary modelling approaches to predict the likely development of the treeline ecotone in some mountains in Austria which are exposed to the combined impacts of climate and land use changes.

### Land use maintenance mitigates climate induced treeline rise

Land use maintenance at the treeline ecotone may be a measure for mitigating the consequences of climate change driven habitat shrinkage for alpine species. A series of static habitat distribution models showed that the conservation of summer pastures could almost halve the reduction of non-forest habitats predicted by different climate change scenarios (Figure 1). Populations of alpine plant species may use these non-forest refuges for regional survival (Dirnböck et al. 2003). However, such models are static and do not account for the migration of species per se, which adds complexity.

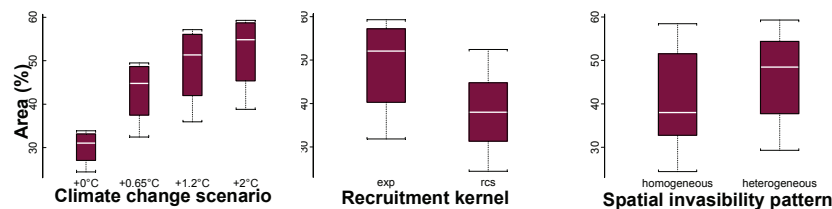


**Figure 1.** Predicted total area (above 1600 m a.s.l.) of non-forest habitats at Mt. Schneeberg (Austria) which remain after *Pinus mugo* reaches its potential distribution which can be expected from temperature increases of 0.6 and 2°C. The solid line represents the scenario under land use maintenance and the dashed line land represents total abandonment of land use.



## Complexities of treeline response

A spatial dynamic model of one treeline species (*Pinus mugo*) exemplifies that pace and pattern of future treeline dynamics may be highly idiosyncratic. Species-specific dispersal properties and competitive ability during the recruitment phase interact with the region-specific resident vegetation cover and its competitive effect on recruits to modulate a purely temperature driven range shift of the pine (Dullinger et al. 2004). The region-specific resident vegetation has in turn been shaped by land use history which created areas more or less invisable for the climate driven expansion of treeline trees (Dullinger et al.2003). As a consequence, the diversity of climate change driven future habitat patterns at the treeline ecotone may show considerable regional variation at least during potentially extended transient phases (Figure 2). Traditional summer farming in any case will not only reduce the area available for treeline expansion but will probably also delay this process by creating barriers to tree migration.



**Figure 2** Effects of assumed temperature increase, shape of the recruitment kernel and spatial pattern of invasibility on percentage area of the subalpine and alpine belt of Mt. Hochschwab (Austria) predicted to be covered by the shrubby growing treeline tree *Pinus mugo* 1000 years after present. Boxplots are drawn from the results of 160 simulations.

## Conclusions

Although the future pathways of climate change driven vegetation dynamics may vary among mountain systems the maintenance of traditional alpine farming may help mitigating the detrimental effects of climate warming on European high mountain plant diversity. Although some measures within the agri-environmental schemas are present to conserve specific land use or habitat types most agricultural subsidies do not directly take biodiversity into account. Thus they might be ineffective with regard to conservation efforts. Integrated approaches for mitigating climate change effects on alpine biodiversity are highly needed.

## References

- Dirnböck, T., Dullinger, S. & Grabherr, G. (2003)** A regional impact assessment of climate and land use change on alpine vegetation. *Journal of Biogeography* **30**: 401-418.
- Dullinger, S., Dirnböck, T. & Grabherr, G. (2003)**: Patterns of shrub invasion into high mountain grasslands of the Northern Calcareous Alps (Austria). *Arctic, Antarctic and Alpine Research* **35**: 434-441.
- Dullinger, S., Dirnböck, T. & Grabherr, G. (2004)** Modelling climate change-driven treeline shifts: relative effects of temperature increase, dispersal and invasibility. *Journal of Ecology* **92**: 241–252.
- Grabherr, G., Gottfried, M & Pauli, H. (1994)**: Climate effects on mountain plants. *Nature* **369**: 448.
- Tinner, W. & Kaltenrieder, P. (2005)**: Rapid responses of high-mountain vegetation to early Holocene environmental changes in the Swiss Alps. *Journal of Ecology* **93**: 936-947.

## The interplay of landscape structure and evolution during range shifting dynamics.

J.M.J. Travis, O.J. Burton

Zoology Building, Tillydrone Avenue, University of Aberdeen, AB24 2TZ, UK..  
e-mail: justin.travis@abdn.ac.uk

### Introduction

Evolutionary dynamics may be quite different during periods of range shifting than within stationary populations. These differences may have important consequences for the ability of populations to track the changing climate. In this contribution we review some recent work showing how the genetics and evolution of populations with dynamic ranges may differ. We start by considering the fate of new neutral mutations occurring during range shifting, highlighting recent theoretical studies by Edmonds et al. (2004) and Klopstein et al. (2006), and progress to summarise key findings from our own recent work that asks how non-neutral mutations fare during range shifts. We continue by looking at evidence, both theoretical (Travis & Dytham 2002) and empirical (e.g. Simmons & Thomas 2004; Phillips et al. 2006), that suggests that dispersal characteristics should come under strong selection at expanding range fronts, and also point out that seed dormancy (dispersal in time) may be similarly impacted. To date, the role of landscape structure in determining how evolution proceeds during range shifting has been largely unexplored (but see Hill et al. 2006 for one exception). We argue that the role of landscape structure may be crucial in determining the course of evolution during range expansion, and use some new results from simulation studies to illustrate this point.

### The genetics and evolution of range shifting

#### *The fate of mutations arising during range expansion*

Edmonds et al. (2004) and Klopstein et al. (2006) demonstrate that neutral mutations arising on the edge of a range expansion sometimes 'surf' on the wave of advance and can thus reach a higher spatial distribution and frequency than would be expected in stationary populations. Klopstein et al. (2006) suggest that this surfing phenomenon may increase the rate of evolution of spatially expanding populations, but to assert this with any certainty requires models considering the fate of non-neutral mutations. Here, we present some results from a model where the fate of non-neutral mutations during range shifting are tracked. Initially, we look at the fate of a single mutant arising at a specified location. Our results indicate that almost all deleterious mutations that survive do so by surfing on the range expansion, while only a small proportion of the surviving beneficial mutations have surfed. We also show that mutations arising towards the retreating margin are liable to slip off the rear end of the range as it shifts and thus be lost. We further extend our method to examine the dynamics of a two-locus system with epistasis (non-additive interactions) between the genes.

#### *Dispersal and dormancy evolution*

During range expansion selection would generally be anticipated to select for greater rates of emigration and greater dispersal distances: at an expanding front individuals arriving at a patch first are able to exploit the resources there free from competition. Theoretical work and some empirical data support this idea, although if an Allee effect operates then the increase in emigration rate at the front is far less pronounced (Travis & Dytham 2002). Similarly, selection for seed dormancy is likely to be relaxed at expanding fronts. We will present some results showing during range expansion, rates of dormancy may evolve to levels at which

population resilience to a set of poor years (which, in a stationary population, dormancy protects against) is substantially reduced.

*A role for Landscape structure: two examples*

The composition of different landscape elements (both habitat and matrix) is likely to play an important role in determining the evolutionary dynamics of range shifting. Klopstein et al. (2006) ran some simulations examining the fate of neutral mutations arising during human colonisation of Europe. One assumption made in their model was that suitability for human occupation was the same in every cell with land. Here, we demonstrate that relaxing this assumption by restricting occupation to cells with a mean altitude lower than 1000m can substantially alter the results. Simulation results utilising simple artificial landscapes further demonstrate that the fate of two identical mutations may be very different depending on where they arise.

Landscape structure is likely to determine the degree of local adaptation present within populations, and this in turn will influence the ability of a population to migrate as the climate alters. The landscape can influence the degree of local adaptation in at least two ways. Firstly, a greater degree of specialisation to a particular habitat would be expected if different suitable habitats tend to be clumped in space, as most dispersal and hence gene flow will be between subpopulations occupying similar habitat. Secondly, the configuration of the matrix will determine the degree of dispersal from one patch to another. We highlight this as a particular area deserving of future attention. In conclusion, we suggest that relatively simple simulation models linking population genetics and spatial (or landscape) ecology (e.g. Travis et al. 2005; Ezard & Travis 2006) may provide important new insights into the likely response of biodiversity to climate change.

**References**

- Edmonds, C.A.; Lillie, A.S. & Cavalli-Sforza, L.L. (2004)** Mutations arising in the wave front of an expanding population. *P.N.A.S.* **101**: 975-979.
- Ezard, T.H.G. & Travis, J.M.J. (2006)** The impact of habitat loss and fragmentation on genetic drift and fixation time. *Oikos* **114**: 367-375.
- Hill, J.K.; Hughes, C.L.; Dytham, C. & Searle, J.B. (2006)** Genetic diversity in butterflies: interactive effects of habitat fragmentation and climate-driven range expansion. *Biol. Lett.* **2**: 152-154.
- Klopstein, S.; Currat, M. & Excoffier, L. (2006)** The fate of mutations surfing on the wave of range expansion. *Mol. Biol. Evol.* **23**: 482-490.
- Phillips, B.L.; Brown, G.P.; Webb, J.K. & Shine, R. (2006)** Invasion and the evolution of speed in toads. *Nature* **439**: 803-803.
- Simmons, A.D. & Thomas, C.D. (2004)** Changes in dispersal during species' range expansions. *Am. Nat.* **164**: 378-395.
- Travis, J.M.J. & Dytham, C. (2002)** Dispersal evolution during invasions. *Evol. Ecol. Res.* **4**: 1119-1129.
- Travis, J.M.J.; Hammershøj, M. & Stephenson, C.M. (2005)** Adaptation and propagule pressure determine invasion dynamics: insights from a spatially explicit model for sexually reproducing species. *Evol. Ecol. Res.* **7**: 37-51.

**Projecting the shifting climate envelope of species and how the landscape can enhance or hamper the response of populations.**

**P.M. Berry<sup>1</sup>, J.M. Baveco<sup>2</sup>**

<sup>1</sup> Environmental Change Institute, OUCE, University of Oxford, South Parks Road, Oxford, OX1 3QY, UK.

e-mail: pam.berry@eci.ox.ac.uk

<sup>2</sup> Alterra, PO Box 47, 6700 AA Wageningen, The Netherlands.

## **Introduction**

It is projected that during this century global temperatures could increase by between 1.4 to 5.8°C and global sea levels could rise by 9 to 88 cm (IPCC, 2001a). The impacts of climate change could be profound and will affect biodiversity at all scales from the global to the European to the local, with some species becoming more vulnerable (IPCC, 2001b; Harrison *et al.*, 2006). Species may respond to such climate change by shifts in their range and these can be projected through the use of climate envelope models. In order to colonise new suitable climate space, species will need to disperse across the landscape. However, due to pressures of land use, many of their habitats have become fragmented and intensive land use has lowered the permeability of the landscape for species' movement. This paper, by combining climate envelope model outputs with a dispersal model in spatial explicit landscapes, will test how climate proof are current ecological networks and what can be done to fill gaps that hamper range expansion.

## **Methodology**

### *Climate envelope model*

The SPECIES model uses an artificial neural network (ANN) to integrate bioclimate variables for projecting the current and potential future suitable climate space for species through the characterisation of bioclimatic envelopes. In the BRANCH project, such envelopes have been modelled for nearly 400 species, but 9 species with specific ecoprofiles and representative of 3 ecosystem types have been selected for the ecological network analysis

### *Dispersal model*

A grid-based dispersal model (GridWalk) is used to estimate the connectivity of all habitat patches in the area, taking into account the permeability of the landscape in between the patches. For each of the 9 species, suitable habitat patches are delineated using the CORINE land use map. The model simulates movement as a random walk through a landscape consisting of areas of different attractiveness. The result is a large matrix of probabilities of moving from each patch to each other patch.

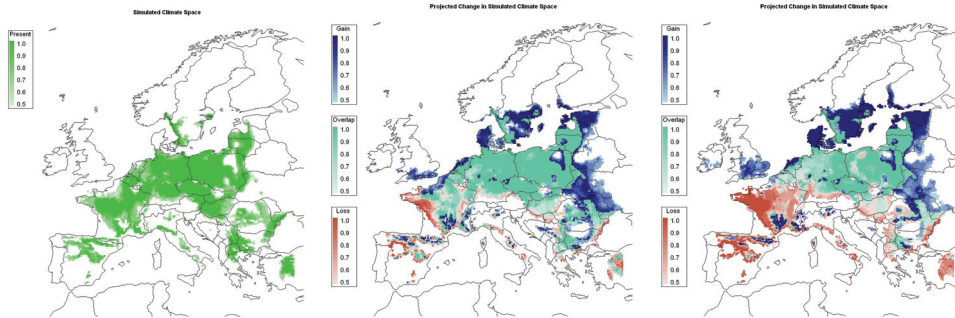
### *Climate-based Ecological Network Analysis*

Climate envelopes and the connectivity matrix together are used to define ecological networks consisting of well-connected and climate-suitable patches, for each of the time slices (current, 2020, 2050). In a GIS analysis we identify the networks showing little or no overlap with networks of a previous time slice. These networks require mitigation measures, e.g. creation of linkages to climate-proof networks. Networks with sufficient overlap are climate-proof, because they either don't need to be colonized, or can be colonized from within the network itself.

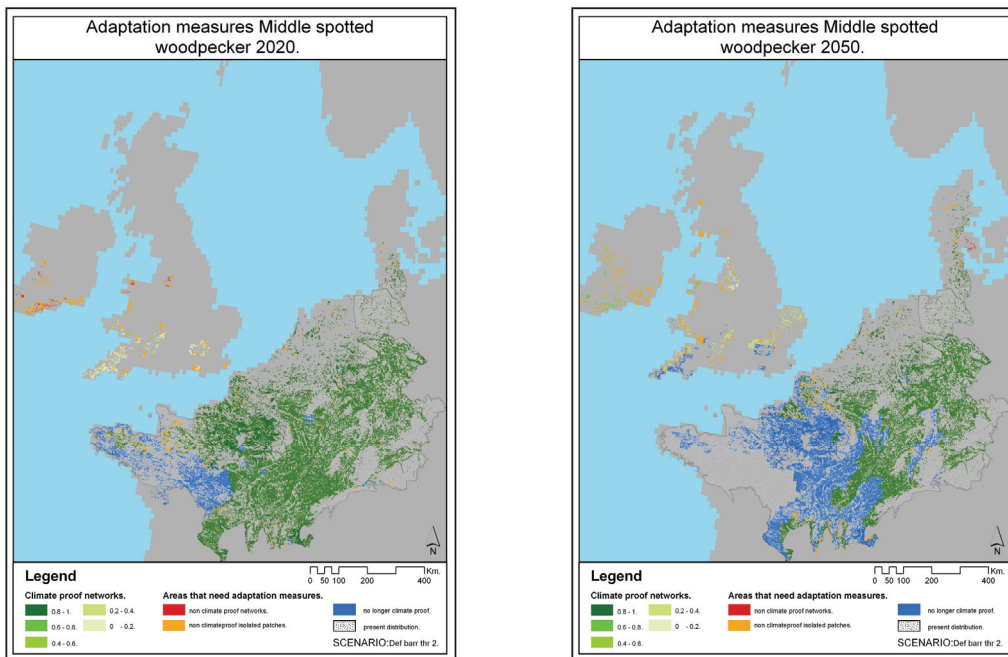
## **Examples**

**Theme 8: Global Change impacts**  
**8.1 Symposium 14: Effects of climate change on fragmented landscapes**

We present the results for two forest species, the Middle spotted woodpecker and the Agile frog. Figure 1 shows how the potential suitable climate space for Middle spotted woodpecker could increase in England and Scandinavia, but be lost from the southern parts of its range. Figure 2 shows that most habitat in the increased climate space will be very fragmented and can hardly or not (England) be colonized from functioning networks in the previous time slice.



**Figure 1:** Potential suitable climate space for Middle spotted woodpecker under current climate (left); 2020s HadCM3A2 (middle) and HadCM3 2050s A2 emission scenario (right).



**Figure 2:** Climate proof networks and areas requiring adaptation measures for the Middle spotted woodpecker under 2020s HadCM3A2 (left) and HadCM3 2050s (right) A2 emission scenario.

**References**

**Harrison, P.A., Berry, P.M., Butt, N. & New, M. (2006)** Modelling climate change impacts on species' distributions at the European scale: Implications for conservation policy. *Environmental Science and Policy*, 9: 116-128.

**IPCC (2001a) Climate Change 2001: The Scientific Basis.** Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

**IPCC (2001b) Climate Change 2001: Impacts, Adaptation and Vulnerability.** Summary for Policymakers. Cambridge University Press, Cambridge.

## Large scale modelling of potential future distribution of tree-species under a climate change scenario in central and southern Italy

F. Attorre<sup>1</sup>, F. Francesconi<sup>1</sup>, M. Alfò<sup>2</sup>, F. Bruno<sup>1</sup>

<sup>1</sup> Department of Plant Biology – Sapienza University of Rome, P.le A. Moro 5, Rome, Italy.  
e-mail: Fabio.attorre@uniroma1.it.

<sup>2</sup> Department of Statistics – Sapienza University of Rome, P.le A. Moro 5, 00185 Rome, Italy.

### Introduction

Many studies aimed at modelling the climate change effects on the potential future distribution of plant species have been carried out. Most of them have used small-scale presence-absence (Ohlemüller et al., 2006, Thuiller et al., 2005) or abundance data (Iverson & Prasad, 2002). A reduction of the recognised uncertainties associated to this approach (Pearson & Dawson, 2003; Thuiller, 2004) can be achieved through large-scale analyses based on quantitative data of plant species distribution. Therefore, a project aimed at the evaluation of the current and future potential distribution of tree species in Italy has been started. The results of the adopted methodology for central and southern Italy are here presented.

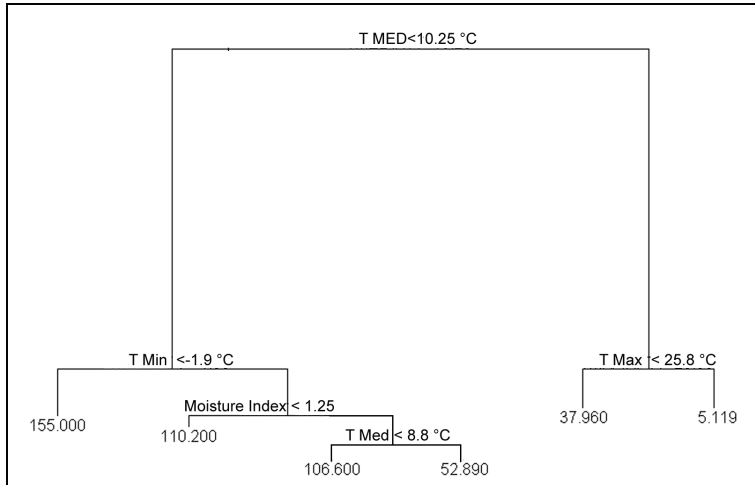
### Methods

We used abundance data for twenty species, sampled in 2100 plots, distributed on a 3x3 km grid. A climatic model provided high resolution current climatic surfaces, while a climatic scenario for 2080 was obtained using the A1FI emission scenario of HadCM3 GCM. A deterministic Regression Tree Analysis (RTA) was applied in order to define the realised niche of the species in relation to the chosen environmental variables. RTA is based on a recursive data partitioning algorithm that splits the data into subsets based on a single best predictor variable. The output is a tree with branches and terminal nodes indicating the average abundance of the species for each node. The tree diagram for *Fagus sylvatica* (Fig. 1) shows the most important environmental variables affecting its current distribution. Using this statistical model, maps of its potential current and future abundance distribution were produced (Fig. 2a, b). The percentage change in the potential area, the mean abundance and mean altitude were calculated in order to quantify the effects of climate change that the species are likely to face.

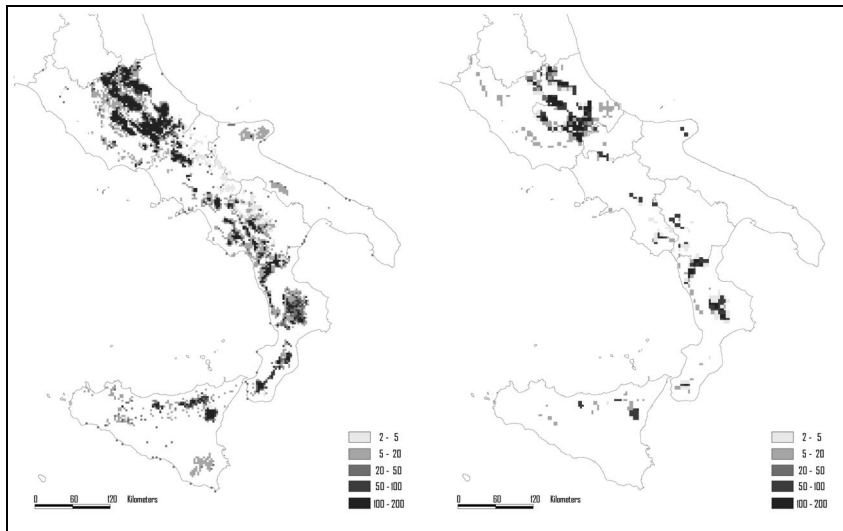
### Main Results

This approach allowed the production of detailed maps depicting the predicted changes of the potential areals of the main tree species of central and southern Italy. Mediterranean species are likely to be favoured by the predicted climate change, while Sub-Mediterranean and Eurosiberian species showed a species-specific response depending on the autoecological characteristics of the species. The integration of this information with land cover/use maps, as a measure of the fragmentation and anthropization of the landscape, will be useful to support decisions for the identification of the species at higher risk of local extinction, ecological networks for species migration, and potential refugia.

**Theme 8: Global Change impacts**  
**8.1 Symposium 14: Effects of climate change on fragmented landscapes**



**Figure 1.** Tree diagram for *Fagus sylvatica*. The importance of each variable is proportional to the length of the corresponding couple of branches. The numbers at the termination of each node of the tree show the average abundance at that node.



**Figure 2a, b.** Current and future predicted potential distribution of *Fagus sylvatica* (A, B)

**References**

- Iverson, L.R. & Prasad, A.** (2002) Potential redistribution of tree species habitat under five climate change scenarios in the eastern US. *Forest Ecology and Management*, 155, 205–222.
- Ohlemüller, R. Gritti, E.S. Sykes, M.T. & Thomas, C.D.** (2006) Quantifying components of risk for European woody species under climate change. *Global Change Biology*, 12: 1788-1799.
- Pearson R.G. & Dawson, T.E.** (2003) Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global Ecology and Biogeography*, 12, 361–371.
- Thuiller, W.** (2004) Patterns and uncertainties of species' range shifts under climate change. *Global Change Biology*, 10, 2020–2027.
- Thuiller, W. Lavorel, S. & Araújo, M.B.** (2005) Niche properties and geographic extent as predictors of species sensitivity to climate change. *Global Ecology and Biogeography*, 14, 347–357.

## Climate change, habitat fragmentation and the resilience of ecological networks

K. Watts<sup>1</sup>, A.E. Eycott<sup>1</sup>, M. Broadmeadow<sup>1</sup>, D. Ray<sup>2</sup>, L. Sing<sup>2</sup>, J. Latham<sup>3</sup>

<sup>1</sup> Forest Research - Alice Holt Lodge, Farnham, Surrey, UK.  
e-mail: kevin.watts@forestry.gsi.gov.uk

<sup>2</sup> Forest Research - Northern Research Station, Roslin, Midlothian, UK

<sup>3</sup> Countryside Council for Wales - Maes-y-Ffynnon, Penrhosgarnedd, Bangor, Gwynedd, UK

### Introduction

Climate change is predicted to have a significant impact on biodiversity with many species being forced to adjust their range pole-wards and to higher elevations as a result. Range margins could move quite rapidly and many species may not be able to track their future climate space (Thomas *et al.*, 2004). This problem is further compounded by habitat fragmentation, with the increasingly hostile matrix inhibiting this range adjustment (Opdam and Wascher, 2004).

Ecological networks are often proposed as an adaptation measure to mitigate the impacts of climate change and habitat fragmentation, reflecting the current inadequacy of site-based conservation systems (Bennett, 2002; Jongman and Pungetti, 2004). There are now obligations for many countries to develop strategies to improve the ecological coherence, especially the connectivity, of important biodiversity sites. For instance, the EU Habitats Directive (EEC, 1992) promotes the creation of ecological networks to improve the ecological coherence of SACs (Special Areas of Conservation) and SPAs (Special Protection Areas) as part of the Natura 2000 network across the European Union.

### Woodland networks in Wales, UK

Native woodland habitat within Wales, as in much of the UK, is highly fragmented and occurs within a primarily agricultural landscape with low ecological permeability (Watts, 2006). A major policy direction is to combat this fragmentation and provide the infrastructure for species to adapt to the impacts of climate change (Forestry Commission, 2001). Local and regional woodland networks have been developed within Wales to aid the operational and strategic management and conservation of woodland (Watts *et al.*, 2005).

There is now interest in extending these approaches to the national scale to account for predicted range shifts in response to climate change, and to meet the obligations to develop Natura 2000 networks. Large scale networks are being developed for current native woodland across Wales, with a particular focus on woodland SACs and other protected sites. These networks utilise least-cost analysis techniques to account for matrix permeability (Adriaensen *et al.*, 2003) and are intended to provide a strategic framework for the future protection, management, restoration and creation of woodland and associated habitats.

### Climate impact and woodland suitability

Crucial to the success of large scale habitat networks is their long term ecological suitability, because of the relatively long time scale of woodland habitat development. A changing climate makes this particularly challenging, and there are concerns over the future suitability of particular native woodland species/types throughout the UK (Broadmeadow *et al.*, 2003; Broadmeadow *et al.*, 2005). We examine the current and predicted future climate suitability of these networks for particularly important and sensitive woodland types. This approach is based on site suitability using a spatial implementation of Ecological Site



Classification (Ray *et al.*, 2003; Pyatt *et al.*, 2001) combined with climate predictions for the UK for 2050 and 2080 (Hulme *et al.*, 2002).

## Conclusions

This work identifies vulnerable protected woodland sites, in terms of both ecological isolation and climate suitability. It also identifies the significance of non-protected woodland in enhancing the ecological function of the network. The future resilience of the network, and subsequent actions, can be evaluated and revised as necessary to ensure its long term sustainability.

## References

- Adriaensen, F.; Chardon, J.P.; De Blust, G.; Swinnen, E.; Villalba, S.; Gulinck, H. & Matthysen, E. (2003) The application of 'least-cost' modelling as a functional landscape model. *Landscape and Urban Planning* **64**: 233-247.
- Bennett, A. (2002) *Linkages in the Landscape: The Role of Corridors and Connectivity in Wildlife Conservation*, IUCN, Gland, Switzerland and Cambridge, UK.
- Broadmeadow, M.; Ray, D.; Sing, L. & Poulson, L. (2003) Climate change and British woodland: what does the future hold? *Forest Research Annual Reports and Accounts 2002-2003*: 70–83.
- Broadmeadow, M.; Ray, D. & Samuel, C.J.A. (2005) Climate change and the future for broadleaved tree species in Britain. *Forestry* **78**: 145-161.
- EEC (1992) *Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild flora and fauna*, European Commission, Brussels.
- Forestry Commission (2001) *Woodlands for Wales: the National Assembly for Wales strategy for trees and woodlands*, Forestry Commission, Aberystwyth, UK.
- Hulme, M.; Jenkins, G.J.; Lu, X.; Turnpenny, J.R.; Mitchell, T.D.; Jones, R.G.; Lowe, J.; Murphy, J.M.; Hassell, D.; Boorman, P.; McDonald, R. & Hill, S. (2002) *Climate Change Scenarios for the United Kingdom*. Tyndall Center for Climate Change Research, Norwich, UK.
- Jongman, R.H.G. & Pungetti, G. (2004) *Ecological Networks and Greenways: Concepts, Design, Implementation*. Cambridge University Press, Cambridge, UK.
- Opdam, P. & Wascher, D. (2004) Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. *Biological Conservation* **117**: 285-297.
- Pyatt, D.G.; Ray, D. & Fletcher, J. (2001) *An Ecological Site Classification for Forestry in Great Britain*. FC Bulletin 124, Forestry Commission, Edinburgh, UK.
- Ray, D.; Clare, J. & Purdy, K. (2003) Applying an Ecological Site Classification to woodland design at various spatial scales. Humphrey, J.; Latham, J.; Gray, H.; Kirby, K.; Poulson, E. & Quine, C. (Eds). *The Restoration of Wooded Landscapes*. Forestry Commission, Heriot-Watt University, Edinburgh. UK. pp. 59-68.
- Thomas, C.D.; Cameron, A.; Green, R.E.; Bakkenes, M.; Beaumont, L.J.; Collingham, Y.C.; Erasmus, B.F.N.; Siqueira, M.F.D.; Grainger, A. & Hannah, L. (2004) Extinction risk from climate change. *Nature* **427**: 145-148.
- Watts, K. (2006) British forest landscapes: The legacy of woodland fragmentation. *Quarterly Journal of Forestry* **100**: 273-279.
- Watts, K.; Griffiths, M.; Quine, C.; Ray, D. & Humphrey, J.W. (2005) *Towards a Woodland Habitat Network for Wales*. Contract Science Report 686, Countryside Council for Wales, Bangor, UK.

## 8.2 Symposium 15: Consequences of climate change for freshwater wetlands

### Using multiple models to elucidate the effects of climate change on floodplain ecology in the Okavango Delta, Botswana.

P. Wolski<sup>1</sup>, M. Murray-Hudson<sup>1</sup>.

1 Harry Oppenheimer Okavango Research Centre, University of Botswana, Private Bag 285, Maun, Botswana.  
e-mail: pwolski@orc.ub.bw

#### Introduction

Botswana's Okavango Delta is a 16,000km<sup>2</sup> complex of flood-pulsed wetlands and islands, which support a variety of subsistence livelihoods, and a wildlife-based tourism industry that is the country's second largest source of foreign revenue. The Delta is the distal part of the endorheic Okavango River system, fed primarily by rainfall in the catchment in the Planalto Central of Angola, several hundred kilometres to the north-west, where mean annual rainfall is considerably higher than that prevalent in the Delta. In this paper we describe an approach to modelling the effects of potential climate change on the distributions of floodplain classes by using a combination of a suite of hydrological models linked to vegetation functional groups and a simple dynamic ecosystem (stock-and-flow) model.

#### Methodology

##### Hydrological models

A hydrological model of the catchment of the Okavango River is used to determine inflow to the Okavango Delta under the climatic conditions prevailing in the catchment. A second hydrological model of the Delta itself is then used to simulate flooding in this system under the given inflow and local climate. The Delta model allows the determination of spatially variable characteristics of flooding such as flood extent and flood duration (for a single year), and flood frequency for a series of years, with a spatial resolution of 1 km<sup>2</sup>, which can further be downscaled to 30 m. These characteristics are related to floodplain functional types, or ecotypes, allowing for translation of hydrological conditions into ecotype distribution. Projected future changes in climate are expressed as vectors of change compared to the observed past conditions. These vectors, when incorporated into the modelling procedure, allow determination of changes in inflows, inundation characteristics and finally the extent of floodplain ecotypes, compared to the past, observed conditions.

##### Ecological Model

An aggregated dynamic energy systems language model is then used to investigate potential effects of the changes in ecotype extent on the aquatic and terrestrial ecosystems for which they are the basis. This stock-and-flow model is predicated on plant succession trends in floodplains driven by inter-annual flooding frequency, and relates primary production to consumer biomass, of grazing ungulates in the case of grasslands and fish in the case of sedgeland and perennially flooded areas.

#### Results and Discussion

Simulated hydrological changes affect the Delta floodplain ecosystems, with projected changes in the areas and proportions of the 3 main ecotypes (perennial swamp, seasonal sedgeland and flooded grasslands) in response to changes in flood distribution and duration. Simulations show that changes resulting from possible future climate change are comparable to, but stronger than the effects of existing climatic variability observed over the time of

record (~1930-present). The effects of such change, importantly, are clearly shown to be spatially manifested throughout the system, and not simply around the periphery. This effect is to be expected in such a complex landscape, yet has not been explicitly addressed prior to this study.

The stock-and-flow model produces similar changes in the areas of the 3 ecotypes, with corresponding changes in the biomass of primary production and first-level consumers in each ecotype. Projected reductions in flood amplitude such as those generated by lower regional rainfall cause both terrestrial and aquatic systems to decline, with a loss of savanna landscapes to encroachment by woody species and consequent declines in mammalian grazing species and fish populations. Increased variability in flooding results in an increase in seasonally flooded grassland, and favours the terrestrial system with grazing ungulates at the expense of the aquatic one. The integrative effect of monitoring consumers rather than producers in the system can clearly be seen in the lack of response of these stocks to intra-annual variation in inflow; they do, however, respond to the longer term wet and dry cycles observed in the hydrological record.

### **Conclusions and Future Directions**

The ability to translate hydrological change into ecological change provided by the use of combined models is critical for assessing the potential impacts of climate change on the system of man and nature in the Okavango Delta. The spatial variation in landscape pattern produced by the combined hydrological model helps to give a quantitative idea of how flooding patterns might change. Planners and managers of wildlands such as the Okavango, however, can benefit from having these landscape changes expressed in terms of ecological change.

The use of two different model systems to assess projected change in the system not only provides a means of corroborating and comparing outputs, but also the possibility of identifying ecological interactions which warrant further investigation. The nature of causality in such potential changes needs to be well understood, and the ability to run quick hypothesis tests with the dynamic model is a significant tool in aiding that understanding.

The hypothetical links between primary production and consumers in the system (such as habitat preferences for the many different grazers, or the importance of the seasonal sedgelands for the aquatic system) are not well studied or documented in the Okavango Delta, and these are important subjects for further research. Similarly the link between ecological processes in floodplain vegetation communities and flood regime is not quantified; this is the emphasis of current research. The aggregation necessary to reduce the dynamic model to manageable proportions obscures finer details and nuances that may give management insights, too, and development of models of these subsystems is considered an important progression of this approach.

## Vulnerability of central North American wetlands to climate change

W.C. Johnson<sup>1</sup>, A.G. van der Valk<sup>2</sup>, G.R. Guntenspergen<sup>3</sup>

<sup>1</sup>South Dakota State University, Brookings, South Dakota, 57007 USA  
e-mail: carter.johnson@sdstate.edu

<sup>2</sup>Iowa State University, Ames, Iowa, 50011 USA

<sup>3</sup>U.S. Geological Survey, Laurel, Maryland 20706, USA

The Prairie Pothole Region (PPR) lies in the heart of North America and contains 5-8 million glacially-formed, depressional wetlands embedded in a landscape matrix of grassland and agriculture. The PPR is one of the largest and most productive inland wetland regions in the world (van der Valk 2006). In addition to providing valuable ecosystem services, like nutrient removal and flood-water storage, the PPR produces 50-80% of the continent's ducks, earning it the title of North America's "duck factory." High productivity and biodiversity historically have been maintained by a notoriously variable and extreme continental climate (Johnson et al. 2004).

Prairie wetlands have disappeared from many PPR landscapes because of draining for agriculture. In general, drainage has been most prevalent in wetter parts of the PPR with more stable water levels and where agriculture is the most profitable. For example, prairie wetland drainage was nearly complete along the eastern fringe of the PPR in the states of Iowa and Minnesota in a sub-humid climate (Dahl 1990). Further west with its semi-arid climate, fewer than one-third of the wetlands have been drained.

Previous studies using the simulation model WETSIM have demonstrated that prairie wetlands are highly sensitive to climate variability and climate change (Poiani et al. 1996). WETSIM models the temporal and spatial dynamics of the hydrology and vegetation of a single semi-permanent wetland basin. Semi-permanent wetlands are relatively deep, discharge wetlands with surface water persisting through the ice-free season in most years. Initial experiments with WETSIM showed that a 3-4° C increase in air temperature greatly increased drought frequency and thus decreased wetland hydroperiods and slowed the speed of the vegetation cycles. Overall, the model wetland in a warmer climate was less productive, less dynamic, and supported lower biodiversity.

Recent studies applied WETSIM to 18 long-term weather stations across the PPR to yield a broad geographic perspective of space and time variability in wetland characteristics during the 20<sup>th</sup> century. These simulations also served as a baseline against which to compare scenarios of future climate (Johnson et al. 2005). The most striking result was that habitat for breeding water birds would shift under an effectively drier climate (3° temperature scenario) from the center of the PPR to the wetter eastern fringes, areas currently less productive or where most wetlands have been drained. Unless the few remaining wetlands in these regions are protected or wetland landscapes restored, there will be little insurance for water birds against future climate warming. Simulations also suggest that changing farming practices in wetland watersheds, by shifting from high water-use row crops to managed grassland could offset some portion of the negative effects of climate warming on wetland water budgets, depending on how much the climate warms.

Simulations just conducted using a new model, WETLANDSCAPE, provide additional insight into the potential effects of climate change on prairie wetlands. WETLANDSCAPE models a wetland complex, including the three PPR wetland permanence types: temporary, seasonal, and semi-permanent. Initial simulations indicate that wetlands in the northwestern portion of the PPR (Saskatchewan and Alberta, Canada) have already begun to dry from climatic warming during the 20<sup>th</sup> century. Quite surprisingly, simulations suggest greater vulnerability of the more permanent wetland types to climate warming if the magnitude of warming is uniform across seasons. For example, a 3° C warming could shorten annual hydroperiods of seasonal wetlands by an average of 2 months. WETLANDSCAPE promises

**Theme 8: Global Change impacts**  
**8.2 Symposium 15: Consequences of climate change for freshwater wetlands**

to provide more complete analyses of wetland vulnerability to climate change than have been possible up until now.

**References**

- Dahl, T. E. 1990.** Wetlands losses in the United States 1780s to 1980s. U. S. Dept. of the Interior. Fish and Wildlife Service, Washington, DC. , USA
- Johnson, W. C., S. E. Boettcher, K. A. Poiani, and G. Guntenspergen. 2004.** Influence of weather extremes on the water levels of glaciated prairie wetlands. *Wetlands* 24:385-398.
- Johnson, W. C., B. V. Millett, T. Gilmanov, R. A. Voldseth, G. R. Guntenspergen, and D. E. Naugle. 2005.** Vulnerability of northern prairie wetlands to climate change. *BioScience* 55:863-872.
- Poiani, K. A., W. C. Johnson, G. A. Swanson, and T. C. Winter. 2006.** Climate change and northern prairie wetlands: simulations of long-term dynamics. *Limnology and Oceanography* 41:871-881.
- van der Valk, A. G. 2006.** *The Biology of Freshwater Wetlands.* Biology of Habitats. Oxford University Press, Oxford and New York. 173 pp.

## Climate change consequences for tidal freshwater wetlands at the east and west coast of the Atlantic

D.F. Whigham<sup>1,2</sup>, A. Barendregt<sup>3</sup>, C. Craft<sup>4</sup>, S. Neubauer<sup>5</sup>

<sup>1</sup> Smithsonian Environmental Research Center, Edgewater, MD, USA.  
e-mail: whighamd@si.edu

<sup>2</sup>Landscape Ecology, Institute of Environmental Biology, Utrecht University, P.O. Box 80084, 3508 TB Utrecht, The Netherlands <sup>3</sup> Copernicus Institute, Utrecht University, P.O. Box 80115, 3508 TC Utrecht, The Netherlands. <sup>4</sup>University of Indiana, School of Public and Environmental Affairs, Bloomington, IN, USA. <sup>5</sup>University of South Carolina, Baruch Marine Field Laboratory PO Box 1630, Georgetown, SC, USA.

### Fresh water in the estuary

Tidal Freshwater Wetlands (TFW) are flooded twice a day and typically are rich in nutrients, have high biomass production and high rates of nutrient turnover. A brackish estuarine zone and a non-tidal riverine system form the boundaries. They occur in the estuarine zone of maximum turbidity and for that reason are rich in sedimentation of clay and are very fertile. TFW occur in coastal estuaries where river discharge is constant on an annual basis and flows are high enough to limit the upstream extent of brackish water, so that no salinity fluctuations occur except for the lower end of the fresh water zone where fresh and brackish tidal waters mix (Barendregt *et al.*, 2006). TFW occur in estuaries of the main rivers of Western Europe, Eastern North-America and Alaska.

A variety of habitats occur in TFW. Sub-tidal habitats (creeks and mud flats) have no vegetation or floating/emergent aquatic beds. Higher in the tidal zone, herb dominated low and high marsh habitats occur and are dominated by species of *Scirpus* and *Phragmites* (Europe) or *Nuphar* and *Zizania* (North-America). Still higher in the intertidal zone, shrub-scrub dominated areas and forested areas occur. Most TFW have mosaics of vegetation types. Biodiversity increases with the elevation and while diversity is typically high in TFW, few species are restricted to this type of wetland and few threatened or endangered plant species have been identified. They are characterized by high biomass production, with values as high as 20 ton/ha/year. At the same time decomposition rates are high, as are turnover rates of nitrogen and other nutrients such as silica. Water quality is mesotrophic to eutrophic in river systems that also have a variety of intense human dominated land-uses. Many TFW are impacted by high nutrient concentrations associated with treated or untreated human waste.

Humans have influenced TFW habitats for a long period. In Europe, for millennia people lived in these areas, mostly to harvest fish and mammals. Around 500 BC agriculture started and by 100 AD the first hydrological structures had been developed to manage water for purposes of improving agriculture. During the last 500 years many areas have been reclaimed for agriculture and in the last century TFW have been impacted by expanded industrial activities. In North-America TFW also have a long history of being impacted by human activities, but more of the original landscapes survives compared to Europe.

### Global change in TFW

In TFW, global changes are likely to manifest themselves in three ways: sea level rise, (positive or negative) changes in precipitation and increasing temperature. The consequences will be discussed for the different possibilities.

Sea level rise could result in an up-estuary distribution of brackish water into areas now dominated by TFW, The rate at which this will occur may depend on the geomorphology of each river system. In lowland regions with deltaic plains, such as in NW Europe, sea level rise may not have as much of a negative impact on TFW when space will be available for them to move further upstream. Moreover, the high sedimentation rates (1 cm/year is

possible) will effect a reshaping of the new areas in the estuary. In regions of eastern North-America where the boundary between the coastal plain and the piedmont is characterized by a sharp increase in elevation, real problems occur and many TFW may disappear.

Changes in precipitation can affect TFW in two ways. Higher amounts of precipitation will result in an increasing discharge of the river and the brackish front in the estuary will be pushed in the direction of the sea; resulting in a down-estuary movement of TFW and an increase in their aerial extent. Lower precipitation will result in less river discharge and an up-estuary movement of brackish water; resulting in the replacement of the fresh water portion of rivers or a reduction in its extent. A third scenario could occur in areas where precipitation continues to be high but becomes unpredictable so that the discharge might fluctuate and result in salt intrusion. In these situations TFW are likely to be reduced in extent.

Rising temperatures will effect processes and species distribution. Comparing species distributions along the latitudinal gradient where TFW occur along the east coast of USA or west coast of Europe suggests that changes in vegetation in response to rising temperatures will be minimal. It seems likely that there will be a replacement of some species as southern plants move northward. However, the ecological characteristics of these species will be comparable with the present species and no impact on the ecosystem functions can be foreseen.

The most prominent change in the landscape processes will be performed when salt intrusion occurs into the tidal fresh zone of rivers that have TFW, resulting in a system change from fresh to brackish. Species distribution and the diversity will be affected as plant species characteristic of brackish wetlands move into TFW habitats. The consequences of the change (possibly short-term) will be a decrease in productivity, but more important are the changes in gas emissions from a system that emits methane to one that is biogeochemically driven by processes that occur in brackish wetlands.

### **Effect of global change on TFW**

Based on present climate models, can we predict what changes are likely to occur in some of the areas where TFW occur in North-America and Europe? The set of estuaries in North-west Europe will at the same time be affected by a higher discharge from the river and a downward change of the brackish front, and a sea level rise with an upward change of the brackish front. A preliminary global prediction is a zero effect.

However, the estuaries in South-west Europe might be endangered by either a decrease in precipitation or increase in the timing of precipitation resulting in altering periods of wet and dry conditions. Under this scenario the characteristic landscape ecological processes in TFW might be impacted and replaced by brackish marshes.

On the east coast of North-America comparable processes with South-west Europe might occur, since less precipitation and especially the increase in fluctuations of water levels and storms will result in more intrusion of brackish water. Moreover, these regions will suffer from the increase in sea level and by that in a reduction of the available area for TFW.

Our ability to predict the types of changes that will occur in the tidal fresh zone of river systems that support TFW will increase as the accuracy of global change models increases. In the interim, examination of long-term data sets on patterns of riverine salinity offer the best source of information for examining where changes are likely to occur and the rate at which the changes are likely to happen.

### **References**

- Barendregt, A., Whigham D., Meire, P., Baldwin, A. & van Damme, S. (2006)** Chapter 6 - Wetlands in the Tidal Freshwater Zone. In: R. Bobbink, B. Beltman, J.T.A. Verhoeven & D.F. Whigham (Eds) *Wetlands: Functioning, Biodiversity Conservation, and Restoration*. Ecological Studies - Volume 191, Springer Verlag, Berlin, pp. 117-148.

## Does the NATURA 2000 web still function ? The effects of climatic changes on the dystrophic waters and their dragonfly fauna in the biosphere reserve "Pfälzerwald"

J. Ott<sup>1,2</sup>

<sup>1</sup> L.U.P.O. GmbH, Friedhofstraße 28, D-67705 Trippstadt, Germany,  
e-mail: L.U.P.O.GmbH@t-online.de;

<sup>2</sup> University of Landau, Dept. of Environmental Sciences, Fortstraße 7, D-76829 Landau, Germany

### Introduction

Dragonflies are good indicators for the quality of aquatic environments as well as for environmental changes (Corbet 1999). Consequently they are used recently as monitoring organisms to demonstrate the effects of climatic changes, e.g. via the range expansion of southern species to the north or via the shifts within communities (Ott 2001, Ott 2007 a, b). Here the first results of a study carried out during the last two years – and still ongoing for the next two years – in the transboundary biosphere reserve "Pfälzerwald-Vosges du Nord" are presented.

### Material and methods

The dragonfly fauna and the environmental conditions of more than 20 waters – mainly dystrophic lakes (NATURA 2000-code 3160, see also Roweck *et al.*, 1988) – were monitored in 2005 and 2006 and compared with previous investigations of these waters (e.g. Niehuis 1984). The dragonflies were investigated during the entire vegetation periods while visiting the waters in minimum at 3 good days (Schmidt 1985) and by observing and/or catching the adults and by collecting exuviae to proof autochthony of the species. During these visits also the abiotic conditions of the waters and in the surrounding were registered and information on the use in the catchment area were collected (e.g. groundwater extraction). Climatic data were obtained from official climatic stations (e.g. [www.agrarinfo-rlp.de](http://www.agrarinfo-rlp.de)). All these waters are part of the national NATURA 2000 network and beside this they are also protected by the national and federal nature conservation law.

### Results

#### Climatic data and abiotic conditions

The climatic data of several climatic stations in the investigated area show a clear trend to warmer temperatures – in comparison to the long term mean about 1-1,5 ° C. – and to more extremes in precipitation in the last years. In particular the dry summer of 2003 is remarkable: after years with higher precipitation in comparison to the mean, this year had a precipitation about 30-40 % lower than the mean.

As a consequence of the conditions in 2003 - and in some cases also because of synergistic effects (e.g. ground water extraction) - the water level in the waters dropped down about 1 – 2 meters, depending on the local situation (e.g. geology and size of the catchment area, biotopes/land use in the surrounding) and the nearby wetland biotopes dried out. This lack could not been filled up if the following 3 years and the water table sank even more. This lead to a reduced water body having no more contact to the vegetation of the shoreline and in addition vast open areas came into existence.

#### Changes in the dragonfly fauna

The dragonfly fauna reacted quickly on these changes: Within very short time most of the stenoecious and endangered mooreland species, which are characteristic for the dystrophic



waters (sensu Ssymanck et al., 1998), could not anymore be registered at most of the waters (e.g. *Somatochlora arctica*, *Aeshna juncea*, *Leucorrhinia dubia*, *Coeagrion hastulatum*) and they are now nearly extinct for the German part of the biosphere reserve. E.g. for *Somatochlora arctica* presently only one population is left, being highly isolated (Ott 2006 a). On the other hand these waters were colonised in the same time by euryoecious and ubiquitous species, which are now dominating the coenosis (e.g. *Anax imperator*, *Orthetrum cancellatum*, *Libellula depressa*) and indicating the strong disturbance. Some of these waters were also colonised by protected species, such as *Lestes barbarus* (Ott 2006 b), but also this is more an indicator for the deterioration of the waters, as this species is typical for waters drying out regularly.

Some of the waters even dried out completely and lost totally their value for any aquatic fauna, not only for the dragonflies.

If no changes of the climatic conditions will occur in the near future and if no management and mitigation measurements will be undertaken immediately, also the remaining waters will lose their importance for the NATURA 2000 network within short time and devalue the concept and the coherence completely. This will be in complete contrast to the present policy and goals in the national nature conservation strategy (see Ssymanck et al., 2006).

### References

- Corbet, P.S. (1999)** *Dragonflies – Behaviour and Ecology of Odonata*. Harley Books, Colchester.
- Niehuis, M. (1984)** Verbreitung und Vorkommen der Libellen (Insecta: Odonata) im Regierungsbezirk Rheinhessen-Pfalz und im Nahetal. – *Fauna und Flora in Rheinland-Pfalz* **3** (4): 1-203.
- Ott, J. (2001)** Expansion of mediterranean Odonata in Germany and Europe – consequences of climatic changes. Walter, G.-R. et al. (Eds.) (2001) „*Fingerprints*“ of *Climate Change*. Kluwer Academic Publishers, New York et al., pp. 89-111.
- Ott, J. (2006 a)** Die Arktische Smaragdlibelle – *Somatochlora arctica* (ZETTERSTEDT, 1840) in der Pfalz: übersehen oder kurz vor dem Aussterben? (Insecta: Odonata: Corduliidae). *Fauna und Flora in Rheinland-Pfalz* **10** (4): 1323-1338.
- Ott, J. (2006 b)** Die Südliche Binsenjungfer – *Lestes barbarus* (FABRICIUS, 1798) – erobert den Pfälzerwald (Insecta: Odonata: Lestidae). *Fauna und Flora in Rheinland-Pfalz* **10** (4): 1315-1321.
- Ott, J. (2007 a)** The expansion of *Crocothemis erythraea* (Brullé, 1832) in Germany – an indicator of climatic changes. in: B. K. Tyagi (Ed.) (2007): *Odonata - Biology of Dragonflies*. Scientific Publishers (India), pp. 210-222.
- Ott, J. (2007 b)** Effects of climatic changes on dragonflies – results and recent observations in Europe. In: Ott, J. (Ed.) (2007): *Monitoring of Climate Change: the example “dragonflies”*, Pensoft Publishers, Sofia & Moscow (in prep.)
- Roweck, H., M. Auer & Betz, B. (1988)** Flora und Vegetation dystropher Teiche im Pfälzerwald. POLLICHA-Buch Nr. 15, Bad Dürkheim.
- Schmidt, E. (1985)** Habitat inventarization, characterisation and bioindication by a "Representative spectrum of Odonata species (RSO)". *Odonatologica* 14(2): 127 - 133
- Ssymanck, A., Hauke, U., Rückvriem, C. & E. Schröder (1998)** Das europäische Schutzgebietssystem NATURA 2000. Schriftenreihe für Landschaftspflege und Naturschutz. H. 53. Landwirtschaftsverlag, Bonn-Bad Godesberg.
- Ssymanck, A., S. Balzer & K. Ullrich (2006)** Biotopverbund und Kohärenz nach Artikel 10 der Fauna-Flora-Habitatrichtlinie. *Naturschutz und Landschaftsplanung* 2/2006: 45-49

Study carried out within the EC-ALARM-project (www.alarmproject.net – Code: GOCE-CT-2003-506675)

### 8.3 Open Session 14: Modelling and Impacts of global change

#### Effects of recent land use and land cover change on the rates and patterns of fires and C emissions in Colombian savannas

A. Etter, A. Sarmiento

Depto. Ecología y Territorio, Facultad Estudios Ambientales y Rurales, Universidad Javeriana, Tr 4 Nr 42-00 Piso 8, Bogotá, Colombia.  
e-mail: aetter@javeriana.edu.co

#### Introduction

The contribution of carbon emissions from land use dynamics and change to the global carbon cycle is still uncertain, a major concern in global change modeling (Ramankutty *et al.*, 2007). Carbon emissions from fires in the tropics are significant and represent 9% of the net primary production (Van Der Werf *et al.*, 2003). Mouillot *et al.* (2006) estimate that 50% of worldwide C emissions due to fires come from savanna fires. However, C emissions from fires vary significantly due to differences in ecosystem types, biomass and combustion efficiencies (Delmas *et al.*, 1995).

Colombia has some 30 MHa of mesic savannas which have been historically burned. Due to changes in market demands and improved accessibility, large yet unknown areas of savannas changed land use during the last 20 years, from predominantly extensive grazing on natural grasslands, to crops and intensive grazing systems (Etter, 1998a).

The aim of this research is to quantify and evaluate the impact of such land use changes on the spatial and temporal burning patterns and C emissions in the Orinoco savannas of Colombia.

#### Methods

The study area covers over 17 MHa and includes the eastern lowlands in the Orinoco basin in Colombia, where herbaceous savannas are dominant. Before 1980 this region was devoted to extensive grazing and had low human population densities.

We study the effect of these land use change patterns on the dynamics of fire using remote sensing data from MODIS (NASA/University of Maryland, 2002) and Landsat, ecosystem mapping products (Etter, 1998b), and spatial GIS analysis. We analyze and quantify the patterns and extent of burned areas in the 2000's for different savanna ecosystem types, and varying land use and management systems.

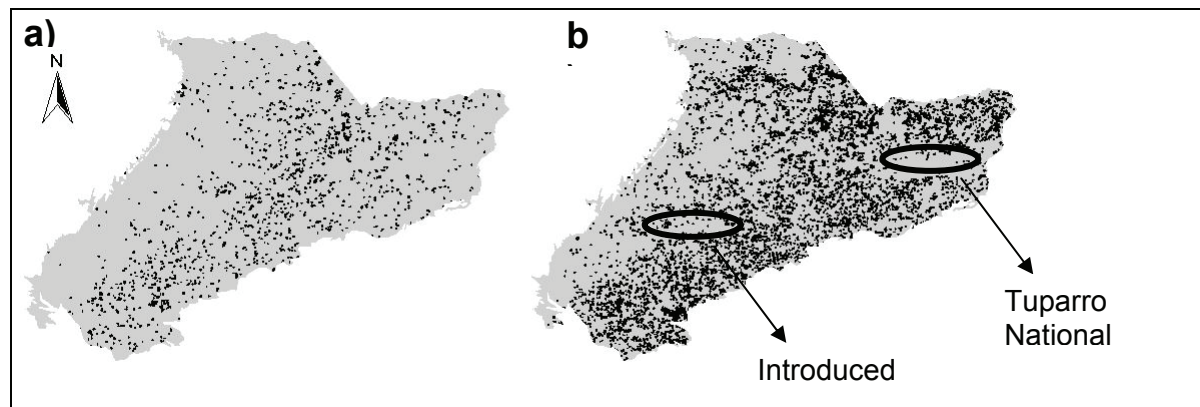
#### Results

In 2000 more than 500k hectares of natural savannas were transformed to sown pastures (*Brachiaria* spp.), 100k hectares were planted with oil palm and irrigated rice. By 2007 we estimated using sample areas that these figures have increased by at least 30%.

Our results indicate a reduction of fire frequencies between 40 and 70% in areas where savannas were replaced by *Brachiaria* spp. pastures. Because these land use changes have been occurring in savanna types with better soils that have higher aerial biomass values, the effect on reduction of C emissions is some 30 to 50% larger than the effect on area reduction.

There is a seasonal variability of fires with most events occurring during the dry season between December-March (Figure 1). Noteworthy is the contrast between grazed savannas and non-grazed savannas (The National Park), indicating that most fires are human induced (Figure 1b). Also, our analysis shows that fire frequencies vary consistently

among savanna types, with highest frequencies and largest areas in the well-drained savannas of the southern part of the region.



**Figure 1.** Spatial patterns of fires in Colombian savannas in a) dry and b) wet season (Data from MODIS 2005 (NASA/University of Maryland, 2002)).

Although these results point to a reduction in the carbon emissions from changes in fire regimes, this needs to be integrated with other sources of carbon, such as those derived from changes to irrigated rice that our figures do not include.

Because the land cover changes are selective towards clearing the better soil savannas, the price for this carbon emission reduction is a decline in the local biodiversity derived from the selective destruction of certain savanna ecosystem types from the landscape.

#### References

- Delmas, R., Lacaux, J.P. and Brocard, D., 1995.** Determination of biomass burning emission factors: Methods and results. *Environmental Monitoring and Assessment*, **38**: 181-204.
- Etter, A., 1998a.** Ecosistemas de Sabanas. In: M.E. Chaves and N. Arango (Editors), *Informe Nacional sobre el Estado de la Biodiversidad Colombia 1997*. IAvH y PNUD, Bogotá, pp. 76-95.
- Etter, A., 1998b.** Mapa general de ecosistemas de Colombia - 1:2 000 000. (General ecosystem map of Colombia). in, Chaves, M.E. and N. Arango (Eds.) *Informe Nacional sobre el Estado de la Biodiversidad en Colombia - 1997 (National Biodiversity Report - 1997)*. Instituto Alexander von Humboldt, Bogotá.
- Mouillot, F., Narasimha, A., Balkanski, Y., Lamarque, J. and Field, C.B., 2006.** Global carbon emissions from biomass burning in the 20th century. *Geophysical Research Letters*, **33** ( L01801): L01801.
- NASA/University of Maryland, 2002.** MODIS Active Fire Detections. Data set. MODIS Rapid Response Project, NASA/GSFC [producer], University of Maryland, Fire Information for Resource Management System [distributors]. Available on-line [<http://maps.geog.umd.edu>].
- Ramankutty, N., Gibbs, H.K., Achard, F., Defries, R., Foley, J.A. and Houghton, R.A., 2007.** Challenges to estimating carbon emissions from tropical deforestation. *Global Change Biology*, **13**(1): 51-66.
- Van Der Werf, G.R., Randerson, J.T., Collatz, G.J. and Giglio, L., 2003.** Carbon emissions from fires in tropical and subtropical ecosystems. *Global Change Biology*, **9**(4): 547-562.

**Potential impacts of climate change on birds and trees of the eastern United States:  
newest climate scenarios and species abundance modelling techniques**

**L.R. Iverson, A.M. Prasad, S.N. Matthews, M.P. Peters**

Northern Research Station, USDA Forest Service, Delaware, Ohio 43015 USA  
e-mail: [liverson@fs.fed.us](mailto:liverson@fs.fed.us)

## **Introduction**

Climate change is affecting an increasing number of species the world over, and evidence is mounting that these changes will continue to accelerate. There have been many studies that use a modelling approach to predict the effects of future climatic change on ecological systems, including by us (Iverson et al. 1999, Matthews et al. 2004); this modelling approach uses a new tool for evaluating multiple species of trees and birds.

## **Methods**

We modelled and mapped current and potential future suitable habitat for 134 tree species and 150 bird species from the eastern United States for potential response to several scenarios of climate change. Each species was modelled individually to show current and potential future distributions according to two emission scenarios (A1fi-high emissions on current trajectory and B1-reasonable conservation of energy implemented) and three climate models: the Parallel Climate Model, the Hadley CM3 model, and the Geophysical Fluid Dynamics Laboratory model. We modelled with Random Forests, a regression tree ensemble method that models better than any other known method as long as there is a sufficient number of samples of presence/absence data (Prasad et al. 2006). We also evaluated both emission scenarios under an “average” future climate from all three models, and evaluated the species for their quality of prediction models.

The primary products of this research are maps (to a resolution of 20x20 km) and tables of potential changes of the species' suitable habitat under the various scenarios of climate change. We also calculated the mean centres and changes of mean centres, under all scenarios, to enable estimation of distance and direction of movement potential by species.

## **Results and Discussion**

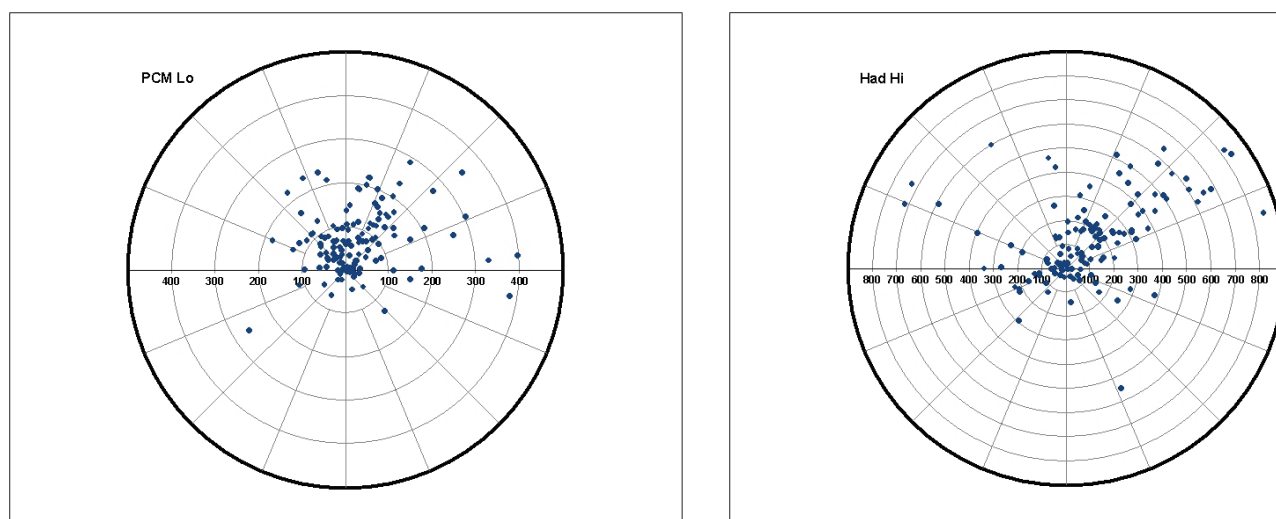
We found that species with small ranges, though shown to have more vulnerability to extinction after climate change, also have more uncertainty in predictions of current and potential future habitat distributions because of small sample size and the relatively higher contribution of non-climate variables, like soils or topography, to the models (Schwartz et al. 2006). More local species are relatively more controlled by local environmental conditions and thus may be less endangered by changing climates. These results create a conservation dilemma in that excluding these small-ranged species from climate change analyses underestimates extinction risk, whereas including them may overestimate extinction risk.

We found that the harshest situation and greatest changes in suitable habitat for tree species occur with the high emission scenario (A1fi) under the HadleyCM3 model and the least harsh situation and smaller changes were with the lower emission scenario (B1) under the PCM (Table 1). Most tree species' habitats will move in a north or northeast direction, up to about 800 km with the HadleyCM3-high emissions, and about 400 km with the PCM-low emissions (Fig. 1). All maps, data, and publications, on tree and bird analysis, can be found on our website, [www.nrs.fs.fed.us/atlas](http://www.nrs.fs.fed.us/atlas) (Prasad et al. 2007).

**Theme 8: Global Change impacts**  
**8.3 Open Session 14: Modelling and Impacts of global change**

**Table 1.** Potential species changes in area-weighted importance value for habitat suitability for 134 species in the eastern United States. A future : current ratio below 1 indicates a loss, while a value above 1 indicates a gain. (lo and hi refer to emission scenarios, see text).

Scenario	< 0.5	0.5 - 0.9	0.9 - 1.1	1.1 - 2	> 2	Total
PCM lo	14	37	21	54	8	134
PCM hi	25	25	14	40	30	134
Ave lo	15	38	20	48	13	134
Ave hi	23	35	9	37	30	134
GFDL lo	14	40	15	44	21	134
GFDL hi	26	28	12	31	37	134
Had lo	20	34	13	50	17	134
Had hi	25	31	12	36	30	134



**Figure 1.** Range of potential mean centre movement for 134 tree species under the least harsh scenario (PCM, low emissions, left) and most harsh scenario (HadleyCM3, high emissions, right).

**References**

- Iverson, L.R.; Prasad, A.M.; Hale, B.J.; Sutherland, E.K. (1999)** *Atlas of current and potential future distribution of common trees of the eastern United States*. GTR-NE-265. Northeastern Research Station, USDA Forest Service, Newtown Square, PA. 245 pp. (also available at [www.treearch.fs.fed.us/pubs/7662](http://www.treearch.fs.fed.us/pubs/7662))
- Matthews, S.N.; O'Connor, R.; Iverson, L.R.; Prasad, A.M. (2004)** *Atlas of climate change effects in 150 bird species of the Eastern United States*. GTR-NE-318. Northeastern Research Station, USDA Forest Service, Newtown Square, PA. 340 pp. (also available at [www.treearch.fs.fed.us/pubs/7514](http://www.treearch.fs.fed.us/pubs/7514))
- Prasad, A.M.; Iverson, L.R.; & Liaw, A. (2006)** Newer classification and regression tree techniques: bagging and random forests for ecological prediction. *Ecosystems* **9**: 181-199.
- Prasad, A.M.; Iverson, L.R.; Matthews, S.N.; Peters, M.P. (2007)** *Climate Change Atlas*: [www.nrs.fs.fed.us/atlas](http://www.nrs.fs.fed.us/atlas)
- Schwartz, M.W.; Iverson, L.R.; Prasad, A. M.; Matthews, S.N., O'Connor, R J. (2006)** Predicting extinctions as as result of climate change. *Ecology* **87**: 1611-1615.

## Spatial structure of southern taiga landscape energy balance and temperature field based on remote sensing data

R.B. Sandlerkiy<sup>1,2</sup>, Y.G. Puzachenko<sup>2</sup>, D.N. Kozlov<sup>1</sup>

<sup>1</sup> Lomonosov Moscow State University Faculty of Geography, 119899, Moscow, Leninskiye Gory 1, Russia, e-mail: srobert\_landy@mail.ru

<sup>2</sup> A.N. Severtsov Institute of Ecology and Evolution RAS, 119071, Moscow, Leninsky prospect 33, Russia

Remote sensing allows the estimation of the energetic condition of a terrestrial surface and features of solar energy transformation in ecosystems at the moment of survey. Satellite measurements in the different spectral zone of the reflected solar energy in comparison to a solar constant permit to calculate absorbed solar radiation on unit of a surface, albedo. The image of thermal channel shows the spatial heterogeneity of land cover temperatures.

The most part of the absorbed energy is used for transpiration, biological production, biogeochemical processes, is partially preserved in ground and partially dissipates in the form of thermal radiation. The absorbed energy going on production and circulation of moisture refers as exergy. Exergy is the maximal work which the thermodynamic system can make at transition from the given condition in a condition of balance with environment (Jorgensen, Svirezhev, 2004). The working capacity of systems sometimes refers to exergy. Exergy is a function of a distance between the current condition of system and the thermodynamic balance condition. Exergy of solar radiation in landscape cover can be measured through a distance between distribution of capacities on a spectrum of the absorbed solar energy for unit of a surface and an equilibrium condition with hypothetical absorption of a solar energy proportional to distribution of capacities in a spectrum of a solar constant. The degree of a deviation of a real spectrum of absorption from equilibrium spectrum is estimated on the base Kullback's entropy (Jorgensen, Svirezhev 2004). Kullback's entropy is a measure of distinction of two compared distributions, and it is the important physical parameter of open no equilibrium thermodynamic systems. The more Kullback's entropy, the more exergy. A part of the absorbed energy which is not used for useful work increases the internal energy of ecosystems. This part of absorbed energy passes in the energy molecular movement (heat exchange) and chemical communications (internal energy). The increment of internal energy is estimated as the difference between values of the absorbed energy and the exergy. Thermodynamic characteristics allow estimating character and efficiency of energy transformation in landscape depending on its internal structure.

Calculation of thermodynamic variables is carried out on Landsat 5 and 7 multispectral scenes. Multispectral scanners of these satellites allow to calculate quantity of reflected radiation in a strip of lengths of waves 0.45 - 2.35 microns - for elementary unit of a surface - 28.5 m and thermal long-wave radiation in a strip 10.12 - 14.5 microns (57 m), covering the most part of a solar radiation spectrum. Variables are calculated for five terms of surveying: March, April, May, June, and September at 11 AM o'clock Moscow time. Research is carried out for territory of Central-Forest Biospheres Reserve (33° E, 56.2° N). The landscape properties are in many respects unique (moraine ridges height with boreal spruce and complex spruce forest in a combination with peatlands, windfalls, cutover patches and fields), creates a basis for comparison of properties of various types of a surface and their territorial combinations. On five terms of survey the following thermodynamic variables (for each elementary unit of a surface) have been calculated: incoming solar energy ( $W/m^2$ ), the reflected solar energy ( $W/m^2$ ), albedo, the absorbed energy ( $W/m^2$ ), Kullback's entropy (nit), exergy ( $W/m^2$ ), an increment of internal energy ( $W/m^2$ ), flow of heat ( $W/m^2$ ), temperature of a surface (°C), a share of the absorbed energy spent for manufacture of biological production (%), a share of the absorbed energy spent on transpiration (%). Average values of variables for various types of a surface are estimated: forests, agricultural fields, meadows, peatlands,

and wind blow areas. Maps of components of the energy balance and a field of temperatures with the resolution of 30x30 m are created.

Transformation of energy within a landscape for each season has the following features. In the winter condition (March) the intensity of heat flow is substantially determined by absorbed solar energy. As a whole the land-cover is as close as possible to equilibrium, energy is spent for physical processes. In the summer a landscape is maximal non equilibrium, exergy is maximal and the landscape function is evapotranspiration and bio-productivity. To distinguish the contribution of energy to these two processes without additional measurements is impossible. During the spring and autumn exergy of solar radiation in landscapes has decreased relative to the summer level.

The seasonal changes of thermodynamic variables are identical for different land-cover types. They differ only in size of absorbed radiation and exergy. Forests as a whole intensively evaporate water, thus old spruce and pine forests under these characteristics approach open water. Wind blow and young forests have essentially smaller exergy; minimal exergy is at meadows and the agricultural fields. On the average the highest the temperature of a surface, the less is the exergy. The heat inputs for evaporation are large for forests on reserves as they are mostly occupied by old spruce forests. The area of reserves is much colder than ambient landscapes with secondary young small-leaved forests alternating with the agricultural fields. Probably that defines mesoclimate and modern features of vegetation and soil covers.

The behavior of thermodynamic variables for peatlands with an area of a few square kilometers differs greatly. In the spring and in autumn exergy and nonequilibrium of peatlands is much greater, than meadows and agricultural land. In the summer the peatlands have a more equilibrium condition. Accordingly, transpiration is lower, than in meadows. Actually peatlands function only in the spring and in the autumn with minimal evaporation during the summer. These features support stability of peatlands even in conditions of possible climate fluctuations.

The variation of thermodynamic variables in space at various hierarchical levels of the landscape organization allows the allocation of types of elementary landscape units and their hierarchically coordinated complexes and their corresponding spatial gradients. It is possible to believe, that scales of their spatial gradients determine features of their function.

Field measurements of spatial variation in air and a soil temperatures and leaf-area index by means of fisheye digital camera on transect (length of 7 km) with step of 20 m in August, November and January have been carried out. There is a reliable enough connection of spatial variation of these variables with remote sensing data and derivative thermodynamic variables. The combination of the remote information and field observations has allowed interpolating of results for territory and for various time of day and seasons of year. On the same basis it is possible to allocate an exergy balance the work connected with a synthesis of bio-productivity. Finally, the combination of a complex of field and remote measurements should assist an understanding of the mechanisms of interaction between relief, soil, vegetation and an atmosphere at various hierarchical levels of the landscapes organization and to create a basis for development of model of mesoclimate shaping, as a result of landscapes functioning.

The research is made with support of RFBR projects №06-05-64937.

## **References**

**Jorgensen S.V., Svirezhev Y. M. (2004).** Towards a Thermodynamic Theory for Ecological Systems. *Elsevier Ltd. The Boulevard, Oxford UK, 369 p.*

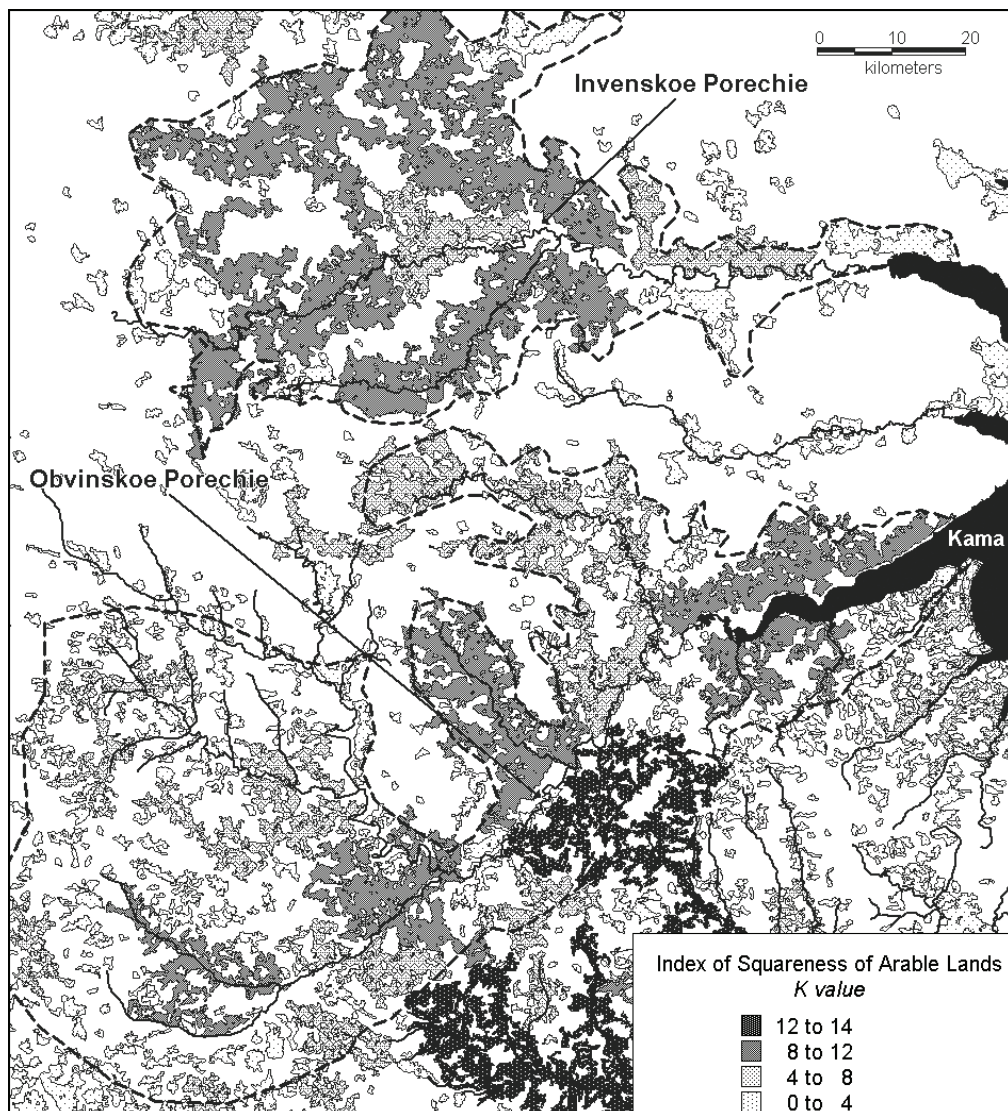
**Indicative properties of agricultural landscapes for studying changes of the environment due to climatic changes within the forest zone of East European Plain**

**O.N. Trapeznikova**

Institute of Environmental Geoscience, Ulanskii per., 13, P.O. Box 145, Moscow, Russia,  
e-mail: dist@geoenv.ru.

**Introduction**

Agricultural landscapes of the forest zone are convenient for indicating environmental changes due to their ready interpretation in remote sensing images. In comparison with natural ecosystems, agricultural land is less stable. One can detect environmental changes using analysis of changes within agricultural landscapes, such as land use changes and new types of crop rotation because these are visible in remote sensing images. At the same time, the indication analysis should take into account relations between agricultural landscape structure and the economic and social factors of agriculture development, including geographical position, economic status of the region, population peculiarities, and other factors.



**Figure 1.** Map of arable lands of the Western Part of the Middle Kama Basin

**Research**



Our research deals with taiga landscapes in the east of the East European plain west to the river Kama between 57°30' and 59°20' NL. It is an insecure agriculture region, which is characterized by poor soils and a rather severe climate. Nevertheless, it is a stable centuries-old agrarian area, where agricultural land covers currently from 21 to 53 % of the whole territory, while forest is from 35 to 67 % of the area. Most of the territory is divided between two basins of the large tributaries of Kama. They form agricultural ecosystems of Invenskoe porechie (the Inva basin) at the north, and Obvinskoe porechie (the Obva basin) at the south (Figure.1). In Russian "porechie" means a near river area. The two agricultural ecosystems are very close in their historical, social, and economic history, geology, and geomorphology. The main difference is that In'venskoe porechie is situated about 300 km to the north from Obvinskoe porechie and, thus, the climate is the main factor by which these two landscapes differ from each other.

The agricultural landscapes were studied in detail using both statistical data and space images. In particular, a spectral space image made on 10.05.97 by scanner MSU-SK from satellite Resurs-01-3 was processed with ENVI software package. The scanner MSU-SK gives middle resolution images (pixel dimension 140 m X 185 m) that provide possibilities for a certain generalization of agricultural units. Supervised image classification was applied to determine arable land, forests, water bodies, settlements, and some other classes of image patterns. Arable land is well recognized at the image using training classes, i.e. selected groups of pixels (ROIs) that represent desired areas.

Qualitative analysis shows that these two large agricultural landscapes have different spatial patterns. In'venskoe Porechie is characterized with a clear branched pattern, due to its connection with small river valleys, while Obvinskoe Porechie, especially its right southern side, is characterized by a more complicated pattern. Arable land is located here within the large river valleys and at watersheds, while small river valleys are covered with forest. One can also see that the agricultural landscape pattern of Invenskoe Porechie is much poorer and uniform. Crop land selects the microclimates of small valleys and croplands are usually situated generally at slopes and terraces with a south exposure. In fact, the better climate of Obvinskoe Porechie allows more land to be used by farming, and therefore has more diverse pattern.

In order to detect the pattern differences it is necessary to choose a parameter, which, from one hand, provide for essential information about image pattern features and, from the other hand, is easy to estimate and is rather independent on possible errors of computer image processing. A parameter based on ratio between perimeter and area was taken and named "Index of Squareness":  $K = P/(4\sqrt{S})$ , where P is perimeter and S is area. The obtained values of K for tracts of arable land vary from 1.02 to 13.84. All tracts are divided on 4 ranks according to K with a step equal 4 (Fig.1).

Pattern analysis according to the Index of Squareness indicates the range of different agricultural landscape patterns of Obvinskoe Porechie and Invenskoe Porechie. Invenskoe Porechie is characterized by large tracts of arable land with a high value of K (8-12). In the center of the Porechie with its main settlement the town of Kudymkar K is lower (4-8). Large tracts of arable land with low and middle values of K are also located within rather wide and flat river terraces of the lower Inva. Obvinskoe Porechie is larger and is characterized by a more diverse pattern according to K value. The most indented tracts (K>13) are situated there.

## Conclusion

Climatic warming would therefore lead to a more diverse and complicated spatial pattern in Invenskoe Porechie. On the contrary, climatic cooling could result in degradation of the complex agricultural landscape patterns of Obvinskoe Porechie.

## 8.4 Posters

### Effects of spatial cohesion and climate change on changing butterfly distribution patterns

A. Cormont

Wageningen UR, Landscape Centre, Land Use Planning group/Alterra, Wageningen, The Netherlands.

e-mail: anouk.cormont@wur.nl

#### Introduction

In the Northern hemisphere, species respond to climate change by shifting northward (Parmesan *et al.*, 1999). Considering the current fragmentation of nature areas, it is important that species can shift in time (Opdam and Wascher, 2004). Bottlenecks in the Dutch National Ecological Network (EHS, Ecologische Hoofdstructuur) are expected, with regard to habitat fragmentation and climate change. Where and how can measures be taken to reduce the risks of climate change to biodiversity?

#### Methods

Butterflies are ectothermic species, and their behaviour is influenced by temperature and irradiation. For the next century, the spatial scale of their shifts in range is likely to resemble the extent of the EHS.

Several butterfly species are selected to study their response to climate change. Questions that need to be answered are:

- *How do spatial cohesion and climate change affect butterfly distribution patterns?*
- *To what extent can this effect be considered as a risk or a chance to the species?*
- *Which climate and landscape parameters are important risk factors to the species?*

Distribution patterns of butterfly species for various periods will be compared to weather data, collected during the last century in The Netherlands. The butterfly data is well-suited to study the range shifts by the increase in temperature. Changes in occurrence patterns will be correlated to weather records. With the correlative studies, the important climate parameters will be identified. Statistical patch occupancy models, based on metapopulation theory (IFM), will be used to find indications for the effects of habitat fragmentation and climate on real metapopulations.

Results will be achieved by the time of the presentation

#### References

- Opdam, P. & Wascher, D. (2004) Climate change meets habitat fragmentation: linking landscape and biogeographical scale levels in research and conservation. *Biological Conservation* **117**, 285-297.
- Parmesan, C., Ryrholm, N., Stefanescu, C., Hill, J. K., Thomas, C. D., Descimon, H., Huntley, B., Kaila, L., Kullberg, J., Tammaru, T., Tennent, W. J., Thomas, J. A. & Warren, M. (1999) Poleward shifts in geographical ranges of butterfly species associated with regional warming. *Nature* **399**, 579-583.

## Using the right metric: a comparative analysis of landscape fragmentation measures

L.T. Olson<sup>1</sup>, L. Tischendorf<sup>2</sup>, K.F. Lindsay<sup>3</sup>

<sup>1</sup> Geomatics and Landscape Ecology Research Lab, Carleton University – 1125 Colonel By Drive, Ottawa, Ontario, K1S 1S3, Canada.

e-mail: leif.olson@gmail.com

<sup>2</sup> ELUTIS Modelling and Consulting Inc. – 681 Melbourne Avenue, Ottawa, Ontario, K2A1X4, Canada.

<sup>3</sup> Manager, National Indicators & Reporting Office, Knowledge Integration Directorate, Environment Canada. – 70 Cremazie St., Gatineau (Hull), Quebec, K1A0H3, Canada.

The ecological impact of habitat fragmentation has received widespread research attention with at times contradictory conclusions (Fahrig, 2003). Meta-analysis of these results is hindered by unquantified differences in methodology. This study investigates two widely used fragmentation measures: F\_WADE, as proposed by Ritter (2000) and implemented by Wade *et al.* (2003), and F\_LDIV, as a 100% proxy for the “Effective Meshsize” measure proposed by Jaeger (2000). We analyse their numeric response to well defined fragmentation phases and to natural and controlled variations in landscape pattern (Tischendorf, 2001).

F\_LDIV reflects all phases of fragmentation and predicts increase or decrease of fragmentation consistently and in accordance with accepted definition. F\_WADE does not consistently respond to all fragmentation phases. Inconsistencies and differences in magnitude are the result of the measure’s dependency on the size of a moving window. F\_WADE generally predicts higher fragmentation when measured in smaller moving windows because smaller window sizes (< 5% of the total landscape area) are more likely to cover areas without any habitat, which may artificially inflate and bias F\_WADE.

F\_WADE and F\_LDIV are both dependent on habitat/forest amount in a landscape. F\_WADE shows a strong and consistent negative linear relationship with habitat amount, which impedes comparisons of F\_WADE values obtained from landscapes with different amounts of habitat/forest in a landscape. F\_LDIV shows a non-linear relationship to habitat amount, with almost no dependency up to habitat amounts of 30% of the total landscape. F\_WADE is sensitive to shape of habitat/forest patches, because of its dependency on habitat cell edges. In contrast, F\_LDIV is solely based on size of habitat patches and therefore not responsive to edge related landscape characteristics. From these insights we conclude that F\_LDIV or the Effective Meshsize is the more appropriate measure for landscape or habitat fragmentation *per se*.

### References

- Fahrig, L. (2003) Effects of habitat fragmentation on biodiversity. *Annual Review of Evolutionary Systems* **34**: 487-515.
- Jaeger, J.A.G. (2000) Landscape division, splitting index, and effective mesh size: new measures of landscape fragmentation. *Landscape Ecology* **15**(2): 115-130.
- Tischendorf, L. (2001) Can landscape indices predict ecological processes consistently? *Landscape Ecology* **16**(3): 235-254.
- Riitters, K.H.; Wickham, J.D.; O’Neill, R.; Jones, K.B. & Smith, E. (2000) Global-scale patterns of forest fragmentation. *Conservation Ecology* **4**(2): 3-4.
- Wade, T.G.; Riitters, K.H.; Wickham, J.D. & Jones, K.B. (2003) Distribution and causes of global forest fragmentation. *Conservation Ecology* **7**(2): 7-8.

### Interrelation of geosystem formative factors at the biosphere level

Y.G. Puzachenko<sup>1</sup>, A.G. Sankovski.<sup>2</sup>, E.V. Siunova<sup>1</sup>, D.N. Kozlov<sup>1</sup>

1 – A.N. Severtsov Institute of Ecology and Evolution RAS, 119071 RF Moscow,  
Leninsky prospect 33,  
e-mail:puzak@orc.ru

2 – ICF Consulting, USA, Washington

Land cover is a term widely used during last decade in world practice to mean reflection of earth surface biophysical properties through multispectral remote sensing systems and images. The term is certainly close to landscape but the difference is that land cover is oriented to those properties which can be observed and measured by remote sensing means whereas landscape in any interpretation is connected with models of spatial-temporal dynamics of processes. The term landscape cover in this context is a projection of observed and measured in the geosphere at various scales and directly and involves primary properties of the biosphere. The latter fact is determined by the leading role of remote sensing data in landscape cover research. The most important functional property of biosphere, it is biological productivity – reflected by the Normalized Difference Vegetation Index (NDVI). The seasonal change of index is widely used in creating global maps of landscape cover – e.g. Land Cover Map 2000, Department for Environment, Food and Rural Affairs, NASA's Terra Satellite Refines Map of Global Land Cover, NASA's Earth Observatory etc. It is clear that spatial variation of biological productivity and land cover structure are functions of climatic variables, surface elevation and their associated morphometric properties, and soil forming rocks. The contribution of these variables to biological productivity can be various and non-additive. Detaching integral factors which determine spatial variation of biosphere properties can improve the understanding of landscape function. The hypothesis of univocal ratio of biosphere features and external variables is correct only for equilibrium conditions of the whole global system. There is good reason to believe that inertia of vegetation types can affect equilibrium relation with rapidly changing climate. The degree of this affect can be assessed.

Grid maps with 0.5° x 0.5° resolution of NDVI, NPP, vegetation cover, climate and relief (New, 2002, ISLSCP, 2004) allow the realization of this assessment. Besides soil databases (FAO) enable the assessment of the terrestrial carbon stock throughout the world. Using the ratio of biological productivity, climate and relief variables and carbon stock we can assess important parameters of the carbon circle in the terrestrial biosphere. We have also found reliable data about carbon stock in Russia bogs and have included them into our analysis.

Linear relations of hydrothermal mode (eight types of variables), NDVI, relief (four variables), seasonal and permafrost, NPP have been analysed by factor analysis. Six external factors were determined that influence the general characteristic of the biosphere - NPP ( $R^2=88\%$ ). We also illustrate in our report the extent of soil carbon stock and development of bogs in the northern hemisphere. We have also considered the degree of equilibrium between landscape cover types and external variables. On this basis we determine areas with non-equilibrium state (approx 20% of dry land) which are expected to rapidly modify its land cover

The research was supported by RFBR projects ## №03-05-64280, 01-05-06012

#### References

- The International Satellite Land-Surface Climatology Project (ISLSCP) (2004)** Retrieved from: <http://islsdp2.sesda.com>
- New M., D. Lister, M. Hulme, I. Makin. (2002)** A high-resolution data set of surface climate over global land areas. *Climate Research, Vol.21. p. 1-25*

## Climatic factors and the development of bogs in northern Eurasia

M.V. Fedyaeva<sup>1</sup>, D.N. Kozlov<sup>1</sup>, Y.G. Puzachenko<sup>2</sup>

<sup>1</sup> Lomonosov Moscow State University Faculty of Geography, 119899, Moscow, Leninskiye Gory 1, Russia, e-mail: danilko@nm.ru

<sup>2</sup> A.N. Severtsov Institute of Ecology and Evolution RAS, 119071, Moscow, Leninsky prospect 33, Russia

All variations in the development of bogs are excellent examples of landscape evolution. Having begun approximately 6000 years ago, bogs have shown phenomenally stable growth. They have steadily covered gently sloping surfaces. Climatic control of the distribution of peatlands and boggy forests are without doubt. At the same time reliable estimates of their climatic ecological niche are not known. Peatlands cadastral data from the European part of Russia, Archangelsk and Komi region, Western Siberia, combined with high-resolution grids of monthly climate for the global land surface (New, 2002) and digital elevation models create the necessary tools for the execution of this task.

Total peatland area, mean and maximum depth, carbon stock and peat ash value have been calculated for grid units of 1x1°. Analysis showed that each peatland variable has non-linear relations with monthly temperatures, precipitation and the hydrothermal index. Only ash-content grows with the temperature increase and precipitation decrease. Comparing R-squared for partial parabolic functions we can see that leading role in the development of bogs belongs to the hydrothermal index in May, August and September. There is a joint influence of temperature and precipitation influences on bog development in July.

As a whole, general properties of peatlands are determined by a non-linear dependency on temperature and precipitation in spring and winter months. Summer climate plays a small but independent role. To build a general statistical model, we can calculate two-dimensional dependences between peat density and temperature and precipitation. Then we add to this model independent variables – elevation and slope of surface. Apparently, peatlands are not especially typical high or low altitudes. The next independent variable added to the model is slope. Finally, the statistical model describes 62% of peatland carbon stock variation with a standard error of estimate 3.8 g/m<sup>2</sup>. Spatial variation of peatland area and peat depth is described by the same dependency type but with other parameters. We should note that the statistical model does not account the initiation of bog development and it is assumed that all peatlands have equal age. On the one hand this degrades model quality but on the other hand it shows that age of peatlands of this extensive region is rather equal.

Thus, the carbon accumulation rate is a function of climate and relief. The optimum for development is a May temperature +2.5°C and 36 mm of precipitation, June – +11°C and 40 mm, July – +15°C and does not depend on precipitation amount, August – +12°C and 54 mm, September – +5°C and 44 mm. However, the leading role belongs to hydrothermal patterns in spring and autumn. Thus, active period of bog, its growth and borders strongly depends on the spring climate. Autumn determines the growth rate and summer climate plays a minor role in peat accumulation.

We believe that peatlands began to form in the warm period in the Holocene, which caused an increase in precipitation and an extension of the vegetative period. The peatlands of the boreal forest zone are sustainable under modern climate changes as Sphagnum has a low sensitivity to summer and winter climate.

The research is made with support of RFBR project №05-05-64706-a.

### References

New M., Lister D., Hulme M., Makin I. (2002). A high-resolution data set of surface climate over global land areas. *Climate Research*, Vol.21. p. 1-25.

**Long term trends in landscape patterns on high-diverse marine benthic communities  
in the NW Mediterranean Sea**

**N. Teixidó, J. Garrabou, J.G. Harmelin**

Centre d'Océanologie de Marseille, Université de la Méditerranée, CNRS - UMR 6540  
DIMAR, Station Marine d'Endoume, Rue de la Batterie des Lions  
13007 Marseille, France.  
e-mail: teixido@com.univ-mrs.fr

Long-term data series in marine ecosystems are scarce. This study focuses on Mediterranean rocky benthic communities dwelling in dimly lit habitats in the north-western Mediterranean Sea. These marine communities are highly diversified and structured and they are mainly dominated by long-lived species. The aim of this study is to understand the ecological structure and dynamics over long-term period of these Mediterranean communities, which are considered particularly sensitive to global climate change. To achieve this goal this study analyzed underwater photographs using techniques from the field of landscape ecology. We analyzed a total of 130 permanent plots from three long-term photographic series monitored yearly in two study areas: the Medes Island (Catalan coast, NE Spain) and Riou Archipelago (Provence coast, SE France). We examined different measurements of landscape indices to describe changes in structural and dynamic patterns over long term. The integration of Landscape ecology to this long-term trajectory of marine communities provides a powerful tool to explain global patterns.

## Impacts of climate change on the landscapes and human vulnerability of arid central Asia

E. Lioubimtseva

Geography and Planning Department, Grand Valley State University, 1 Campus Drive,  
Allendale, MI 49428, USA  
e-mail:lioubime@gvsu.edu

### Introduction

Countries of Central Asia (Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan and Tajikistan) have experienced an accelerating warming trend and dramatic land-use and land-cover changes over recent decades. Climate change modelling scenarios provide useful information about potential implications of climate change under various socio-economic pathways at the macro-regional scale. Significant changes in the regional temperature and precipitation regimes and vegetation cover have been recorded by the meteorological and remote sensing data series.

### Methods

Factors defining vulnerability and adaptations to climate change include both biophysical and socio-economic variables. Our assessment of the recent impacts of climate change on the landscapes and human vulnerability of arid Central Asia is based on the analyses of satellite imagery from the Pathfinder Advanced Very High Resolution Radiometer (AVHRR) Land dataset since 1981, as well meteorological station data, agricultural statistics, demographic and economic data, and health statistics.

Using the scenarios from four General Circulations Models (ECHAM4, HADCM3, GFDL-R30, and CGCM3) for this region under four possible socio-economic "storylines" developed by the International Panel on Climate Change (A1, A2, B1 and B2) and the national socio-economic data we then explore the potential future role of climate change as well the anticipated land-use changes for the human vulnerability of Central Asia.

### Conclusions

The landscape-scale mapping provides a very useful framework for assessing how two key areas of human vulnerability, such as agriculture and human health might respond to climate change under different regional climate change scenarios in the context of different socio-economic and land-use changes.

## Theme 9: Concepts for Landscape Planning and Design





## 9.1 Symposium 17: The Scientific Basis of Design for Landscape Sustainability

### Science as a mediator: facilitating a negotiation process between stakeholders on corridor planning

B.J.H. Koolstra<sup>1,2</sup>, C.C. Vos<sup>1</sup>, E.G. Steingröver<sup>1</sup>

<sup>1</sup> Alterra Green World Research, Box 47 , 6700AA Wageningen, The Netherlands

<sup>2</sup> Arcadis, PO-box 63, NL-9400 AB Assen, The Netherlands.

e-mail: b.j.h.koolstra@arcadis.nl

#### Introduction

When planning an ecological corridor, both ecological knowledge on the functioning of corridors and local knowledge of the local situation is needed. Quite often the planners and local stakeholders lack the specific ecological knowledge needed to create an ecological corridor which will be effective. On the other hand it is impossible for an ecological expert to design a corridor without specific knowledge of the local situation. And sometimes the local stakeholders, e.g. the local government and nature conservation organisations, have different opinions on how the corridor should be designed. These factors have to be taken into account for each ecological corridor, but especially so when creating a corridor in an urbanised area.

#### Cooperation

##### The need for cooperation

The above makes clear that cooperation of scientists and local stakeholders is needed to design an effective corridor. If a scientist would design a ecological corridor without specific knowledge of the local situation, the design will probably be impossible to realise due to local factors. These factors can be other spatial plans in the area, opposition by local stakeholders, different opinions between local stakeholders on the way the corridor should be designed. To cope with this problem, the practise is quite often that local stakeholders adapt the design of a corridor to "fit it in", and thereby change the ecological parameters, without consulting the scientist who created the design.

##### An interactive approach

We have a growing experience with an interactive approach of the design process which proves to be very effective. In this process we provide –based on scientific research, expert knowledge and wishes of the stakeholders- the ecological parameters for the design of the corridor. This includes figures on the dimensions of the corridor (width and maximum length), the need for stepping stones and the types of habitat in the corridor. Usually a number of alternatives are created. The local stakeholders provide the information on the local situation, like land use, other plans and projects in the area, and so on. The confrontation of the ecological demands and the local situation finds place in a workshop. The ecological demands for the corridor (width, size of stepping stones, types of habitat etc.) are used as fixed parameters..

#### Planning process

The local stakeholders use these parameters to design a number of alternative designs of the corridor on maps or aerial photos. The ecological expert present at the workshop will do nothing more than check if the ecological parameters are implemented correctly and facilitate the negotiation process between the stakeholders. Because the basics are set and (in

principle) non-negotiable the discussion focuses on the implementation (“fitting in the corridor in the existing landscape”) and not on the starting points. Furthermore, if the basics are changed, the effects on the corridor (e.g. the corridor will function for less species) will be clear immediately. This way the creation process is clear, transparent and reproducible.

### Example: the municipality of Tilburg

#### Setting

Tilburg, in the southern part of the Netherlands, is a quickly expanding city surrounded by city's which are also growing rapidly. To prevent the permanent destruction of existing ecological relations by the growing cities, Tilburg decided to create a “Groene Mal” (Green Mould) around the city. The “Groene Mal” will function as an ecological corridor wich allows the species to migrate around the city. Part of the “Groene Mal” goes between the main part of Tilburg and the outskirt “Reeshof”.

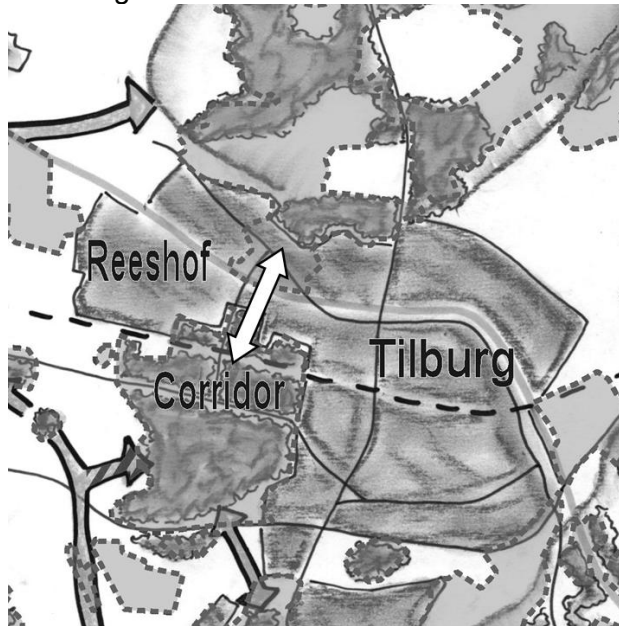


Figure 1. Tilburg, Reeshof and the location of the corridor

#### Problem

The planned location for the corridor houses at the moment a large number of different functions, like a cemetery, allotment gardens, gardening centre, a school and a police station. This means that to fit the corridor in, changes to the current land use must be made. The stake holders have different opinions on how to solve this problem.

#### Solution

The workshop resulted in two different designs of the corridor zone. Both designs meant a large change in the current land use. Because the ecological parameters were fixed, the stakeholders had to discuss how to fit it in, and could not solve the problem by minimising the ecological parameters of the corridor.

#### Outcome

The city-counsel of Tilburg found the changes in the current land use unacceptable and decided to look for a different solution of the problem. With a different “old style”- approach, the ecological parameters of the corridor probably would have been changed to fit it in. That way a non-functioning corridor would have been created.

## Influencing landscape trajectories through alternative futures analyses

D.W. Hulse<sup>1</sup>, A. Branscomb<sup>2</sup>, C. Enright<sup>1</sup>

<sup>1</sup> Department of Landscape Architecture, 5234 University of Oregon, Eugene, OR. USA  
e-mail: dhulse@uoregon.edu

<sup>2</sup> Institute for a Sustainable Environment, University of Oregon, Eugene, OR. USA 97403.

### Introduction

Scenario-based investigations are being used to explore alternative future courses of action in a widening array of situations (Busch 2006, Hulse *et. al.*, 2004, Van Dijk 2003, Carpenter 2002, Robinson 2003, Meadows 2003). Anticipating patterns of land and water use, and the human values that create these patterns, are recurring needs in such investigations. While scenario-based approaches to these needs vary with each project's purpose, there are four common steps: 1) defining future scenario assumptions, 2) depicting spatially explicit alternatives through land and water allocation modeling using parameters from scenario assumptions, 3) modeling the effects of alternative land use and land cover change trajectories on key natural and cultural resources, and 4) producing synthesis products which characterize the differences between the alternatives. While it is accepted that how scenario assumptions are framed and who frames them matters (Shearer 2005), the sensitivity of resulting trajectories to contrasting scenario framing processes is rarely tested.

Using the same study area and comparable scenarios, we contrast the land use and land cover change trajectories produced from two distinct approaches to defining and modeling scenario assumptions: the first using lay citizen groups and deterministic land allocation modeling, the second using experts from the biophysical and social sciences and agent-based modeling. Future land and water use scenarios are defined and mapped for the year 2050 in western Oregon's Willamette River basin along a gradient of conservation-oriented to development-oriented assumptions using first citizen-based and then expert-based approaches. The landscape variability and trajectories for the citizen-based Conservation 2050 and Development 2050 scenarios are then characterized and compared with the landscape variability and trajectories of the expert-based Conservation 2050 and Development 2050 scenarios. Results identify those portions of the landscape whose trajectories from 2000 to 2050 always vary regardless of approach or scenario, and those that never vary, regardless of approach or scenario. Policy influence on future landscape trajectories is illustrated using agent-based model results where land conversion serves both wealth production and ecosystem function purposes. Agent-based model results depict areas with strongest coupling between policy and landscape trajectory as those places that experience the same pattern of landscape change over time, regardless of scenario.

Our conclusions are organized into three types of lessons: 1) lessons from comparing the expert-driven agent-based modeling with the citizen-driven deterministic modeling; 2) lessons regarding strength of coupling between landscape trajectories and policies, and 3) lessons regarding the avoidance of scarcity.

### A Typology of Scenario Studies and the uses of trajectory

The reasons people engage in scenario studies vary widely, and these reasons influence how they go about the work. Liu *et. al.* (in prep) diagram a typology of approaches with three broad types: *strategic*, *exploratory*, and *anticipatory*. They argue that *strategic scenarios* are of interest to modelers and researchers and are aimed at identifying inconsistencies in the approaches used by different disciplines to describe components of a complex system under study. The emphasis of strategic scenarios is on making explicit the assumptions, patterns, and data selected by each involved discipline. *Exploratory scenarios* characterize the future according to known processes of change and extrapolations from the past (McCarthy *et al.*, 2001), while *anticipatory scenarios* are based on different desired or feared visions of the

future that may be achievable or avoidable if certain events or actions take place. Anticipatory scenarios make use of past and possible future conditions in their construction, sometimes with high subjectivity (Godet and Roubelat, 1996; McCarthy et al., 2001).

Trajectory is a concept relevant to all three types of scenarios. As used here a *landscape trajectory* is a change in land use and land cover emerging from interactions among biophysical and human cultural processes over space and time. A trajectory is evident through observable change of patterns at discrete grain, extent, frequency and duration. The particular patterns of land use and cover observed in an alternative future are influenced by many things, but foremost among them are the design and planning processes of defining scenario assumptions and the approach taken to modeling the connection between these assumptions and corresponding changes in land use and land cover. Where the focus is on anticipating trajectories of change caused by human use of land and water, scenario-based approaches provide a framework for effectively incorporating science into a community-based decision-making process.

### References

- Busch, G. (2006)** Future European agricultural landscapes – What can we learn from existing quantitative land use scenario studies? *Agriculture, Ecosystems and Environment*. **114** 121-140.
- Carpenter, S. R. (2002)** Ecological futures: building an ecology of the long now. *Ecology*. **83** 2069-2083.
- Godet, M., Roubelat, F., (1996)** Creating the future: The use and misuse of scenarios. *Long Range Planning* **29** 164-171.
- Hulse, D.W., A. Branscomb, S. Payne. (2004)** Envisioning alternatives: Using citizen guidance to map future land and water use. *Ecological Applications*. **14** (2) 325-341.
- Liu, Y., M. Mahmoud, H. Hartmann, S. Stewart, T. Wagener, D. Semmens, R. Stewart, H. Gupta, D. Dominguez, D. Hulse, R. Letcher, B. Rashleigh, C. Smith, R. Street, J. Ticehurst, M. Twery, H. van Delden, R. Waldick, D. White, L. Winter. (In prep.)** Towards a formal scenario development approach for environmental impact assessment studies.
- McCarthy, J. J., Canziani, O. F., Leary, N. A., Dokken, D. J., White, K. S., (2001)** Climate Change 2001: Impacts, Adaptation and Vulnerability. In: *Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press: Cambridge.
- Meadows, M.E. (2003)** Soil erosion in the Swartland, Western Cape province, South Africa: implications of past and present policy and practice. *Environmental Science and Policy* **6** (1)17-28.
- Robinson, J. (2003)** Future subjunctive: backcasting as social learning. *Futures*. **35** 839-956.
- Shearer, A. W. (2005)** Approaching scenario-based studies: three perceptions about the future and considerations for landscape planning. *Environment and Planning B: Planning and Design*. **32** 67-87.
- Van Dijk, T. (2003)** Scenarios of Central Europe land fragmentation. *Land Use Policy* **20** (2) 149-158.

**Does conservation need landscape ecology? Does landscape ecology need conservation?**

**J.A. Wiens**

The Nature Conservancy, 4245 North Fairfax Drive, Arlington VA, 22203, USA.  
e-mail: [jwiens@tnc.org](mailto:jwiens@tnc.org)

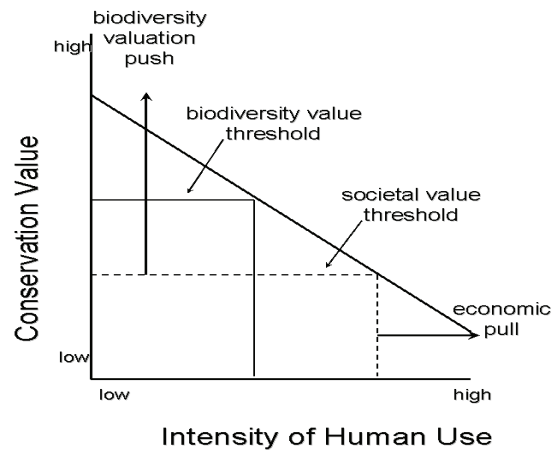
This paper is a contribution to a symposium on design for landscape sustainability. So it is appropriate to ask what we mean by “design of sustainable landscapes” in the context of conservation. Simply stated, design of sustainable landscapes is about *the creation and management of a landscape composition and configuration that ensure the persistence of biological diversity*.

How should this be done? How can the discipline of landscape ecology inform conservation practice to achieve this goal? When all is said and done, conservation is about protecting the places that plants and animals need to survive. This has generally been accomplished by setting aside protected areas – parks, nature preserves, wildlife refuges, wilderness areas, marine protected areas, and the like. The impetus to establish protected areas for conservation has gained global emphasis from the Convention on Biological Diversity, which mandates that signatory countries will place 10% of each of the World’s ecological regions under conservation protection by 2010.

Protected areas are often treated as if they were islands in a sea of otherwise hostile and inhospitable habitat (as in some cases they are). The analogy with islands has been encouraged by the appeal and seeming relevance of island biogeography theory, which has both facilitated and stifled the burgeoning enterprise of reserve design. But protected areas are *not* islands of habitat separated from their surroundings, no matter how different those surroundings may be. If landscape ecology tells us anything, it is that the elements of a landscape are interconnected, that the context of an area affect what goes on within that area, and (from a conservation perspective) the conservation value of a protected area is contingent on its surroundings.

Conservation practitioners know all of this, at some level. Increasingly, conservationists recognize that protected areas alone will not suffice to address the looming loss of global biodiversity, and conservation actions are being implemented at broader scales than that of protected areas alone. The reality of heterogeneous landscape mosaics is acknowledged, and the focus is gradually being expanded to encompass areas outside the boundaries of the protected areas. These, of course, are the places where people live and work, where human activities create and alter the landscape context of the protected areas. There is an unfortunate tendency to regard these as the places where biodiversity and people come into conflict, and human uses of the landscape are often regarded as a threat to biodiversity. Indeed, habitat loss and fragmentation are widely deemed to be the preeminent causes of declining species populations and biodiversity loss. The response is often a “circle the wagons” approach to reserve design, to build a wall (not always figuratively) that buffers the reserve from the “eternal external threat” of human land use.

But the World is not black-and-white, and not all land uses are incompatible with conservation. Instead, land uses are arrayed across a spectrum of differing intensities and potential impacts to biodiversity (Figure 1). In general, the “conservation value” of an area or landscape (i.e., its capacity to support the native biodiversity of an area in a sustainable fashion)



**Figure 1.** The relationship between the intensity of human use of an area or landscape in relation to the conservation value (biodiversity protection) of that area or landscape.

declines as the intensity of human use in the landscape increases. As shown in Figure 1, there may be a threshold of land-use intensity beyond which the biodiversity value slips below some acceptable level to maintain a functioning natural ecosystem (the biodiversity value threshold). Society may be willing to accept further diminishment in conservation value in the interests of increased intensity of human use (the societal value threshold). Economic forces and incentives tend to pull the societal value threshold to lower levels of conservation value, while efforts to enhance biodiversity value (i.e., most conservation work) aim to push the biodiversity value threshold higher by reducing the intensity of human land use.

So conservation needs landscape ecology to understand how to deal with the complex reality outside of protected areas, to determine how to assess the compatibility of human land uses with biodiversity protection, and to develop landscape-level management approaches that can balance the needs of native biota with those of the people who share the landscape. What can conservation contribute to landscape ecology? First, as conservation moves to link biodiversity protection with human activities, it is creating a new framework for understanding and managing landscapes, a framework that broadens the domain and relevance of “traditional” landscape ecology. Landscape ecologists will have new questions to address, and a new constituency asking the questions. Second, conservation is firmly rooted in the ecological sciences that have been the foundation of North American landscape ecology, but it also encompasses the social and humanistic approaches that have long been the underpinnings of a good deal of European landscape ecology. Conservation may provide the catalyst to bring these approaches together and to foster the emergence of a unified discipline of landscape ecology, something long talked about but yet to be realized.

**Restoration in the city: insights into the rewilding and recultivating phenomena in the Twin Cities, Minnesota, U.S.A.**

**L. R. Musacchio**

Department of Landscape Architecture, University of Minnesota, 89 Church St. SE,  
Minneapolis, MN, 55455, U.S.A.  
e-mail: musac003@umn.edu

The purpose of my presentation is to explore the conceptual basis for the rewilding and recultivating phenomena, which is a part of my study of human-vegetation interactions in conservation design projects in the Twin Cities, Minnesota, U.S.A. First, I will explain why these projects have more to teach us about new theories of emergent landscape systems and patterns than what meets the eye. I will explore how the emphasis in landscape science on the protection of large patches over small ones and the emphasis of geographic information science on large-scale land use and land cover phenomena are limiting our understanding of the emergent qualities of landscape change. In a nutshell, my research is one of many studies that try to answer this question: Why do people go to all the trouble to protect and restore small places in their city or region when ecologists emphasize the “bigger is better” approach? This incongruity between local and scientific knowledge seems to be an important gap in current theories and approaches of land use and land cover change in the U.S.A., which largely focus on natural landscapes outside metropolitan statistical areas (metro areas). This disparity is reinforced by much of the ecological literature in the U.S.A. that emphasizes the conservation of very large patches over small patches in human-dominated environments even though most metro areas have only remnant bits of habitat available for open space systems (Forsyth and Musacchio, 2005).

**What is Conservation Design?**

In the United States, conservation design in metro areas has these characteristics:

1. Mitigates the negative effects and impacts of urbanization on a region’s ecosystems;
2. Uses an integrative process that draws on knowledge from the ecological and social sciences as well as knowledge of ecoregions, places, and local cultures;
3. Emphasizes spatially-based solutions that support more sustainable human behaviors, values, and practices toward vegetation, hydrology, and biodiversity;
4. May include a strong community-based stewardship approach with important volunteer efforts of local citizens; and
5. Promotes environmental values based on the healing of land and human relationships.

These projects enhance human-nature relationships by allowing people to actively participate in the recovery of a place that is perceived to be derelict, such as a weedy vacant lot. By working with plants, participants’ understanding about the connection between ecological function (e.g., seasonal changes and pollination) and urban landscapes are changed. In my study, I examine two types of conservation design in center cities: the *rewilding the city* as the protection and restoration of remnant habitats and the *recultivating the city* as the establishment of community gardens. In the Twin Cities, these projects are often small areas of less than 10 hectares (25 acres), but they occur with high frequency across Minneapolis and St. Paul and are sometimes embedded in a much larger greenway or park system. Another characteristic that differentiates these places from other small open spaces and parks is that they typically receive more human attention and care, especially if a community-based stewardship approach is used to manage and monitor vegetation succession. As an emergent landscape pattern across a metro area, I hypothesize conservation design projects represent intense areas of vegetation change that can potentially cause major shifts in the larger urban landscape if these practices are adopted and formalized into institutional and



governmental decision making. The major idea is small changes can have major effects upward in scale (Gunderson *et al.*, 1995), which is a well known idea in landscape science and has been applied to many ecosystem types, but not to urban ecosystems.

### **Bigger is Better in Landscape Science**

In landscape science, studies have shown large patches capture a wider diversity of plant and animal species and by logical extension, large patches should be the backbone of conservation plans. Yet, many of these studies of human-dominated environments have focused on natural landscapes outside metro areas, which are not heavily populated by humans; even though these landscapes are described as human-dominated in the ecological sciences. Moreover, these studies draw on theories of human-vegetation relationships that are strongly influenced by plant ecology, which emphasizes population, community, and ecosystem changes in species patterns and interactions. Despite the importance of plant ecology, this branch of ecology is probably not robust enough to fully explain the unique human-vegetation interactions that occur in rewilding and recultivating cities as emergent landscape patterns in vegetation succession. The complexity of ecological and social interactions that is concentrated in these small patches calls for a fresh look at vegetation succession models based on new approaches in urban ecology that can explain these landscape change dynamics.

### **Geographic Information Science and Land Use and Land Cover Phenomena**

Geographic information science provides insights about land use and land cover changes over large areas that are beyond ordinary human perception and experience. These tools have been integrated into land use and land cover change models that grow more and more sophisticated. However, these tools and models have a number of limitations for explaining the human-vegetation interactions in conservation design projects. The issues revolve around the coarse grain at which land use and land cover change is detected, which is related to minimum mapping units and sensor pixel size. Other issues are focused on the conceptual basis of human-vegetation interactions with people treated abstractly as agents of change and with human perception and cultural practices reduced to boxes and arrows in land use and land cover change models.

### **Conclusion: Emergent Landscape Change in Metropolitan Regions**

The rewilding and recultivating of cities represents an important link among geographic space, sustainability, landscape health, and quality of life issues. These phenomena are a type of emergent landscape change that have received little attention as an explanation for land use and land cover change in metro areas. The distributed nature and small areas of these phenomena explain why ecologists have not paid much attention. Another explanation is that these projects are about design, which is considered to be applied. However, urban ecologists are beginning to provide evidence that human design of the environment is an underestimated force in the emergent properties of urban landscapes and that sustainable landscape practices, such as rewilding and recultivating cities, will be an important physical manifestation of intangible concepts like sustainability and ecosystem health.

### **References**

- Forsyth, A. and L. Musacchio. (2005).** Designing Small Parks: A Manual for Addressing Social and Ecological Concerns. John Wiley & Sons, New York.
- Gunderson, L.H., Holling, C.S. & Light, S.S. (1995).** Barriers and Bridges to the Renewal of Ecosystems and Institutions. Columbia University Press, New York.

## Knowledge transfer from landscape science to practice and back: the role of design as an interface

P. Opdam<sup>1</sup> and J.Iverson Nassauer<sup>2</sup>.

<sup>1</sup> Wageningen University, Department of Land use planning and Alterra, PO box 46, 6700 AA Wageningen NL.

e-mail: paul.opdam@wur.nl

<sup>2</sup> School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI 48109-1041, USA.

### Introduction

It is widely recognized that scientific knowledge on landscape pattern and process is poorly transferred to planning practice. Probably the main reason for this phenomenon is that scientists and practitioners follow a *linear model* of knowledge transfer, in which scientists write papers and reports, or develop decision support systems, and expect practitioners to use these. However, such knowledge might be unsuitable for a variety of reasons:

- the information is too generic for application in a specific context, for example there is no spatial relationship between a landscape function and a landscape pattern;
- the scientific information was gathered in a context different from the case in which it needs to be applied, for example information in natural landscapes can not be transferred to rural or urban landscapes;
- the information includes normative choices, for example if guidelines for landscape design are implicitly based on nature conservation values set by the researcher;
- the information is too rigid to be applied in negotiation processes, for example if only one solution can be based on it.

In this paper we explore the various pitfalls in knowledge transfer between science and practice, and propose a cyclic model of interactive knowledge production, in which practice is incorporated into the scientific arena. We built this idea on our experience with incorporating ecological knowledge into landscape planning.

### Ecological knowledge in landscape planning

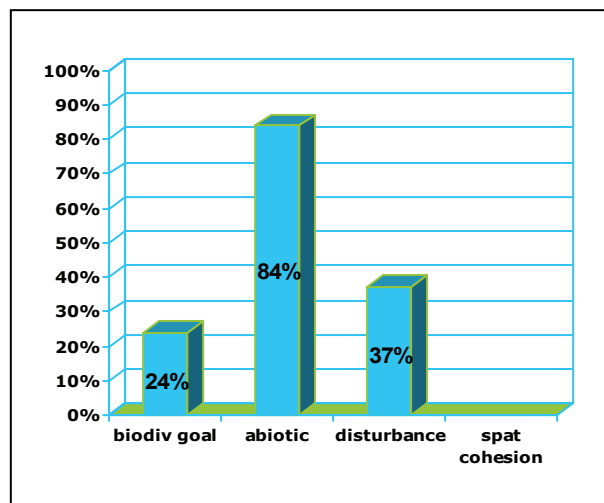
Humans enjoy landscapes for their beauty and derive cultural values from them, they use landscapes to earn money from products and services, and, last but not least, their physical living environment depends on the ecological functioning of the mosaic of ecosystems that constitute the landscape system. Hence, in connection to their evolving needs, humans change landscape use and structure. Where many user interests coincide and compete, a variety of stakeholders is involved in decision making. The process of planning and design of landscapes is not straightforward and linear, but is part of a complex and cyclic negotiation process. For example, an initially preferred biodiversity goal may appear not being achievable further on in the process. Modern strategic spatial planning facilitates the communication between, and collaboration of stakeholders and shareholder groups. All the way through this negotiation, both landscape services and required environmental and spatial conditions are shifted up and down between the preferred and the minimum acceptable level. During this process, their functional relationship must be kept. For example, if it is decided for less space for natural ecosystems, targeted levels of species diversity must also be lowered.

To be applicable in a negotiation process, scientific information needs to be based on spatially explicit relations between a quality indicator for a landscape service and quantitative features of the ecosystem pattern. Also, the information must be suitable to generate alternative solutions and allow actors to shift between levels of ambition and levels of scale. The theory of ecosystem networks provides a number of examples to illustrate these claims.

## Knowledge production includes applications in practice

We show how spatial designs of ecosystem networks (developed in a close interaction between science and practice) played a key role in the cooperation between science and practice. We will illustrate how such designs allowed stakeholder involvement, how designs invoked the transformation of scientific knowledge for decision-making, and how they generated new scientific research. It leads us to propose a *cyclic model* of knowledge production, in which knowledge is produced in a process of co-evolution rather than by unidirectional transfer. In this model, application of scientific knowledge in practical cases by scientists and practitioners together is an essential step.

We conclude that a common landscape design based on scientific concepts is a strong mediator in cooperative knowledge transfer. A commonly design promotes the convergence and integration of scientific knowledge of different disciplines; it invokes the development of critical thresholds and exerts a strong role in communication of scientific principles. Also, it can be regarded as a scientific hypothesis, generating a new series of hypothesis.



**Figure 1.** Quantification of knowledge gap between landscape ecology and application in regional spatial planning. Percentage of plans (n=38) using explicit knowledge in nature goal setting and ecosystem pattern design (based on Termorshuizen et al. 2007).

## References

- Azerrad, J. M. & Nilon, C.H., 2006.** An evaluation of agency conservation guidelines to better address planning efforts by local government. *Landscape and Urban Planning* **77**:255-262.
- Opdam, P., Steingröver, E. & Rooij, S. van, 2006.** Ecological Networks: a spatial concept for multi-actor planning of sustainable landscapes. *Landscape and Urban Planning* **75**:322-332.
- Pullin, A. S., Knight, T. M., Stone, D. A. & Charman, K., 2004.** Do conservation managers use scientific evidence to support their decision-making? *Biological Conservation* **119**:245-252.
- Vos, C., Opdam, P., Steingröver, E. & Reijnen, R., 2007.** Transferring ecological knowledge into landscape planning: a design method for ecological corridors. In J. WU and R. Hobbs, editors, *Key topics and perspectives in landscape ecology*. Landscape ecology series, Cambridge University Press, New York. (in press)
- Termorshuizen, J., Opdam, P., & Brink, A. van den, 2007.** Incorporating ecological sustainability in landscape planning. *Landscape and Urban Planning* (available on line).

## Landscape ecology and design principles for sustainability

J. Wu

School of Life Sciences & Global Institute of Sustainability, Arizona State University, P.O.  
Box 874501, Tempe, AZ 85287-4501, USA.  
e-mail: Jingle.Wu@asu.edu

As humans have just transformed themselves from a predominantly agrarian to urban species, the world has become an increasingly planned and designed place. However, instead of improving the global environment, the increasingly designed and planned planet is met with an increasing number of problems. The world is highly fragmented ecologically, economically, and sociopolitically. This multifaceted fragmentation has resulted in accelerated biodiversity loss, ecosystem degradation, economic inequity, and social instability. These problems pose unprecedented challenges that humanity must deal with in order to sustain the biosphere and *Homo sapiens* itself.

I see two important implications from the current trend with global urbanization. First, as more urban areas are developed to accommodate increasing urban populations, the world will become inevitably more “designed”. Second, while cities have played an instrumental role in human civilization as centers of cultural, economic, and scientific endeavours, they also are a major source for a myriad of environmental problems. This means that our design principles for cities as well as rural and natural areas have serious problems. Undoubtedly, the rapidly growing population will continue to increase its resource consumption and thus its ecological footprint. To achieve long-term sustainability of any region or the entire world, human activities must be constrained by sound planning and design principles at the local, regional, and even global scale. It seems evident that, to live with nature harmoniously, we cannot just wait for nature to tell us what to do (nature does not know best!); instead, humans must make proactive decisions: implement design and planning actions across all scales. From this perspective, considering the world as a global “landscape” to emphasize the relationship between its spatial configuration and functionality is probably more fruitful than a global “ecosystem” that is the whole of spatially implicit interacting parts.

Landscape ecology is the science and art of studying and influencing the relationship between spatial pattern and ecological processes on different scales (Wu and Hobbs, 2007). It is intuitive and logical that landscape ecology should play a critically important role in developing better design and planning principles for achieving sustainability on all scales. There are several reasons for this. First, the human landscape (or region) may be considered as a basic spatial unit for studying sustainability. Second, landscape ecology provides a hierarchical and integrative ecological basis for dealing with issues of biodiversity and ecosystem functioning. Third, landscape ecology has developed holistic and humanistic approaches to studying nature-society interactions (e.g., Zonneveld 1972, 1995, Naveh and Lieberman 1984). Fourth, landscape ecology offers theory and methods for studying the effects of spatial heterogeneity on sustainability. Fifth, to develop a rigorous science of sustainability, methods and metrics in landscape ecology can be used to quantify sustainability. Sixth, landscape ecology provides both methodological tools for dealing with scaling and uncertainty issues fundamental to most nature-society interactions.

To help develop better design principles for sustainability on various scales, landscape ecology need to be integrated with landscape architecture (Ahern 2005) and the emerging sustainability science which is a new transdisciplinary science that focuses on the dynamic relations between nature and society on local, regional, and global scales (National Research Council 1999, Kates et al. 2001, Clark and Dickson 2003, Parris and Kates 2003). Because the essence of sustainable development is meeting fundamental human needs while conserving the life-support systems of the earth (Kates et al. 2001), any planning and design principles that do not explicitly consider humans are inadequate. Here I explore several issues that may help this integration:

Sustainability requires spatial planning and design so that core areas for biodiversity conservation and human resource use can be properly delineated and holistically managed. All design and planning principles should consider the environmental, economic, and social dimensions of sustainability simultaneously.

Design principles may differ significantly at different scales (e.g., neighbourhood, local community, landscape, region, nation) because factors that determine spatial pattern and its amiability to designing and planning change with scale.

Design and planning principles need to explicitly incorporate change and uncertainty instead of relying on assumptions of stability and predictability, emphasize functional resilience instead of centering on structural aesthetics, and promote placed-based, solution-driven research instead of dwelling on hypothetical landscapes that generate intriguing but unrealistic questions.

Contrary to the traditional way of ecological thinking, urbanization based on ecologically, economically and socially sound principles may be a solution rather than a barrier to achieving regional and global sustainability because maximally concentrating humans and their activities seems essential to biodiversity conservation and ecosystem management.

Landscapes and regions may represent the most operational scales for planning and design practices for sustainability.

Sustainability measures must be developed and used to assess the effectiveness of design and planning principles and projects.

## **References**

- Ahern, J. 2005.** Integration of landscape ecology and landscape architecture: an evolutionary and reciprocal process. Pages 311-319 in J. A. Wiens and M. R. Moss, editors. *Issues and Perspectives in Landscape Ecology*. Cambridge University Press.
- Clark, W. C. and N. M. Dickson. 2003.** Sustainability science: The emerging research program. *Proceedings of the National Academy of Sciences (USA)* 100:8059-8061.
- Kates, R. W., Clark, W. C., Corell, R., Hall, J. M., Jaeger, C. C., Lowe, I., McCarthy, J. J., Schellnhuber, H. J., Bolin, B., Dickson, N. M., et al. 2001.** Sustainability Science. *Science* 292:641-642.
- National Research Council (Board on Sustainable Development). 1999.** *Our Common Journey: A Transition Toward Sustainability*, National Academy Press, Washington D.C. ([www.un.org/millennium/sg/report/full.htm](http://www.un.org/millennium/sg/report/full.htm))
- Naveh, Z., and A. S. Lieberman. 1984.** *Landscape Ecology: Theory and Application*. Springer-Verlag, New York.
- Parris, T. M. and R. W. Kates. 2003.** Characterizing a sustainability transition: Goals, targets, trends, and driving forces. *Proceedings of the National Academy of Sciences (USA)* 100:8068-8073.
- Zonneveld, I. S. 1972.** *Land Evaluation and Land(scape) Science*. International Institute for Aerial Survey and Earth Sciences, Enschede, The Netherlands.
- Zonneveld, I. S. 1995.** *Land Ecology: An Introduction to Landscape Ecology as a Basis for Land Evaluation, Management, and Conservation*. SPB Academic, Amsterdam.
- Wu, J. 2006.** Landscape ecology, cross-disciplinarity, and sustainability science. *Landscape Ecology* 21:1-4.
- Wu, J., and R. Hobbs. 2007.** Landscape ecology: The-state-of-the-science. Pages 271-287 in J. Wu and R. Hobbs, editors. *Key Topics in Landscape Ecology*. Cambridge University Press, Cambridge, UK.

## Managing and planning for sustainability in north Australia's landscapes: reflections on a decade of cooperative research

G. Duff<sup>1</sup>, D. Garnett<sup>1</sup>, P. Jacklyn<sup>1</sup>, J. Landsberg<sup>2</sup>, J. Ludwig<sup>3\*</sup>, J. Morrison<sup>4</sup>,  
P. Novelty<sup>5</sup>, P. Whitehead<sup>1</sup>

<sup>1</sup> Tropical Savannas Cooperative Research Centre (TS-CRC); 1 – Charles Darwin University, Darwin, Northern Territory 0909 Australia

<sup>2</sup> TS-CRC and Queensland Department of Primary Industries & Fisheries; 2 – deceased

<sup>3</sup> TS-CRC and Commonwealth Scientific & Industrial Research Organisation; 3 – CSIRO Sustainable Ecosystems, PO Box 780, Atherton, Queensland 4883 Australia;  
email: john.ludwig@csiro.au;

<sup>4</sup> TS-CRC and North Australia Indigenous Land & Sea Management Alliance; 4 – Charles Darwin University, Darwin, Northern Territory 0909 Australia

<sup>5</sup> TS-CRC and Western Australia Department of Agriculture & Food; 5 – PO Box 19, Kununurra, Western Australia 6743 Australia

### Introduction

Achieving the sustainable use of landscapes requires a robust design to plan and manage natural and cultural resources. An important component of this design is collaboration where research providers and users cooperate to learn how to utilize resources in a landscape while sustaining its long-term health. For the landscapes of north Australia, a Tropical Savannas Cooperative Research Centre (TS-CRC) was established in 1995 to foster collaborative research. The TS-CRC is a joint venture of major organizations involved in research and land management.

This paper is an overview of some key lessons learned over 11 years about how to effectively foster cooperation and integration to achieve practices leading towards the sustainable management of savanna landscapes in northern Australia. These lessons are based on the combined experiences of TS-CRC Chief Executive Officers (Duff, Garnett), a Communications Officer (Jacklyn) and Research Theme Leaders (Landsberg, Ludwig, Morrison, Novelty, Whitehead).

### Lesson One

We learned that collaboration (working in combination), not necessarily integration (combining parts into a whole), must be the main goal. While integration might seem a worthy ideal, diverse stakeholder values and aspirations seldom lend themselves to integrated solutions. Integration across culturally diverse perspectives can devalue the position of the less empowered participants. In contrast, we found that positive outcomes were achieved by embracing and respecting differences within a cooperative framework, where different stakeholders work together to gather new information (via collaborative research projects) and develop new tools (information and mapping websites) to achieve land management goals, such as how to effectively use and control fire across vast savanna regions (Fig. 1).

### Lesson Two

A lesson learned was that trust and respect amongst the participants was critical. A collaborative research organization must value the trust of its stakeholders above all else.



**Figure 1.** Andrew Edwards, Dean Yibarbuk and Otto Campion use maps printed from a TS-CRC website to plan strategic burns in Arnhem Land, northern Australia.

### Lesson Three

A cooperative venture must be able to act as an honest broker by resisting advocacy of one view over another.

**Table 1.** A few key publications by the Tropical Savannas Cooperative Research Centre. A complete list is provided in Tools and Information for Savanna Country: Product Guide 2006, available from the TS-CRC, Charles Darwin University, Darwin.

Publication title	Year
Defining and measuring the health of savanna landscapes	2000
Savanna burning	2001
Slower than the eye can see	2002
Healthy rangelands	2004

### Lesson Four

A cooperative venture must invest in communication and networking so that people can learn from one another's experiences, understand each other's challenges, and respect each other's choices. To foster networking and information exchanges, the TS-CRC actively publishes its research (Table 1) and produces a full-colour, widely distributed newsletter (Savanna Links) twice a year. It also maintains an award winning website, [www.savanna.cdu.edu.au](http://www.savanna.cdu.edu.au), with links to other websites on natural resource management.

### References

- Dyer, R; Jacklyn, P; Partridge, I; Russell-Smith, J. and Williams, D. (Eds) (2001)** *Savanna burning: understanding and using fire in northern Australia*. Tropical Savannas CRC, Darwin, Australia
- Lewis, D. (2002)** *Slower than the eye can see: environmental change in northern Australia's cattle lands – a study from the Victoria River District, Northern Territory*. Tropical Savannas CRC, Darwin, Australia.
- McCullough, M. & Musso, B. (Eds) (2004)** *Healthy rangelands: principles for sustainable systems. Focus on Australia's Burdekin rangelands*. Tropical Savannas CRC, Darwin, Australia
- Whitehead, P; Woinarski, J; Jacklyn, P; Fell, D. and Williams, D. (Eds) (2000)** *Defining and measuring the health of savanna landscapes: a north Australian perspective*. Tropical Savannas CRC, Darwin, Australia

## 9.2 Symposium 18: Coupling science and decision making in landscape sustainability: thresholds, models, and prediction

### Linking science, decision making, and management for landscape sustainability

R.J. Aspinall

Macaulay Institute, Craigibuckler, Aberdeen, AB15 8QH, Scotland  
e-mail: r.aspinall@macaulay.ac.uk

#### Introduction

This paper presents a framework for exploring linkages between science, decision making, and management in the context of landscape sustainability. The framework takes its terms of reference from two contemporary trends in science and three themes that focus on transition to sustainable landscapes. The science-society linkages are a) growth in interdisciplinary approaches that build understanding of landscapes as coupled natural and social systems and b) growing demands for science to be policy-relevant. The three themes are: a) identification and interpretation of landscape functions and sustainability thresholds, b) modelling landscape change, and c) use of predictive models of possible future landscapes by managers and planners. Development of a framework on the basis these terms of reference is described here. The three themes are expanded in other papers in symposium 18. The goal of the papers in Symposium 18, taken as a set, is to provide a synthesis of the state of the science of landscape sustainability within the contexts of both landscape ecology and the practices of landscape management and planning.

#### A framework for linking science, decision-making and management

The framework has three elements, representing the two trends and three themes identified above and is organised around a structure that links research integrating natural and social science, processes of decision making for policy and management practitioners, and a series of questions that address different aspects of landscapes.

The need to address landscapes as exemplars of coupled natural and human systems and the growth of interdisciplinary science requires the framework to foster interdisciplinary approaches, and most particularly to encourage interdisciplinary science that involves natural and social scientists. This is achieved through an architecture for interdisciplinary science that promotes a focus on linkage of social and natural systems rather than placing landscapes into compartments or other elements that are attached to distinct disciplinary subsets.

The growth in demand for science to be policy-relevant places the questions, scientific products, and case study examples of landscape sustainability to develop understanding, as well as the development and execution of the science, into a collaborative and co-learning partnership between land managers and decision makers with interdisciplinary (teams of) scientists. Issues of policy-relevance are included in the framework through exploration of the potential contribution of science to policy and decision making processes (and vice versa, considering the contributions of policy and decision making needs in the scientific process for a particular case study or project).

The framework is further organised around a series of questions that expand on work by Steinitz *et al* (2003). These are combined with the structure to link research integrating natural and social science with policy and management practitioners. Questions include attention to the description, function, operation, change, interdependency, and management of landscapes as well as societal preferences for landscapes (Table 1). Landscapes are considered to have spatial and temporal characteristics that influence the direction of research to address the questions. The questions are interpreted as collectively leading to an improved understanding and interaction with landscape change.



### Evaluation of the framework

The framework will be used to evaluate critically where and how science may contribute to development of sustainable landscapes. The focus of the framework on linking policy-relevant science and the series of questions in Table 1 is particularly important in this context. The framework potentially provides a link between improved scientific study and understanding of landscapes with policy and decision making; identifying opportunities for communication as an explicit outcome. In particular, the importance of description, monitoring, and modelling in communicating landscape science and scenarios and projections in communicating with policy and management decision makers is emphasised. In the context of Symposium 18 at IALE, the framework provides a context for synthesis of the technical issues reported in the papers presented, and the papers provide a test of the framework. The Symposium papers are organised a) to examine measurement and modelling of thresholds related to landscape function for a variety of sustainable ecosystem services, b) to explore policy and management implications of thresholds in landscapes directed towards sustainable landscape futures, c) to assess the current use and limitations of various landscape ecological modelling approaches for analysis and understanding landscape dynamics over space and time, especially those that integrate socio-economic drivers and that consider consequences of change for a variety of ecosystem services, d) to discuss quantification of uncertainties in models linked to decision making concerning future landscapes, e) to examine predictive modelling of future landscapes with a particular emphasis on coupling understanding and models of ecosystem services and function as elements of integrated predictive models that address impact and consequences of change, and f) to explore the use of landscape ecological models in analysis and planning for sustainable future landscapes. The framework is an essential foundation for integration and synthesis across this suite of activities based around thresholds and limits in sustainable landscapes.

**Table 1.** Framework questions (modified after Steinitz *et al.*, 2003)

---

1) What type of landscape is this?	6) How is this landscape changing?
2) How can we describe this landscape?	7) What causes this landscape to change?
3) How does this landscape work?	8) How might this landscape change?
4) Is this landscape working well?	9) What are the possible consequences of this landscape changing?
5) Is this landscape sustainable?	10) How should/might this landscape change?

---

### References

Steinitz, C., Arias, H., Bassett, S., Flaxman, M., Goode, T., Maddock, T., Mouat, D., Peiser, R., Shearer, A. (2003) *Alternative Futures for Changing Landscapes; The Upper San Pedro River basin in Arizona and Sonora*. Island Press, Washington DC.

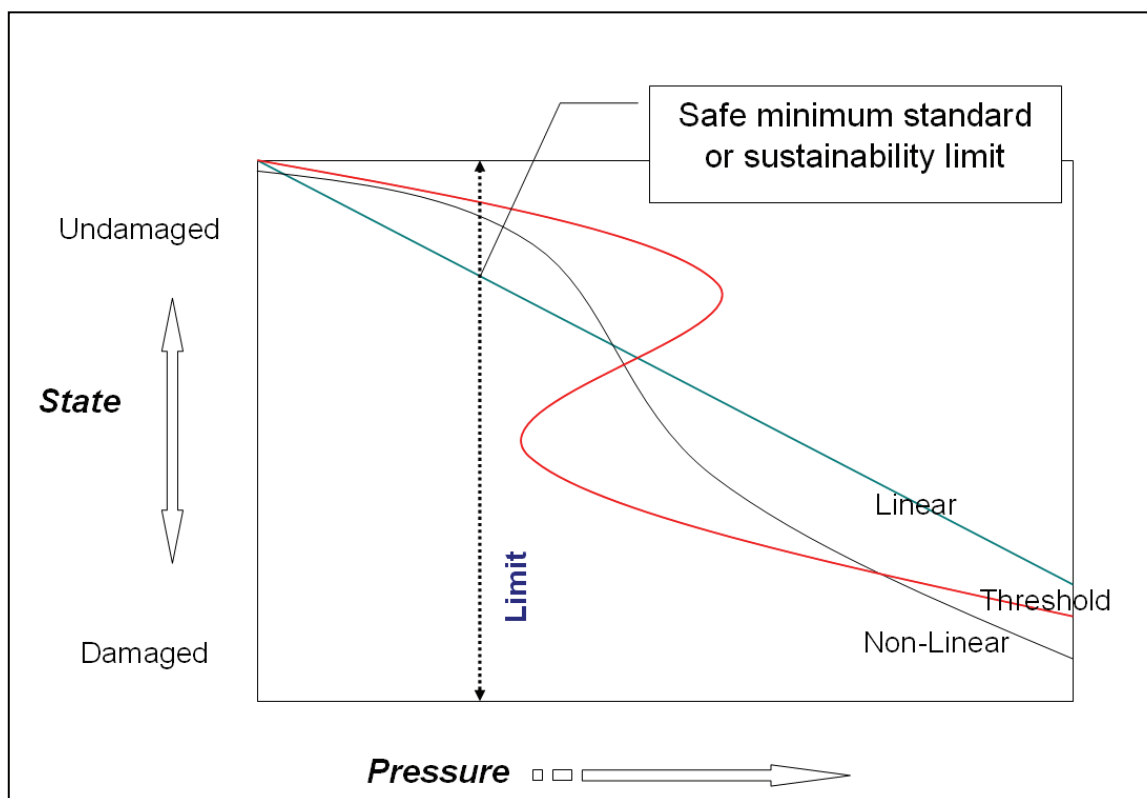
## Using a landscape ecological approach for the identification of sustainability limits: the scientific and policy challenges

R.H. Haines-Young, M.B. Potschin

Centre for Environmental Management, School of Geography, University of Nottingham, Nottingham, NG7 2RD, UK  
e-mail: Roy.Haines-Young@Nottingham.ac.uk

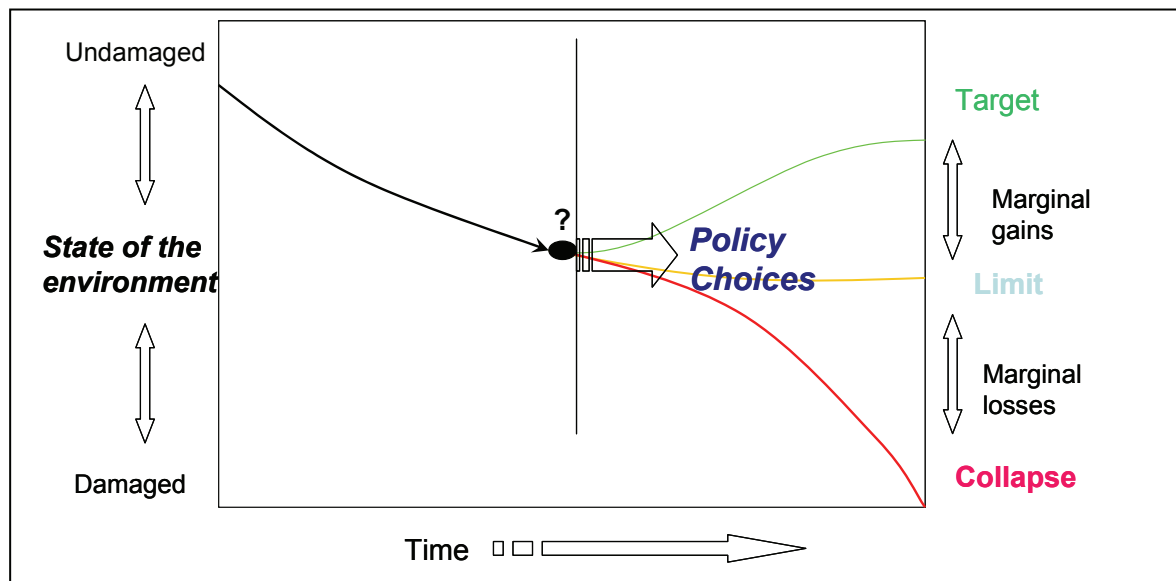
The identification of limits for the output of ecosystem goods and services represents a major challenge for the sciences community. An understanding of limits (see Fig. 1) is, for example, an essential part any kind of sustainability assessment, and therefore an important component of policy development and appraisal (see Fig. 2).

**Figure 1.** Relationship between thresholds and limits and different types of system



response to environmental pressures (adapted from Haines-Young et al., 2006).

Systems can show a range of responses to some external driver. The responses may be linear or non-linear, or show 'threshold' behaviour, involving a regime shift. The concept of a limit can be used to specify the extent acceptable change in terms of the levels of benefit the system can generate or the risks and uncertainties involved in approaching some threshold. Faced with increasing levels of damage, there may come a point at which society looks at the policy options, ranging from maintaining the status quo (i.e. deciding that some limit of acceptable change has been reached), restoration or enhancement of function, or of allowing collapse. The choice between options depends on weighing the marginal gains and losses in relation to some limit.



**Figure 2.** Policy choices (adapted from Haines-Young et al., 2006).

This paper will critically review current progress and consider the advantages and disadvantages of a landscape level approach, and the extent to which it allows the integration of environmental, social and economic constraints in a multifunctional and spatial framework. The definition of limits will also be considered in relation to the general problem of valuing environmental goods and services. The paper will draw upon case study materials from recent project work undertaken in the UK and elsewhere in Europe, and consider how integrated land and ecosystem accounts might be used as a framework for implementing the 'ecosystem approach' to environmental management. The prospects for using our understanding of sustainability limits for developing policy relevant models and scenarios will also be explored.

## References

- Haines-Young, R.; Potschin, M. & Cheshire, D. (2006)** Defining and identifying Environmental Limits for Sustainable Development. A Scoping Study. Final Full Technical Report to Defra, 103 pp + appendix 77 pp, Project Code NR0102. available from: <http://www.defra.gov.uk/wildlife-countryside/natres/evidence.htm>
- Haines-Young, R.; Langanke, T. & Potschin, M. (2007)** Landscape Character as a framework for the assessment of environmental change. B Jones et al. (Eds) *Frameworks for the assessment of Environmental change" in Use of Landscape Science for the assessment of environmental Security* (Springer, New York) (in press)
- Potschin M, Haines-Young R. (2006)** Rio+10, sustainability science and Landscape Ecology. *Landscape and Urban Planning* 75(3-4):162-174
- Potschin, M. & R. haines-Young (2007):** Making Sustainability Impact Assessments: Limits, Thresholds and the Sustainability Choice Space. Helming, K.; Tabbush, P. and M. Perez-Soba (Eds): *Sustainability Impact Assessment of Land Use Policies*. Springer (in press))

### **Spatial characterization of landscape functions**

**L. Willemen, P.H. Verburg, L. Hein, M. van Mensvoort, T. Veldkamp, R. Leemans**

Wageningen University, Department of Environmental Sciences, PO Box 47, 6700 AA  
Wageningen, the Netherlands.  
e-mail: Louise.Willemen@wur.nl

#### **Introduction**

Landscape functions indicate the capacity of a landscape to provide goods and services to society. In addition to agricultural production, most rural regions supply a range of other landscape functions, such as the provision of opportunities for recreation or nature conservation. The various landscape functions are not equally distributed over the landscape as their spatial variability depends on the local processes and the different components of the landscape. These spatial characteristics are important in land use and spatial planning, as they determine how different land use functions can be combined and optimized in a certain area. Many of the current descriptive landscape models that are used to support policy making are, however, based on one or only a limited amount of landscape functions, and they lack the possibility to express and analyze the multifunctionality of landscapes.

The presented study aims to quantify the spatial variability and multifunctionality of selected landscape functions in relation to their surrounding social and biophysical processes and conditions. We will show that spatial characterization of functions based on social and biophysical indicators is possible, and that the best mapping method depends on the evidence of current functions and availability of indicators.

The 'Gelderse Vallei' region of the Netherlands (see Figure 1) was used to illustrate this study. This rural region has a multifunctional landscape and is highly dynamic as a consequence of current land use conversions, mainly related to agricultural reforms and growth of residential areas.

#### **Data and Methods**

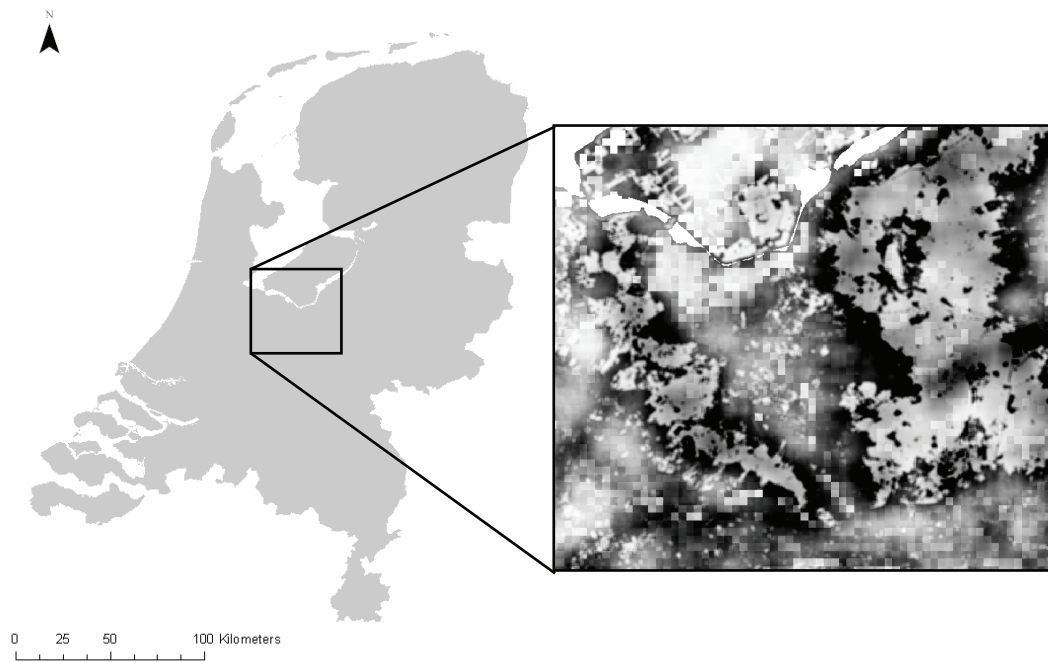
Determining the presence of landscape functions is not straightforward as not all functions can be observed directly from the landscape. By solely observing land cover, identifying the 'agricultural production function' is less complicated than detecting a 'tourism' function, because 'tourism' is not related to one single land cover type. In this study spatial indicators related to social and biophysical characteristics of the landscape were used to assess the presence of visible and less visible landscape functions and their capacity to provide goods and services.

Data on factual presence of functions were derived directly from a land cover map (e.g. arable land for agricultural production function) or, when no direct information from a land cover map could be used, a proxy for a function was used (e.g. tourist accommodation for tourism function). Based on the spatial coverage of the functions, we statistically tested to exploratory power of selected spatial indicators. The selection of a set of potential indicators was based on suggestions from experts and literature review. Indicators like land cover configuration, distance figures, and biophysical states were included in the analysis.

The spatial indicators were used to calculate the capacity, indicated with a probability, of selected landscape functions to provide good and services to humans for the complete study region (See example Figure 1). Comparing the location of these landscape functions probabilities together with their quantified indicators, information of possible synergies and

Theme 9: Concepts for Landscape Planning and Design  
9.2 Symposium 18: Coupling science and decision making in landscape sustainability: thresholds, models, and prediction

conflicts between landscapes functions was obtained, which could be of direct use in spatial planning.



**Figure 1.** Tourism function probabilities (0-1) in the Gelderse Vallei region, the Netherlands. Dark colors indicate a high probability. In this example open rural areas with abundant biking and hiking possibilities near nature are assigned a high tourism probability.

## Landscape functional response groups: definition, identification and utility for sustainable land management

J.Q. Radford<sup>1</sup> and A.F. Bennett<sup>1</sup>

<sup>1</sup> School of Life and Environmental Sciences, Deakin University, 221 Burwood Hwy, Burwood, 3125, Australia.  
e-mail: jradford@deakin.edu.au

### Introduction

Spatial models that simultaneously explore the economic, social and ecological consequences of land-use change (e.g., Groot *et al.*, 2007) provide a transparent process by which land managers can make informed decisions. Our objective in this research is to improve the rigour and relevance of ecological data used in spatial models. Integrating faunal responses into predictive models of landscape change is problematic because (i) it is impractical to model the response of every species potentially affected by landscape change, (ii) species-specific responses are highly variable and often counter to expectations generated from assemblage-level variables and (iii) most fauna-habitat models are restricted to patch-level inference.

In response to (i), ecologists frequently aggregate species with similar life-history traits (e.g., diet, foraging substrate) or assumed habitat preference (e.g., 'forest-dependent') into guilds and use these *a priori* classifications to examine assemblage-level responses to landscape change. This approach has produced inconsistent results, in part because the functional response of a species – changes in distribution and abundance in relation to landscape change – is likely to be a complex expression of many ecological and life-history factors. A more profitable approach for developing a predictive capacity may be to directly assess the functional response of species first, and then look for correlates within groups of species with similar functional responses.

Studies on the distribution and abundance of fauna in relation to patch attributes provide a basis for modelling the likely effects of land-use change at the patch-level. However, landscapes have properties that differ from those of their component parts and landscape change, including habitat loss and fragmentation, is a landscape-level process (McGarigal and Cushman, 2002). Therefore, predicting 'whole-of-landscape' consequences requires landscape-level inference of the how landscape properties affect native fauna (Bennett *et al.*, 2006). To obtain a landscape-level perspective, researchers and land managers must consider 'whole landscapes' as a single entity, rather than focus on the individual patches that occur within it. In this paper, we present an approach that combines functional responses with landscape-level inference by searching for 'landscape functional response groups': assemblages of species that respond to similar components of landscape structure and composition.

### Methods

We surveyed the avifauna four times at ten 2-ha sites in each of 24 agricultural landscapes (each 100 km<sup>2</sup>) in south-eastern Australia (Radford *et al.* 2005). The landscapes were selected to represent a gradient in native vegetation cover from 60% to less than 2%, and to contrast landscapes in which native vegetation was 'aggregated' with those in which it was dispersed among many patches. Survey sites were allocated among large remnants (>40 ha), small remnants, riparian vegetation, roadside strips and scattered trees among farmland, based on the relative proportions of these features in the landscape. Landscape change was characterised by 11 explanatory variables that captured the (a) extent of native vegetation; (b) configuration of native vegetation; (c) composition (e.g., agricultural land-use); and (d) geographic location of each landscape.

The incidence of each species per landscape was defined as the number of surveys (out of 40) in which it was recorded. We then used a Bayesian approach to model species

incidence as a function of the 11 explanatory variables, using multi-trial logistic regression. All bird species (except waterbirds) that were recorded from five or more landscapes were modelled. The posterior probability distribution describes the probability that a particular variable is included in the most plausible model of species incidence. This generates a landscape-level measure of the response of each species to a range of landscape properties that describe land-use change. We then identified groups of species with similar functional responses (i.e., posterior probability distributions) to variation in landscape properties.

## **Results**

Landscape functional response groups were identified across three domains: (1) extent and configuration of native vegetation; (2) extent and composition of native vegetation; and (3) extent of native vegetation and dominant agricultural land-use. In each domain, functional groups were identified, reflecting the response of species to different landscape properties. For example, in the extent-configuration domain, we identified species that were 'sensitive' to decreases in vegetation extent and increased fragmentation of native vegetation, sensitive to extent but not fragmentation, 'unresponsive' to changes in extent but sensitive to fragmentation, unresponsive to both extent and fragmentation, and 'robust' (increased) to decreases in extent and increased fragmentation. Importantly, the posterior probability distributions can be interpreted in terms of uncertainty in functional response group membership. This provides flexibility and transparency during the allocation of species to particular groups, and results in 'fuzzy' boundaries between groups.

## **Application**

In contrast to *a priori* classifications, the approach described here is data-driven and explicitly examines landscape-level responses. We contend that landscape-level inference will enhance ecological understanding by recognising that landscape properties may have separate and distinct influences on biota from patch-level attributes. Conservation outcomes will be improved by devising landscape-level strategies to complement patch-based management. We acknowledge that our study adopted a fixed scale of investigation and other functional responses will undoubtedly emerge at smaller and larger scales.

Functional response groups provide a useful link between land management and ecosystem sustainability because they identify species at risk from changes in particular landscape properties, and provide insight into the mechanisms by which land-use change affects species assemblages. For example, if functional response groups are validated for a biome, land managers can implement strategies to meet the requirements of desirable functional response groups. We suggest coupling quantitative models of functional response groups as a function of the landscape parameters that underpin them with projections of land cover change may provide a sound ecological basis for informing spatial models of land-use change. The challenge remains to test the generality of landscape functional response groups and integrate them into decision-making processes.

## **References**

- Bennett, A.F.; Radford, J.Q. & Haslem, A. (2006)** Properties of land mosaics: Implications for nature conservation in agricultural environments. *Biological Conservation* **133**: 250-264.
- Groot, J.C.J.; Rossing, W.A.H.; Jellema, A. et al. (2007)** Exploring multi-scale trade-offs between nature conservation, agricultural profits and landscape quality – A methodology to support discussions on land-use perspectives. *Agriculture, Ecosystems and Environment* **120**: 58-69.
- McGarigal, K. & Cushman, S.A. (2002)** Comparative evaluation of experimental approaches to the study of habitat fragmentation effects. *Ecological Applications* **12**: 335-345.
- Radford, J.Q.; Bennett, A.F. & Cheers, G.J. (2005)** Landscape-level thresholds of habitat cover for woodland-dependent birds. *Biological Conservation* **124**: 317-337.

## **Multiple functions and multiple ownership patterns; implications for the utilisation of landscape ecological models in decision making**

**A. Gimona<sup>1</sup>, D. van der Horst<sup>2</sup>**

<sup>1</sup> Macaulay Institute, Craigiebuckler, Aberdeen AB15 8QH, UK. Tel: +44(0)1224 498200  
Fax: +44 (0) 1224 311556.

e-mail: a.gimona@macaulay.ac.uk

<sup>2</sup> School of Geography, Earth and Environmental Sciences, University of Birmingham.  
Edgbaston Birmingham B15 2TT.

### **Introduction**

This paper explores two aspects that are relevant for the actual utilisation of most landscape ecological models, namely the potential conflicts or synergy with other (i.e. non-ecological) policy objectives, and the challenges involved in the acceptance and operationalisation of such models in the policy making process. The first aspect centres around the notion of landscape multifunctionality, while for the second aspect we limit ourselves to a closer look at the problem of operationalising ecological models in areas that are under multiple ownership and where the state seeks to intervene only through incentive-based and thus voluntary policies. Using as a case study an existing landscape ecological model which maps the aggregate potential biodiversity gains from the afforestation of farm land (van der Horst and Gimona, 2005), we explore each of the two aspects in turn.

### **Ecological models and landscape multifunctionality**

Many conservation and restoration efforts in developed countries are increasingly based on the premise of recognising and stimulating more 'multi-functionality' in agricultural landscapes. Public policy making is often a pragmatic process that involves efforts to negotiate trade-offs between the potentially conflicting demands of various stakeholders. Conservationists' efforts to influence policy making, therefore stand to benefit from tools that will help them to identify any other socio-economic functions or values that coincide with good ecological conservation options. Various types of socio-economic objectives have in recent years been mapped across landscapes and so there are now important opportunities to explore the spatial heterogeneity of these diverse functions across the wider landscape in search of potential spatial synergies, i.e. 'multiple win locations' or multifunctional 'hotspots'. The first part of this paper explores the potential occurrence of such synergies within the agricultural landscape of northeast Scotland and evaluates an existing woodland planting policy using and combining three different policy objectives. Our results show that there are indeed broad areas of the studied landscape where multiple objectives (biodiversity, visual amenity and on-site recreation potential) could be achieved simultaneously (hotspots), and that the case study policy which we evaluate (the Farm Woodland Premium Scheme) could be much better spatially targeted with regards to each individual objective as well as with regards to these hotspots of multifunctionality.

### **Ecological models and the complexity of land ownership patterns**

Landscape ecology has made great strides in the development of models that can inform policy makers where and how to intervene in the landscape in order to conserve biodiversity or sustain the provision of ecosystem services. However many scientists have to wait long to see their research findings actually used to improve policies. There are a number of different reasons why their findings may be lost, diluted or misinterpreted in the translation to policies on the ground. A better understanding of these reasons is important as it will help landscape ecologists to become more proactive in the translation process and seek to develop models



that are more end-user friendly, i.e. more readily utilisable in the relevant policy process. The second part of this paper explores one particular challenge for the implementation of landscape ecological models for the sustained provision of ecosystem services at the landscape scale, namely the effect of complex private land-ownership patterns. Most landscape ecological models can be readily used to develop management plans and action plans for policy makers who have the power to take 'command-and-control' measures. These powers are usually limited to designated protected areas, state land or to spatial planning issues of national importance which merit compulsory purchase orders. However most productive land is in private hands. Some farmers and other land-owners may be happy to undertake certain ecological interventions on a voluntary basis, some may accept these interventions on a cost-recovery basis and others may be very hard to persuade even with high incentive payments. The collection of data on land owner behaviour usually lies outside the remit of landscape ecology. However this data is fairly widely collected by other disciplines and this paper seeks to demonstrate that landscape ecologists are fully equipped to interpret this data and its consequences for the effective implementation of landscape ecological models by government agencies. Our analysis explores how different land ownership patterns can affect the level of uncertainty of the outcomes of ecological interventions which are implemented through incentive payments and it highlights the importance for the research community to gain wider access to detailed landownership data which often exists but is protected.

### **References**

**Van der Horst, D.; Gimona, A. (2005)** Where new farm woodlands support Biodiversity Action Plans; a spatial multi-criteria analysis. *Biological Conservation* **123**, 421-432.

## Mapping landscape-functions at the European scale

F. Kienast<sup>1</sup>, J. Bolliger<sup>1</sup>, R.S. deGroot<sup>3</sup>, M. Potschin<sup>4</sup>, R. Haynes-Young<sup>4</sup>, I. Heller<sup>2</sup>

<sup>1</sup> Swiss Federal Research Institute WSL, Zürcherstrasse 111, CH-8903 Birmensdorf, Switzerland,

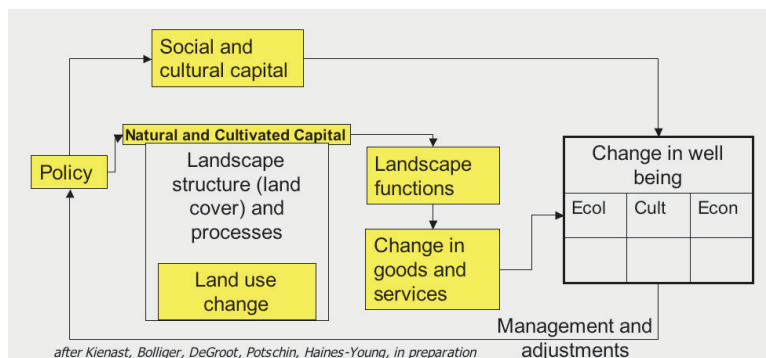
e-mail: felix.kienast@wsl.ch

<sup>3</sup> Environmental Systems Analysis group, Wageningen UR, PO Box 47, 6700 AA Wageningen, The Netherlands

<sup>4</sup> Centre for Environmental Management, School of Geography, University of Nottingham, Nottingham NG7 2RD, England

### Introduction

Landscape functions measure to what degree landscapes fulfill societal and ecological needs. In the past few years the concept of landscape functions has been promoted by several authors and has gained an international reputation (e.g. (Bastian and Lutz, 2006; Bills and Gross, 2005; de Groot, 2006). In a recent report, Hein & de Groot (2005) suggested embedding the landscape function approach in the framework of ecosystem goods and services which is best elaborated in the ecosystem millennium assessment ([www.maweb.org](http://www.maweb.org)). According to this framework policy affects both the social/cultural and the natural/cultivated capital of society (see Fig. 1). Both have decisive impacts on people's well-being. Within this framework, landscape functions act as a link between land-use (change) and the goods and services of an ecosystem. Goods and services are assumed to be direct drivers of human well-being. The reasons to place landscape functions between "goods and services" and "land-use" is two-fold: firstly landscape is a holistic expression of the physical, biological and human properties of a given parcel of land and acts at a higher spatial aggregation level than simple land-use or land cover. Secondly, as formulated by Brandt et al. (2000): "a single land use can involve numerous functions. Different land uses can result in different functions, but not all functions can be expressed as land uses".



**Figure 1.** The conceptual framework of landscape functions used in the present analysis.

We present a promising approach of linking land properties (bedrock, climate, land-use/land pattern) with various landscape functions at

the European scale (10 – 26 functions depending on the purpose of the study).

### Methods

We used three hierarchical sets of landscape functions. They run on a detailed, medium and coarse level. At the coarse level nine functions have been identified, at the medium level 15, and at the fine level 24. In line with the literature, the landscape functions are assigned to four major groups of goods and services: (i) provisioning functions; (ii) regulation functions; (iii) habitat functions; and (iv) cultural and amenity functions.

Landscape functions are modeled using simple look-up tables. The latter provide a link between land characteristics and landscape functions. Two sets of independent input variables are used, the first being a collection of *physical land properties*, the second

consisting of *socio-economic characteristics*. Both data sets enter the calculations separately. Physical properties are linked with landscape functions using non-weighted loadings, the latter being a measure of whether a land characteristic supports a function (assigned value = 1) or not (assigned value = 0). The rating was done with the aid of an expert panel, consisting of five landscape ecologists. Socio-economic properties are assumed to influence landscape functions indirectly via land-use change. To do so we generated a set of scenarios expressing future land-use change as a function of socio-economic drivers. All independent variables enter the calculations at the aggregated spatial level of NUTS-X regions (approx. 500 administrative regions of Europe).

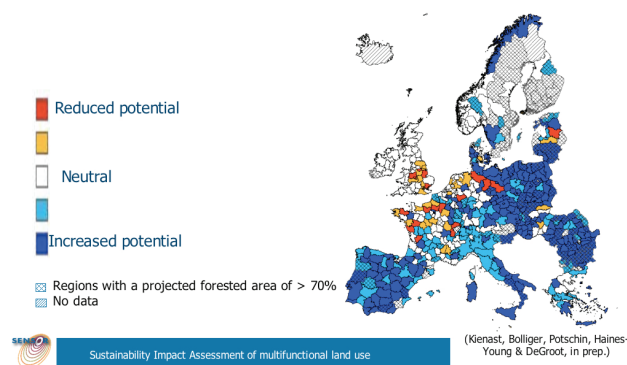
## Results

The approach proved to generate meaningful map representations of landscape functions at the NUTS-x level. The major highlights of the approach are as follows:

- linking land characteristics with landscape functions via look-up tables is intuitively easy to understand by experts and has thus a high acceptance potential.
- the spatially explicit representation of landscape functions (maps) are ideal communication tools fostering communication among experts and stakeholders. The maps can be easily evaluated with existing knowledge bases.

We observed the following shortcomings of the preliminary approach:

- it is highly debatable whether the merely intuitive links between land characteristics and landscape functions represent the best solution to capture expert knowledge
- socio-economic variables are difficult to link DIRECTLY with the landscape functions. We suggest to link them indirectly via land-use change scenarios that are driven by socio-economic properties (see Figure 2).



**Figure 2.** Projected change of the landscape function „C-fixation and other GHG“ under a liberalization scenario.

## References

- Bastian, O., Lutz, M.,** 2006: Landscape functions as indicators for the development of local agri-environmental measures. *Ecological indicators* 6(1): 215-227.
- Bills, N., Gross, D.,** 2005: Sustaining multifunctional agricultural landscapes: comparing stakeholder perspectives in New York (US) and England (UK). *Land Use Policy* 22 (4): 313-321.
- Brandt, J., Tress, B., Tress, G.** (eds), 2000: Multifunctional Landscapes: Interdisciplinary Approaches to Landscape Research and Management. Conference material for the conference on "multifunctional landscapes", Centre for Landscape Research, Roskilde, October 18-21, 2000.
- de Groot, R.,** 2006: Function-analysis and valuation as a tool to assess land use conflicts in planning for sustainable, multi-functional landscapes. *Landscape and Urban Planning* 75 (3-4): 175-186.
- Hein, L., de Groot, D.,** 2005: Analysis of landscape functions: typology and sustainability indicators. Draft Report (June, 21, 2005) to SENSOR MODULE 3, WP 3.2. Environmental Systems Analysis Group, Wageningen University.

## Understanding and improving ecological function: guiding landscape restoration on private land in the Australian wheat and sheep zone

D.H. Duncan<sup>1</sup>, J.W. Dorrough<sup>1,2</sup>

<sup>1</sup> Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, VIC 3084, Australia.  
e-mail: david.duncan@dse.vic.gov.au.

<sup>2</sup> Currently at CSIRO Sustainable Ecosystems, Canberra ACT 2601.

### Introduction

Major decisions regarding native vegetation management are looming in the intensively cropped landscapes of southern Australia (Vesk and Mac Nally 2006). The scale and intensity of farming enterprise is growing rapidly in response to declining economic terms of trade, creating a tension for native vegetation management around a complex mix of threat and opportunity. Soil types favoured for sheep and wheat farming were extensively cleared before 1945. Thus for over 60 years the landscape has been highly fragmented, with around 5% cover of native vegetation remaining. Small patches (<5 hectares) of native vegetation account for a substantial proportion of native vegetation cover but are typically heavily degraded. We bring together new ecological and social data to explore the complex problems facing regional native vegetation management decision-makers in the context of ecological, economic and social uncertainty.

### Method

We conducted field site assessments of soil and vegetation characteristics and aerial photograph comparisons of vegetation cover and land use for 60 remnants within a 28,777 km<sup>2</sup> study area. The remnants were in three size classes; small (<3 ha), medium (5-10 ha), and large (>20 ha). For a subset of 35 remnants, we interviewed the landholder about the history and likely future of remnant management.

### Results

Analysis of land cover change from air photos suggested that remnant vegetation cover was around 5% in 1945 and has remained largely static since, but the land use in adjacent paddocks has shifted strongly toward cropping in preference to grazing. Our interviews confirmed the same trends. Farmers considered that small and medium size remnants were retained rather than cleared primarily for their value of stock shelter. The smaller remnants were still grazed as part of the farming system in almost all cases, whereas many larger patches have been protected, or are now publicly owned.

Stock shelter and grazing pressure was the largest management factor affecting the ecological function of remnants, strongly associated with phosphorous enrichment (Duncan et al in review), bare ground cover and exotic weeds, and negatively correlated with native herb, grass, shrub, cryptogam and litter cover. There was no recruitment of woody shrub or tree species in any small remnants, but there were saplings in larger sites where stock grazing was light or absent.

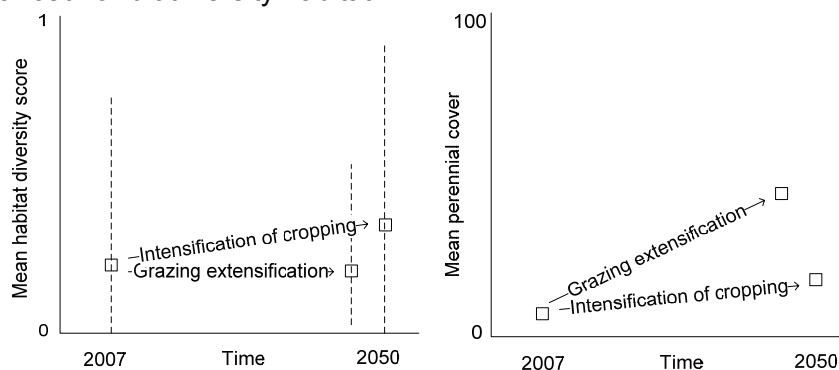
### Discussion

Many patches of native vegetation on farms are valued principally for the service of shelter they provide to stock, yet stock grazing is at present the greatest threat to regeneration of native species and the medium-long term viability of smaller remnants. Remnants of less than 5 ha in area account for almost a quarter of remnant native vegetation in the study area and without them the regional targets of more than 15% native cover will be far more difficult to achieve.

Looking further into the future we see two major trends that may emerge, with varying implications for the ecology of the dryland landscapes. We refer to these trends as intensification of cropping, and extensification of grazing (Figure 1). A continuing trend

towards intensification of cropping will provide opportunities for de-stocking remnant vegetation in some cases, and for revegetating parts of the land that become unusable due to increased size machinery size and automation. However, without stock shelter value, extant small remnant patches and isolated paddock trees may be perceived primarily as an impediment to the larger, semi automated farm machinery (eg. Maron 2005), and be further threatened by intensified application of agrichemicals. Furthermore, while cropping remains profitable, there are clear limits to the total amount of gain in native vegetation cover that may be expected.

Global climate change is predicted to cause a further reduction in rainfall in the study area, which may increase risk for cropping enterprises, leading to a shift back towards livestock grazing on a more extensive basis, with opportunistic cropping. Under these circumstances we see that properties may increase in the cover of perennial vegetation through a mixture of perennial pasture, forage, and natural regeneration of indigenous species, all strategically grazed. However, less area may be protected from grazing and enhanced for biodiversity habitat.



**Figure 1.** Potential future mean habitat diversity and percentage cover of perennial vegetation cover under two land use scenarios. Dotted lines in left panel indicate expected range of habitat value. Extensification leads to greater perennial vegetation cover; however the habitat diversity of the vegetation is generally lower.

The biodiversity outcomes of each scenario are likely to be different, and favour different suites or functional groups of species, as there is a clear trade-off implied between quantity and quality of habitat. Equally, the structure of incentives and other mechanisms should be different for each scenario in order to achieve ecological and biodiversity gain.

### Acknowledgements

This research was supported by the North Central and Mallee Catchment Management Authorities, the Natural Heritage Trust, the National Action Plan for Salinity and Water Quality, and the Victorian Government's Our Rural Landscapes Program. We especially thank Claire Moxham, Matt White, Huon Stephens, Sally Kenny, Cassia Read; and our research partners CSIRO and the Birchip Cropping Group.

### References

- Duncan DH, Dorrrough J, White M, Moxham C (in review)** Blowing in the wind? Nutrient enrichment of remnant woodlands in an agricultural landscape. *Landscape Ecology*
- Maron, M.** (2005) Agricultural change and paddock tree loss: Implications for an endangered subspecies of Red-tailed Black-Cockatoo. *Ecological Management and Restoration* 6: 206-211
- Vesk PA, Mac Nally R (2006)** The clock is ticking - revegetation and habitat for birds and arboreal mammals in rural landscapes of southern Australia. *Agriculture Ecosystems & Environment* 112: 356-366

## Modeling impacts to water quality from future land cover change in the Chesapeake Bay watershed

<sup>1</sup>P.R. Claggett, <sup>2</sup>C.A. Jantz, <sup>3</sup>J. Reilly, <sup>4</sup>R. Burgholzer, <sup>4</sup>K. Hopkins, <sup>5</sup>N. Zhou

<sup>1</sup>U.S. Geological Survey, 410 Severn Ave., Suite 109, Annapolis, Maryland, 21403 USA  
e-mail: pclaggett@usgs.gov

<sup>2</sup>Shippensburg University, Dept. of Geography & Earth Science, 1871 Old Main Drive,  
Shippensburg, PA 17257 USA

<sup>3</sup>Maryland Dept. of Planning, 301 W. Preston St., Suite 1101, Baltimore, MD 21201 USA

<sup>4</sup>University of Maryland, 410 Severn Ave., Suite 109, Annapolis, MD 21403 USA

<sup>5</sup>Virginia Polytechnic Institute, 410 Severn Ave., Suite 109, Annapolis, MD 21403 USA

### Introduction

Restoring water quality and aquatic health in large inland water bodies is a lengthy process. During this process, increasing human and animal populations and changing landscapes challenge the ability of planners and land managers to successfully restore aquatic systems. Rapid urbanization and associated landscape changes have the potential to slow or even reverse restoration progress. For this reason, managers of large scale restoration efforts should account for the impact of potential future land cover and population changes when developing and targeting restoration actions. To assess potential future water quality conditions under various management scenarios, regional land cover and land use change models coupled with watershed models are needed.

The Chesapeake Bay Program (CBP) is a voluntary federal, state, and local government partnership dedicated to restoring the health of the Chesapeake Bay. In a previous effort to relate future land change with water quality, the CBP produced an 8-year forecast of land change based on linear extrapolations of historic population, land cover, and crop distribution data. These forecasts were used as inputs to the Chesapeake Bay watershed model to simulate nutrient and sediment loads to the Bay through the year 2010. Short-term forecasts, however, have proven to be of limited value for restoration planning due to the multi-year duration of planning and implementation activities and historic evidence that high rates of urban development and farmland loss are likely to continue well beyond an 8-year forecast (Claggett, 2007). In recognition of these facts, the CBP requested the development of longer-term forecasts of land change to account for the potential impacts of future urbanization on the Bay restoration effort. The CBP also identified the need to develop a more sophisticated technique to forecast long-term land change because linear extrapolations of recent land use trends over a twenty-year timeframe can provide very implausible results.

### The Chesapeake Bay Watershed Model

Methods selected for simulating the water quality impacts from land change should depend partly on the approaches used to model water quality. Since 1985, the CBP has used an application of the Hydrologic Simulation Fortran-Program model to simulate nitrogen, phosphorus, and sediment loads from the 165,700-square-kilometer watershed to the Chesapeake Bay (Linker, *et al.*, 2002). The CBP Watershed Model is a lumped parameter model that simulates loads from over twenty different land uses. The water quality impacts from a particular land use vary at the county-scale (mean size: 820-square-kilometers) based on land use class, atmospheric nitrogen deposition, fertilizer and manure application, and crop yield potential. Water quality impacts further vary at the sub-county scale based on reported implementation levels of best management practices (e.g., nutrient management plans, conservation tillage). To meet the data requirements of the CBP watershed model, a land change model should be capable of forecasting change at the

county scale while providing additional information on the relative extent of different land uses at the sub-county scale.

### The Chesapeake Bay Land Change Model

The Chesapeake Bay Land Change Model consists of two main components, a growth allocation model (GAME) and a cellular automata model (SLEUTH). Together, these models serve to integrate population and employment projections with data on historic trends in agriculture and impervious surfaces. The modeling system is designed to simulate the impact of a variety of development policies on land use, land cover, and other nutrient sources (e.g., sewer outflows, farm animals units).

GAME is a *growth allocation model* that converts exogenous county forecasts of population and employment to sub-county estimates of residential and commercial land use extent (Reilly, 2003). SLEUTH (*slope, land use, excluded land, urban extent, transportation*) is a cellular automata model that simulates future urban development by extrapolating recent historic growth patterns into the future (Clarke, *et al.*, 1997). GAME provides the means to estimate the amount of urban growth in a sub-county area while SLEUTH simulates the pattern of growth to generate the proportions of non-urban land uses converted to either residential or commercial use. Loosely coupled together, these models serve to integrate the best nationally available data on land cover, demographic, employment, and agricultural trends to produce 30-meter resolution raster maps representing plausible future land cover scenarios. Therefore, the Chesapeake Bay Land Change Model has great potential for simulating future water quality conditions in other large watersheds in the conterminous United States.

### References

- Claggett, P. (2007)** Future land change in the Chesapeake Bay watershed, Presented to the Chesapeake Bay Commission, Annapolis, Maryland, USA, January 4, 2007.
- Clarke, K.C., Hoppen, S., and Gaydos, L. (1997)** A self-modifying cellular automaton model of historical urbanization in the San Francisco Bay area, *Environ. Plann. B: Plann. Des.* **24**,247–261.
- Jantz, C.A., Goetz, S.J., and Shelley, M.K. (2003)** Using the SLEUTH urban growth model to simulate the impacts of future policy scenarios on urban land use in the Baltimore–Washington metropolitan area, *Environ. Plann. B: Plann. Des.* **31**(2):251-271.
- Linker, L.C., Shenk, G.W., Wang, P., Hopkins, K.J., & Pokharel S. (2002)** A short history of Chesapeake Bay modeling and the next generation of watershed and estuarine models. Presented at the Watershed 2002 Conference, Fort Lauderdale, Florida, USA
- Reilly, J. (2003)** The New Jersey (USA) Growth Allocation Model: development, evaluation and extension', in S. Geertman and J. Stillwell (Eds.) *Planning Support Systems in Practice, Advances in Spatial Science Series*, Springer, Berlin, pp.373-389.

## Multifunctional use of Landscape Services: Applications and Results of Optimization Techniques of Land Use Scenario Development

R. Seppelt <sup>1</sup>, A. Holzkämper <sup>1</sup>

<sup>1</sup> UFZ Helmholtz Centre for Environmental Research, Permoserstraße 15, Leipzig, Germany,  
e-mail: Ralf.Seppelt@ufz.de

### Introduction

Scenario analysis is one of the most common approaches for analysis of historic, recent and future developments of landscapes. Scenarios originate from external forces, such as land use change due to agro-economic and -cultural development (common agricultural practice, CAP), climate change (like IPCC scenarios) or demographic development (Rounsevell, Reginster et al. 2006)

Especially on a regional scale at which human impact is most visible, and changes in management can be implemented most easily, these scenarios are prone to neglect the complexity of spatial interactions of processes and patterns, which needs modelling and simulation as an integrative analysis tool.

In this presentation we contribute to the problem by solving different tasks of land use configuration for maintaining and improving ecosystem services of landscapes such as retention capability of nutrients in a watershed as well as habitat suitability for selected species. We can show that this approach gives a better understanding of the interplay of patterns and processes within landscapes and supports the well known story-telling approach of scenario development.

### Methodology

Spatially explicit ecosystem models allow the calculation of water and matter dynamics in a landscape as functions of spatial localization of habitat structures and matter input, see for instance (Seppelt and Voinov 2002). These process models are capable of providing the information and data of different state variables of a landscape that characterize the abiotic site conditions. Thus these parameters serve as input to assess habitat suitability for certain species of traits (Rudner et al. 2007). But also landscape structure – which may be considered dynamically due to land use change – is an important input variable to analyzing habitat suitability (Schröder and Seppelt 2006).

To answer questions on the maintenance and improvement of certain ecosystem functions we formulated different optimization tasks. The independent variable that is modified to maximize for instance habitat suitability or nutrient retention is land use type and land use intensity. This again can be considered on different scales using different ways of spatial coding the independent variables: as a grid cell, e.g. regular parcel in the landscape, a patch of certain land use, or the portion of land use within a region/catchment. On these different spatial levels of scale the task of optimization differs.

The most important methodological finding is that results from the different scales can be transferred or are invariant across these scales. These results will be illustrated using several examples and case studies.

### Applications and Case Studies

Agricultural landscapes are the dominating landscape types in many parts of the world. Land-use intensification and spatial homogeneity are major threats to biodiversity in these landscapes. Thus cost-effective strategies for species conservation in large-scale agricultural landscapes are required.



### Example 1: Retention function

For mainly agricultural region we studied the nutrient balance as a function of different management schemes. For this purpose we formulated optimization tasks, which compare economic aspects, such like farmer's income from harvest, with ecologic aspects, such like nutrient loss out of the watershed. The task was to calculate optimum land use maps and fertilizer application maps maximizing the performance criterion. A major novelty is that spatial changes are performed according to a patch topology that allows to simultaneously integrating changes of different landscape elements (e.g. in agricultural fields and linear changes along corridors). The objective function evaluation is based on a grid representation of the landscape where neighbourhood dependencies like lateral flows or the landscape pattern can explicitly be considered (Seppelt and Voinov 2002).

### Example 2: Species conservation

The optimisation of spatial land-use patterns to identify the most effective allocation of a given budget for conservation in real landscapes is often limited by computational power. This case study presents a simplifying methodology for analysing cost-effectiveness of management actions on a regional scale. Based on optimisation results for small scale landscape samples we derive a target- and site-specific cost-benefit function that can be applied to predict ecological improvement as a function of costs and local conditions on a large spatial scale. Thus, it is possible to identify areas where management actions for ecological improvement are most efficient with respect to a certain conservation goal. The fitted function is validated independently. In a case study we analyse cost-effectiveness of management actions to enhance habitat suitability for three different target species. The approach is flexible and could be applied to a variety of other landscape planning problems dealing with the effective allocation of management measures (Holzkämper et al. 2006).

As a result, important areas with high retention capabilities were identified and fertilizer maps were set up depending on soil properties. This shows that optimization methods even in complex simulation models can be a useful tool for a systematic analysis of management strategies of ecosystem use.

### **References**

- Holzkämper, A., A. Lausch, R. Seppelt (2006).** Optimizing landscape configuration to enhance habitat suitability for species with contrasting habitat requirements. *Ecological Modelling*. 198: 277-292
- Rounsevell, M. D. A., I. Reginster, et al. (2006).** "A coherent set of future land use change scenarios for Europe." *Agriculture, Ecosystems and Environment* **114**: 57-68.
- Rudner, M., R. Biedermann, B. Schröder, M. Kleyer (2007):** Integrated Grid Based Ecological and Economic (INGRID) landscape model. *Environmental Modelling and Software*. 22: 177-187
- Schröder, B. and R. Seppelt (2006).** "Analysis of pattern–process interactions based on landscape models—Overview, general concepts, and methodological issues." *Ecological Modelling* **199**: 505-516.
- Seppelt, R. and A. Voinov (2002).** "Optimization methodology for land use patterns using spatially explicit landscape models." *Ecological Modelling* **151**(2-3): 125-142.

## Optimal localisation of linear landscape elements using multi-criteria optimisation

B.C. Meyer<sup>1</sup>, R. Grabaum<sup>2</sup>, T. Wolf<sup>2</sup>

<sup>1</sup>University of Dortmund, Faculty of Spatial Planning, Landscape Ecology and Landscape Planning, August-Schmidt-Str. 10, D - 44227 Dortmund, Campus Süd,  
e-mail: burghard.meyer@uni-dortmund.de,

<sup>2</sup>OLANIS Expertensysteme GmbH, Permoserstr. 15, D - 04318 Leipzig

### Introduction

The MULBO-framework (multi-criteria landscape assessment and optimisation; Meyer and Grabaum 2003) focuses on the enhancement of the planning process by the integration of multiple functions into optimal compromises, which consider different goals of a landscape and future land use pattern mosaics or distributions. So far the scenario approach estimates basically the spatial distribution of land uses. The integration of linear landscape elements into MULBO is now realised. Linear landscape elements have a high impact on cultural landscapes, e.g. as described for water river catchment problems, biodiversity and recreation purposes (Hirt et al., 2005, Ihse, 1995, Kantelhardt et al., 2003).

### Problem

Land use optimisation based on Geographical Information Systems (GIS) uses the existing smallest common geometry as basis of the optimisation problem (raster or vector data). The aim is to find an optimal spatial distribution of linear landscape elements to solve multifunctional problems in rural landscapes. There is however an indefinite number of potential solutions for linear landscape elements and a line grid or line net must be generated first to reduce the problem. By utilising the idea of optimisation of linear landscape elements the authors have developed and coupled different tools to solve the problem.

### Methods and tools

The three main steps of localisation of linear landscape elements by using multi-criteria optimisation and assessment tools are as follows (Figure 1):

- Generation of potential line net with the GIS tool "LINE GENERATOR",
- Landscape function assessment of the line net by using suitable assessment tools,
- Optimisation of a new line net on the basis of stakeholder aims (scenario settings, weights and rankings) using the compromise optimisation tool "LNOPT 2.0".

The framework was applied on different test sites in the larger Leipzig region.

### Application

The example of the intensively used agricultural landscape in Barnstaedt (Saxony-Anhalt, Germany) focuses on a solution to solve problems of wind erosion, water erosion and habitat qualities for key species (*Emberiza calandra*, Corn Bunting; Meyer et al. 2007). By the formulation of targets (e.g. the planned length or type of new linear landscape elements) multi-criteria optimisation was applied as described by Grabaum and Meyer (1998) by using LNOPT 2.0. The improvements of landscape functions? are measured on the basis of the landscape assessment tools for "wind erosion", "water erosion" and "corn bunting" (Grabaum et al., 2006).

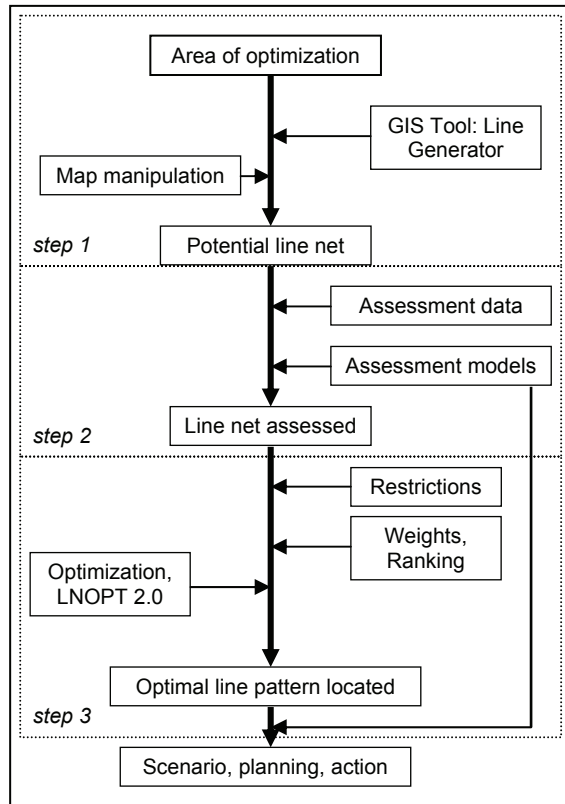
### Outcomes

The recapitulation of the benefits and disadvantages of our scenario approach by the combination of the tools described relates firstly to the objectification of the planning process. Future aspects of the model development will be

- the introduction of semi-automatic generations of assessments and line net definitions,

**Theme 9: Concepts for Landscape Planning and Design**  
**9.2 Symposium 18: Coupling science and decision making in landscape sustainability: thresholds, models, and prediction**

- the focus on trade-offs for better integration of linear element impacts into landscape assessment tools, with the benefit to integrate functional and structural indicator assessments,
- a more detailed test on the sensitivity of all parts of the integrated tools.



**Figure 1:** Framework and tools for the optimal spatial location of linear landscape elements using MULBO.

### References

- Grabaum, R. & Meyer, B.C.** (1998) Multicriteria optimization of landscapes using GIS-based functional assessments. *Landscape and Urban Planning* 43:21-34.
- Grabaum, R., Meyer, T., Gerung, J., Wolf, T., Friedrich, K.E., Kildal, T., Schreiner, V. & Meyer, B.C.** (2006) *The digital user manual for the multicriteria assessment and optimisation method (MULBO)*. In: Meyer B.C. (ed.) Sustainable Land Use in Intensively Used Agricultural Regions. Landscape Europe, Wageningen. Alterra Report 1338:127-132. ([www.landscape-europe.net/](http://www.landscape-europe.net/)).
- Hirt, U., Hammann, T. & Meyer, B.C.** (2005) Mesoscale estimation of nitrogen discharge via drainage systems. *Limnologia* 35(3):206-219.
- Ihse, M.** (1995) Swedish agricultural landscapes - patterns and changes during the last 50 years, studied by aerial photos. *Landscape and urban planning* 31:21-37.
- Kantelhardt, J., Osinski, E. & Heissenhuber, A.** (2003) Is there a reliable correlation between hedgerow density and agricultural site conditions? *Agriculture, Ecosystems and Environment* 98:517-527.
- Meyer, B.C. & Grabaum, R.** (2003) *Multikriterielle Landschaftsoptimierung – reif für die Praxis?* In: Bastian, O., Grunewald, K., Schanze, J., Syrbe, R.-U. & Walz, U. (eds) Bewertung und Entwicklung der Landschaft – Ergebnisse der Jahrestagung IALE-Deutschland 2002 in Dresden. *IÖR-Schriften* 40:105-118.
- Meyer, B.C., Mammen, K. & Grabaum, R.** (2007) A spatially explicit model for integrating species assessments into landscape planning as exemplified by the Corn Bunting (*Emberiza calandra*). *Journal Nature Conservation*, (in print).

## Ecological restoration priorities for achieving integrated environmental and economic objectives

N.D. Crossman, B.A. Bryan

Policy and Economic Research Unit, CSIRO Land and Water, PMB 2, Glen Osmond, South Australia, 5064, Australia.  
 e-mail: neville.crossman@csiro.au

### Introduction

The shift toward a more integrated approach to natural resource management and sustainable land use has arisen from the increased realisation that biological, physical, economic and social processes are inextricably linked and decision-making has to consider and account for this complexity. A potentially effective framework is the concept of integrated natural resource management that aims to achieve multiple environmental objectives such as reducing land degradation, conserving biodiversity, improving water quality and reducing the effects of accelerated climate change, in addition to meeting economic and social objectives such as minimizing opportunity costs and community impacts.

This paper begins by examining data requirements for geographic prioritisation of ecological restoration for integrated natural resource management, and in the process, brings together traditionally disparate landscape-scale biophysical data and models. Spatial optimisation models identify optimal locations to restore under a set of policy options defined by economic, sustainability and resource management principles. The focus of this study is the agricultural landscapes of the Lower Murray region of south-eastern Australia.

### Methods and Results

Methods are three-fold: i) modelling of key biophysical and economic elements of the Lower Murray landscape; ii) development of integer programming models that select the optimal locations for ecological restoration that minimise a cost-benefit function, whilst meeting areal targets defined by existing policy, and; iii) exploration of trade-offs between alternative policy options. Spatial outputs are presented that identify priorities for ecological restoration under each policy option. Table 1 list the datasets that form the spatial database.

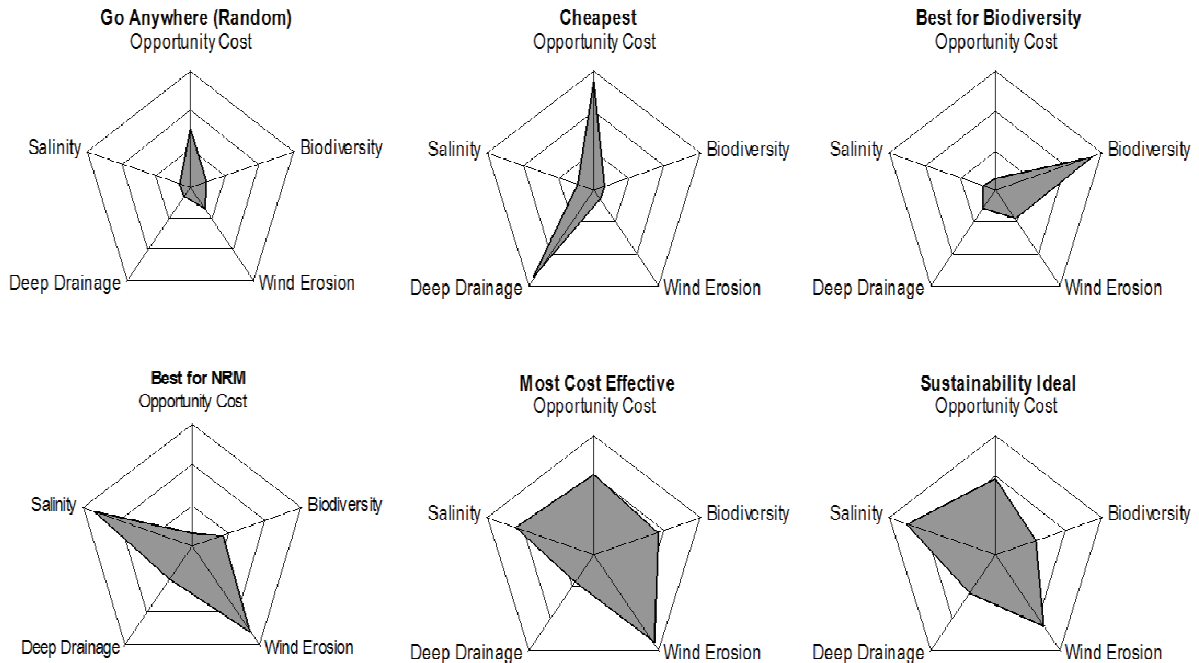
**Table 1.** Core datasets describing biophysical and economic elements of the study area.

Ecological	Soil salinity	Wind erosion	Economic
Remnant vegetation surrogates	Deep drainage	Wind erosion factor	Opportunity cost of lost production
Remnant vegetation	Depth to groundwater table	Benefits of managing wind erosion	
Risk of degradation to remnant vegetation	Benefits of managing deep drainage		
Conservation priorities			
Landscape fragmentation metrics			

Figure 1 summarises the benefits, costs and trade-offs of each ecological restoration policy option in the study area according to key indicators. Each radar plot represents a different policy option. The objective function of the optimisation models varies in each policy option. For example, under the 'cheapest' option, the objective is to minimise the opportunity cost when identifying locations for ecological restoration. Similarly, under the 'best for biodiversity' option, the objective is to maximise biodiversity benefits only. The 'most cost

**Theme 9: Concepts for Landscape Planning and Design**  
**9.2 Symposium 18: Coupling science and decision making in landscape sustainability: thresholds, models, and prediction**

effective' option is a function of cost and multi-objective resource management benefits. The axes report on the performance of the policy option for each particular indicator – the closer to the outer edge, the better. The greater the area covered by the radar plot – the better and more well rounded the performance of the policy option.



**Figure 1.** Performance of model outputs according to the policy option.

### Discussion and Conclusion

This study models and integrates a variety of environmental and economic data layers to identify spatial priorities for ecological restoration under different policy options. Quantitative targets extracted from existing resource management plans for the region have been operationalised in the models and form the basis for data integration, synthesis and analysis. Rarely is cost to a private landowner explicitly considered so this paper also estimates opportunity cost of forgone agricultural production following conversion to ecological restoration that ameliorate against degrading natural resources. While some actions may potentially generate income, e.g. through sale of carbon credits, it is still important to identify those landowners who may be worse off financially and are therefore less prepared to take a risk with changing land use. Furthermore, the exploration of different policy options arms regional policy makers with a set of tools and improved knowledge base for better natural resource management planning and decision making.

**Alternative Future Growth Scenarios for Utah's Wasatch Front: assessing the impacts  
of development on the loss of prime agricultural lands**

**T.C. Edwards Jr.<sup>1</sup>, G. Busch<sup>2</sup>, R.J. Lilieholm<sup>2</sup>, R.E. Toth<sup>2</sup>**

<sup>1</sup> USGS Utah Cooperative Fish and Wildlife Research Unit, College of Natural Resources,  
Utah State University, Logan, Utah, USA.  
e-mail: t.edwards@nr.usu.edu

<sup>2</sup> Department of Environment and Society, College of Natural Resources, Utah State  
University, Logan, Utah, USA.

**Introduction**

The Greater Wasatch Front (GWF) is a rapidly urbanizing region of north-central Utah, USA, lying between the Wasatch Mountains to the east, and the Great Salt Lake to the west. The U.S. Census (2000) found that the GWF was home to 1.9 million people in 2000. However, with an annual growth rate of 1.8%, the population is predicted to increase to 3.3 million by 2030, and as many as 5 million people could live in the region by 2050 (Envision Utah, 1999). Due to this large population growth and an increasingly built-out land base, urban development is rapidly spreading to outlying cities and towns. If traditional sprawl-like development continues through 2050, the GWF will undergo substantial change. Indeed, while urban growth often provides opportunities for employment, income, and entertainment, it also typically results in increased air and water pollution, and the irreversible loss of wildlife habitat, open space, and agriculture lands.

Our goal was to assess current development trends by examining how the GWF might develop over the next 25 years with the addition of 1.4 million new residents by creating hypothetical "alternative futures". We first assessed the location and scale of urbanization within the region from 1990 to 2000. Next, using GIS and logistic models, we developed a grid-based urban growth model to estimate the probability of future development for all undeveloped areas in the GWF. Finally, we calculated the potential loss of prime agricultural soils resulting from their conversion to development under two estimates of future settlement density.

**Methods**

Three steps were followed to develop future growth scenarios for the GWF: (1) develop a logistic growth model for the region; (2) allocate future population growth across the study area; and (3) assess the impacts of future growth on prime agricultural lands.

We first developed a logistic growth model that predicted the probability of future development for undeveloped lands based on past growth patterns and each pixel's spatial characteristics. The result is a map showing the probability of any given location changing from undeveloped to developed status, based on the spatial attributes of that location. The second step was population allocation. Allocation refers to placing a predicted future population across a landscape based on the most probable locations as determined by the logistic model. The result is a development "footprint" for the region at some point in the future. Last, we assessed the effects that predicted future development could have on prime agricultural lands in the GWF. This was generally accomplished by overlaying the predicted development footprint onto a map of environmental factors to locate areas of overlap (Landis, 1995).

**Results and Discussion**

Theme 9: Concepts for Landscape Planning and Design

9.2 Symposium 18: Coupling science and decision making in landscape sustainability: thresholds, models, and prediction

Population in the GWF is expected to increase from 1.95 million in 2000 to 3.32 million by 2030 -- an increase of 1.37 million people (75%). The approximate footprint of urban development in 2000 was 115,807 ha. Depending on densities of future development, the new population could increase the developed area by as little as 48% (55,308 ha) at 25 people per acre, or as much as 80% (92,281 ha) at 15 people per hectare.

Of the 1,286,449 ha of private lands within the GWF, 212,810 ha (16.5%) is considered agricultural soil. Of this, 49,486 ha (23%) had been built upon by 2000, leaving 163,324 ha as an agriculture base in 2000. By 2030, an additional 25,794 ha of these soils will be lost under the highest density alternative, and 64,922 ha under the low density alternative. Based on these scenarios, the GWF will retain as much as 63% or as little as 46% of its original prime agriculture soils by the year 2030 (Table 1).

Table1. Predicted prime agriculture soil loss using two different development densities of 25 and 15 people/ha.

Year	25 people/ha		15 people/ha	
	Loss (ha)	Percent loss	Loss (ha)	Percent loss
2010	9,235	4.34	14,992	7.04
2020	8,986	4.22	13,881	6.52
2030	7,572	3.56	11,511	5.41
Predicted loss:				
2000-2030	25,793	12.12	40,384	18.98
Total loss:				
prime soils	137,531	35.37	122,940	42.23

Throughout Utah, and especially within the GWF, urban and residential development is taking place on agriculturally productive lands. This trend is similar throughout the United States, where significant amounts of farmland are converted every year from the production of food to homes (Alterman, 1997). In many respects, this conversion represents an irreversible process. Reporting potential trends of farmland loss is of political, social, and economic concern, and is one of many potential applications of this logistic growth model.

Under the scenarios presented here, the majority of prime soils remaining in 2030 are likely to be west and south of Utah Lake. It is doubtful, however, that sufficient irrigation water would be available in those areas to provide for agricultural needs. Therefore, it is likely that urban development will eliminate most prime agriculture soils from the Wasatch Front by 2030.

**References**

**Alterman, R. (1997)** The challenge of farmland preservation: lessons from a six-nation comparison. *Journal of the American Planning Association*, **63**:220-239.

**Envision Utah (1999)** Salt Lake City, UT, [www.envisionutah.org](http://www.envisionutah.org)

**Landis, J. (1995)** Imagining land use futures: applying the California urban futures model. *Journal of the American Planning Association*, **61**:438-457.

**U.S. Census Bureau, (2000)** Census 2000 Geographic Terms and Concept:Appendix A. [www.census.gov/geo/www/tiger/glossary2.pdf](http://www.census.gov/geo/www/tiger/glossary2.pdf)

## Grass strips in the CAP reform: from scientific results to policy making, the loss of efficiency

F. Burel<sup>1</sup>, A. Ernoult<sup>1</sup>, J. Baudry<sup>2</sup>, T. Delattre<sup>1</sup>, A. Javelle<sup>1</sup>, P. Kindlmann<sup>1,3</sup>, J.B. Pichancourt<sup>1</sup>

<sup>1</sup> Ecobio, CNRS- Université de Rennes 1, campus de Beaulieu, 35042 Rennes cedex, France.

e-mail: Francoise.burel@univ-rennes1.fr

<sup>2</sup> INRA-SAD paysage, 65 rue de Saint Briec, 35042 Rennes cedex, France,  
<sup>3</sup> University of South Bohemia, Czech Republic

### Introduction

For policy makers grass strips must achieve two main goals, first they are part of the set aside schemes and help to reduce agricultural production and second they participate to the protection of natural resources, water and biodiversity. For farmers they are first perceived as one more constraint from the administration rather than an environmental measure. Evaluation of their ecological effect has to be carried out. In this paper taking advantage of the setting of such a measure at the landscape scale, we pose the question of the social and ecological value of grass strips.

### Study site

The work is based on a long term socio-ecological site where research on the response of biodiversity to landscape and agriculture dynamics have been followed for 14 years. It is a hedgerow network landscape of 8500 ha 60 km north of Rennes, mainly agriculture oriented, with a mix of dairy and crop productions. The density of the hedgerow network varies from 48 m/ha in the North where a reallocation programme took place, to 98m/ha in the South. The crops are mainly maize, wheat and rape. The farmers have to comply with CAP measures, as throughout the European Union. Hedgerows have been studied to find out whether they create greenways (Burel and Baudry 1995; Ouin et al. 1999; Burel et al. 2004). The hedgerow length and connectivity have fallen by 22% and 35% respectively, between 1952 and 1993 (Michel et al. 2006).

### Methods

Grass strips have been implemented since autumn 2005. Using field surveys, mapping and farmers interviews we have assessed the effects on ecological processes e.g. the response of biodiversity at different scales, from field to landscape, and the efficacy of such measures for the environment. Models of landscape dynamics and population dynamics are one of the tools which have been developed

We use simulation models to assess connectivity changes associated with population dynamics for a butterfly species *Maniola jurtina*. The meadow brown (*Maniola jurtina*) is one of the most abundant butterfly species in agricultural landscapes, found in a variety of habitats, although many populations have been lost due to agricultural intensification.

We compare the actual grass strips: (1) with a potential scenario where a grass strip is allocated on a 10 m wide buffer along streams when crops are present, and (2) with past state of the landscape, prior to strips being set up. Landscape connectivity considers functional distances between suitable patches with friction costs depending on landscape heterogeneity. A spatial population model integrates this heterogeneity at the landscape scale, and habitat quality at a local scale. The habitat quality of strips is derived from floristic composition.



Farmers' and scientists' interviews permit the understanding of the eventual discrepancies between regulation, its scientific objectives and its implementation and to propose guidelines for the future.

## Results

### Ecological value of grassy strips –

Floristic surveys in 2006 and 2007 showed grass strip heterogeneity: - heterogeneity in term of species composition despite the common use of rye grass, - heterogeneity in term of vegetation structure (vegetation height, vegetation covering...) according management of the strips.

Landscape level measures of connectivity for *Maniola jurtina* do not vary much with the setting of actual or potential grass strips. This may be linked to landscape organisation where even in the open hedgerow network landscape most of the land bordering streams is grassland or woodlots. Effects are significant for species with a lower mean dispersal distance.

Individuals of *Maniola jurtina* use strips of various qualities for their movements. The corridor effect of strips is measured by the change in flux intensity and size of interconnected grassland patches, using an individual based model (Kindlmann et al. 2004). After calibrating this model with capture-recapture data set of the year, projections will give us the short/long-term potential of different scenarios of grassy strip networks to maintain the populations.

### Social value of grass strips

Analysis of interviews shows that the final regulations for implementation have little environmental consistency. Indeed, some of the scientists underline some inconsistencies of the cross-compliance scheme (such as the possibility to break-up the grass patches, thus liberating the nitrogen that was originally supposed to be stopped, or to leave on the spot the cut grass that makes the soil even richer, or even to reap or crush an area that would find its equilibrium without any intervention). Furthermore, farmers have difficulties in integrating the regulation because of the inability of the administration to understand how the scheme should be applied.

## Conclusion

We pose that new research questions linking social (policy, farming) and ecological dynamics have to be undergone including: evaluation of current implementations, governance, and landscape rather than farm or field scale approach.

## References

- Burel, F.**, and **J. Baudry** (1995). "Species biodiversity in changing agricultural landscapes: A case study in the Pays d'Auge, France." *Agriculture Ecosystems and Environment* **55**: 193-200.
- Burel, F.**, **A. Butet**, **Y. R. Delettre** and **N. Millan de la Pena** (2004). "Differential response of selected taxa to landscape context and agricultural intensification." *Landscape and Urban Planning* **67**(1-4): 195-204.
- Kindlmann, P.**, **S. Aviron**, **F. Burel** and **A. Ouin** (2004). "Can the assumption of a non-random search improve our prediction of butterfly fluxes between resource patches?" *Ecological Entomology* **29**(4): 447-456.
- Michel, N.**, **F. Burel** and **A. Butet** (2006). "How does landscape use influence small mammal diversity abundance and biomass in hedgerow networks of farmins landscapes?" *Acta Oecologica* **30**: 11-20.
- Ouin, A.**, **G. Paillat**, **A. Butet** and **F. Burel** (1999). "Spatial dynamics of *Apodemus sylvaticus* in an intensive agricultural landscape." *Agriculture, Ecosystem, Environment*.

## Structural, functional and temporal fragmentation: the impossibility of pleasing everyone

S.A. Hinsley<sup>1</sup>, R.A. Hill<sup>1</sup>, P.E. Bellamy<sup>1</sup>, P.N. Ferns<sup>2</sup> & N.M. Harrison<sup>3</sup>

<sup>1</sup>Centre for Ecology and Hydrology, Monks Wood, Abbots Ripton, Huntingdon, Cambridgeshire PE28 2LS, UK.  
e-mail: sahi@ceh.ac.uk

<sup>2</sup>School of Biological Sciences, Cardiff University, Cathays Park, Cardiff CF10 3TL, UK

<sup>3</sup>Department of Life Sciences, Anglia Ruskin University, East Road, Cambridge CB1 1PT, UK

### Introduction

As landscape ecologists we are familiar with the concepts of habitat fragmentation, mainland/island relationships and metapopulations. These envisage discrete habitat patches dispersed in some type of non-habitat matrix and the standard "habitat patch" is often a uniform entity with extent, but no internal structure. In reality, habitat structure is often highly heterogeneous, and different organisms' resource requirements e.g. food, shelter, nest sites etc. are usually unevenly distributed in time as well as space. Therefore, fragmentation need not be only structural. Habitat composition, and phenology of both the habitat and the inhabitants, may also contribute detrimental fragmentation effects which are not immediately apparent from patch structure and extent alone.

### Examples of Fragmentation

#### Structural gaps

For arboreal insectivorous birds such as great tits, *Parus major*, and blue tits, *Cyanistes caeruleus*, the availability of trees around the nest hole is vital for breeding success. For 22 nest boxes in woodland, the mean percentage gap fraction (gaps defined as heights < 1 m obtained from a Digital Canopy Height Model derived from airborne remote sensed data acquired using Light Detection and Ranging, LiDAR, Hinsley *et al.*, 2002) within a 25 m radius circle of each box was  $0.64 \pm 1.18\%$ , with a range of 0-4.3%. In contrast, in an urban park, the corresponding mean value of the gap fraction for 26 boxes was  $32.7 \pm 22.6\%$ , with a range of 0.1-88%. Such gaps are likely to contribute to the poor breeding success typical of park-breeding tits (Table 1). Furthermore, the costs to the adults of rearing young (measured as female daily energy expenditure,  $\text{kJ day}^{-1}$ , using doubly labelled water) appeared to increase rapidly above a threshold of about 35% gap (Hinsley *et al.*, in prep.).

#### Functional gaps

For woodland tits in the UK, oak trees are favourable as foraging sites (e.g. Naef-Daenzer *et al.*, 2004). Again, using airborne remote-sensed data (multi-spectral Airborne Thematic Mapper, ATM), for the same sample areas around the 22 woodland nest boxes, the canopy cover of English oak, *Quercus robur*, was  $19.6 \pm 16.9\%$ , range 1.7-66%. In the park, the incidence of English oak was zero for most boxes. Unlike the wood, many of the tree species in the park were exotics. Compared with native species, exotics may be poor foraging substrate for invertebrates and thus also poor foraging substrate for insectivorous birds. Therefore, in addition to the spatial gaps around their nest sites, the park birds may also encounter functional gaps. The significance of functional gaps was demonstrated by the woodland birds where the daily energy expenditure of female great tits rearing young increased as the proportion of oak around their nest boxes decreased (Hinsley *et al.*, in prep.).

**Table 1.** Reproductive success of tits in relation to the degree of fragmentation of their habitat. Fragmentation increases from large woods to small woods to parks.

	GREAT TIT			BLUE TIT		
	Mean chick body mass, g	No. chicks fledged	n	Mean chick body mass, g	No. chicks fledged	n
Large woods c. 150 ha	17.7	9.0	49	10.2	10.0	16
Small woods c. 1 ha	15.8	6.1	22	10.0	7.6	15
Urban park	14.8	4.6	26	9.0	6.1	45

### Temporal gaps

Recent work on the effects of climate change and increasing spring temperatures in Europe has identified the possibility of a temperature-induced mismatch between birds' timing of breeding and that of their food supply (Both and Visser 2005). Exotic tree species may also present birds with phenological problems; should they prove suitable as invertebrate hosts, their timing of leafing may be too early or too late for the birds. Urban great tits tend to breed earlier than their woodland counterparts, whereas timing in blue tits remains similar, e.g. in 2006, mean first egg date for great tits ( $n = 11$ ) and blue tits ( $n = 7$ ) in Bute Park, Cardiff was  $20.6 \pm 5.3$  and  $26.1 \pm 2.3$  respectively, compared to  $27.6 \pm 5.7$  for great tits ( $n = 16$ ) and  $26.1 \pm 4.8$  ( $n = 16$ ) for blue tits in woodland (where April 1<sup>st</sup> = 1). Overall, tree leafing in the park was about 12 days earlier, but the range was wider due to the much greater number of tree species. Thus there is considerable scope for mismatching between birds, trees and invertebrates.

### **Discussion**

An organism's susceptibility to deleterious effects of fragmentation may also vary with other factors. For example, when egg laying, a female tit is relatively free to move around its habitat, fragmented or not. However, when feeding young, all food must be taken to the nest increasing the costs of exploiting patchy habitat (Hinsley 2000). Exposure to inclement weather may also be greater in fragmented habitat and probably contributes to the greater variability between years in breeding performance of tits in parks compared to large woods.

Therefore, habitat may be more fragmented than is simply apparent from its structure at a particular time. While management often seeks to increase habitat diversity and maintaining or increasing biodiversity in general is desirable, or even essential for long-term ecosystem function, there may be circumstances where diversity favours generalists at the expense of specialists. In the UK, most semi-natural habitat occurs in small patches and tends to be highly fragmented. Networks of patches and linear features have high edge to interior ratios. In densely populated countries where most of the landscape is highly modified and managed, is it inevitable that habitat specialists will lose out to generalists?

### **References**

- Both, C. & Visser, M.E. (2005)** The effect of climate change on the correlation between avian life-history traits. *Global Change Biology* **11**: 1606-1613.
- Hinsley, S.A. (2000)** The costs of multiple patch use by birds. *Landscape Ecology* **15**: 765-775.
- Hinsley, S.A.; Hill, R.A.; Gaveau, D.L.A. & Bellamy, P.E. (2002)** Quantifying woodland structure and habitat quality for birds using airborne laser scanning. *Functional Ecology* **16**: 851-857.
- Naef-Daenzer, L.; Nager, R.G.; Keller, L.F. & Naef-Daenzer, B. (2004)** Are hatching delays a cost or a benefit for great tit *Parus major* parents? *Ardea* **92**: 229-238.

## Fractal analysis of landscape features in northeastern São Paulo State, Brazil

M.C. Hott<sup>1</sup>, M. Batistella<sup>1</sup>, C. Criscuolo<sup>1</sup> and V.P. Soares<sup>2</sup>

<sup>1</sup> Brazilian Agriculture Research Corporation - Embrapa Satellite Monitoring Av. Dr. Julio S. de Arruda, 803, Campinas, SP, CEP 13088-300, Brazil.

e-mail: marcos@cnpem.embrapa.br

<sup>2</sup> Federal University of Viçosa, Av. P.H. Rolfs, Viçosa, MG, CEP 36570-000, Brazil.

### Introduction

Fractal analysis has been used to evaluate natural and anthropogenic phenomena, as well as to describe spatial and temporal landscape characteristics. The Fractal Dimension (FD) indicates the complexity of a patch through a perimeter-area proportion. Low values are derived when a patch has a small perimeter in relation to the area. If the patches are more complex, the perimeter increases and produces a higher FD (Herold *et al.*, 2003). Also, the association of simulated ecological shapes and FD can be useful for the extraction of scaling properties (Kallimanis *et al.*, 2002), an important topic in decision making towards landscape sustainability. This paper analyses an agricultural landscape in Brazil trying to understand the implications on the use of such metrics for conservation and development issues.

### Spatial Data and Methods

The aim of this work was to analyze the overall and average FD based on perimeter-area shape metrics and on linear regression of land-cover/use patches classified from Landsat ETM+ imagery. The study area of 51,650 km<sup>2</sup> is located in northeastern São Paulo State, Brazil.

FD was calculated for each patch through a perimeter-area ratio (Olsen *et al.*, 1993), which is indicated by  $FD = 2 * \log(\text{Perimeter}/4) / \log(\text{Area})$ . Overall FD was calculated as a result of the adjustment, by linear regression, of perimeter-area pairs. The angular coefficient (A) was used following the equation:  $FD_{\text{Overall}} = 2/A$  (Krummel *et al.*, 1987).

### Results and Discussion

The results in Table 1 indicate that the average FD is related with the overall FD in different ways. Some classes have low average values even if their overall FDs have higher values (e.g., water bodies). The opposite also occurred (e.g., Forestry). Other classes presented the same hierarchical position for overall and average FD (e.g., central pivots and riparian vegetation). Figure 1 illustrates the linear regression obtained for riparian vegetation including approximately 6,000 perimeter-area pairs.

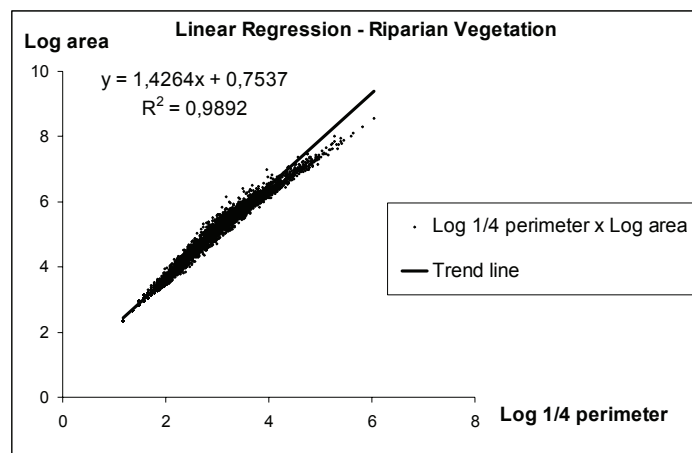
The histogram for overall FDs indicates a possible threshold above 1,2210, separating the main classes of natural vegetation (i.e., seasonal forest, secondary forest, and riparian vegetation), as well as water bodies and mining areas. Fieldwork confirmed that both natural vegetation and mining areas occur nearby water bodies. The riparian vegetation reached the greatest overall FD because of human policies fostering their preservation and due to typical hydrogeomorphic characteristics, as also indicated by Rex & Malanson (1990).

Further analyses will be carried out to provide complementary information about these landscape features and current conservation practices to inform land use planning towards landscape sustainability.

**Table 1.** Results obtained for fractal analyses and ranked by Overall FD.

**Theme 9: Concepts for Landscape Planning and Design**  
**9.2 Symposium 18: Coupling science and decision making in landscape sustainability: thresholds, models, and prediction**

	Average FD	STD	Angular Coeff.	R <sup>2</sup>	Overall FD
Central Pivots	1,0265	0,017	1,7347	0,96	1,1529
Forestry	1,0771	0,041	1,7346	0,981	1,1530
Grasslands	1,0707	0,035	1,727	0,977	1,1581
Annual Crops	1,0717	0,045	1,7091	0,985	1,1702
Fruit Crops	1,0762	0,043	1,7041	0,984	1,1736
Others	1,0891	0,044	1,7037	0,965	1,1739
Rubber Tree	1,0677	0,026	1,677	0,973	1,1926
Urban Areas	1,0767	0,038	1,676	0,978	1,1933
Coffee Plantations	1,0766	0,038	1,6721	0,979	1,1961
Sugar Cane Plantations	1,0759	0,059	1,6668	0,988	1,1999
Pasture	1,0836	0,052	1,6536	0,983	1,2095
Seasonal Forest	1,0797	0,042	1,638	0,969	1,2210
Secondary Forest	1,0853	0,046	1,637	0,968	1,2217
Water Bodies	1,0618	0,046	1,5931	0,965	1,2554
Mining Areas	1,0935	0,042	1,5328	0,847	1,3048
Riparian Vegetation	1,1121	0,096	1,4264	0,989	1,4021



**Figure 1.** Graphic of linear regression on perimeter-area pairs for riparian vegetation.

**References**

**Herold, M., Liu, X. & Clarke, K. C. (2003)** Spatial metrics and image texture for mapping urban land use. *Photogrammetric Engineering & Remote Sensing*, **69**: 991-1001.

**Kallimanis, A. S., Sgardelis, S. P. & Halley, J. M. (2002)** Accuracy of fractal dimension estimates for small samples of ecological distributions. *Landscape Ecology*, **17**: 281-297.

**Krummel, J. R., R. H. Gardner, G. Sugihara, R. V. O'Neill & Coleman, P. R. (1987)** Landscape patterns in a disturbed environment. *Oikos*, **48**: 321-324

**Olsen, E. R., Ramsey, R. D., & Winn, D. S. (1993)** A modified fractal dimension as a measure of landscape diversity. *Photogrammetric Engineering & Remote Sensing*, **59**:1517-1520.

**Rex, K.D. & Malanson, G. P. (1990)** The fractal shape of riparian forest patches. *Landscape Ecology*, **4**: 249-258.

## Effects of land-use change on landscape attractiveness

J. Bolliger, F. Kienast, R. Soliva, K. Gehring, M. Hunziker

Swiss Federal Research Institute WSL, Zürcherstrasse 111, CH-8903 Birmensdorf,  
Switzerland.

e-mail: janine.bolliger@wsl.ch

### Introduction

Land-use changes, mostly related to agricultural decline have been an increasingly important process during the last decades in shaping the European Alps (Meeus *et al.*, 1991). Consequences of agricultural decline include undergrazing or elimination of grazing in pastures and meadows leading to spontaneous colonisation by trees. The effects of such land-use changes are varied and include e.g., significant losses of open-land habitats (Dirnböck *et al.*, 2003; Dullinger *et al.*, 2003), although, in the short term, spontaneous colonisation by trees may locally cause an increase in landscape structure (Söderström *et al.*, 2001) and thus an increase in structural habitat diversity.

In this paper, we evaluate potential consequences of various scenarios of land-use change with respect to people's preferences at the landscape scale (Switzerland, 41,000km<sup>2</sup>). The land-use change scenarios encompass: (1) business-as-usual scenario which relies on trends of land-use change observed during the last 15 years, (2) liberalisation scenario where no public support is given to agriculture or conservation, and (3) extensively managed open-land scenario which assumes subsidies for biodiversity and conservation.

In line with a variety of similar studies (Hunziker and Kienast 1999; Sung *et al.*, 2001; Franco *et al.*, 2003), we show that landscape attractiveness and the quantifiable landscape structure using landscape metrics can be correlated. This study, however, takes the issue one step further by projecting local-scale qualitative information to large spatial scales under potential future scenarios of land-use change. Advantages of the approach include that potential sensitive areas of attractiveness change may be located spatially explicitly as a function of land-use change scenarios and may thus provide baseline information for future landscape management and planning.

### Material and methods

Based on the premise that landscape attractiveness can be associated with quantifiable physical landscape characteristics, the physical landscape properties may be used as proxies to project people's preferences for landscapes under scenarios of land-use change. We first assessed the relationship between landscape attractiveness and land-use with local-scale image series showing different degrees of landscape structure (i.e., colonisation by trees). To assess landscape attractiveness, a representative sample of the Swiss population ( $n=628$ ) was presented with various series of images depicting gradual colonisation by trees for personal evaluation. The image series were quantified by landscape metrics (e.g., number of patches) and used to conceptually extrapolate landscape attractiveness from the image series to the landscape scale. Results are spatially explicit landscape-attractiveness statistics for various degrees of increasing tree cover scenarios.

### Results

#### Linking landscape attractiveness with landscape structure

Landscape attractiveness as assessed using the local-scale images shows that intermediate to highly structures landscapes are preferred, independent of the people's professional or personal background.

Projecting landscape attractiveness to future scenarios of land-use change

Overall, major gains in landscape attractiveness are observed for both the extensification and the business as usual scenario. Overall losses in landscape attractiveness are observed in the liberalisation scenario. Regionally different gains of landscape attractiveness in Switzerland are observed for the Jura mountains under the business as usual and the extensification scenario. Most regions, however, lose attractiveness under the liberalisation scenario. The largest losses in landscape attractiveness are located in the mountains (Northern, Central, and Southern Alps) where colonisation is likely to be the highest.

**References**

- Bolliger, J; Kienast, F; Soliva, R. & Rutherford, G.N. (in press)** Spatial sensitivity of species habitat patterns to scenarios of land-use change (Switzerland). *Landscape Ecology*.
- Dirnböck, T; Dullinger, S. & Grabherr, G. (2003)** A regional impact assessment of climate and land-use change on alpine vegetation. *Journal of Biogeography* **30**: 401-417.
- Dullinger, S; Dirnböck, T. & Grabherr, G. (2003)** Patterns of shrub invasion into high mountain grasslands of the Northern calcareous Alps, Austria. *Arctic, Antarctic, and Alpine Research* **35**: 434-441.
- Franco, D; Manninon I. & Zanetto G. (2003)** The impact of agroforestry networks on scenic beauty estimation. The role of landscape ecological network on a socio-cultural process. *Landscape and Urban Planning* **62**: 119-138.
- Hunziker, M; & Kienast F. (1999)** Potential impacts of changing agricultural activities on scenic beauty - a prototypical technique for automated rapid assessment. *Landscape Ecology* **14**: 161-176.
- Meeus, J; Van Der Ploeg, J.D. & Wijermans, M. (1991)** Changing agricultural landscapes in Europe: continuity, deterioration or rupture?, IFLA conference, Rotterdam, The Netherlands.
- Söderström, B; Svensson, B; Vessby K. & Glimskär A. (2001)** Plants, insects, and birds in semi-natural pastures in relation to local habitat and landscape factors. *Biodiversity and Conservation* **10**: 1839-1863.
- Sung, D.-G; Lim, S.-H; Ko J.-W. & Cho G.-S. (2001)** Scenic evaluation of landscape for urban design purposes using GIS and ANN. *Landscape and Urban Planning* **56**: 75-85.

## 9.3 Symposium 19: Landscape Planning: Building the evidence base and creating the vision

### Managing landscapes of the Australian Northern Territory for sustainability: Visions, issues and strategies for successful planning

D.M. Pearson<sup>1</sup> and J.T. Gorman<sup>2</sup>.

<sup>1</sup> Tropical Spatial Science Group, School of Science and Primary Industries, Charles Darwin University, NT 0909 Australia.

e-mail: [diane.pearson@cdu.edu.au](mailto:diane.pearson@cdu.edu.au)

<sup>2</sup> Livelihood and Policy Theme, School for Environmental Research, Charles Darwin University, Darwin, NT 0909 Australia.

#### Introduction

The landscapes of the Australian Northern Territory (NT) are fairly unique in that they are relatively structurally intact having not undergone the same pressures of urban and agricultural development as their southern state counterparts. Factors that have contributed to their preservation are related to isolation, a sparse population and limited infrastructure but these factors also can be seen as being disadvantageous for development. Adding to the uniqueness of these landscapes and contributing to their relatively good condition in terms of ecosystem health is the fact that just over half of the land is under Aboriginal land title (mostly communal ownership) and of marginal agricultural value. However, when these landscapes are considered holistically a large proportion of the indigenous population that reside within them are seen to be living in third world conditions with major social and health problems. In 2005, the first Integrated Natural Resource Management (INRM) Plan for the NT, Australia was completed entitled 'Sustaining our resources – people, county and enterprises' (Landcare Council of NT, 2005). The vision of this plan values cultural knowledge systems in the management of the diverse and unique landscapes and aims at sustaining biodiversity and the economies and livelihoods they support. The INRM plan strives, through a series of management action targets, to improve quality of life for all Territorians by recognising, quantifying, mapping, maintaining, protecting and developing the important assets found within the region. The essence of this vision, or potential *Leitbild*, takes a holistic approach to planning by considering people as an important natural resource and asset. It is well recognised now through indigenous Community Ranger programs that there is a link between healthy landscapes and healthy people, and many of the services that can be provided by indigenous management of landscapes have a public good which has not been assigned an economic or social value. This paper explores the vision for the NT, examines the issues behind the vision, and discusses some strategies to make the vision a reality.

#### Background

Planning for the NT needs to encourage development to promote growth and increased opportunities for livelihoods for the regions growing population. The expected growth in the regions population is predominantly indigenous, with increases to the population growth rate for young indigenous people of employment age expected to go up by 18-20% between 2001 and 2009 (DEET, 2006). However, one of the major issues facing this region is the lack of relevant employment opportunities particularly in remote communities. An important feature of the NT society that is significant for the NT landscape is the strong commitment that Aboriginal people have to place and country. It is important that traditional aboriginal land management knowledge and connections to land are not lost as these have been demonstrated to be important for NRM. Also important is the knowledge of pastoralists, fishers and other natural resource managers that have historical connections with the landscape in this region. The INRM plan recognises, appreciates and incorporates the diversity of knowledge and information into the planning process. It has also created a high



demand for knowledge brokering and information exchange between NT landscape stakeholders.

### **Ongoing research – finding solutions and strategies**

Considerable work is being done with Aboriginal communities both in the wet/dry tropics of the NT and in the central desert region to facilitate sustainable natural and cultural resource management and encourage the creation of 'jobs on country'. Just one ongoing research project is the Sustainable Community ranger project which forms part of Desert Knowledge CRC Core project 1 *Livelihoods inLand*<sup>TM</sup>. Community ranger groups have become a major framework for Aboriginal NRM/CRM activities and have generated positive social and environmental outcomes particularly in the wet/dry tropics of the NT where they have been well established for some time now. Current research is trying to match indigenous aspirations with state policy goals and encourage long term meaningful employment that is of benefit to the NT people and environment. One aspect of what is being investigated is the idea of contracting out NRM activities by government and maps of potential services that could be provided by Community Ranger groups are being created.

With regard to facilitating knowledge exchange a proposal has been submitted to create an NT Applied Landscape Education and Research Network for the NT aimed at the exchange of information and knowledge transfer between a range of stakeholders and researchers/lecturers/trainers engaged in practical natural resource management in the NT. The ultimate vision of such a network is to create partnerships, understanding and communities of practice to work towards sustainable resource management. Expected NRM outcomes of such a network include - coordinating and developing a virtual network of knowledge, databases, research facilities and scientific infrastructure that is accessible to NRM practitioners which will assist people to work towards solutions to real issues with research priorities directed towards on the ground issues, as well as facilitating integrated social, economic and environmental learning activities that can contribute to the long term sustainability of landscapes, lifestyles and livelihoods in the NT.

### **Problems and Issues**

Planning for sustainability should take into account the strong links between biodiversity, livelihoods and health but management and governance in remote and marginal parts of the NT is complex. In the NT landscape management is shared between Federal, Territory and local governments and public and private land owners (indigenous and non-indigenous). Current changes to the social security system initiated by the Federal government may result in Aboriginal people moving from smaller settlements into larger townships which disconnect people with their land and limit the public and environmental services they can provide. This may have major implications for land management in this region and threaten the vision of the INRM plan. If the NRM vision for the NT is to become reality then better collaboration and integration is needed between government agencies, landowners, industry, community and researchers. And a real understanding of the complex forces (environment, social and political) that determine the success or failure of activities like those of the community rangers is needed.

### **References**

- Department of Employment, Education and Training (DEET). (2006).** *Workforce NT report 2005*. Northern Territory Government.
- Landcare Council of the Northern Territory. (2005).** *Sustaining our resources - people, country and enterprises*. Integrated Natural Resource Management Plan for the Northern Territory.

## **Green-blue landscape networks link private and public interests at different spatial scales: the case of the Hoeksche Waard**

**E.G. Steingröver, W. Geertsema, W. van Wingerden**

Landscape Centre, Alterra Green world Research, Wageningen University, PO Box 47, 6700 AA, Wageningen, The Netherlands.  
e-mail: eveliene.steingrover@wur.nl

### **The study area**

The Hoeksche Waard is an area of 30,000 ha of mostly arable land. It is located just south of the city of Rotterdam and is highly renowned for its open space and green landscape. The area is intertwined with a network of dikes and creeks which have many functions, for recreation, water management, agriculture and supporting biodiversity. Besides this regional more robust network, we find a finer green-blue network of smaller landscape elements like ditches, road margins and field margins on a lower scale level. There is large consensus among local inhabitants, farmers and policy makers, water managers and conservation organizations to maintain this agricultural landscape and conserve its unique quality of openness, quietness, dikes and polders with creeks, and to use the existing green-blue network for natural pest control.

### **Natural pest control supported by green-blue veining**

In agricultural landscapes, natural pest control is a way to reach more sustainable, cleaner types of agricultural practices with less dependency upon pesticides (Thies and Tschardtke, 1999). Natural pest control aims to enhance the diversity and abundance of natural enemies that suppress and control pest insects through predation and parasitism. Natural enemies need not only arable fields, but also semi-natural vegetation, which can be found in the green-blue network of robust and finer landscape elements. Major pest insects in local arable fields are aphids, thrips, caterpillars and slugs. Their most important natural enemies are ladybirds, hoverflies, parasitic wasps, ground dwelling spiders and carabid beetles. It is generally the larvae of these natural enemies that predate upon pest insects. However, the adults need nectar, pollen and shelter from extreme weather conditions. They find food and shelter in semi-natural elements, without which natural pest control is not possible. The mobility of these natural enemies is limited, so the distance between crops and green-blue veining should not be too large.

### **Designing a green-blue network for natural pest control**

The function of natural pest control sets specific conditions for the green-blue network, in terms of spatial distribution, plant species composition, vegetation structure, and vegetation management (Bianchi *et al.*, 2005). The robust and finer green-blue landscape elements have different functions in natural pest control. Both function as habitat, from which insects actively move into the fields. The robust elements also function as overwintering habitat and sources for passive dispersal over larger distances. The network of robust elements function as the arteries for natural pest control. This network should be completed with the fine elements, that function as capillaries.

To design a green-blue network for natural pest control, spatial and habitat norms have to be derived and translated into general design rules, easily applied by local stakeholders (Opdam *et al.*, 2005). At present, the various green-blue landscape elements are owned and managed by different groups of stakeholders and organizations, organized on different spatial scales, representing both private and public interests and include private

farmers as well as local councils, water boards, and nature organizations. So, how can the ambition level be reached in such a way that both benefits and costs are divided over the different stakeholder groups in a satisfactory way?

Using the latest scientific knowledge, quantitative and qualitative norms for both robust and finer elements of the green-blue network were derived. This knowledge was made available to stakeholders in the form of design rules, which allowed them to analyze the current situation and to assess the necessary actions to be taken, on the landscape scale as well as on the individual farm level (Geertsema et al., 2004 and 2006). The design rules were constructed in such a way that stakeholders could distinguish and negotiate about the desired public and the private contribution to their joint aim. Strategies to reach the desired situation were based on spatial and stakeholder arrangements. The green-blue network acted as a powerful link between the necessary action on local and landscape level and therefore between the interests of farmers and public organizations.

### **References**

- Bianchi, F.J.J.A; van Wingerden, W.K.R.E; Griffioen, A.J; van der Veen, M; van der Straten, M.J.J; Wegman, R.M.A. & Meeuwsen, H.A.M. (2005)** Landscape factors affecting the control of *Mamestra brassicae* by natural enemies in Brussels sprout. *Agriculture, Ecosystems & Environment* **107**: 145-150.
- Geertsema, W; Steingröver, E; van Wingerden, W; van Alebeek, F. & Rovers, J. (2004)** In Dutch: Groenblauwe dooradering in de Hoeksche Waard. Een schets van de gewenste situatie voor natuurlijke plaagonderdrukking. *Alterra report* 1042, ISSN 1566-7197.
- Geertsema, W; Steingröver E; van Wingerden, W; Spijker, J. & Dirksen, J. (2006)** In Dutch: Kwaliteitsimpuls groenblauwe voor plaagonderdrukking in de Hoeksche Waard. *Alterra report* 1334, ISSN 1566-7197.
- Opdam, P; Steingröver, E. & van Rooij, S. (2005)** Ecological Networks: a spatial concept for multi-actor planning of sustainable landscapes. *Landscape and Urban Planning* **75**: 322-332.
- Thies, C. & Tschardtke, T. (1999)** Landscape Structure and Biological Control in Agroecosystems. *Science* **285**: 893-895.

## What are landscape planners up to?

C.v. Haaren

Department of Environmental Planning, Leibniz University of Hannover, Herrenhaeuser  
Strasse 2, D-30419 Hannover, Germany.  
e-mail:haaren@umwelt.uni-hannover.de

The European Landscape Convention (ELC) has already been ratified by 26 European states thus resulting in a commitment to promote landscape protection, management, and planning (Art.3). As a consequence, there will be a growing need for 'classical' landscape planning activities in many European states which include the definition and assessment of landscapes and landscape changes (Art 6ELC) and the proposal of suitable goals and measures. This creates the opportunity to use landscape plans as a multifunctional environmental tool for many applications. Possible applications lie in three general fields:

1. Precautionary impact regulation and compensation, rehabilitation and improvement of ecosystems
2. Participation and raising environmental awareness
3. Implementation of landscape relevant goals by "marketing of nature".

These three points do not only represent challenges for the methodological development of landscape planning. They also stand for fields in which new tasks or a shift of work to new focuses may arise for landscape planners in the near future.

### **1. Impact regulation and compensation, rehabilitation and improvement of ecosystems**

Classical tasks such as environmental impact studies, habitat network concepts or spatial planning and zoning which promote development of ecologically suitable sites will continue to be an operating field of landscape planners. However, new skills are needed in integrating the different instruments into approval documents, which should not deal with the different environmental factors (water, soil, climate, biodiversity...) and the corresponding regulations separately. Likewise, new requirements for Strategic Impact Assessments (SEA) also exist. Here lies a field of application for landscape plans, which are needed as an information base for the scoping and screening process as well as for the environmental report and as an instrument for monitoring. If procedural landscape planning is drawn up or continued parallel to spatial planning and zoning, it will be part of and facilitate an effective and efficient SEA, which is integrated into both planning processes and allows addressing problems of shrinking cities as well as those of urban sprawl (Scholles & Haaren 2004).

Lately, dealing with the environmental impacts of the rapidly growing renewable energies and the issue of climate change is a rising challenge. The ecological effects of biomass cropping differ from those of conventional agriculture and forestry (Rode 2005). On one hand, the use of newly bred or genetically modified plants can cause hitherto unknown environmental effects. An example is the effects of new maize varieties which are more than 4 m high and will dramatically affect landscape aesthetics. On the other hand, the increased share of environmental risky bioenergy crops like rape seed or maize in acreage and crop rotation changes the impact of agriculture and forestry on the ecosystems considerably. A sound information base provided by landscape planning, i.e. about regions where certain kinds of biomass should not be cropped, could be a valuable contribution to the solution of these problems.

### **2. Information participation and raising environmental awareness of the public**

Public access to environmental information and requirements as well as public participation (Aarhus Convention, ELC) must be improved in many countries. For landscape planners the use of new technologies and participation via the Internet will undoubtedly gain in importance. Additionally, the demand for visualisation and scenario techniques will increase

as these are important tools in order to communicate planning proposals to the public. Rising environmental awareness and education as demanded by the Aarhus Convention and the ELC may likewise gain more significance for planning. Landscape planners might connect landscape planning to learning modules for various age groups which focus on landscape issues and offer teachers, students, citizens and tourists opportunities for self-guided learning and better understanding of the local landscape. (v. Haaren, Warren-Kretzschmar 2006).

### **3. “Marketing of nature”**

Landscape planning can support the “marketing of nature” to help people to make a living from ecological qualities and landscape amenities. If environmental services beyond the level of good farming practice are needed, these additional services on the basis of common environmental objectives must be purchased from land users. In the EU, the United States or Japan, agri-environmental programs have been set up to offer incentives for farmers (OECD, 2005). However, compensation payments are not sufficiently targeted on areas in need of special measures beyond GFP. Furthermore, there is a sceptical attitude towards more demanding environmental services and a lack of training and awareness of the farmers, which further aggravates the successful implementation of such programs (e.g. for Germany: Osterburg 2004).

Landscape planning can be used in this context primarily as a comprehensive information tool that indicates societal demand for landscape qualities or need for environmental action (v. Haaren 2007). Conservation authorities need such information to prioritise funding for efficient and demand-orientated environmental services. If the “greening” of European agricultural and forestry subsidies will proceed, the importance of LP in this context will rise.

Also the land user can make use of such information either as base for offering environmental services or as a foundation for environmental farm management. Recently, the EU has started to financially support environmental advice to land users and eco-friendly farm management systems. This may start a new professional field for interdisciplinary teams of landscape planners, agronomists and foresters in many European countries.

Finally, the public demand for environmental services is augmented by private markets for high quality, organic, regional or nature conservation products or for tourism. Landscape planning, in this case, can be used to define regional provenance, locations or habitats as a criteria for certification

### **References**

- v. Haaren, C., B. Warren-Kretzschmar 2006:** The interactive landscape plan - Use and benefits of new technologies in landscape planning, including initial results of the interactive Landscape plan Koenigslutter am Elm, Germany .- Landscape Research, Vol.31, No.1.83-105
- Osterburg, B., 2002.** Analyse der Bedeutung von naturschutzorientierten Maßnahmen in der Landwirtschaft im Rahmen der Verordnung (EG) 1257/1999. SRU (Ed.) Metzler-Poeschel, Stuttgart. [www.umweltrat.de](http://www.umweltrat.de)
- Rode, M. 2005: Rode, M. (2005):** Energetische Nutzung von Biomasse und der Naturschutz. Natur und Landschaft 9/10 (80), S.403-412.
- Scholles, F., & v. Haaren, C., 2004:** Co-ordination of SEA and Landscape Planning. In: Schmidt, M., Joao, E. & E. Albrecht (Eds.): Implementing Strategic Environmental Assessment (Environmental Protection in the EU, Vol.2). Springer Verlag: 557-570.

## Application of a Leitbild in the pre-alpine Lake District of Salzburg

H. Klug

Centre for Geoinformatics (Z\_GIS), University of Salzburg  
Hellbrunnerstr. 34, 5020 Salzburg, Austria  
e-mail: hermann.klug@sbg.ac.at

### Introduction

Understanding the complexity of landscapes is an essential requirement to exhibit strategies for landscape development in the mid-term future to predict long-term effects of landscape alteration and maintain future demands to landscape resources. In order to steer today's landscapes to an aspired future state (German: Leitbild), it becomes clear that landscape planning should include considerations of socio-cultural, economic and political components in addition to the reflection on aspects of the ecosystem (Klug 2006). In response to this challenge, this paper presents a methodology developed for describing and planning landscape visions based on a transdisciplinary, holistic Leitbild concept.

The key idea of this planning framework is to adopt a land use strategy that focuses on a shift from functional segregation towards functional integration combining different theories and methodologies from social, political, economic and environmental perspectives. This method-mix should be locally adaptable and facilitate successful implementation of future landscape solutions.

The overall aim of this paper is to enhance and improve the capacity to carry out a harmonised integrated landscape resource management approach as addressed in e.g. the European Water Initiative. The paper establishes the transfer of professional expertise to approaches and tools based on a case study in the pre-alpine Lake District in the north-eastern part of the city of Salzburg. With an overall size of approximately 250 square kilometres the Mondsee catchment is a mid-sized watershed of the Traun River Basin, situated at an altitude between 500 and 1600 m in Austria's Provinces Salzburg and Upper Austria.

### Methods

It has been argued, given the diverse pressures on the landscape, that single disciplines cannot provide the knowledge necessary to understand or solve these pressures (Naveh 2000, Potschin and Haines-Young 2006). As landscape development is target driven, there is not *one single* preferable holistic concept to plan landscapes. As a consequence, until now only partial attempts have been made to combine physical-geographical and human-geographical perspectives. In agreement with e.g. Naveh (2000) the author agrees that there is a strong need for inter- and transdisciplinary concepts in landscape planning.

Building further on these challenges this publication elucidates a concept in the pre-alpine Lake District by using GIS technology. Possible spatially explicit land use options from certain interest groups have been elaborated in a semi-operational analysis and evaluation of current and manageable future environmental conditions with states, processes and functions, potentials and risks using scenario techniques. Comparing and negotiating the scenarios lead to the construction of a commonly accepted future state which most of the stakeholders can agree with (Klug 2007).

The remaining question is how to tackle this process and if there is any standard solution to recommend. First, this question addresses the way of human interaction through participation, which should assist and support the ecologically driven planning process. Secondly, the question addresses how to build consensus out of different visions of landscape towards a commonly agreed aspired future state. Klug (2007) shows the general framework in which public participation is possible through scenario building while Klug

(submitted) developed the overall framework theoretically analysed in Klug and Potschin (submitted).

## **Results**

The result of this work is a general assessment system adapted to the regional natural, cultural, political and economic conditions of the given case study area. As a further result, the goal oriented planning procedure is shown to be a successful tool to enhance communication, fulfil scenario development, and enable planning and monitoring of land use developments. Therefore, this methodology can bridge the gap between ecological analysis, socio-economic demands and development of planning oriented scenarios in a transparent framework.

With a deeper insight in the cause-effect relationships and the interconnectedness of processes we should be able to evaluate alternative intervention options and - to a certain extent - formulate a prognosis about the expected changes. Therefore, the major advantage of a holistic planning method is to understand and improve our methods applied for a successful and pro-active rather than a re-active steering of our future landscape.

With respect to the application developed on the regional case study the added value at the local level lies in a possible contribution to the building of the professional capacity and creation of awareness for the integrated character of the landscape under consideration. The results that are transferable beyond the specific local context are the state-of-the-art integrated holistic approach and innovative methodological developments that strengthen the way how transdisciplinary landscape development could take place being based both on natural and social science.

## **Discussion**

Although the planning approach introduced here does not change the general approach to landscape planning, it identifies a number of different management implications. Therefore, this approach does not reject traditional approaches; it rather incorporates a more holistic means of inquiry. This study shows ideas of stakeholder participation not precluding science in general; rather they change the way in which science is brought into practice. With support of the growing body of literature in sustainability science as summarized e.g. in Potschin and Haines-Young (2006) this hypothesis could put some added value to the research activities yielding more knowledge on perceptions, attitudes and behaviour of stakeholders, conflict (re)solutions and preferences in decision making.

## **References**

- Klug, H. (2006)** The Leitbild concept: A holistic transdisciplinary approach for landscape planning. PhD Thesis submitted to the University of Salzburg, June 2006
- Klug, H. & Potschin, M. (submitted)** Planning and the operationalisation of landscape visions: The Leitbild concept as an integrative approach. Submitted to Environment and Planning
- Klug, H. (submitted)** No landscape planning without a vision: an extended process-driven Leitbild methodology. Submitted to Journal of Land Use Science
- Klug, H. (2007)** Participative landscape planning using a GIS approach for facilitation. In: Mander, U., Helming, K., Wiggering, H. (Eds.): Multifunctional Land Use: Meeting Future Demands for Landscape Goods and Services. Berlin, Heidelberg: Springer, pp. 195-233
- Naveh, Z. (2000)** What is holistic landscape ecology? A conceptual introduction. In: Landscape and Urban Planning, Vol. 50, S. 7-26
- Potschin, M. & Haines-Young, R. (2006)** "Rio+10", sustainability science and Landscape Ecology. In: Landscape and Urban Planning, Vol. 75, S. 162-174

**Exploring scenario thinking in the discussion on 'landscape quality objectives' as defined by the European Landscape Convention. Case study - Mértola (Portugal)**

**I.L.Ramos**

CESUR - Technical University of Lisbon - Av. Rovisco Pais, 1049-001 Lisbon, Portugal.  
e-mail: isa.ramos@netcabo.pt

The European Landscape Convention calls for the definition of “landscape quality objectives” as “the formulation by the competent public authorities of the aspirations of the public with regard to the landscape features of their surroundings”. Even though it is not defined how the integration of the public and its visions for their landscape should be achieved, Prieur and Dourousseau (2006) call for a consultation process of local citizens in the framework the general planning activity conducted by the territorial or central authorities concerned with the implementation of landscape and spatial planning policies. In marginal rural landscapes, facing social and economical regression and with poor participatory culture, dealing with the future seems not to be a straightforward task. This communication aims at contributing to the ongoing debate on methodological approaches to address the definition of “landscape quality objectives” by proposing the use of exploratory landscape scenarios as a tool to trigger discussions amongst stakeholders on possible and desirable futures for specific landscapes, as well as the definition of strategies to achieve them.

Traditionally landscape scenarios do not build explicitly on a scenario thinking approach. Nassauer & Corry (2004) point out the wide array of landscape scenario approaches that have been used by landscape ecologists in order to integrate ecological values in landscape planning practice - scenarios' main objective is to make policy options visible (Nassauer & Corry, 2000) and its normative nature is justified by the need to give decision makers something to aim at. Nevertheless the underlying assumption of structural continuity from the present into the future may present its limitations: “we can not predict the future of our landscapes and their rapid sometimes even chaotic changes by simply extrapolating from the past and present into a uncertain future” (Naveh, 2005: p353). Drivers of local landscape change besides being manifold and are located at increasingly most distant spheres of decision and may be source of surprises that local stakeholder will have to cope with. In marginal rural landscapes the structural continuity is not ensured and in some cases, where development trends are perceived as negative, it might not even be considered desirable. These landscape are looking for new futures that reflect new social values, beliefs and demands and that are the setting for new relationships between society and the environment (Antrop, 2006).

Where scenario thinking approaches use mostly narratives in order to describe the future (Schwartz, 1996), landscape scenarios make the future visible and therefore facilitate the communication and discussion of the future among the public (e.g. Tress & Tress, 2003). The methodological approach presented here combines the openness of intuitive scenario techniques (Schwartz & Ogilvy, 1998) with the richness (conceptual and visual) of landscape scenarios. The scenario development follows a three-step approach: (a) the identification of driving forces, (b) the definition of plausible futures 25 years from now and (c) the validation of the scenarios by an expert-panel. It is applied to Mértola - in the southeast of Portugal - a desertification prone area facing a decrease in economical and social vitality and where agriculture used to be the main economical driver in past.

Four scenarios were organized along two mains vectors: (1) “continuity” (i.e. the use of local knowledge and environmental characteristics) and (2) “state protection” (i.e. levels of support by the state to the different sectors). In each scenario agriculture plays a distinct role: it may be engaging in energy crops if energy prices continue to rise, or be transformed into a new form of landscape gardening, setting the background for tourism, notably for use by the increasingly aged population of Europe, finding protection with increased social awareness of the fundamental value of biodiversity or gaining impetus from new residents that find refuge



from over populated urban areas working at a distance by taking advantage of new communication technologies that invest in a lifestyle based on traditional agriculture (Figure 1). The visual simulation of the scenarios used digital photo manipulation. It aims at combining the 'conceptual images' approach (Artner et al., 2006) with a more photorealistic approach (e.g. Nassauer & Corry, 2000; Tress & Tress, 2003; Dockerty et al., 2006) in order to facilitate the communication of major issues in each scenario and thereby stimulate the creation of a shared vision of a sustainable and desirable society amongst the public.



**Figure 1.** Scenarios developed for Mértola in 2030 (from left to right): "Environmental technocracy", "Oasis recreated", "Living the idyllic countryside" and "Fashion wilderness"

Even though it may not be surprising what people aim at in their lives - "people want to feel safe, they want to feel healthy, they want to take care of their children, they want to be proud of where they live, they want to get along with their neighbours, and they want make a living" (Nassauer, 2005: 275), the definition of landscapes able to provide such services may be achieved in various alternative ways that will have to be determined by adequate local responses to a changing world. Therefore, it is argued that the definition of "landscape quality objectives" benefits from the combined application of exploratory and normative scenarios in the development in strategic options that take into account the aspirations of the public.

## References

- Dockerty, T; Lovett, A.; Appleton, K.; Bone, A. & Sunnenberg, G. (2006)** Developing scenarios and visualizations to illustrate alternative policy and climatic influences on future agricultural landscapes. *Agriculture, Ecosystems & Environment*, **114**:103-120.
- Tress, B., Tress, G., 2003.** Scenarios visualisation for participatory landscape planning – a study from Denmark. *Landscape and Urban Planning*, **64**:161-178.
- Artner, A; Frohn Meyer, U.; Matzdorf, B.; Rudolph, I.; Rother, J. & Stark, G. (2006)** *Future Landscapes: perspektiven der Kulturlandschaft*. Bundesministerium für Verkehr, Bau und Stadtentwicklung, Berlin.
- Nassauer & Corry (2004)** Using normative scenarios in landscape ecology. *Landscape Ecology* **19**(4):343-356.
- Naveh, Z. (2005)** Towards a transdisciplinary landscape science. John Wiens & Michael Moss (Eds). *Studies in Landscape Ecology*. Cambridge University Press, Cambridge, pp. 346-354.
- Prieur, M. & Dourousseau, S. (2006)** *Landscape and public participation. Landscape and sustainable development: challenges of the European landscape Convention*. Council of Europe, Strasbourg, pp. 163-207.
- Schwartz, P. & Ogilvy, J. (1998)** Plotting your scenarios. *Learning from the future: competitive foresight scenarios*. Liam Fahey & Robert Randall (Eds.). Wiley & Sons, New York, pp.57-80.
- Schwartz, P. (1991)** *The Art of the Long View: Planning for the Future in an Uncertain World*. Currency Doubleday, New York.
- Antrop, M. (2006)** Sustainable landscapes: contradiction, fiction or utopia. *Landscape and Urban Planning*, **75**:187-197.

## Landscapes of desire or landscapes of fate

**M.B. Potschin, R.H. Haines-Young**

Centre for Environmental Management, School of Geography, University of Nottingham,  
Nottingham, NG7 2RD, UK  
e-mail: Marion.Potschin@Nottingham.ac.uk

It is clear from the scientific and policy literature that unless landscape planning is based on, or takes note of, the visions of people it is unlikely to achieve the overall aims of sustainable development. However there are two fundamentally different approaches to the creation of such visions. On the one hand people can develop a vision based on their understanding of present possibilities, policies and trends. This knowledge can be used as a framework and scenarios can be constructed in terms of what types of outcome are likely given current constraints or trends, and what steps might be needed to avoid or minimise any undesirable consequences. These scenarios essentially represent the landscapes of 'fate'. On the other hand one can create a vision independent of present constraints that represent for people something approaching like a "landscape of desire". The task for the science and policy community then becomes one of identifying what policies or actions are needed in order to ensure that planning leads to outcomes that match these aspirations.

When working with these different types of vision, an understanding of the Leitbild Concept that is widely used in the German speaking literature can be very helpful, because the latter offers a set of conceptual tools that can help ensure that the visions that are created are as realistic and robust as possible. A Leitbild is defined as "an aspirational summary statement describing a desired and releasable future state for a specific issue or spatial unit, which takes account of the primary objectives and drivers in a holistic and integrated way. All present knowledge is used to balance future constraints and demands from social, economic, cultural, political and environmental perspectives. Therefore, a commonly accepted Leitbild projects a specified trajectory for the future spatial structure, distribution, utilisation, condition and development of the socio-natural system. It provides a set of guidelines that shape actions, and a framework within which the impact of particular developments can be judged and socially negotiated." (Potschin et al., submitted).

In this paper it will be argued that the Leitbild Concept can be used by the landscape ecological community as a set of guiding principles within which we can create the landscape visions that are so essential for planning purposes. The paper will describe approaches to constructing scenarios related to the landscapes of 'fear' and 'desire', and how they can be articulated more effectively by using the Leitbild concept. This paper will set the basic framework for the second part of the symposium and will be followed by a paper presenting a successful application of a GIS-based Leitbild in Austria (Klug).

### References

- Potschin, M.B.; Klug, H. & Haines-Young, R.H. (submitted)** From Vision to Action: Framing the Leitbild Concept in the context of Landscape Planning. *Environmental Science and Policy*.
- Gaede, M. & Potschin, M. (1999)** Requirements on the Leitbild-term – a planning perspective. In: *Berichte zur Deutschen Landeskunde* 75(1): 19-32, Flensburg. (in German)

**Introduction of the spatial concept: design as a medium for the transfer of scientific knowledge to planning and society**

**J. Iverson Nassauer<sup>1</sup>, P. Opdam<sup>2</sup>**

<sup>1</sup> School of Natural Resources and Environment, University of Michigan, 440 Church St., Ann Arbor, MI 48109-1041,  
e-mail: nassauer@umich.edu

<sup>2</sup> Alterra, Department of Land use planning and Alterra, PO box 47, 6700 AA Wageningen.

To increase the influence of landscape ecology on landscape change and on the societies that dramatically influence landscape change, we broaden the landscape ecology paradigm beyond pattern:process to explicitly incorporate intentional human action as an intervention between process and pattern, *process:design:pattern*. We define a landscape design as a spatial pattern conceptualized by people (sometimes professional planners or designers, and infrequently, scientists) to express a desired set of landscape functions, including aesthetic, ecological, economic, hydrological dimensions. Such design may range from theoretical patterns, abstracted to simple elements, to precise patterns devised to guide change in a specific place. It may be devised across a wide range of spatial extents, and could involve constructing, maintaining, restoring, or protecting landscape patterns.

Our tripartite paradigm suggests that “design” can act as the fulcrum from which science can influence planning, policy, and landscape decision-making, and, conversely, that design is a fruitful medium by which planning, policy, and landscape decision-making can influence science. It suggests that design is not merely of theoretical importance for landscape ecology, but also is an essential means by which the science of landscape ecology affects the character of landscape change. Design is the means for acknowledging and employing landscape pattern as a language by which ecological processes are represented to policy and culture. As such, design communicates the importance and value of certain landscape patterns to society in a way that, in turn, further affects landscape change.

Our paradigm suggests that policy that affects the environment should be fundamentally informed by understanding of both landscape design and ecological processes, two aspects of landscape function that are frequently subordinated or ignored in favour of economic issues when policy decisions are made. The practical relevance of our paradigm is illuminated by considering agriculture, real estate development, and industrial development as dimensions of environmental policy – along with more conventional realms like protection of nature, habitats, and water quality, and the remediation of environmental contamination. When such everyday human manipulations of landscapes are understood as both normative activities by people who are changing the landscape to make it the way they think it “should” be, as well as inherent acts of ecological disturbance, the pragmatic benefits of linking normative change (or design) with scientific knowledge of ecological processes are clear.

Further, our tripartite paradigm *process:design:pattern*. emphasizes that design and ecological process are not simply two parallel factors that should affect planning for landscape pattern; they are critically related. Design draws essential content from scientific understanding of ecological processes, and, by design, ecological processes gain essential representation in the realm of human experience and decision-making. While both design understandings of societal norms for and aesthetic characteristics of desirable landscape patterns, and scientific understanding of ecological processes should critically affect landscape policies and plans, each form of understanding more powerfully influences landscape pattern when it is considered in relationship to the other.

This is a type of technology transfer that may require a precautionary approach: using design knowledge to respect ecological functions rather than to test the limits of disturbance.

**Theme 9: Concepts for Landscape Planning and Design**  
**9.3 Symposium 19: Landscape Planning: Building the evidence base and creating the vision**

Viewed from another perspective, our paradigm also suggests that *process:design:pattern* relationships should be incorporated as variables in scientific investigations of ecological process: making landscape innovation as well as known trajectories of landscape change the subject of investigation.

In this paper, we detail our tripartite paradigm and explore the relationship of design and science understandings as means for improving the power of landscape ecology to affect landscape change. Further, we suggest that understanding the varied, appropriate means for values to enter into the science of landscape ecology opens pathways to enhance the effect of science. We will discuss design as an iterative activity in which designers, planners, and scientists can and should meet to conceptualize desirable landscape change.

## **Environmental Minimum Requirements in the assessment and planning of agricultural landscapes**

**O. Bastian, M. Lütz**

Saxon Academy of Sciences and Humanities, Working Group on Natural Balance and Regional Characteristics, Neustädter Markt 19 (Blockhaus), D-01097 Dresden, Germany.  
e-mail: Olaf.Bastian@mailbox.tu-dresden.de

### **Introduction**

For the assessment of the environmental situation and for the definition of meaningful targets for the future development, the results of analyses must be compared with some benchmarks, thresholds, baselines or reference systems, so-called Environmental Minimum Requirements (EMR). This is a very important, let's say the crucial but nonetheless complicated step of any planning procedure, whether in the framework of landscape planning or of agri-environmental programmes. On examples of the EU-project AEMBAC ("Definition of common European analytical framework for the development of local agri-environmental programmes for biodiversity and landscape conservation"), the role of EMR will be described, and limitations are discussed.

### **Limit values and Safe Minimum Standards**

EMR represent a special type of limit values, which are basing on thresholds substantiated scientifically, i.e. they "imply critical values of the independent variable around which the system flips from one stable state to another, that is ecological thresholds" (Muradian, 2001). Scientific fundamentals are very important but they can be only the first step of defining limit values. Ecological facts are free of value. There is no reason to consider a situation found in nature automatically "normal" and desirable only because of its existence. That would be a wrong conclusion, a naturalistic fallacy (Moore 1903). Targets must be fixed by an observer, by stakeholders or the society, an evaluating decision is required.

In 1952 Ciriacy-Wantrup introduced the term Safe Minimum Standards (SMS) that marks "the critical zone – that is, those physical conditions, brought about by human action, which would make it uneconomical to halt and reverse depletion." SMS are related to the problem of carrying capacity that is often equated with the treatment of critical loads and critical levels (e.g. Nagel & Gregor, 1999). Bishop (1993) highlighted the link of SMS to the principles of sustainability.

### **Environmental Minimum Requirements (EMR)**

Comparing with SMS, the EMR approach is not focussing so strongly on mostly unknown or hypothetical "safeties". Instead of this, EMR are oriented more towards demands or desires of the society for a particular environmental situation. Regarding the relation between agriculture and biodiversity, the European Commission used concept of EMR "to link the granting of aid to compliance with basic environmental requirements relating to biodiversity (COM 1999)." EMR represent the minimum values of a state indicators, below which the particular landscape function is becoming in danger to be performed in an area. Thus, EMR are related to landscape visions (leitbilder), and they can help to maintain the peculiarities of the different landscapes. The comparison of the actual situation and the EMR reveals deficits (gaps) caused by impacts that can be exerted by different human activities.

### **Application of EMR in the AEMBAC methodology**

The overall objective of the AEMBAC project was to create a common tool for the identification, development and evaluation of locally appropriate agri-environmental measures basing on the analysis of the state and pressure indicators and the assessment of landscape functions (Simoncini et al., 2004; Bastian & Lütz, 2006).

The AEMBAC methodology is based on the identification and analysis of state indicators, which describe the state of each agro-ecosystem and its ability to perform environmental functions, and pressure indicators, which describe the pressures that local agricultural systems exert on the environment. The comparison of the actual situation and the EMR reveals deficits (gaps) caused by impacts that can be exerted by agricultural practices and/or other socio-economic activities. EMR can also be used to assess the ecological sustainability of the performance of an environmental function in an area. If the data of a state indicator of an environmental function are below the threshold, the performance of this function is not sustainable. The gap analysis and the sustainability assessment are pre-conditions to determine effective agri-environmental measures (AEM). Indicators and environmental targets have. The setting of EMR must be done locally (at most at sub-regional level), to take the variability of European agricultural landscapes and the regional peculiarities (biotic potentials, landscape character) into account.

The definition of EMR is a complicated procedure involving several scientific disciplines, normative judgements and socio-economic conditions. As sources / reference values for EMR can be used:

- The values of selected state indicators in natural ecosystems or “optimal” areas of the similar landscape type performing the function of interest,
- The past situation (e.g., before the large-scale intensification of agriculture in many countries had begun),
- The Best Professional Judgement for certain indicators,
- Data from scientific literature, or discursive processes (expert teams, stakeholders),
- Particular agro-ecosystems (organic agriculture, abandoned fields) where the environmental function was/is performed successfully.

### **Conclusion**

Due to the complexity of the ecosystems and the partly poor ecological knowledge, the definition of scientifically based EMR is difficult. But there are also fundamental problems with EMR, because value-driven aspects in defining EMR go beyond the “pure” scientific analyses, and the danger of naturalistic fallacy cannot be denied. Admittedly, EMR should base on the scientific knowledge available, but in the end, targets have to be defined by human society (different stakeholders). But this is also a chance to define realistic and meaningful targets to implement the three columns (ecological, economic, and social issues) of sustainable development.

### **References**

- Bastian, O. & Lütz, M. (2006)** Landscape functions as indicators for the development of local agri-environmental measures. *Ecol. Indicators* 6:215-227.
- Bishop, R.C. (1993)** Economic efficiency, sustainability, and biodiversity. *AMBIO* 22:69-73.
- Ciriacy-Wantrup, S. (1952)** *Resource conservation economics and politics*, Univ. of California, Div. of Agriculture Sciences. Berkeley, Los Angeles.
- COM (1999)** Communication of the Commission of the European Communities, Directions towards sustainable agriculture, COM (1999) 22 final, in reference to Regulation (EC) No 1259/1999
- Moore, G.E. (1903)** *Principia Ethica*, Cambridge Univ. Press, Cambridge.
- Muradian, R. (2001)** Ecological Thresholds: a survey. *Ecol. Economics* 38:7-24.
- Nagel, H.-D. & Gregor, H.-D. (1999)** *Ökologische Belastungsgrenzen – critical loads & levels: ein internationales Konzept für die Luftreinhaltepolitik*, Springer, Berlin, Heidelberg.
- Simoncini, R.; Milward, S.; Christophersen, T.; Bastian, O.; Groot, R. de; Landau, B.; Pacciani, A.; Sepp, K.; Karácsonyi, Z. & Hasund, K.P. (2004)** *How to develop and implement effective local agri-environmental measures: Guidelines for rural development planners and administrators*, IUCN, Cambridge, UK, 20 pp.

## Landscape visions, urban sprawl and “reality” – an “anatomy” of a transformation

H. Palang

Center for Landscape and Culture, Tallinn University, Uus-Sadama 5, 10120 Tallinn, Estonia  
e-mail: palang@tlu.ee

### Background

One of the most visible features of the peri-urban countryside of Estonia of the last decade has been the emergence of new urban residential developments, which very often are situated amidst former agricultural landscapes. Ideon (2006, unpublished) has demonstrated that built-up area has increased in most of the rural communities surrounding Tallinn, the capital. Ideon also showed that 69% of the new built-up areas are situated within 1 km from adjacent town and 88% are less than 1 km away from a main road. However, there is far less research into the internal structure of these settlements.

### Landscape visions

Since this development is extremely rapid and has supposedly no analogues in the country's history, it causes also some new, unforeseen problems, in addition to the common ecological, environmental, demographical and transportation ones. As said, often these new developments are amidst former agricultural land, which is used as a selling argument – the new dwellers will have a chance to “start building their landscape from the scratch”, there are no trees or other features that limit their choice of options, the new dweller can “realize his or her own vision”. This gives a chance to study closely how the new emerging landscapes reflect or result from different visions of different people involved in planning, building and dwelling of these.

The visions people are driven by are surprisingly miscellaneous. Often, in conditions of agricultural decline landowners initiate these developments not only to make profit, but also on the argument of “not letting the land go waste”, i.e. to keep it cultural. There are some surprising patterns where farms that were first to buy their land for property in the turn of 19<sup>th</sup>-20<sup>th</sup> centuries were also the first hundred years later to divide their lands into plots and initiate real estate development.

The new inhabitants seem to have two main dwelling strategies. One group opts for ready-made solutions, i.e., they buy homes with finalized landscaping. In this case it is the planner who has defined the vision. Another group starts shaping the land according to their *own* ideas, visions and understanding of beauty, sustainability and stewardship. The outcome could be uniform landscapes that have almost no links with the past, or, alternatively, extremely hectic ones where different “visions” have to fit in close to each other. Another question is how these new landscapes fit in with the existing ones, both in terms of physical structures and social networks. Since van Eetvelde and Antrop (2006, unpublished) showed that landscape metrics do not reflect adequately the change in densely settled areas, we have used qualitative approach to study the differences. In the presentation I will follow the development of one of these new built-up areas from an abandoned field to a diverse arena of somewhat contrasting visions of the former owners, planners, new dwellers, people from the neighboring “old village”, and the local authority. The questions raised in the paper will include how the newcomers adapt to the existing structures (as landscape can never be “built from the scratch”); in what way do the patterns created by the two aforementioned strategies differ from each other; is it possible to judge whether one of them is closer to the traditional landscape (see Antrop 1997, 2000) than the other; in what way are the traditions sustained in these new landscapes.

**References**

- Antrop, M. (1997)** The concept of traditional landscapes as a base for landscape evaluation and planning. The example of Flanders Region. *Landscape and Urban Planning* **38**: 105-117.
- Antrop, M. (2000)** Background concepts for integrated landscape analysis. *Agriculture, Ecosystems and Environment* **77**: 17-28.
- Ideon, A. (2006)** *Suburbanization in Tallinn agglomeration. The growth of built-up areas in 1995-2005.* Retrieved on 31.1.2007 from:  
<http://www.utlib.ee/ekollekt/diss/mag/2006/b18333783/ideonandres.pdf>
- Van Eetvelde, V., Antrop, M (2006).** *Changing meaning of characteristic settlement types in rural landscapes due to urbanisation - examples around the city of Ghent, Flanders.* Presentation at the PECSRL, 06.09.2006, Berlin.



## Linking ecological and economic indicators to ecosystem networks for multifunctional participatory landscape planning

W. Geertsema<sup>1</sup>, C.M. van der Heide<sup>2</sup>, A.T de Blaeij<sup>2</sup>

<sup>1</sup> Alterra and Land Use Planning Group, Landscape Centre – WUR, PO Box 47, 6700 AA Wageningen, the Netherlands;

e-mail: willemien.geertsema@wur.nl.

<sup>2</sup> Agricultural Economics Research Institute (LEI) – WUR, PO Box 29703, 2502 LS Den Haag, the Netherlands.

### Introduction

The aim of multifunctional participatory landscape planning is to elicit spatially explicit preferences of stakeholders in terms of how they would like an ecosystem network in a particular case study area to be designed. This paper describes an approach that supports such multifunctional participatory landscape planning by integrating ecological and economic indicators. The approach under consideration gives insight in the spatial, economic and ecological consequences of spatial plans for ecosystem networks, thereby aiding the decision making process on a regional level.

Ecosystem networks are the primary focus of this study. They are key landscape features that support biodiversity. However, ecosystem networks are not only important features for the realisation of ecological values (such as survival of target species), but they are also a source of economic benefits (de Groot 1992). Ecosystem networks provide, for example, a setting for recreation and tourism, attractive locations for housing, clean air and water. Therefore, not only nature conservation organisations, but many other stakeholders benefit from the presence and maintenance of ecosystem networks.

Because land is a finite resource, habitats suitable for protected species compete with, for example, agricultural and economic development. In landscape planning, attention is therefore usually focused on the conflicts between ecological and economic interests, rather than on the positive interaction between these two. In addition, there is a lack of good economic indicators for ecosystem networks that can be implemented in spatial planning, which has resulted in decision making that is not based on a good balance between ecology and economy.

### A tool for multifunctional participatory landscape planning

Our ambition is to elicit spatially explicit preferences of stakeholders in terms of how they would like an ecosystem network in a particular case study area to be designed. This information provides valuable input to early stages of the planning cycle.

The approach involves a search for characteristics of the ecosystem network that can be used as indicators for ecological values and economic functioning. Characteristics relevant for ecological values are area and spatial cohesion (Opdam *et al.*, 2003), while recreational facilities and the level of accessibility of the area are examples of economic characteristics (Goossen and Langers, 2000). The different indicators will be used to develop scenarios. By using a choice experiment (Hanley *et al.*, 1998), these scenarios will be presented to the various stakeholders in a case study area.

Important input for the design of the choice experiment is a workshop with stakeholders to decide on which characteristics and levels of characteristics of the ecosystem network are needed for the realization of goals they have for this network.

From the results of the choice experiment we can derive the preferences that different stakeholder groups have for different spatial options, and what they are willing to pay for these options. These insights can help decision makers as it clarifies on which characteristics

agreement exists between stakeholders, and on which not. The information about the willingness to pay makes clear how important certain characteristics are to stakeholders.

We expect that this method will help to elucidate the relation between physical characteristics of ecosystem networks and the valuation of these characteristics through different stakeholder groups. This insight may help to produce sustainable landscapes.

### Case study areas

Cooperation with various stakeholders (be they 'economic' or 'environmental') in two case study areas is the backbone of the project. In this project we participate with two case study areas. They are characterized by multiple goals of different stakeholder groups. Ecosystem networks are characteristic for the areas. The case study area *Friese Meren* is located in the province Fryslân in the north of the Netherlands. It is characterized by lakes and water courses and dairy farming. It is one of the most important areas in the Netherlands for both wetland conservation as it is for water recreation. It is a rural area with low urbanization. The other case study area *Het Groene Woud* is located in the province of North-Brabant. It is characterized by a heterogeneous landscape with large nature reserves, small scale landscapes with a network of landscape elements. This landscape is surrounded by urban areas. Different stakeholders value the ecosystem network in the area for biodiversity, tourism and an attractive landscape for housing and settlement of companies.

Experience with the tool so far in the case study areas will be presented and discussed.

### References

- Goossen, M. & Langers, F. (2000)** Assessing quality of rural areas in the Netherlands: finding the most important indicators for recreation. *Landscape and Urban Planning* **46**: 241-251.
- Groot, R.S. de, 1992.** *Functions of Nature; Evaluation of Nature in Environmental Planning, Management and Decision Making*. Wolters-Noordhoff, Groningen.
- Opdam, P.; Verboom, J. & Pouwels, R. (2003)** Landscape cohesion: an index for the conservation potential of landscapes for biodiversity. *Landscape Ecology* **18**: 113-126.
- Hanley, N.; Wright, R.E. and Adamowicz, V. (1998)** Using Choice Experiments to Value the Environment. *Environmental and Resource Economics*, **11**: 413-428.

## **A transactional approach to understanding visitor perception of sustainable recreational landscape management strategies**

**D.G. Pitt<sup>1</sup>, R.B.M. van Marwijk<sup>2</sup>**

<sup>1</sup>Department of Landscape Architecture, College of Design, University of Minnesota,  
89 Church St. SE, Minneapolis, MN 55455, USA.  
e-mail: pittx001@umn.edu

<sup>2</sup>Forest and Nature Conservancy Policy Group, Wageningen University and Research  
Center, P.O. Box 47, 6700 AA Wageningen, the Netherlands.

### **Introduction**

Increasing demand for outdoor recreation threatens the integrity of remnant natural environments in northwestern Europe. Planners face the dilemma of managing recreational settings that provide significant economic, social and psychological benefits to individuals and communities (Kaplan and Kaplan 1989) while also protecting key ecosystem services whose quality and quantity have been taxed by centuries of agricultural intensification and urban expansion. High quality natural settings become “social traps” in which the personal and social values derived from interaction with these environments begets increased use. Eventually the ecosystem services initially defining the resource’s attraction to visitors are “loved to death” (Favero et al. 1988).

Managing recreational use in high quality natural settings considers site conditions (e.g. “hardening” the site to increase its resiliency) and both direct regulation of visitor behaviour (e.g. through temporal or spatial zoning) and manipulation of information and application of moral suasion to indirectly guide visitor behavior. Practices moderating human behavior to protect ecosystem services are more apt to be adopted if they reflect the interests of the recreationists whose behavior is affected (Innes 1996). The effects of practice adoption on experiential quality must be understood. Measuring the provision of ecosystem services as a product of recreational management practice adoption is well established. However, in Europe, measuring the effects of management on visitor experience quality is in its infancy.

This paper presents a transactional approach to evaluate the experiential implications of recreational visitor management strategies. The paper reviews literature applying this framework in varying recreational settings and proposes its use to examine visitor response to the adoption of management practices designed to protect ecosystem services in a Dutch national park.

### **Transactional Understanding of Recreational Experiential Quality**

Our approach to investigating recreational visitor perception of management practices emanates from the role these practices play in moderating the transaction of people and environment (Ittelson 1973, Stokols 1978, Zube et al. 1982, Pitt 1989). Goal-seeking individuals and groups evaluate environment based on its salience to desired outcomes and in terms of its congruence or ability to afford behavioural opportunities for realizing desired goals (Stokols 1978, Gibson 1986). The environmental scan provides a cognitive framework for action toward accomplishment of intention and satisfaction of needs. Feedback from life-world experiences with environment refines the participant’s understanding and provides a basis for further exploration and comprehension (Seamon 1979). Transactional outcomes relate to consequences of and benefits derived from a person’s recreational experiences with environment and may be measured using psychological, social, economic or physical criteria.

### **Parameters of Transactional Outcomes in the Context of Outdoor Recreation**

Operationalizing a transactional framework requires specification of three sets of parameters. The effects of multi-sensory attributes of environment (including the practice and

the biophysical and socio-cultural context of its adoption), on specified parameters of experiential quality must be examined. Variability in participant attributes (e.g. socio-economic status, life cycle/style, mobility impairments, cultural/ethnic characteristics, childhood experiences, personality traits and value/belief systems) affects the production of transactional outcomes.

A person returning to the same environment in a different context of participation will experience varying outcomes. Differences in psychological context may occur with repeat visitation: to pursue alternative behaviours, in different emotional dispositions, with varying motivations/expectations, with increased skill in recreational behaviour, following acquisition of more information or new knowledge about the environment or having evolved alternative place meanings. Variation in social context involves repeat visitation with: different referent social groups, alternative norms for group behaviour, changing interpersonal dynamics among group members, variability in a participant's conformance to group norms and variability in encounters with others during the transaction. Physical context refers to mode, speed and direction of movement as well as the participant's position relative to the environmental setting. Fluctuations in temporal context relate to a participant's integration of specific in linear time (i.e. the past) or cyclical time (experiences based ritualistically around either place or behaviour).

### **Application to Dwingelderveld National Park**

Dwingelderveld National Park contains patches of mixed forest vegetation and the largest heath in northwestern Europe. Annual visitation exceeds two million visitors. Primary activities include hiking, biking, horseback riding, bird watching, camping and excursion touring. Ecological management objectives focus on protection of the heath and reestablishment of a wet forest hydrologic regime. Previous studies provide a transactional profile of visitors and visitation in the park (Marwijk et al. 2007). From participants in these studies, the effects of alternative management strategies for heath protection and forest wetland restoration on recreational experience quality will be elicited using standard psychometric scaling technology. Settings will be presented using electronically generated photographic simulations. Subjects will receive varying levels of information describing the environmentally beneficial effects of depicted management treatments. Perceptual responses to the images will be interpreted relative to the biophysical and socio-cultural dimensions of the practice and its setting, various dimensions of participant characteristics and participation context, and information treatment administered to the subjects in eliciting perceptual judgements.

### **References**

- Favero, P., D.G. Pitt, and D.F. Tuthill. 1988.** Land use policies, water quality and the Chesapeake Bay. *Natural Resources and Environmental Economics*. Ed. G.N. Johnston, D. Freshwater, and P. Favero. Boulder: Westview Press. 71-90.
- Gibson, J. J. 1986.** *The Ecological Approach to Visual Perception*. Hillsdale, NJ: Lawrence Earlbaum Associates.
- Ittelson, W. H. 1973.** *Environment and Cognition*. New York: Seminar Press.
- Innes, J. E. 1996.** Planning through consensus building: A new view of the comprehensive planning ideal. *Journal of the American Planning Association* 62(4):460-472.
- Kaplan, R. and S. Kaplan. 1989.** *The Experience of Nature: A Psychological Perspective*. New York: Cambridge Univ. Press.
- Pitt, D.G. 1989.** The attractiveness and use of aquatic environments as outdoor recreation places. *Public Places and Spaces*. Ed. I. Altman and E.H. Zube. New York: Plenum. 217-254.
- Seamon, D. 1979.** *A Geography of the Life World*. New York: St. Martin's.
- Stokols, D. 1978.** Environmental psychology. *Annual Review of Psychology* 29:253-295.
- Marwijk, R. B. M. v., Elands, B. and Lengkeek, J. 2007.** Experiencing nature: The recognition of the symbolic environment within research and management of visitor flows. *Forest Snow and Landscape Research*. (in review)

## Making visions visible

E. Lange, S. Hehl-Lange

The University of Sheffield, Department of Landscape. Arts Tower, Western Bank. Sheffield  
S10 2TN, United Kingdom.  
e-mail: E.Lange@sheffield.ac.uk

### Visualization in a changing planning environment

Traditional approaches to landscape planning are characterized through a planning process that is predominately organized in a top-down fashion. Landscape visualization in such a planning context was often used as a tool for visualizing the results of the planning process. This approach neglects opportunities in incorporating visualization at an early stage in the planning process (Lange and Hehl-Lange 2006). This presentation will explore the role of 3D visualization and the challenges for landscape planners and landscape ecologists in developing visible visions for our future landscapes.

Although traditional top-down approaches also include some participatory elements incorporating the views of the public, recently, we are faced with a paradigm shift from the top-down 'governmental' approach towards a more participatory 'governance' approach involving not only expert planners and decision-makers but also a wide range of stakeholders (e.g. Einig *et al.* 2005). These changes offer opportunities for the involvement of stakeholders in developing visions for the future and ultimately in decision-making. On the other hand, participatory processes were already conducted some decades ago in the past. It has to be made clear that these are not new inventions although it might come across as such when looking at recent topics of publications. Research on participatory processes in landscape planning and decision-making has a long tradition (e.g. Arnstein 1971). In the past, visualization technologies did not play key roles in such approaches to planning. Some notable exceptions include examples from urban design (e.g. Markelin and Fahle 1979) in which physical models were included in the planning process.

With the advent of desktop digital visualizations permitting to perform digital photomontages since around the late 1980s and the development of real-time visualization software, at the time limited to expensive hardware platforms such as Silicon Graphics (Danahy and Wright 1988), new opportunities for landscape planners were arising due to the availability of these new tools.



**Figure 1.** Visualization in forest management, Alport Valley, Peak District National Park

Although our expectation was that these new innovations would be commonplace in landscape planning practice within a few years it took nearly up to today that visualization tools and technologies are becoming more integrated in planning in general and landscape planning in particular, and also in participatory processes accompanying the classical

approaches to planning (Bishop and Lange 2005). Consequently, landscape planners are faced with new challenges. While in the past they were developing visions for future landscapes among their peers or in interdisciplinary groups of experts including e.g. botanists, zoologists, landscape ecologists, they are nowadays having to deal with the opinions but also the knowledge of local lay persons.

In such a new planning environment visualization can take up a different role than it had assumed in the past. Then, typically associated with top-down planning processes, visualization was mostly seen as the icing on the cake, i.e. basically being used for visualizing the result of the planning process. Nowadays, we can incorporate visualizations in the planning process at a much earlier stage (Hehl-Lange 2001). This poses of course challenges to the so-called expert planner or expert landscape ecologist.

One of the key challenges in this new process is being able to react timely to new inputs from the participating stakeholders (Lange and Hehl-Lange 2005). This will not always be possible.

## **Outlook**

At the same time we are faced with raised expectations on the side of the stakeholders. Nowadays, in our everyday life we are confronted with highly realistic and even interactive visualizations, e.g. in the weather forecast (e.g. BBC Weather), in advertising and in sports ('hawk eye' in tennis). Sophisticated developments in the game industry, e.g. in strategy games such as Caesar IV, permit not only instant reactions to prescribed changes within those virtual landscapes but also offer instant visualizations of these new landscapes in three dimensions. These examples are of high relevance to planning applications and to a certain degree incorporate the concept of sustainability, such as the interrelation of e.g. building new infrastructure while at the same time maintaining a solid basis for food in such a game environment.

Important developments that are already happening and that will influence the way in which we develop the visions of our future, perhaps jointly among landscape experts and stakeholders, and how we make these visions visible include especially web-based visualization technologies (e.g. VEPS 2007) permitting to incorporate the knowledge and the views of all experts and stakeholders in developing visible visions of our future.

## **References**

- Arnstein, S.R. (1971)** A Ladder of Citizen Participation, *Journal of the Royal Town Planning Institute* 57: 176–182.
- Bishop, I.; Lange, E. eds. (2005)** *Visualization in Landscape and Environmental Planning. Technology and applications.* Taylor & Francis, London, New York.
- Danahy, J.W.; Wright, R. (1988)** Exploring Design Through 3-Dimensional Simulations. *Landscape Arch.*, July / August: 64-71.
- Einig, K.; Grabher, G., Ibert, O., Strubelt, W. (2005)** Urban Governance. *Informationen zur Raumentwicklung* 9/10: I-IX.
- Hehl-Lange, S. (2001)** Structural elements of the visual landscape and their ecological functions. *Landscape and Urban Planning* 54: 105-113.
- Lange, E.; Hehl-Lange, S. (2005)** Combining a Participatory Planning Approach with a Virtual Landscape Model for the Siting of Wind Turbines. *Journal of Environmental Planning and Management* 48 (6): 833-852.
- Lange, E.; Hehl-Lange, S. (2006)** Integrating 3D Visualisation in Landscape Design and Environmental Planning. *GAIA* 15 (3): 195-199.
- Markelin, A.; Fahle, B. (1979)** *Umweltsimulation. Sensorische Simulation im Städtebau.* Schriftenr. 11, Städtebaul. Inst. Universität Stuttgart. Krämer, Stuttgart.
- VEPS 2007.** Virtual environmental planning. <http://www.veps3d.org>. Accessed 31.1.2007.

## **Spatial concepts as vehicles to communicate landscape conservation strategies**

**L. Ribeiro<sup>1</sup>, T. Barao<sup>2</sup>**

<sup>1</sup>Department of Landscape Architecture, Agronomy Superior Institute, Lisbon Technical University, 1300 Lisbon, Portugal.

e-mail: lribeiro@isa.utl.pt

<sup>2</sup>Topiaris, Lda, Rua Fradesso da Silveira, 8, 3B, 1300-609 Lisbon, Portugal.

### **Introduction**

Spatial concepts have been used in landscape planning and design as means of creativity using objective knowledge. Their success is also due to the fact that they are simple and strong enough to be understood by different people. The aim of this communication is to show that these concepts have been useful for implementing landscape quality and sustainability. This is argued through the analysis of the greenway concept in the Portuguese context. Currently we need to explore new spatial concepts for efficiently improving the sustainability of landscapes.

### **The significance of spatial concepts in landscape management**

Spatial concepts have been used in landscape planning and design in order to foster sustainable use of natural landscape resources. Examples include greenbelts (Hall, 1992), ecological corridors (Smith and Hellmund, 1993), greenways (Fabos, 1995), stepping stones patches or urban green-lungs (Spirn, 1984). The sustainable conservation of heritage sites has also used spatial concepts such as the integrity of landscape cultural patterns. These concepts constitute creative ideas to understand or to plan and design landscapes. At the same time, they are based on scientific knowledge such as biogeography of islands and meta-populations theories (Ahern, 1995), urban heat island (Spirn, 1984), landscape assessment methods (Dawson, 1995), or the functioning of human ecosystems (Lyle, 1985). Some of these concepts have been evolving for a long time, as demonstrated by Fabos (1995) through the existence of an international greenway movement, or the growing concern on the cultural/historical value of landscapes and gardens leading to concepts of cultural landscapes and historical gardens. These concepts have frequently projected their influence at the legislative level, such as the concept of National Heritage Corridors in the USA, or the REN (national ecological reserve) in Portugal.

### **Outreach of landscape design and planning spatial concepts**

Through the analysis of five case studies, where the authors were involved as planners and designers, it was hypothesized that the spatial concept of greenway was useful, in the Portuguese context, as a communicative tool, either between the diversified members of a planning team, or with planning authorities, politicians and the public (Ribeiro and Barao, 2006). These case studies are located in Tâmega river valley and run through urban and rural landscapes. The following aspects intend to establish a framework, aiming to justify the potential of the greenway concept as a communication vehicle among different groups:

- Greenway planning and design recognises the existence of valuable resources in the landscape, which underlies its quality and its opportunities for development and leisure, therefore more effective in conveying the importance of these resources;
- The design of greenways is supported by the spatial patterns revealed by landscape assessment methods. Greenway makes more understandable the value of landscape resources by different professions dealing with planning;
- Greenway planning and design strategies rely both upon rational and objective approaches, recognizing the importance of creativity and human decision, hence a concept

that attempts to address post-modern criticism. Therefore it is a contemporary concept capable of being shared by different theoretical and professional trends;

- Through the greenway concept it is possible to reconcile different planning objectives such as nature conservation, heritage protection, development and recreation, therefore conveying its main objectives to the political and official planning agencies involved.

The five case studies of Portuguese greenway analysed by the authors showed that through the greenway concept it was possible to share landscape conservation and improvement objectives with national, regional and local planning authorities, as well as with multidisciplinary teams composed by geographers, engineers, architects and planners. This potential is corroborated by current literature review on the topic such as in New York (Walmsley, 2006) and Britain (Turner, 2006), among others.

## **Conclusions**

The hereabove synthesized study of greenway examples in Portugal showed that this spatial concept was useful to communicate with different professions and social groups in order to achieve landscape and environmental quality. But this quality does not rely only on safeguarding linear spatial patterns of valuable resources. Other issues, such as the functioning of ecological and cultural systems, among others, need to be addressed in order to foster environmental quality and design of sustainable landscapes. There is a need therefore to creatively search for diverse spatial concepts that can help to attain these objectives. Such spatial concepts should be easily understood by different professional groups, which deal with planning as well as by the public as in the case of the greenway concept (Ribeiro & Barao, 2006; Turner, 2006; Walmsley, 2006). It is here hypothesized as a conclusion that the search for new spatial concepts should address the following qualities:

- Simplicity and clearness to be understood by a large range of social groups;
- Support by scientific knowledge;
- Capacity of enthusiastically motivate different social groups, by addressing their expectations and beliefs;
- Capable to be used by planners and designers both in rational and creative ways.

With a better communication between planners, designers, politicians, managers, and the general public, it is possible to convey and implement planning and design strategies to achieve better sustainable landscapes.

## **References**

- Ahern, J. (1995)** Greenway as a planning strategy. *Landscape and Urban Planning* **33**: 131-155.
- Dawson, K. (1995)** A comprehensive conservation strategy for Georgia's greenways. *Landscape and Urban Planning* **33**: 27-43
- Fabos, J., (1995)** The greenway movement, uses and potentialities of greenways. J. Gy. Fabos & J. Ahern (Eds). *Greenways: the beginning of an international movement*. Elsevier, Amsterdam, pp 1-13.
- Hall, P. (1992)** *Urban & Regional Planning*. Routledge, New York
- Lyle, J. (1985)** *Design for human ecosystems*. Van Nostrand Reynolds Company, New York
- Ribeiro, L. & Barão, T. (2006)** Greenways for recreation and maintenance of landscape quality: Five case studies in Portugal. *Landscape and Urban Planning* **76**: 79-97
- Smith, D. & Hellmund P. (1993)** *Ecology of greenways; design and function of linear conservation areas*. University of Minnesota Press, Minneapolis
- Spirn, A. (1984)** *The granite garden, urban nature and human design*. Basik Books, Cambridge, Mass
- Turner, T. (2006)** Greenway planning in Britain: recent work and future plans. *Landscape and Urban Planning* **76**: 240-251
- Walmsley, A. (2006)** Greenways: multiplying and diversifying in the 21<sup>st</sup> century. *Landscape and Urban Planning* **76**: 252-290



## 9.4 Open session 1: Concepts theory and history

### A Healthy Landscape Benefits Both Wildlife and Humankind

C-Y. Chang<sup>1</sup>, W-C. Su<sup>1</sup>, Y-H. Lin<sup>1</sup>, H-F. Tang<sup>2</sup>

<sup>1</sup>Landscape Architecture Division, Department of Horticulture, National Taiwan University,  
138 Keelung Rd. Taipei, Taiwan 10673  
e-mail: cycmail@ntu.edu.tw

<sup>2</sup>Dept. of Leisure and Recreation Management, Asia University, 500 Lioufeng Rd., Wufeng,  
Taichung, Taiwan 41354

#### Introduction

Within the framework of a research plan of human and sustainable environmental development, this study tries to discuss the relationship among natural ecological species, recreational areas, and the user's psychophysiological responses, to depict the relationships and dynamics between human and ecological environments.

The belief, that being in a natural environment, is good for our mental and physical health is not new. Many medical professionals, among them Florence Nightingale, have encouraged people to go to the country to convalesce after illness. Research studies provide some validation for these views (Regan & Horn, 2005). The findings also show how exposure to natural stimuli, compares with urban stimuli. They also reduced physiological arousal and less attentional selectivity provide an important step in understanding why natural stimuli are experienced as restorative (Laumann, 2003).

In summary, this study tries to develop a relationship for assessing how people benefit from the restorative potential of ecological environments; the theory is based on ART (Attention Restoration Theory), the outdoor recreational experiences, the state anxiety, and biofeedback fields. This article also investigates types of the natural environment and activities that might be expected to influence the ratings in predictable ways.

To achieve this goal, this study established basic ecological species information (richness, diversity, evenness, capita) and adopted the indices of landscape ecology as indicators to determine the interaction between wildlife species and the environment in different recreational areas. Selected testing areas included urban greenlands, rural areas, and natural woods.

The content of this study include: 1) a review of the related literature to establish the evaluation framework. 2) The realization of the relationships among wildlife species, recreational areas, and psychophysiological benefits of humankind. 3) A comparing of the relationships between landscape and human psychophysiological responses for the urban green land, the rural environment, and the natural woods. 4) Finally, with the premise of the condition of the achievement of healthy people, this study tries to build an executable evaluation model and indicators for the healthy landscape.

#### Method and material

This study evaluated the "healthy" conditions of the test areas according to the diversity of the species. Using biofeedback instruments and theories of environmental psychology, and evaluated the psycho-physiological benefits of humankind within various recreational areas.

By establishing the basic ecological species information and adopting the methods of landscape ecology to realize the interaction between wildlife species and ecological environment at different recreational areas. The region in the urban green land, the rural environment, and the natural woods were selected as the test areas.

This study evaluates the "healthy" condition of the test areas according to the criteria of landscape ecological principles. Landscape ecological related data were collected at various landscape areas. Trained volunteer investigators collect the data at the selected sites. Aerial photography Maps (Scale: 1/5000) was adopted to analyze the landscape ecological structure indices of the selected locations. Landscape elements were categorized from the

maps with two different hierarchies. The coarse and refined landscape ecological data were digitized using eCognition 5.0; Fragstats 3.3 were adopted to provide the landscape ecological information of different scenarios.

The indices of the wildlife species include richness, diversity, evenness, and capita. The most frequent observed, frequent observed, and sub-frequent observed species were listed and compared.

On the other side, by applying the biofeedback instruments and the theories of environmental psychology, this study estimates the psychophysiological benefits for humankind under different recreational areas with different activities. The evaluation indicators that merit both wildlife and human kind are discussed.

### Result and discussion

Our major purpose was to test the relationships between participants' psychological and physiological benefits in different ecological-based landscapes. Participants' psychological outcomes were measured with their attention restoration effect while their physiological responses were measured with their Electromyography (EMG) and Heart Rate (HR). Besides the effect of the activities on the respondents' benefits, all other hypotheses were fully or partially agree with what this study expected.

### Conclusion

In our framework, the ecological environment plays the role of a beginner; it can have the effect on visitors' experiences and can influence the benefits directly. The visitors' experiences seem a good stepping-stone to interpret the effect in between. It connects the effect from the environment (Phase I) and delivers the effect to the respondents' benefits.

Finally, with the premise of promoting the achievement of healthy people, this study attempted to build an executable planning and evaluation model and proposes important indicators for a healthy landscape that benefit both wildlife and humankind.

### Reference

- Chang, C. -Y. and Perng, J. L. (1998)** Effect of Landscape on Psychological and Physical Responses. *Journal of Therapeutic Horticulture* **9**: 73-76.
- Chiang, Y. -C. & Chang, C. -Y. (2004)** Exploring the Sustainable Environment Based on Landscape Ecology and Landscape psychophysiology. *Landscape Cognition and Preference*, The Outdoor Recreation Association of ROC, Taipei, pp. 153-167. (in Chinese)
- Hartig, T., Mang, M. and Evans, G. W. (1991)** Restorative Effects of Natural Environment Experiences. *Environment and Behavior* **28**: 44-72.
- Herzog, T. R., Black, A. M. & Fountaine, K. A. & Knotts, D. J. (1997)** Reflection and Attentional Recovery as Distinctive Benefits of Restorative Environments. *Journal of Environmental Psychology* **17**: 165-170.
- Kaplan, S. (1995)** The restorative Benefits of Nature: Toward an Integrative Framework. *Journal of Environmental Psychology* **15**: 169-182.
- Kong, F. & Nakagoshi, N. (2006.)** Spatial-temporal Gradient Analysis of Urban Green Spaces in Jinan, China. *Landscape and Urban Planning* **3**: 147-164.
- Laumann, K., Gärling, T. & Stormark, K. M. (2001)** Rating scale measures of restorative components of environment. *Journal of Environmental Psychology* **21**: 31-44.
- McGarigal, K., Cushman, S.A., Neel, M.C. & Ene, E. (2002)** FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer Software Program Produced by the Authors at the University of Massachusetts, Amherst. Available at the following website: [www.umass.edu/landeco/research/fragstats/fragstats.html](http://www.umass.edu/landeco/research/fragstats/fragstats.html).
- Tennessen, C. M. & Cimprich, B. (1995)** Views to nature: Effects on attention. *Journal of Environmental Psychology* **15**: 77-85.
- Ulrich, R. S. (1981)** Natural versus Urban Scenes Some Psychophysiological Effects. *Environment and Behavior* **13**: 523-556.

## The importance of people in landscapes: valuing Aboriginal land management

J. Gorman<sup>1</sup>, M. Luckert<sup>2</sup>, and B. Campbell<sup>1</sup>

<sup>1</sup>School for Environmental Research, Institute of Advance Studies, Charles Darwin University, NT 0909 Australia.

e-mail: julian.gorman@cdu.edu.au

<sup>2</sup>Department of Rural Economy, University of Alberta Edmonton, AB, T6G 2H1 Canada.

### Introduction

Landscapes in the Northern Territory of Australia are characterised by their rich diversity of environments and cultures. The environments span the continental climatic range from the wet monsoons in the north to the deserts in the south. Most of these environments are still relatively intact and include world heritage sites and internationally recognised wetlands. The cultural diversity is reflected in the extraordinary number of Aboriginal language groups that are found across this region. A key mechanism for managing biodiversity and other key ecological processes is indigenous knowledge and where indigenous natural resource management has been practiced, biodiversity is potentially less threatened and key ecological processes are maintained. There are various programmes that facilitate indigenous natural resource management such as indigenous ranger programmes which are community based and involve western and indigenous management techniques. However, over vast areas of the Northern Territory many of the natural values are now threatened as a result of contemporary western land management practices. The major issues relate to fire management, land clearing and water use. Land management in the Northern Territory is made difficult by the low population status of this region and a predominantly urban population. The 58,000 Aboriginal people who live in the Northern Territory are predominantly based outside major cities on Aboriginal owned land trusts (620,000 km<sup>2</sup>) and suffer major socio-economic problems. Many of these people are actively involved in land management practices which provide public goods, but are given little or no acknowledgement or financial assistance for their efforts. Land management in the Northern Territory will become increasingly more important if Australia is to meet international biodiversity conservation commitments and reduce green house gas emissions into the future. Aboriginal people are well placed to assist in land management activities but there must be on going employment, education, and infrastructure incentives for them to remain and progress on these marginal lands. This paper discusses a model of engaging Aboriginal people which has potential to provide real jobs and operational funds in return for landscape management activities.

### Northern Territory Landscapes

Aboriginal people have occupied and managed large areas of land in Australia continuously for many thousands of years. In the Northern Territory (NT), Aboriginal people make up 28.5 % of the population and own 40% of the land, including 87% of the coastline (Storrs *et al*, 2003) and this country is linked through strong cultural connections. Early European colonisation and the spread of pastoralism in the 19th and 20th centuries resulted in the removal of Aboriginal people from their traditional lands onto government outstations and missions. This trend was partly reversed in the 1970s due to the *Northern Territory Land Rights Act 1976* where many Aboriginal people moved back onto country. Much of the land currently held under communal freehold title by Aboriginal people is remote, infertile and degraded but perhaps largely for these reasons is also intact and biologically diverse with internationally recognised centres of plant and animal biodiversity (Storrs *et al.*, 2003; Altman and Whitehead, 2003). Many of the natural resource management activities currently conducted by Aboriginal people on country can be seen to have public good but there is

often little, if any, Government recognition for this work. Social disfunction, along with inadequate health, education and basic infrastructure, are some of the issues facing many of the 200 Aboriginal communities in the NT that range from small family groups at outstations to townships of up to 2000 people (Altman and Whitehead, 2003). Although there is a low level of formal educational training amongst Aboriginal people they have an extensive knowledge about their land and its biological resources. Development and livelihood opportunities must be carefully planned so that they compliment these existing skills held by the Aboriginal custodians and do not adversely impact upon the strong cultural links between country and people.

### Threatening processes

Some of the main threatening processes influencing the NT landscape are fire, weeds and feral animals (Woinarski *et al.* 2001). Fire is an integral part of the Australian landscape but the hot uncontrolled wild fires resulting from present land management practises are detrimental to both the environment and property. Tighter control of fuel levels to break this trend will require management at a much finer scale than current practice. Weeds are choking river systems, adversely affecting biodiversity and increasing fuel levels and are more easily managed if detected early and not allowed to establish. Feral pests and the diseases they carry also have a huge impact on biological and physical resources and need intensive local management.

### Models for the future

The current Indigenous land and sea ranger program is integral to the future natural resource management of NT landscapes (Storrs *et al.* 2003). It integrates the incredible wealth of knowledge about country that Aboriginal people have with more traditional western management techniques. These programs currently rely on federal funding and there is a need for greater private sector investment in management of this country. Opportunity exists for development of a range of offset projects across Northern Australia in terms of carbon abatement and maintenance of biodiversity. The mining industry is one area of private sector investment that is likely to fund such offset projects. Both project types are likely to involve large scale NRM practise and have potential to substantially increase livelihood prospects for Aboriginal people already occupying these remote areas.

### References

- Altman J. C. & Whitehead P. J. (2003)** Caring for country and sustainable Indigenous development: opportunities, constraints and innovation. Working Paper 20/2003. Centre for Aboriginal Economic Development, Australian National University, Canberra.
- Storrs M., Ashley M. & Brown M. (2003)** Caring for country: the rapidly developing formalised structure for land management on Aboriginal lands of the Top End. In: H. Jacob, Dodd, J. and Moore, J. (eds.), 13th Australian Weeds Conference, Plant Protection Society of WA, Perth, WA..
- Woinarski J. C. Z., Milne D. J. & Wanganeen G. (2001)** Changes in mammal populations in relatively intact landscapes of Kakadu National Park, Northern Territory, Australia. *Austral Ecology* **26**: 360-370.

## Landscape science and landscape ecology: Russian experience, concepts and scientific domains

K.N.Dyakonov, N.S.Kasimov, Y.G.Puzachenko, A.V.Khoroshev

Moscow State University, Faculty of Geography, Vorobyovy Gory, 119992, Moscow, Russia.  
e-mail: landrus@geogr.msu.ru

### Historical review

The origin of landscape science in Russia dates back to seminal studies by V.V.Dokuchaev and L.S.Berg. Its rapid development in the 1960s was strongly influenced by geomorphology from which effective principles of landscape unit's delineation were developed. The focus on analysis of landscape genesis and structure favored the elaboration of the hierarchy concept for holistic entities referred to as natural territorial complexes, or geosystems (N.A.Solntsev, A.A.Vidina, A.G.Isachenko). The Moscow landscape school focused research on structure and genesis of landscapes. N.A. Solntsev proposed to reject an understanding of landscape simply as a territory with certain relationships between natural components or type of locality or countryside. He defined landscape as a genetically uniform territory with regular and typical repetition of some interrelated combinations of geological structures, landforms, surface and groundwater, microclimates, soil types, phytocoenoses and zoocoenoses. He considered landscape to be a specific territorial form of organization of nature. Landscape has its peculiar individuality. At the same time some combination of individualities can be represented in typological classifications without significant loss of information.

It was landscape mapping that in 1940-50s served as a basis for elaboration of the concept of morphological structure of landscape as a genetic entity. Hierarchical organization of nested landscape units is the focus of this concept.

### Present-day concepts

Several principal domains of landscape science can be identified since the last quarter of the XXth century: study of structure and genesis, functioning and dynamics, landscape geochemistry, landscape geophysics, evolution, anthropogenic impact. Each of the domains mentioned above is based on fundamental concepts.

Within studies of landscape genesis and structure the most interesting results were obtained using concepts:

- Morphological structure of plain landscapes (N.A.Solntsev, A.G.Isachenko);
- Multi-structural organization having roots in the idea that differentiation of the Earth's landscape sphere depends on interaction of three relatively independent geophysical fields: biocircular, geocircular and geostationary ones (K.G.Raman, V.N.Solntsev);
- Nuclear-like organization of geosystems (A.Yu.Reteyum);
- Mathematical morphology of landscapes (A.S.Viktorov, Yu.G.Puzachenko, V.V.Syssouev).

Domain focusing on study of landscape functioning and dynamics is based on the concepts as follows:

- natural regimes and temporal states of geosystems (V.B.Sochava, N.L.Beruchashvili, I.I.Mamay, V.A.Snytko);
- chronoorganization of landscapes, synchronism-asynchronism, metachronous and heterochronous organization of processes and phenomena (K.N.Dyakonov, V.A.Nikolaev, V.N.Solntsev)
- geophysical balance concept (A.A.Grigoryev, D.L.Armand, M.I.Budyko)
- bioenergetical trophodynamic concept (C.Elton, L.Lindeman, E.Odum)

**Theme 9: Concepts for Landscape Planning and Design**  
**9.4 Open session 1: Concepts theory and history**

Diversification of landscape science resulted in emergence of landscape geochemistry as a separate science in the middle of the XXth century (B.B.Polynov, A.I.Perelman, M.A.Glazovskaya). It developed with a strong connection to the functional domain of landscape science as one of the most effective methods of research. N.S.Kasimov and A.N.Gennadiev systematized the present-day fundamental principles of landscape geochemistry and soil geography.

The study of landscape evolution is based on the following concepts with strong emphasis on:

- self-development of landscapes (V.N.Sukachev);
- Holocene evolution (M.I.Neyshtadt, A.A.Velichko, V.A.Nikolaev);
- anthropogenic evolution (V.A.Nizovtsev);
- resilience and self-regulation of landscapes (A.D.Armand, K.N.Dyakov, Yu.G.Puzachenko, V.A.Svetlosanov)

Concepts applied in studies of anthropogenic landscapes are seen as follows:

### **Results and challenges**

The main results of landscape studies in Russia are seen as follows. Spatio-temporal organization of landscape is the principal focus. Organization of geosystems is expressed in two ways. Firstly, it is a geographical process of structural emergence in space and time (structural-genetic and evolutionary landscape studies). Secondly, geosystems organization is a result of processes manifested in stable system forms as a hierarchically nested temporal states. Integral geographical process and its results are expressed as a triad “evolution – structure – functioning”.

The most intriguing challenges that landscape science faces today deal with the study of geosystems self-organization, mechanisms generating structure, functioning and evolution, non-linear dynamics, spatio-temporal waves and structures. We believe that landscape planning, geoecological projecting and examination, landscape resilience and landscape design are the most important future fields for research in landscape ecology. Although traditionally landscape ecology is strongly biocentric and has roots in ecology and human ecology in particular, landscape ecology and landscape science evidently become progressively closer in principles and concepts. Landscape policy based on scientific achievements should be a necessary basic constituent of state regional policy.

## **Assessment of the incidence of landscape ecology in urban and spatial planning in Southern Europe: revision of Spanish and Italian case studies**

**L.M. Valenzuela Montes, R. Pérez Campaña, F. Aguilera Benavente, A. Matarán Ruiz.**

Department of Urban and Spatial Planning, University of Granada, Edificio Politécnico, Laboratorio de Urbanística y Ordenación del Territorio, Campus Universitario de Fuente Nueva, C.P. 18071. Granada. Spain.  
e-mail: lvmontes@ugr.es.

### **Introduction**

The aim of this article is to analyse the presence and the real influence of the concepts and methods of landscape ecology in the last decade of urban and spatial planning in two European Mediterranean countries: Spain and Italy. However, we also present a detailed review of the main Spanish journals concerning spatial planning, urban planning, landscape ecology, and spatial analysis.

### **Literature review**

The complete review of the Spanish situation is compared with a less broad but representative review of the Italian references in the most significant national journal of planning: "*Urbanística*". However we can compare within these two countries the methodological links between landscape ecology and planning, and the real use on planning of the methods, principles and instruments of landscape ecology.

The reviewing process is addressed to analyse the scientific incidence and the effective use of concepts and tools such as: corridors, landscape matrix, fragmentation, spatial pattern and greenways.

The review recognizes three main subjects in order to classify the selected articles, these subjects are related to the level of relationship between landscape ecology and urban and spatial planning. The three levels in descending order are:

- Application of principles and tools of landscape ecology to urban and spatial planning.
- The use of concepts or models derived from landscape ecology.
- Conceptual analogies linking planning and landscape ecology.

### **Conclusions**

The main conclusions of this review are:

- The applied use of principles and methods in planning is very limited in the last decade and especially in the Spanish literature. Nevertheless, it is emerging strongly in Italian literature in the last two or three years.
- The strongest relationship of spatial analysis and landscape ecology appears when the spatial patterns are being established.
- There are a considerable number of articles in the third category of the following table. It means that the effective use of landscape ecology methods needs further methodological and technical efforts, before it can progress into a transdisciplinary approach.

Theme 9: Concepts for Landscape Planning and Design  
9.4 Open Session 1: Concepts, theory and history

JOURNALS		Spanish Journals		Geofocus	
Italian Journal		Ciudad Y Territorio	Urban	Ecosistemas	
Urbanistica		Estudios Territoriales			
Application of principles and tools of landscape ecology on urban and spatial planning	Gambino, r. (1995): "Separate when necessary and integrate when possible", N. 104, pp. 57-65.	Marull, J. and Mallarach, J.M.. (2006): "Ecological connectivity in planning and strategic assessment: applications in the Barcelona Metropolitan Area". n. 147, pp.41-60.	Marull, J. and Mallarach, J.M. (2002): "Ecological connectivity in planning and strategic assessment: applications in the Barcelona Metropolitan Area". 2002/2	Moizo, P. (2004): "Remote sensing and GIS technology: an application on Landscape Ecology", n. 4, pp. 1-24.	
	Blasi,C. and De Dominicis, V. (2006): "Landscape ecology and spatial governance", n.129, pp. 58-60.		Sastre, et al, C. (2002): "Landscape connectivity models in different scales. Applied examples in the Madrid Region". 2002/2	Mateucci, S. D. and Silva, M. (2005): "Selection of spatial configuration metrics used to regionalize the antropized territory", n. 5, pp. 180-202.	
The use of concepts or models coming from landscape ecology	Zipato, A. (1995): "Environmental planning: the opinion of three planners", n. 104, pp. 50-91.		Sans F.X. (2007): "Agroecosystem diversity". 2007/1		
Conceptual analogies linking planning and landscape ecology	Galuzzi, P. (1999) : "Vademecum of the applied ecological urban planning", n. 112, pp. 66-68.	Naredo, J.M. (1994): "City operation and its incidence in the territory", n.100-101, pp.233-249.	Verdaguer, C. (1999): "Landscape before a battle. Notes for a necessary debate on the ecological paradigm on architecture and planning", n 3, pp. 29-43.	Badia, M. and Rodríguez, F. (2005): "A new methodology to reconstruct the historical evolution of agricultural landscape", n 5, pp. 69-78.	
	Caravaggi, L. (1999): "The environmental project in the new master plan for Bergamo", n. 112, pp. 64-68.	Rueda, S. (1994): "El ecosistema urbano y los mecanismos reguladores de las variables autorregenerativas", n. 100-101, pp. 251-291.	Spars, G. (1999): "Greening European cities: The example of materials flows management in the Berlin construction industry", n. 3, pp.44-52.		
	Angrilli, M. (1999): "Greenways", n. 113, pp. 92-98.	Parra, F. (1994): "The city as an ecosystem", n.100-101, pp.411-419.	Oliva, F. (2000): "New approaches of urban planning in Italy", n. 4, pp. 38-66.	Canosa, et al . (2003): "Methodology to analyse urban parks: the Madrid Region", n. 3, pp. 160-185.	
	Branduini, P. (2005): "The agricultural areas in the peri-urban Italian parks: toward new models?", n. 128, pp. 30-34.				



## Landscape-historical geographical information for land use change investigation

N.A. Marchenko

University Centre in Svalbard, 9171, Longyearbyen, Norway, Nataly.  
e-mail: Nataly.Marchenko@unis.no

From the initial stage of society formation, people lived and live now in close interaction with nature and defined landscapes. There is mutual man-environment influence and unreasonable actions lead to ecological conflict. However traces of modern problem go back in time and can be determined by retrospective analysis of man-nature interaction from the initial stage of landscape formation. For example, In the Bronze Age over-grazing by pigs was the cause of deforestation of the floodplains of Central Russia. In the Iron Age developing slash-burn for ploughed fields resulted in secondary aspen and birch forest. Spatial analysis and mapping are very important for finding of peculiarities and adequate reflection of results, so historical approach and use of GIS-technology is necessary for land use change studies.

The main goal of land use investigation is definition of man and landscape interactions in space and time and the elaboration of research methods for anthropogenic landscape genesis. So landscape-historical GIS of the Moscow region has been made as a generalization of the results of many years field landscape-historical and archeological investigations. So the extensive data from field, expedition and office studies and archive data have been accumulated. These are maps (modern and archive), verbal descriptions and tables. The history of man mastering of landscapes and regularity of society and nature interaction dynamics in Moscow region are shown in GIS. But it is possible now to create such landscape-historical GIS for other regions. We can now create GIS for the northernmost settlement area – Svalbard archipelago and its main island – Spitsbergen (78° N).

It is very important to have three hierarchical levels of mapping and analysis of objects in GIS. 1. For the whole region - Small scale (1:1 000 000 -1:2 500 000) – These are physical-geographical regions and districts on the landscape map. 2. Large districts of region - Middle scale 1:50-100 000 - These are physical-geographical localities (*“urochisches”* in Russian) on the landscape map.3. Mostly detail scale 1:5 000 –1:10 000 - for key plots (*urochisches* and *suburochisches* on the landscape map). For some of key sites (neighborhoods of historical and archeological monuments) scale 1: 2000 would be used. The problems of contours' adjustment and results comparison (common for the whole GIS, especially for historical maps, created in different time with various accuracy and particularity) are decided on the landscape base. The principle maps should be landscape maps, on which natural territorial complexes should be shown. These units are very close to an ecosystem, so GIS can be used for ecological purposes.

Such a GIS has to consist of natural, historical and application blocks for each hierarchical level. The kernels of the natural block are landscape maps characteristics of natural-territorial complexes, drawings and descriptions of soil profiles, etc. The fundamental concept of landscape unity and conjunction of its components allows the compilation of component maps. The historical block consists of the maps of landscapes restored for different temporal stages, archeological and historical maps. These maps reflect the history of the settlement of the region. Most historical maps would be worked out on a landscape base. Application block (assessing and forecasting) contains maps needed for solving specific tasks. These are maps of cultural historical landscapes, outstanding sites, excursion maps, functional zoning and maps for monitoring. There are complex depiction of landscapes and their components, historical notes, sets of explanatory photos and reproductions.

The basis of land use analysis and finding of the first natural-economical systems is reconstruction (by archeological data) types and methods of land use as well as paleo-reconstruction of the initial environment. Such reconstruction is worked out by the landscape-edaphic method, including hidro-trophic estimation of the land. Soil is the component and product of landscape function. Paleopedological data is the basis for paleo-reconstruction of

land cover and land use in past times. The buried and old arable soils were investigated and diagnostic signs of economic actions were determined. Exploring soil structure and combination of layers by means of pedology and paleobotany make it possible to localize concrete ancient tenures (settlements, arable lands, forests and meadow). The other interesting method is place-name analysis. Toponymy (place-name study) and landscape-lexicographical analysis allow the examination of past landscapes. Distribution of place-name data by natural complexes shows their connection with landscape and land use features. So, evolution of interrelations between man and landscapes is studied through identifying the regular transformations of landscape structure. Within long-settled territories, such transformations were brought about by natural changes and different types of land use.

Land use dynamics is investigated on key sites. Landscape structure of the area has been analyzed in details. The main stages of development have been identified, as well as the present-day impact of man and the degree of anthropogenic transformation for the dominant types of landscapes. Changing land use in key plots during 300 years has been researched by means of old map investigation. Accurate localization of maps by means of GIS-technology allows us to superimpose these different scale cartographical original sources. Such standard GIS-operation as Geoprocessing Union and Intersect helped us to make conjugated analysis of natural condition and historical situation. Overlays of landscape and historical maps has shown land use in each natural unit and changing of this land use. Shares (in percent) of area, occupied by define types of land use for four historical moments have been calculated and shown on diagram. Also the changes in share of the dominant landscapes in the main land use types have been defined for the same historical moment.

However the important question is how we can use this material. We have an experience of land use change evaluation for landscapes due to map overlays and further statistics treatments for last 300 years in model key plots. Also we use our GIS for education, ecological tourism and landscape planning of historical places. It is very important to familiarize people at large with history of ecological problem and to use the new data and the results of scientific work in education. We have the experience of such teaching in school and university, and also landscape-historical excursion. The main objects of such excursions are landscape-historical complexes as unity of archeological or historical monuments and their natural environment. Scientists of different specialization take part and geographical, historical, ecological, architectural and design phenomena are learned, mapping and home-tasks are carried out. We make such excursions in outstanding and well-known places, having a long history of man-nature interaction, well-preserved historical and archeological monuments and remnants of different types of land use. There would be special tourist maps in landscape-historical GIS. The routes of landscape-historical excursions and the objects for demonstration would be marked on these maps. Also, pupils and students can use the materials of GIS, when they make their training and scientific works and when can create the map themselves.

Landscape-historical GIS is a new type of GIS, showing history and colonisation processes for land and the coexistence of man and nature in time. Such GIS is created for performance and exploration of anthropogenic landscape genesis processes from sets of maps. In this GIS, the main stages of land use and man impact in region are traced from the upper Paleolithic Age, beginning from equilibrium system "man-nature" to modern anthropogenic transformation of landscapes. The main features of different periods and natural complexes are described. GIS displays show the location of different objects (natural, historical and cultural) in different times. Moreover, the causes of various settlement systems and land use peculiarities, stages of developing and arising ecological problems have been apparent due to set of landscape and historical maps.

## Landscape as a dynamic system

Y.G. Puzachenko<sup>1</sup>, D.N. Kozlov<sup>2</sup>

<sup>1</sup> A.N. Severtsov Institute of Ecology and Evolution RAS, 119071, Moscow,  
Leninsky prospect 33, Russia,  
puzak@orc.ru

<sup>2</sup> Lomonosov Moscow State University Faculty of Geography, 119899, Moscow,  
Leninskiye Gory 1, Russia

The source of direct geographic information is variety of observed phenomena. This variety expands as the technical means of measurement develop but can never be exhaustible. Moreover, newest technical means can lead to new discoveries. Continual representation of natural phenomena with fixed spatial resolution can be derived only through multispectral remote sensing data. Field observations are inevitably discrete. The outstanding role in perception of landscape belongs to vision which continually scans space during field routes or from constant viewpoints. Human brainwork transforming this information compares observations with a priori models and patterns. In fact, human brain works in pattern recognition way. In case reality is provably inadequate to model the scientist searches for better model. New model is developed through mechanisms that validate contradictions. Usually new model are characterized by better generality. Independent of research object the scientist is always limited within existing models and conceptions learned during education.

Like all natural and social sciences geography until end of XX century based on equilibrium process model, equilibrium thermodynamics with principles of gradualism and actualism, nature laws permanence and process reversibility. Severe reality of XX century last quarter significantly decreased the area of this model use. It was developed that thermodynamic model of non-equilibrium and non-stationary processes is more adequate to reality. Equilibrium model became an ideal, limit case (Nicolis, Prigogin, 1979). The fractal model of nature geometry which is closely connected to thermodynamic one was also developed during this period (Mandelbrot, 2002). As an addition to thermodynamics the following models were developed. Synergetic model, which bases on systems of non-linear equations and model of local interactions determined by general rules (order parameters) (Haken, 1993). This new conception synthesis in not final stage of science development. Science actively searches for integration ways of thermodynamics, information theory which can connect structure of system with its functioning (Hazen, 2000). Among all visible differences in these approaches the general system of conceptions appears which can give the basis of more definite understanding of nature evolution and its various occurrences. Although the search of new ideas was stimulated by biology and economy, but it also develops in geology, especially geodynamics.

The general basis of this model is conception of dynamic system (DS) – an object of any nature which state changes in time according to dynamic laws. Term DS is a mean of idealization. Object is being separated from its environment and do not settle all reality.

Let us imagine an ensemble of phenomena which are connected in varying degree. Each of them is characterized by autochthonous dynamics because of feedback. Their fundamental feature is non-linearity i.e. dependence from own state. Dynamics and evolution of such a system is supported by energy and matter flow (open system), which are partly dissipated by system. This system inevitably has hierarchy, has a number of local equilibrium areas, chaotic dynamics succeeded by quasi-harmonic oscillations. The system has an ability of self-development as soon as it searches for local equilibriums with environment.

The land cover of Earth which is given through observations in the given moment, can be presented as projection of numerous realized trajectories of this DS. This projection reflects almost all features of system. It should be a fractal (it is proved), should be hierarchically organized, should have areas with almost stochastic spatial structure and should have various scale local equilibrium areas with real borders – bifurcation points. DS

model allows by the data existence of emergence properties and, accordingly, presence of integrity elements. Due to non-linearity strong interactions and resonance effects can emerge between various phenomena in wide range of spatial-temporary oscillation scale.

This conception of geographical envelope and landscape as its structural part gives basis to synthesize existing spatial-temporary models. The DS model integrates through this point of view the chorological conception and idea of common geographical process. Its basis can be found in theoretical research of Victor Sochava. He developed perception of invariance, geomere and geochore relation.

DS research claims for some change in science methodology, first – the development of close interaction of models of DS behavior. It is very important to have imaginative maximally critical look of naturalist and to analyze measurements which are directed to search the order parameters in phenomena relations in spatial-temporal scale.

The research of landscape from the point of view of DS needs permanent extending of observed features and phenomena, active use of new measure systems and measure complexes which provide maximum information about spatial variation. In Landscape science, full set of measurements made from space should be included in research. We also should not forget analysis of connection between cloud systems and land cover, magnetometry and gravity measurement. Objects of special interest are various scale faults of earth crust as soon as these are areas of non-stationary and a priori active state. Another actual problem of landscape science is forming of meso-climate as synergetic effect of interaction between ground layer of atmosphere and land cover properties and as potential generator of large scale fluctuations of atmospheric processes.

In the given report the basic conception of DS is considered as well as approaches to its research. The properties of geographical envelope and landscape are demonstrated that follow as a result of general DS general idea. Various approaches to its research considered at the basis of remote sensing information and field observations.

The research is made with support of RFBR (projects ## 03-05-64280, 01-05-06012).

### **References**

- Nicolis G., Prigogin I.** (1977) Self-organization in Nonequilibrium System. Wiley, New York.
- Mandelbrot B.** (1982) The Fractal Geometry of Nature, W.H. Freeman & Co.
- Khazen A.** (1993) Maximum entropy production as a motive force of progressive biological evolution. Biophysics, V. 38, №3, pp. 537-565
- Haken H.** (1993) Advanced Synergetics: Instability Hierarchies of Self-Organizing Systems and Devices. New York: Springer-Verlag.

## **Towards a clinical pathology of landscape: criteria for a diagnostic evaluation**

**V. Ingegnoli, E. Giglio**

Natural Sciences, University of Milan, 26 via Caloria, 20133, Milan (Italy)  
e-mail: v.ingegnoli@virgilio.it

### **Introduction and methodological criteria**

A landscape, as a complex system of biogeocoenosis, is much more than a set of spatial heterogeneous characters, being a proper living entity (Forman and Godron, 1986; Meffe and Carrols, 1998; Ingegnoli, 1993, 2002; Ingegnoli and Giglio, 2005). Consequently, landscape ecology should be considered first of all a discipline like medicine, biologically based but transdisciplinary: since the landscape is a biological system, it is the physiology (ecology)/pathology ratio which allows a clinical diagnosis. Main landscape syndromes can be classified and studied (Ingegnoli, 2002).

The main criterion for diagnostic evaluation depends on the capacity to compare the normal behaviour of a system with its present state. This is a difficult operation, because to remove an alteration we need to know the normal process, even if it is just the alteration which permits the normal process to be understood. Therefore, the application of models is indispensable to understand the relations between a normal process and an alteration.

Moreover, in this view, many contradictions in the study of the landscape can be strongly reduced, e.g. the proper use of aesthetic and semiotic perception, the contribution of pollution, the relationships between landscape pathology and human health, the problem of the "judgement of value", the best planning strategies, the conservation biology problems on preserving natural areas, the ecological vs. economical contrasts, etc.

### **The case study of the Park of Monza**

Some examples of landscape diagnostic evaluation could be presented, concerning both the natural and the urban landscapes: respectively in the Alps and in the hinterland of Milan. We wish to underline the importance of the biological-integrated school of landscape ecology (Ingegnoli, 2002) in developing diagnostic methods, useful in every type of landscape syndromes, and consequently in proposing available therapies.

Here we briefly present the case study of the Park of Monza, a large suburban historical park of the hinterland of Milan (730 ha), in the territorial contest or Landscape Unit (LU) of the municipalities of Monza, Veduggio and Biassono (3975 ha).

This park is formed by agricultural farms and forest patches. In the XIX Century the forest cover reached 40.1 %; the Austrian Rulers of the kingdom of Lombardo-Veneto and then the Italian Kings of Savoia also used it for hunting. After the murder of the king Umberto I (1900), the park became the property of the municipalities of Monza and Milan and it was soon altered through the building of the well known car-racing circuit and of a large golf course (1921). Today the park is part of the Regional Park of the Lambro River, which crosses the Brianza hills and its forest cover is reduced to 26.5%. Moreover, the forest vegetation of the Park of Monza is quite degraded, as resulted by a recent analysis (Ingegnoli, 2006).

Ingegnoli proposed a method for the diagnostic evaluation of a LU, based on the gaps between the normal parametric ecological values of a proper landscape type and the measured ones, as shown in Table 1. The evaluation is expressed through a diagnostic index in 4 scores (0, 0.5, 1, 2). The diagnostic significance (Table 2) is articulated in five classes of health, following the principle of clinical pathology even for a landscape evaluation.

**Theme 9: Concepts for Landscape Planning and Design**  
**9.4 Open Session 1: Concepts, theory and history**

Table 1. Example of synthetic diagnostic evaluation of the ecological state of the Monza Park, following the landscape ecological methodology proposed by Ingegnoli. Normal values are referred to a forest-agricultural landscape.

n°	Ecological parameters	Measured values	Normal values	Gaps (%)	Diagnostic index
1	Biological territorial capacity of vegetation (BTC Mcal/m <sup>2</sup> /year)	2,19	2,70-3,30	-18,9	1
2	Human habitat (HH %) of the park	70,6	45-55	28,4	1
3	Connectivity ( $\gamma + \alpha$ ) of park elements	0,10	0,7-1,1	- 85,7	0
4	Not built perimeter (%)	21	35-50	- 40	0,5
5	Ecological efficiency (% LU)	0,22	0,3-07	-26,7	1
6	Photosynthetic surface (%) of the park	85,3	85-95	=	2
7	Allochthonous forest patches (%)	65	20-30	116,7	0
8	Maturity of forest patches in the park(%BTC/BTC*)	48,4	60-90	-19,4	1
9	Forest cover of the park (%)	26,5	30-40	-11,7	1
10	BTC(park) / BTC (LU)	3,32	4-6	-17	1
11	Fluvial functional index (IFF)	III	II-I	-0,25	1
12	Landscape general metastability (LM) of the park	11,08	13-17	-14,8	1
Diagnostic index					0,44

Evaluation of the gaps from normal values (a) 0-10 = 2; (b) 10-30 = 1; (c) 30-60 = 0,5; (d) >60 = 0.  
 LU = landscape unit.  
 Diagnostic index: 10,5/24=0,4375

**Table 2.** Diagnostic evaluation of a landscape in a Temperate (and Alpine) region.

Class	Diagnostic Index	Diagnostic Evaluation	Physio-pathological notes	Ecological Health & Interventions
I	0,85-1,00	Normal	Homeostatic plateau	Quite good health, only prevention needed
II	0,60-0,85	<i>Alteration</i>	Compensation needed	Unstable health, some therapy needed
III	0,35-0,60	Pathology	Some physiological damages	Dysfunction, intervention needed
IV	0,15-0,35	Serious pathology	Harmful effects	High dysfunctions, difficult intervention
V	< 0,15	<i>Extinction</i>	Irreversible damage	Degenerative transformation

**References**

- Forman, R.T.T. & Godron, M. (1986)** *Landscape Ecology*. John Wiley & Sons. New York.
- Ingegnoli, V. (1993)** *Fondamenti di Ecologia del Paesaggio*. Cittàstudi. Milano.
- Ingegnoli, V. (2002)** *Landscape Ecology: A Widening Foundation*. Springer. Berlin, New York.
- Ingegnoli, V (2006)** Criteri di valutazione diagnostica del Parco Reale di Monza secondo l'ecologia del paesaggio. In: Pelissetti (Ed.) *Il Parco della Villa Reale di Monza al Bicentenario della Fondazione*. pp 29-48. Comune di Monza. Monza.
- Ingegnoli, V. & Giglio, E. (2005)** *Ecologia del Paesaggio: Manuale per conservare, gestire e pianificare l'ambiente*. Sistemi Editoriali Se. Napoli.
- Meffe, G.K. & Carroll, C.R. (1997)** *Principles of Conservation Biology*., Sinauer Associates, Inc Publ. Sunderland, Massachusetts.

## The biological-integrated classification of landscapes: concepts and results

E. Giglio, V. Ingegnoli

CdL Natural Science – Department of Biology - University of Milan  
Via Celoria 26, 20133 Milan – ITALY  
e-mail: v.ingegnoli@virgilio.it

### Introduction

Today there is no a complete taxonomy of the landscapes, but only some ordination methods.

There are three the principal methods: (a) dominance of man-made artefacts. (a1) Based on the definition of Total Human Ecosystem (ecosphere = biosphere + technosphere) and involving energy, matter and information inputs from bio- and techno-ecosystems, the method brings to seven major resulting types of landscape, divided into open and built landscapes (last three) (Naveh and Lieberman, 1984, 1994); (a2) ranked according to decreasing naturalness or increasing artificiality, brings five landscape types, divided into bio-ecosystems and techno-ecosystems (the last) (Haber, 1990); (b) phytosociological criteria. Landscapes are classified (b1) on the basis of a survey of their vegetation complexes (Pignatti 1994) or (b2) on the basis of vegetation series or sygmata (synphytosociology and geo-synphytosociology) (Tuexen 1978; Géhu 1988; Rivas-Martinez 1987); (c) hierarchic factors criteria: it is based on the assumption that it is necessary to create valid attributes in a proper hierarchy and that no natural typology gives all attributes equal priority, because of its latent hierarchy (Forman and Godron, 1986). This method proposes: at first a descending hierarchy in five levels (Zonal climates, Climatic regions, Vegetational belts or bioclimatic units, Geomorphic units, human influences); then the identification of five distinct shapes of landscape; finally, four types of structural pattern of landscape elements.

Strictly following the implications of the definition of landscape as a living entity (Naveh et Lieberman, 1984; Forman et Godron, 1986; Forman, 1995; Ingegnoli, 1993, 2002; Meffe and Carroll, 1997), because there is a correct level of the hierarchy of life organisation on the Earth, it is clear that a landscape is much more than 'spatial heterogeneity in an ecological system'. So, the first basic step to classify landscapes needs to examine them as biological entities limited to a specific range of spatio-temporal scale.

### Concepts

First of all, we note that even landscapes have a functional organisation. In fact, life processes of a landscape need ecological landscape elements (ecocenotopes: Ingegnoli, 2002) to be organised in functional structures with the same prevailing function, called Landscape Apparatuses, (that is: they need to be organised in configurations recognisable in the territory, even if not always next to each other). Each type of landscape could be identified on the basis of the presence/absence and importance of the functional landscape apparatuses (Ingegnoli, 1993, 2002).

Deeper studies (Ingegnoli, 2002; Ingegnoli and Giglio, 2005) enhanced that the most important processes concerning a landscape - from a biological point of view - were strictly related to these different types. Among all of them, we focused on:

- (a) the dissipation of energy to maintain a proper level of organisation and metastability, expressed by the average Biological Territorial Capacity of the vegetation (BTC, Mcal/m<sup>2</sup>/yr) (Ingegnoli, 1991, 2002; ) and by the different distribution of its 8 Standard Classes (functional landscape diversity index)(Ingegnoli, 2002; Ingegnoli and Giglio, 1999);
- (b) the supply of subsidiary energy and the ecological control men exert on landscapes, expressed by the % of Human Habitat (HH) in a multidimensional sense (Ingegnoli, 1993, 2002; Ingegnoli and Giglio, 2005)
- (c) the process of occupation of a territory by a human population - despite the ecological needs of both men, territory and other local living entities - expressed by the Carrying

Capacity (SH/SH\*= that is Real Standard Habitat per capita/Theoretical Minimum Standard Habitat per capita) of the landscape (or part of it) (Ingegnoli, 2002;).

## Results

Considering the nine most characterising landscape apparatuses and combining them with different proportions, the Biological Integrated School of Landscape Ecology (Ingegnoli, 2002) noted the emergence of at least 16 types of landscapes (Table 1). With such criteria it is possible to classify most of the landscape types of the world, because they are compatible with the previous hierarchic ordination. In fact for each ecoregion (Bailey, 1996) of the ecosphere we may check the combination of the landscape apparatuses, and finally, if the case, add some elements of the landscape spatial pattern.

As in each biological entity, where a group of processes change behaviour, there we find a threshold: following the integrated behaviour of BTC, HU (Ingegnoli, 2005) and SH/SH\* it had been possible to relate to each type of temperate landscape a proper range of values for the most important specific landscape ecological indexes elaborated for the examined processes (Ingegnoli and Giglio, 2005). Studies on the first five types of landscapes have not been carried out yet.

**Table 1** Main composition of landscape apparatuses forming landscape types

Geo	Exr	Stb	Rsl	Con	Prt	Prd	Rsd	Sus	Landscape Types
++	-	-	+-	-	-	-	-	-	Desert
++	-	-	++	-	+-	-	-	-	Semi-desert
-	+-	-	++	++	+-	+-	-	-	Prairie
+-	+-	+-	++	+-	++	+-	-	-	Shrub-prairie
++	+-	+-	+-	+-	+-	+-	-	-	Shrubby
+-	++	++	++	+-	++	++	-	-	Open forested
-	+-	++	+-	++	++	+-	-	-	Closed forested
+-	+-	++	++	+-	+-	++	-	+-	Semi-natural, > bmass
+-	+-	+-	+-	+-	+-	++	-	+-	Semi-natural, < bmass
+-	++	+-	++	++	++	++	+-	-	Cultivated, protective
+-	+-	-	++	-	+-	++	+-	-	Cultivated, productive
+-	+-	-	+-	-	+-	++	+-	+-	Rural
+-	+-	-	+-	-	+-	+-	+-	+-	Sub-urban, rural
+-	+-	-	-	-	+-	-	+-	++	Sub-urban, industrial
+-	++	-	-	+-	++	-	++	+-	Urban, open
-	+-	-	-	-	+-	-	++	++	Urban, closed

GEO geologic, EXR excretory, STB stabilising, RSL resilient, CON connective, PRt protective, PRD productive, RDS residential, SUS subsidiary, ++ full presence, +- partial presence, --absence, bmass biomass

## References

- Ingegnoli, V. (1993) *Fondamenti di ecologia del paesaggio: Studio dei sistemi di ecosistemi*. CittàStudi (poi UTET-Cittàstudi) Milano
- Ingegnoli, V. (2002) *Landscape Ecology: A Widening Foundation*. Springer-Verlag, Berlin, Heidelberg, NY
- Ingegnoli, V. (2005) La correlazione HU/BTC per un modello di valutazione diagnostica delle trasformazioni del paesaggio. *VA Valutazione Ambientale* 07: 11-18
- Ingegnoli, V. & Giglio, E. (1999) Proposal of a synthetic indicator to control ecological dynamics at an ecological mosaic scale. *Annali di Botanica* LVII: 181-190
- Ingegnoli, V. & Giglio, E. (2005) *Ecologia del paesaggio: manuale per conservare, gestire e pianificare l'ambiente*. pp.704. Simone Edizioni-Esse Libri, Napoli



## 9.5 Open Session 25: Landscape modelling and scenarios

### Study of land-use changes and their effects on a distinct landscape located in Piedmont (Italy) applying a new multidisciplinary approach

F. Larcher, M. Devecchi

Dept. of Agronomy, Forest and Land management, University of Turin  
Via Leonardo da Vinci 44 – 10095 GRUGLIASCO (TO) ITALY.  
e-mail: federica.larcher@unito.it

#### Introduction

This paper will briefly describe methods and results concerning a research project focused on the landscape of a particular rural area of Piedmont in Italy. The two year project (2005-2007), aims to investigate past and current situations of this landscape in order to point out the main problems and distinct features. As results, some concrete actions have been found to direct future sustainable development of the area towards landscape preservation and revaluation.

#### Material and methods

##### Study area

The study area, located in Piedmont in the North-West of Italy, includes five villages (Albugnano, Berzano San Pietro, Castelnuovo Don Bosco, Passerano Marmorito and Pino d'Asti) with about 4600 inhabitants on an area of about 5500 ha.

It is a hilly area between 310 m and 530 m above sea level, historically cultivated with grapevine.

During the last few years, aging inhabitants and increased agricultural production costs – due in part to the appearance of a really dangerous grapevine pathology (*Flavescence dorée*) in Piedmont - bring about soil neglect and consequently a gradual transformation of landscape which loses of its true characteristic features.

##### The approach

In such a context, a multidisciplinary group of researchers has followed a holistic method of study - applying the theory of landscape ecology – which includes all the elements characterizing that landscape. In particular both natural aspects, such as climate, morphology, flora and fauna, and antropic aspects, such as land-use types, history of settlements, cultural and economical resources have been studied.

The study was carried out by bibliographic research and field surveys: all data were compared at different spatial and temporal scales. The analysis included Arc-view GIS software use, in order to understand the landscape structure and to create thematic charts for visualizing the most important characteristics of the landscape itself.

After the evaluation process, as result of the first part of the study, the area was divided into 15 ranges according to different criteria like morphological aspects, patch shapes, land use heterogeneity, etc. Overlaying cultural, historic and ecological features of each range, a sort of list of landscape quality emerged. So work groups concentrated their attention on the best range in order to plan a correct strategy of governance for that landscape.

#### Results and conclusions

##### Landscape analysis and evaluation

Statistical data about the study area revealed that, from 1961 to 2000, the number of farms has decreased by 62% and farmland by 40%. As for the most important land use

classes, from 1970 to 2000, it is important to notice the loss of pastures and meadows (-58%), according to the abandon of many zootecnical farms, and the loss of arboriculture (-49%), caused especially by the abandon of vineyards located on marginal fields. Moreover these aspects have been completed with the historical (end of 1800) and current land use.

A deep analysis of natural aspects, in terms of flora and fauna, has pointed out that the study area has 27 ha of biotopes, which are delimited and described.

Historical, agricultural and natural aspects have been mapped and used for the range delineation. Then each range has been evaluated applying parameters of landscape quality: i.e. presence of natural elements, percentage of meadows, presence of biological methods of cultivation, presence of services like holiday farms or selling of local products, and so on.

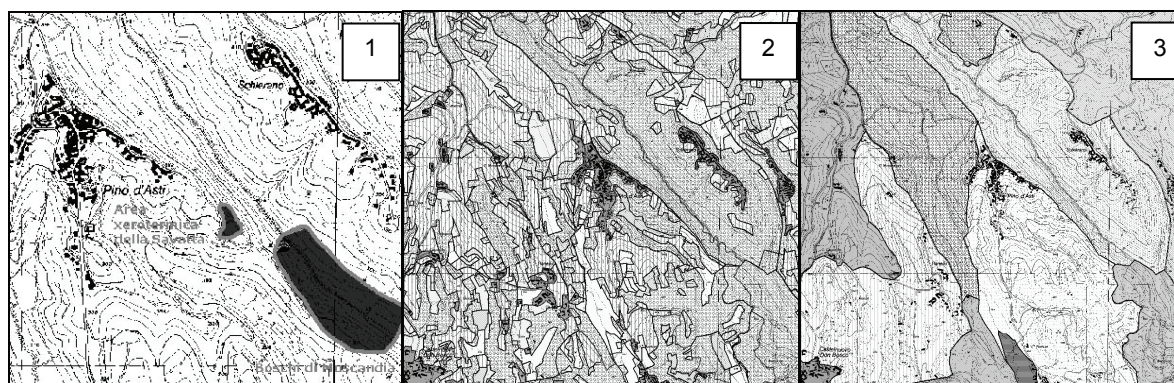


Figure 1. Example of thematic charts about the study area: 1 'Biotopes', 2 'Current land use', 3 'Ranges'.

### Strategies of governance

Landscape quality is closely related with farms and, in particular, with the presence of grapevine production. On the contrary, in the last twenty years EU rural funding policy induced the development of cultivation like maize and poplar, which are not proper for the pedologic and climatic conditions of the area and for landscape characteristics. Furthermore rural villages have no more utilities for inhabitants who are forced to leave the area and to migrate towards the nearby city of Turin.

In such a situation a correct strategy should establish a governance structure like an Ecomuseum. It could vouch for future organized actions on landscape in order to create greenways, to advertise local wines and gastronomy, to promote tourism, to set up and direct the sustainable development of the area on the whole.

### Aknowledgements

We have to thank all researchers involved in this project: Arch. Marco Bianchi, Dott. Giampaolo Bruno, Dott.ssa Marta Colangelo, Arch. Paolo Cornaglia, Dott. Franco Correggia, Dott. Paolo Debernardi, Prof. Vittorio Defabiani, Dott. Lucio Graziano, Prof.ssa Laura Palmucci, Prof. Amedeo Reyneri.

Thanks also to *Fondazione CRT* for financing.

## Future scenarios for the Great Barrier Reef catchment, Australia

### I. Bohnet

CSIRO Sustainable Ecosystems – Tropical Forest Research Centre, PO Box 780, Atherton  
4883, Queensland, Australia.  
e-mail: iris.bohnet@csiro.au

The Great Barrier Reef (GBR) catchment (Figure 1) is changing rapidly, driven by increased demand for housing, industrial development, infrastructure needs and intensifying agriculture. Loss of biodiversity and increased pollutant loads in waterways entering the GBR lagoon have been associated with these developments (Brodie *et al.*, 2003). To save the GBR from further degradation, the Australian and Queensland Governments developed the Reef Water Quality Protection Plan (Reef Plan) with the goal to halt and reverse the decline in water quality entering the GBR lagoon using an integrated natural resource management approach (Australian Government and Queensland Government, 2003).



Figure 1. Geographical location of the GBR catchment.

The wide range of uses and users of the GBR catchment and reef, uncertainty and lack of understanding of the complexity of the catchment to reef system, pose major challenges to planners, natural resource managers and policy makers responsible for the long-term future of the GBR catchment and the implementation of the Reef Plan.

Scenario planning is a method for thinking creatively about possible complex and uncertain futures (Peterson *et al.*, 2002). Scenario planning differs from other forms of planning such as trend projections, forecasts or predictions in that it ultimately helps to make more robust policy and planning decisions in situations of high uncertainty that are difficult to control. The central role of scenario planning, in contrast to other methods, is to consider a variety of futures that address key uncertainties in the system rather than to focus on the accurate prediction of a single outcome.

The use of scenario planning for futures analysis has increased since the late 1960s in response to the failure of strategic planning based on seeking “optimal” strategies for “the” future (Cork *et al.*, 2005). While these strategies have been successful in more controllable systems, they are not well-equipped to address the complexity and unpredictability of social-ecological systems like the GBR catchment. Scenarios are increasingly being developed to explore uncertainty related to social and environmental problems in Australia and worldwide, but to date no scenarios have been developed for the GBR catchment.

Besides developing future scenarios for the GBR catchment, this research also aims to fill an identified gap in the scenario literature, which relates to the use and usefulness of big picture scenarios for end-users. Based on the premise that end-user engagement in the scenario building process ascertains their views and expectations for the future of the GBR catchment and subsequently leads to plausible scenarios that are useful to them in the same way that wind tunnels are useful to aircraft designers, a scenario building process is required that includes main phases of end-user collaboration. Identification of key regional leaders and other potential end-users is therefore as crucial as engaging them to collaborate in the project.

The future scenarios explore what the GBR catchment may look like by 2050. The scenarios consider a variety of plausible futures depicted in a set of qualitative scenario storylines. They are based on different assumptions about key drivers of change and are being developed in collaboration with a broad cross-section of people from government, industry, natural resource management, other research providers, and key social, environmental and cultural sectors. Each scenario storyline features specific land use changes and discusses potential impacts on the environment, society and economy.

The scenarios are designed to stimulate strategic discussion about potential futures for the GBR catchment. They are of relevance to anybody interested in the GBR, but foremost to management agencies, policy-makers, industry groups and regional planners who will be able to test their strategies and plans across each of the “worlds” depicted in the scenarios.

## References

- Australian Government and Queensland Government, 2003.** *Reef water quality protection plan: For catchments adjacent to the Great Barrier Reef World Heritage Area.* Australian Government and Queensland Government. October 2003.
- Brodie, J.; McKergow, L.A.; Prosser, I.P.; Furnas, M.; Hughes A.O. & Hunter H. (2003).** *Sources of sediment and nutrient exports to the Great barrier Reef World Heritage Area.* Australian Centre for Marine and Tropical Freshwater.
- Cork S.; Delaney, K. & Salt, D. (2005).** *Futures thinking about landscapes, lifestyles and livelihoods in Australia.* Land and Water Australia and Delany & Associates.
- Peterson, G. D.; Cumming, G. S. & Carpenter, S. R. (2002).** Scenario Planning: a Tool for Conservation in an Uncertain World. *Conservation Biology* 17, 358-366.

**Modelling future land use changes in Europe: Applying the MOLAND urban and regional development model in Algarve, Portugal**

**L.O. Petrov, C. Lavalle, J.I. Barredo, V. Sagris, M. Kasanko**

European Commission – DG Joint Research Centre,  
Institute for Environment and Sustainability,  
Land Management and Natural Hazards Unit, Ispra 21020, Italy  
E-mail: laura.petrov@jrc.it

European land use faces large modifications and conversions as consequence of modern human activities. New landscapes replace the traditional ones gradually or sometimes abruptly (Eetvelde and Antrop, 2004). The lack or relaxed application of spatial policies to control urban sprawl causes an important loss of original qualities of landscape, economy, and social structure in many parts of Europe.

Land use models are used as a tool to combine different aspects of the complex land use system and enable researchers to study the dynamics of this system (Overmars *et al.*, 2005). Furthermore, land use models are applied to examine future alternative land use scenarios and inform policy makers before irreversible changes are made (Brown *et al.*, 2004).

The MOLAND model for urban and regional scenario simulation (Barredo *et al.*, 2004) is used to evaluate spatial planning for sustainable urban and regional development. The model predicts the likely future development of land use, for each year usually over the next ten to twenty-five years. MOLAND model is operating at both the micro-and macro-geographical levels. At the macro level are integrated several component sub-models, representing the natural, social, and economic sub-systems typifying the area studied. These are all linked to each other in a network of mutual reciprocal influence. At the micro level, a cellular automata-based model determine the fate of individual parcels of land based on their individual institutional and environmental characteristics as well as on the type of activities in their neighborhoods. The approach permits the straightforward integration of detailed physical, environmental, institutional variables, and the particulars of the transportation infrastructure.

For the last 30 years, Portugal is re-shaped by economic and political restructuring, which determined land use modifications, environmental pressures, changes in cultural authenticity, etc. and as well as a re-scale of power-relations between local and global development stakeholders (Roca and Maria de Nazare Oliveira-Roca, 2006).

After the revolution in 1974, a “democratisation of tourism” occurred and profoundly changes of land use pattern throughout the country and especially in Algarve. The population has moved from the inland to the shoreline and registers an annual increase of 0.5% during the eighties. Nowadays more than 65% of the population is settled in the major urban areas at the coast, as Albufeira, Faro and Olhao. These municipalities show an increase of population between 20% and 60% from 1960 to 1991 (Final Report, Murbandy, “Change Algarve”, 1999). This increase is rather due to internal migration than to natural demographic growth.

The tourism is another important driving force in Algarve region, which contributed equally to the increase of infrastructure construction (residential areas, hotels, marinas transport, waste treatment facilities etc), a larger use of space per inhabitant due to the demand for shopping and recreation facilities (golf courses, water sports, thematic parks, beach access and parking, etc) and services sector.

The major pressure of the unorganized urban spread is the shoreline and the western part of Algarve where the urban areas are very small and disperse determining alterations to landscape structure.

From 1986 to 2004, the forest and urban land use classes are quite stable. Meanwhile, the grassland is slightly decreasing. Instead the arable land and fallow land use classes have been decreasing significantly since the 1997s year (Petrov and Lavallo, 2006).

By using the MOLAND model, future scenario simulation were produced for the seashore and the whole area of Algarve Province using CORINE land use datasets covering a twenty-year period (2000-2020). For the seashore area most affected land use classes were arable lands, which decreased by approximately 12%. For the whole Algarve Province, it is foreseeable that there will be an important increase in built-up areas: continuous urban fabric by 1.2 km<sup>2</sup>, discontinuous urban fabric by 21.76 km<sup>2</sup> and industrial and commercial areas by 6.9 km<sup>2</sup>. However, the general form of the developed areas in Algarve based on the initial transport network and land use is still not drastically changed.

In the next phase, the alternative scenarios are produced by modifying the input data in MOLAND model and elaborating complex scenarios of land use evolution. The scenarios are normally driven by "storylines" which in turn should reflect expected or supposed socio-economic trends.

The MOLAND modelling framework developed at the JRC/IES will permit to support European policies of sustainable development and assist in deriving current strategies of rural-urban relationship and urban demands/sprawl.

#### References

- Barredo, J.I.; Demicheli, L; Lavallo, C; Kasanko, M. & McCormick, N. (2004)** Modelling future urban scenarios in developing countries: an application case study in Lagos, Nigeria, *Environment and Planning B: Planning and Design* **32**: 65-84.
- Brown, D. G; Walker, R; Manson, S. & Seto, K. (2004)** Modeling land use and land cover change. In: G., Gutman, B.L., Turner, *Land Change Science: Observing, Monitoring and Understanding Trajectories of Change on the Earth's Surface*, Kluwer, Dordrecht, 1-17.
- Eetvelde, V.v. & Antrop, M. (2004)** Analyzing structural and functional changes of traditional landscapes-two examples from Southern France. *Landscape Urban Planning* **67**: 79-95.
- MURBANDY (1999)** Final Report, Murbandy: Change Algarve, Contract Nr. 14644-1998-12, Centro Nacional de Informacao Geografica, Portugal, CNIG.
- Overmars, K.P; Verburg, P.H. & Veldkamp, T.A. (2006)** Comparison of a deductive and inductive approach to specify land suitability in a spatially explicit land use model, *Land Use Policy* (in press).
- Petrov, L.O. & Lavallo, C. (2006)** Modelling future land use changes in Europe. Preparation for the case study Algarve region, Portugal, European Communities, EUR 22559 EN.
- Roca, Z. & Roca-Oliveira, Maria de Nazare (2006)** Affirmation of territorial identity: A development policy issue, *Land Use Policy*, (in press).

**Linking landscape characteristics and socio-economic profiles for sustainable impact assessment at the regional level – the Spatial Regional Reference Framework (SRRF)**

**C. Renetzeder<sup>1</sup>; M. van Eupen<sup>2</sup>, C.A. Mücher<sup>2</sup>; T. Wrбка<sup>1</sup>**

<sup>1</sup> University of Vienna, Department of Conservation Biology, Vegetation and Landscape Ecology; University of Vienna; Althanstraße 14, 1090 Vienna, Austria.  
e-mail: christa.renetzeder@univie.ac.at

<sup>2</sup> Alterra, Wageningen UR, PO Box 47, 6700 Wageningen, AA, The Netherlands.

## **Introduction**

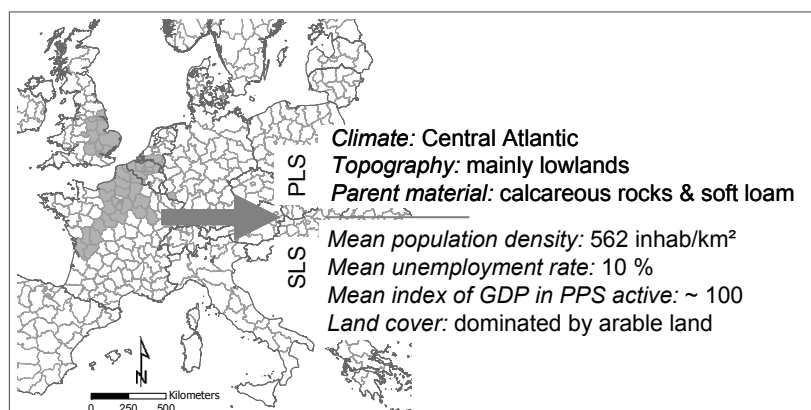
Since the late 1980's, sustainability has become a central term in EU planning and policy. In general, three main policy dimensions are associated with sustainable development: economical, environmental and social. In order to assess the human impact on these sustainability dimensions, indicators and guidelines have been developed as basis for in-depth analysis of sustainability impact assessment (European Commission, 2005). Within the SENSOR-project funded by the European Commission's 6<sup>th</sup> framework programme, objectives are explicitly addressing the question of identifying differences in regional contexts that are relevant for assessing the effects of current trends and of European policy scenarios on regional multi-functional land use objectives. The underlying rationale for conducting a more in-depth regional characterisation is to acknowledge the high degree of cultural and natural diversity existing between European regions (Wascher, 2005; Mücher *et al.*, 2003). Hence it is necessary to examine whether, where and to which degree the expected European trends and changes are going to impact on regional sustainability issues. Stratifying the land into relatively homogeneous regions and integrating biophysical and socio-economic aspects gives a Spatial Regional Reference Framework (SRRF) appropriate to assess the impacts on sustainability issues. The SRRF will enable the identification of European regions which are to a certain extent similar in terms of their environmental, social and economic situations.

## **Methods**

In order to achieve a high level of data compatibility between the different assessments, it was decided to develop a selective composition of European NUTS 2 and 3 administrative units on the basis of the IRENA methodology. These so-called "NUTS-X regions" were used as the interface between socio-economic data on administrative basis and biophysical data on grid and/or vector level. To create the second level of the SRRF, the approximately 700 NUTS-X regions were aggregated into about 30 homogeneous SRRF regions by clustering. The result of this statistical procedure is meant to provide the basis for environmental and socio-economic profiling by identifying relevant and important landscape variables. Following the hierarchical concept of "primary – secondary – tertiary landscape structure (PLS – SLS – TLS)" (O'Neill *et al.*, 1986, Ružicka and Miklos, 1990), formulation of the SRRF regions has been done stepwise. Bio-physical European data (PLS) derived from LANMAP2 (Mücher, 2005) and for the SLS, socio-economic (EUROSTAT database) together with land cover data (LANMAP2) were clustered separately. This offers more transparency in interpreting the results and significant landscape variables. Combining these two cluster-sets to form more or less homogenous clusters within Europe was the major challenge. Aggregation of the two cluster-series with a certain PLS/SLS combination was carried out by building a matrix ordering the clusters according to the distance of their cluster centres. The ones having a low distance to each other were ordered within the neighbourhood, the ones which are more apart were arranged distantly. In this matrix, columns and/or lines which represent a certain resemblance can be joined to one SRRF-cluster.

## Results and discussion

Concerning PLS, 25 clusters could be identified. Mainly climate variables play a role for distinguishing on the broad scale. However, topography and parent material are important for classifying within regions. On basis of the SLS input data, the NUTS-X regions were assigned to 20 clusters. In this case, land cover is mostly responsible for creating clusters, other socio-economic variables play a less important role. The final aggregation resulted in 27 SRRF regions taking into account statistical relations, pre-defined rules, socio-economic and spatial coherency in order to provide a transparent and applicable framework for policy makers. In Figure 1, an example of one resulting SRRF region is illustrated together with the variables which have been mostly responsible for aggregating these NUTS-X regions to the same cluster. Integrating both environmental and socio-economic parameters into a spatial stratification of land must be considered as an innovative concept of sustainability assessment. Especially the use of administrative units as an interface between these domains is one of the crucial points. On the one hand, NUTS-X shows several limitations such as different size, heterogeneity and different composition of land cover classes, but on the other hand, European projects and administrations are almost solely using these units.



**Figure 1.** Spatial distribution of NUTS-X regions belonging to SRRF cluster number 18 with its most characterising parameters.

## References

- European Commission (2005)** Impact assessment guidelines. *SEC(2005) 791*, Brussels.
- Mücher, C.A.; Bunce, R.G.H.; Jongman, R.H.G.; Klijn, J.A.; Koomen, A.; Metzger, M.J. & Wascher, D.M. (2003)** *Identification and Characterisation of Environments and Landscapes in Europe*. Alterra rapport 832, Wageningen.
- Mücher, C.A. (2005)** Update of the European Landscape Typology and Map – a biophysical approximation. Wageningen.
- O'Neill, R.V.; Allen, T.F.H.; De Angelis, D.L. & Waide, J.B. (1986)** *A hierarchical concept of ecosystems*. Princeton University Press, Princeton New Jersey USA.
- Ružicka, M. & Miklos, L. (1990)** Basic premises and methods in landscape ecology planning and optimization. In: I.S. Zonneveld & R.T.T. Forman (Eds). *Changing landscape, an ecological perspective*. Springer, Berlin Heidelberg New York, pp. 233-260.
- Wascher, D.M. (ed) (2005)** *European Landscape Character Areas – Typologies, Cartography and Indicators for the Assessment of Sustainable Landscapes*. Final Project Report as deliverable from the EU's Accompanying Measure project European Landscape Character Assessment Initiative (ELCAI), funded under the 5th Framework Programme on Energy, Environment and Sustainable Development (4.2.2). Alterra rapport 1254, Wageningen.



## Evaluating the impact of integrated catchment management interventions on provision of ecosystem services using GIS

F. Karanja<sup>1,2,3</sup>, N. Reid<sup>1,3</sup>, O. Cacho<sup>2</sup>, L. Kumar<sup>1</sup>

<sup>1</sup> Ecosystem Management, University of New England, Armidale, NSW, 2351 Australia.  
e-mail: fkaranja@une.edu.au

<sup>2</sup> School of Economics, University of New England, Armidale, NSW 2351 Australia

<sup>3</sup> Cotton Catchment Communities CRC, Australia

### Introduction

Ecosystems provide ecological services on which humans depend (Daily, 1997), such as climate stabilisation, carbon storage, protection of hydrological function and biodiversity conservation. International awareness of ecosystem goods and services has been raised by the Millennium Ecosystem Assessment (2005), but there has been little work on incorporating biophysical relationships into economic frameworks to guide implementation of practical activities to address natural resource management (NRM) issues.

The Border Rivers Gwydir Catchment Management Authority (BRGCMA) in New South Wales, Australia, has recently begun investing in natural resource management within its jurisdiction. However, it lacks spatially explicit, bio-economic tools for prioritising expenditure on incentives and extension for land use change, revegetation, vegetation management, riparian protection, erosion, and dryland salinity control and mitigation. Available resources, financial and human, are insufficient to address all these NRM issues instantaneously throughout both catchments, so prioritisation of interventions is necessary. Investments could be guided by identifying areas affected by multiple NRM issues, and overlapping this with areas where successful interventions could provide multiple ecosystem service benefits. We are using an ecosystem services approach to address multiple natural resource management issues in the Gwydir catchment, through biophysical modelling using a Geographical Information System (GIS) and interpreting the outcomes in terms of ecosystem service provision. The study focuses on four major issues: soil erosion, riparian rehabilitation, dryland salinity and native revegetation. GIS was used to determine the current extent of these four NRM issues in the catchment and the impact of proposed land-use changes on water yield, carbon sequestration and biodiversity. Using spatial data, we present our scenario modelling approach, illustrating the interactions between management interventions, biophysical outcomes, and ecosystem service provision from different land uses.

**Salinity:** some 8922 ha in the Gwydir catchment is currently affected by salinity. The Land Use Options Simulator (LUOS) software (Peterson & Herron, 2004) was employed to model reforestation to mitigate salinity. Plantation tree growth was modelled (ABARE & BRS, 2001) to estimate the mean annual increment and potential carbon sequestration benefits of planted forests in the Gwydir catchment. We used Zhang's *et al.* (2001) model to estimate the impact of reforestation of different parts of the catchment on water yield. Salinity mitigation through reforestation was assumed to enhance three ecosystem services: carbon sequestration, water quality and habitat provision for biodiversity. Spatially explicit modelling suggested that reforesting salinity outbreak areas would sequester 40 000-50 000 t of carbon annually and reforesting salinity outbreak areas with an additional 75 m surrounding buffer would sequester between 1.7 and 2.1 million t of carbon annually. Reforestation was estimated to reduce end of valley salt-loads by 0.9% (1387 t annually), and to provide an additional 8922 ha of wildlife habitat. The disbenefits were a reduction in riverine water yield from the affected subcatchments by 0.5% (5620 ML p.a.) and lost agricultural production due to the conversion of crops and pasture to trees and the loss of riverine flows available for irrigation (an annual loss of 1658 ha of crops and 8162 ha of pasture throughout the catchment).

**Erosion:** 282 000 ha of the catchment is affected by rill and sheet erosion, more than half of which is under cropping, and a quarter under pasture. About 15% of areas suffering these forms of erosion are wooded. Land uses and land areas affected by rill erosion were estimated to be contributing to soil loss of between 740 000 and over 1 million t/year. The estimated soil loss through sheet erosion was 1-2 million t/year. Erosion interventions can be designed to prevent soil loss (between 1.75 - 3 million t/year), with additional benefits such as reduced turbidity and reduced siltation in aquatic ecosystems.

**Riparian zone degradation:** Unvegetated riparian zones extend for a total length of 4222 km throughout the catchment, covering 21 191 ha (width of riparian zone, 30 m). Rivers affected by streambank erosion extend 541 km, with most eroding streambanks also being unvegetated. Reforestation of unvegetated riparian zones would generate the following ecosystem services: carbon sequestration (84 000 to 103 000 t of carbon, annually), habitat provision for biodiversity (21 191 ha), and filtration of nutrients from runoff from adjacent farms and paddocks. The disbenefits include reduced water yield (a decline of 25 GL in the annual end-of-valley flow) and lost agricultural production (losses of 5291 ha of crops and 14 726 ha of pastures to riparian reforestation).

**Native revegetation:** land capability assessment suggests there is a deficit of 376 000 ha of tree cover in the Gwydir catchment, due to past overclearing. Reforestation should endeavour to create key wildlife habitats and corridors, and target land capability classes that have less tree cover than recommended (Donaldson, 2002). Reforesting areas identified as key wildlife habitat and corridors would sequester 375 000-460 000 t of carbon annually. Reforesting the area of over-cleared land would sequester between 1.2 and 1.5 million t of carbon annually. This reforestation would impact negatively on catchment water yield, reducing riverine flows by 500 GL annually. Most of the land in the catchment is under agricultural production and revegetation would require such land be retired for environmental outcomes. The annual opportunity cost due to foregone agricultural production would equate to 45 829 ha and 248 541 ha currently under crops and pasture, respectively.

Dealing with land degradation such as dryland salinity and erosion and revegetating overcleared land in the Gwydir catchment will result in both benefits and disbenefits in terms of the flow of ecosystem services to different stakeholders. Integrated land use planning of proposed NRM interventions highlights these ecosystem service tradeoffs. Although we restricted our modelling to just four ecosystem services in this study, the proposed revegetation interventions would influence many other ecosystem services, such as pollination services, natural pest control, recreation and nutrient cycling.

## References

- ABARE & BRS (2001)** *An assessment of the potential for forest plantations in New South Wales, ABARE and BRS report to the New South Wales Plantation Taskforce Steering Committee on plantation capability and suitability.* Bureau of Rural Sciences, Canberra.
- Daily, G.C., ed. (1997)** *Nature's services: societal dependence on natural ecosystems.* Island Press, Washington, D.C.
- Donaldson, S. (2002)** *Gwydir River Catchment: Report on the land degradation and proposals for integrated management.* Department of Land and Water Conservation, Gunnedah.
- Millennium Ecosystem Assessment (2005)** *Ecosystems and human well-being: wetlands and water synthesis* World Resources Institute, Washington, DC.
- Peterson, P. & Herron, N. (2004)** *Land use options simulator (LUOS): Use guide* Department of Infrastructure, Planning and Natural Resources, Sydney.
- Zhang, L., Dawes, W.R., & Walker, G.R. (2001)** Response of mean annual evapotranspiration to vegetation changes at catchment scale. *Water Resources Research*, **37**: 701-708

## 9.6 Posters

### **Management of the landscape changes and strategy of sustainable development of the Biosphere Reserve East Carpathian**

**L. Halada, Z. Izakovičová, J. Oszányi, P. Bezák, M. Boltžiar, M. Moyzeová, F. Petrovič**

Institute of Landscape Ecology, Slovak Academy of Sciences, Stefanikova 3, 814 99  
Bratislava SK,  
e-mail: lubos.halada@savba.sk

The contribution task is to present partial results of the solution of the BIOSCENE project solved within the 5<sup>th</sup> framework program of EU. Its aim was to evaluate influences of the future changes in agriculture on the biodiversity according to the general perception of this territory by the stakeholders and guarantying of permanently sustainable development of the territory. The poster will be presents a case study of the solution BIOSCENE project from the study area in the Slovak republic.

The poster is aimed at the presentation of a example of the management of landcape changes on the study area *Biosphere Reserve East Carpathian*. Its aim was, based on analysis and evaluation of natural and socio-economic conditions of the region, their changes and current state of their utilisation, to elaborate basic strategic objectives of development of the territory. They should ensure the basic positive changes of the region in the line of principles and criteria of sustainable development harmonising development of socio-economic activities with the potential of the region.

The study area is a marginal region in the framework of Slovakia and is characterized by unfavorable socioeconomic conditions, with little developed economical basis, which is focused on development of silviculture and mountain agriculture. The target territory of 21,828 ha consists of 11 existing villages and 7 villages having been evacuated in consequence of construction of the Starina water reservoir. The total number of inhabitants living in the territory is 2,957.

The part of the solution of the project creates elaboration of the three scenarios and their evaluation by stakeholders. The stakeholder evaluated three proposed scenarios from the viewpoint of their influence on the future development of the territory. The first scenario – preservation of the present trends in agriculture, second scenario – liberalization in agriculture and the third scenario – managed protection and support of biodiversity. Opinions of the stakeholders about individual scenarios were influenced by more facts. By the general historical development, socioeconomic changes in the recent period, structure of stakeholders and in many cases by feelings of encumbrance. Opinions of the stakeholders where utilized in the elaboration of the strategy of sustainable development of the study area.

Most stakeholders are agreeing with the fact that sustainable development is to be understood as a complex, in four basic dimensions – environmental, social, economic and institutional. The base of the sustainable development is creation of an economical base providing certain quality of the population life and providing of such social development, which is in harmony with biodiversity protection and protection of nature resources. The opinions of individual stakeholder unambiguously revealed that it is impossible, in the framework of the scenarios and at providing of sustainable development, to separate the human kind from the nature, the socioeconomical development from the territory potential.

## Landscape Ecological Planning Process for Watersheds in Taiwan

C-Y. Chang<sup>1</sup>, W-M. Huang<sup>2</sup>, W-C. Su<sup>1</sup>, Y-H. Lin<sup>1</sup>, Y-T. Chang<sup>1</sup>

<sup>1</sup>Landscape Architecture Division, Department of Horticulture, National Taiwan University,  
138 Keelung Rd. 10673 Taipei, Taiwan

e-mail: cycmail@ntu.edu.tw

<sup>2</sup>Landscape Architecture Division, Department of Horticulture, National Chung-Hsing  
University, Taichung, Taiwan

### Introduction

We proposed a landscape ecological planning process to manage watersheds in rural Taiwan. This process has been successfully used to evaluate proposed land use management plans based on the scenario of the plan. A landscape ecological geographic information system was built as the basic working platform; this system included information on the wildlife species, agricultural use, traffic, and visitors. Within this platform, two different hierarchies were constructed to represent a holistic landscape ecological base. Using a coarse hierarchy to describe the land use conditions throughout the watershed, we proposed the evaluation and planning at this level as well as the selection of the critical spot for detailed evaluation and planning work, followed by a refined hierarchy to evaluate the selected spots and create detailed plans of these areas.

### Method and material

Watersheds in the mountain area of Taiwan were selected for the test site. The area had been affected by the 921 ChiChi earthquake and subsequent typhoons. The proposed system was expected to improve the soil and water conservation condition as well as the land use plan for the ecological, safety, recreational, and landscape concerns.

### Analysis

The coarse and refined landscape ecology were digitized using eCognition 5.0; Fragstats 3.3 were adopted to provide the landscape ecological information of different scenarios.

### Result

The refined system, the complexity of the system, landscape planner, and landowners were required to make decisions during the plan. Using this system results in more effective communication and investigation. Finally, the practice of the system and limitations were suggested for future applications.

### References

- Ahern, J. (1996) Greenways as a Planning Strategy. In: Fabos, J., Ahern, J. (Eds.), *Greenways: The Beginning of an International Movement*. Elsevier: Amsterdam.
- Farina, A. (1998) *Principles and Methods in Landscape Ecology*. Chapman and Hall: London.
- Forman, R. T. T. (1993) Some General Principles of Landscape and Regional Ecology. *Landscape Ecology*. **10**: 133-142.
- Forman, R. T. T. (1995) *Land Mosaics*. Cambridge University Press: Cambridge.
- Smith, D. S. & Hellmund P. C. (1993) *Ecology of Greenways*. University of Minnesota Press: Minneapolis.
- Steinitz, C. (Ed.) (1996) *Biodiversity and Landscape Planning: Alternative Futures for the Region of Camp Pendleton, California*. Harvard University: Cambridge.
- Swetnam, R., Ragou, P., Firbank, L., Hinsley, S. & Bellamy, P. (1998) Applying ecological models to altered landscapes: scenario testing with GIS. *Landscape Urban Planning* **41**: 3-18.

## Numerical simulations for future landscape evolutions: a patchy agricultural mosaic

C. Gaucherel, T. Houet<sup>2</sup>

<sup>1</sup> INRA, UMR AMAP, Montpellier, F-34000 France.  
e-mail: gaucherel@cirad.fr

<sup>2</sup> CNRS, UMR LETG, Rennes, F-35000 France.

Modelling land use and land cover change is essential to understand the evolution of landscape pattern dynamics as well as to assess environmental impacts on ecological processes such as water quality degradation or fauna population dynamics. There are several ways of modelling landscape dynamics, in particular with process-based models implementing specific mechanistic rules which change the mosaic (Costanza and Voinov, 2004). Today, landscape modellers are facing various limits such as modelling patchy landscapes instead of continuous pixel-based mosaics, applying complex socio-economic rules, implementing evolution of composition (land cover) and/or configuration (spatial arrangement), managing multiple scales, etc. Our objective in this work was to explicitly model dynamic patchy landscapes in order to quantify and predict the landscape evolution under various combinations of guiding rules (called scenarios). For this purpose, we developed a domain-specific language (named "L1"; Gaucherel *et al.*, 2006), which we applied to a French agricultural landscape subjected to complex human decisions. Our practical goal was to quantitatively predict the agricultural land use intensification expected in 2020 and to evaluate changes that can occur at a local scale.

The study site was located in Brittany (Western France) and exhibited a dense hedgerow network ( $12 \text{ m}\cdot\text{ha}^{-1}$ ), with small fields (average size of 1.4 ha), associated with a dense wetlands network (220 ha). This intensive agricultural area was mainly devoted to dairy production which has caused a high water pollution in the past 30 years, reaching up to a nitrate concentration of  $39 \text{ mg}\cdot\text{l}^{-1}$  in 2003. In order to quantify and to localise future land cover and landscape changes, we built several indicators based on the presence of maize fields (responsible for water degradation by excess fertilization) and on hedgerow density (reducing impact on water quality). Several scenarios were run from 1998 until 2020, following the farm enlargement trends observed today. Farm and field expansion assumptions were built using practical knowledge of a local agricultural agent and of local farmers.

Results showed an increase of average field size up to 2 ha and a decrease of hedgerow density down to  $11 \text{ m}\cdot\text{ha}^{-1}$ , that could have dramatic consequences on water and nutrient fluxes (Houet and Gaucherel, 2007). Land cover changes were very complex and showed a significant increase of maize occurrence with important changes (positive or negative depending on the scenario) in location of maize fields more than 100 m away from the streams. Such simulations highlight the ability of landscape modelling to handle future landscape changes and suggest developing them to study environmental issues for which complex processes occur at very fine scales.

### References

- Costanza, R. & Voinov, A. (2004).** *Landscape simulation modelling. A spatially explicit, dynamic approach.* Springer-Verlag: New York, Inc.
- Gaucherel, C.; Giboire, N.; Viaud, V.; Houet, T.; Baudry, J. & Burel, F. (2006).** A domain specific language for patchy landscape modelling: the Brittany agricultural mosaic as a case study. *Ecological Modelling* **194**: 233-243.
- Houet, T. & Gaucherel, C. (2007).** Simulation dynamique et spatialement explicite d'un paysage agricole bocager: validation sur un petit bassin versant breton sur la période 1981-1998. *Revue Internationale de Géomatique*, in press.

## Preparation of EIA Guideline for Large Recreational Areas Projects

M. Akbarzadeh<sup>1</sup>, S. Babaei Kafaki<sup>2</sup>

<sup>1</sup> Islamic Azad University, Miyaneh Branch, P.O. Box: 53135/1159, Miyaneh, East Azerbaijan, Iran.

e-mail: mandegarana20@yahoo.com

<sup>2</sup> Islamic Azad University, Science & Research Branch, Post Code: 1477893855, Tehran, Iran.

### Introduction

Regarding the ever increasing use of recreation areas and man's innate need to such places as well as peoples interests in ecotourism, its required to notice recreation areas and expand existing facilities. However, as expanding recreation may cause environmental adverse impacts, it is necessary to have environmental impact assessment report.

### How we can prepare a general model

For each region we have a different model. In mountainous region (in Iran) and with normal population density, after identifying ecological unites on the topographic map by overlying patches, corridors, matrix and network, landscape functions data we can calculate a best area for recreation. In general model we must have minimum points and minimum condition of area for recreation such as wild life. In our area the first plan must have 51% point of quantity, and have minimum quality of landscape.

Preparing a general model to assess large natural recreation areas in our country should carried out by paying close attention to all respects of all natural recreation areas. In addition, the plans of all activities concerning recreation and environment should be mentioned.

### Conclusion

In order to execute the model in this project, Payam Park, was chosen as an example area. The case carried out gradually. The environmental impact assessment of different activities in Payam Park shows that the most adverse impacts of construction phase is related to the destruction of environment and vegetative cover, air pollution, sound pollution and energy consumption. The most adverse impacts of operation phase are destruction of environment and vegetative cover by visitors, energy consumption and sound pollution related to some activities and water pollution. Apart from some activities that cannot be carried out in practise, there are fewer adverse than beneficial impacts. Some assessments and experiments of land use planning are proposed before environmental impact assessment in order to decrease adverse impacts.

### References

Makhdum, M.F. (2004) *Land use Management*. Tehran University Press, Tehran, Iran. Tenhunen, J.D; Lenz, R. & Hantschel, R. (2001) *Ecosystem Approach to landscape Management in central Europe*. Springer publication, Germany.

**The study of ecotonisation of landscape space and current priorities in modern landscape ecology**

**T.V. Bobra, A.I. Lychak**

Taurida National Vernadsky University, Ukraine, Autonomous Republic Crimea, Simferopol,  
Ukraine  
e-mail: bobra@tnu.crimea.ua

The modern stage of development of landscapes is characterized by dominance of human activity, reduction in the extent of natural systems in the spatial structure of the land surface and general ecotonisation.

The destruction of natural (normal) spatially-temporal structures in the landscape sphere, n conforms to the law of spatial differentiation caused by anthropogenic factors. The expansion of areas of different sorts of geocotones determines the process of ecotonisation of landscape space (geo-ecotonisation). The main part of this process consists of reduction of natural biological and landscape variation, the growth of entropy and the lowering of equilibrium and stability of landscape the sphere and its component parts.

Within the limits of territorial units of land-tenure a quantitative index - coefficient of anthropogenic geo-ecotonisation was expected in Crimea (within the operating units of our analysis). The database that was constructed and the use of Arc View Spatial Analysis possibilities allowed spatial interpolation to be carried out with the use of a spline-function. Subsequent extrapolation of data, enabled the visualization of results and gets the degree of anthropogenic geo-ecotonisation territory of Crimea to be determined. To a greater degree the process of anthropogenic geo-ecotonisation (coefficient - 0.05 - 0.2) took place in the central part of the lowlands of the Crimea, Prisivashya is related to intensive agricultural use, and was influenced by the opening of the Severo-Krimskiy channel. The foot-hills are where the greater part of large cities is concentrated but with intensive agriculture in the river valleys reach from the southern part of Sevastopol as far as Sudak.

The landscape sphere is exposed to considerable anthropogenic changes, which then acquires a range of new qualities and properties - it is the objective reason for the necessity of change in the theoretical and methodological basis of landscape ecology. This involves the character of research tasks and the system of approaches and methods (e.g. the use of GIS-technologies, materials of the remote sensing of Earth). Landscape ecotones (geo-ecotones) and the process of ecotonisation of the landscape space (geospatium) at different spatial levels, becomes the main objectives of study in modern landscape ecology.

Geo-ecotones differentiate the genesis, scale, growth, structure, and composition of biotic components. Geo-ecotones in landscape space determine the hierarchical structure of communications and co-operations between geo-systems, which in turn have an influence on the direction and properties of lateral materially-energetic and informative streams.

The analysis of the structure, functioning and roles of geo-ecotones in the organization of landscape space, are especially useful for making decisions about tasks of territorial planning, landscape protection and the maintenance of biodiversity. They are also useful for the organization of monitoring and other tasks relating to the environment.

## **Perspectives of the landscape research with artworks from the start of the common area**

**R-U. Syrbe**

Saxon Academy of Sciences, Neustädter Markt 19, D-01097 Dresden, Germany.  
e-mail: syrbe@ag-naturhaushalt.de

### **Introduction**

It is generally known that there exist many different views about landscape, suggesting that the concept of landscape is a matter of opinion. The question therefore arises if landscape science is also only subjective and which aspects exist and how they can be defined. This poster selects different landscape perspectives beyond ecological and even scientific perceptions and tries to establish essential differences and possible similarities. In doing so, relevant artworks from the start of the common area are used to show the aspects of landscape painters from the start of the Common Era.

### **Strategy**

Beginning from meta-scientific basics, several positions and associated core statements are summarised to establish if there are differences and what they are based on. A first table confronts indisputable theorems of landscape development. Critical rationalism and constructivism are then compared. Landscape aesthetics and scenery are mentioned as one of the oldest basics. Three artistic approaches are discriminated. Landscape perception integrates material and mental factors. Beauty and distinctiveness also assume important aspects.

Some classical and new approaches are confronted, e.g. Forman & Goudrun (1986), including system, theory and humanities showing who claims different positions. A gap occurs unmistakably between the theorems of natural science and humanities dealing with region and space.

The main problems in overcoming the differences mentioned above, are emphasized in part three. Boundaries and natural units are highlighted as points of difference. Objections and hindrances for the cooperation between disciplines are named, for example, misunderstandings and inconsistency in terms.

The poster attempts to draw a consensus because integrated theoretical approaches are rare but present. Some methodological concepts and interfaces can be found. Finally, a theoretical overview is given. Aims for future landscape research are the creation of individual problem solution expertise, designed to improve human-nature relationships, and to contribute linking concepts.

### **Resume**

Landscape research must open itself to a range of views, not only involving natural sciences. There are different perspectives both inside the natural sciences and the humanities. Many differences are epistemologically and theoretically based. Therefore, it is hard to overcome the gaps that have developed. A consensus is possible but achievable only step by step.

### **References**

**Forman, R.T.T. & Godron, M. (1986)** Landscape Ecology. Johan Wiley & Son. New York, USA.



**14 symposia in the Slovak Republic – 40 years of international collaboration: 1967 – 2007**

**M. Kozová<sup>1</sup>, T. Hrnčiarová<sup>2</sup>, and M. Ružička<sup>3</sup>**

<sup>1/</sup> Comenius University in Bratislava, Faculty of Natural Sciences, Mlynská dol. B-2, 842 15 Bratislava, Slovak Republic, e-mail: kozova@fns.uniba.sk

<sup>2/</sup> Institute of Landscape Ecology of the Slovak Academy of Sciences, Štefánikova 3, P. O. Box 254, 814 99 Bratislava, Slovak Republic, <sup>3/</sup> Constantine the Philosopher University in Nitra, Faculty of Natural Sciences, Trieda A. Hlinku 1, 949 74 Nitra, Slovak Republic,

The first ideas for setting up an international organisation for communication and co-operation in the field of landscape ecology were conceived during the International Symposia on Problems of Landscape Ecological Research. These symposia have been organised in former Czechoslovakia (and later since 1993 in the Slovak Republic) triennially by professor M. Ružička and his team from the Slovak Academy of Sciences since 1967. Especially until 1989, these symposia played an important role at the enhancement of international contacts and acted as a bridge between the East and the West.

Intensive preparation of IALE foundation started during the International Congress “Perspectives in Landscape Ecology” held in April 1981 in Veldhoven (the Netherlands). But the birthplace of IALE is Piešťany (in former Czechoslovakia), on October 29<sup>th</sup> 1982. IALE was founded within the 6<sup>th</sup> Symposium as an honour to the Czechoslovak science and research. In 1984, at the first IALE seminar in Roskilde, the EC (Executive Committee) of IALE

- 7<sup>th</sup> Symposium: Topical Problems of Landscape Ecological Research and Planning (1985, Pezinok) – the 2<sup>nd</sup> meeting of the IALE General Assembly was held.
- 8<sup>th</sup> Symposium: Spatial and Functional Relationships in Landscape Ecology (1988, Zemplínska Šírava) – a short meeting between the old and the new EC and the General Assembly of IALE were held as well as the “Temporary Council” was established.
- 10<sup>th</sup> Symposium: Present State and New Trends in Landscape Ecology (1994, Smolenice) – reflected results of the World Summit in Rio (1992). EC IALE expressed its gratitude to L. Miklós (Slovakia) for his contribution including landscape ecological issues into Agenda 21.
- 11<sup>th</sup> Symposium: System Approaches in the Landscape Research (1997, Nitra) – Conference of IALE Working Group “Landscape System Analysis and Environ. Management” (chairman: A. Richling, Poland) was held.
- 12<sup>th</sup> Symposium: Protected Areas and Landscape Ecological Research (2000, Stará Lesná) – the meeting of IALE working group “Landscape Analysis in Environ. Management” and a preparatory meeting of the Slovak IALE region were held.
- Jubilee Slovak conference in occasion of the 20<sup>th</sup> anniversary of IALE establishment was held at the same place where IALE was established (October 2002, Piešťany).
- 13<sup>th</sup> Symposium: Landscape Ecology – an International Tool in Environ. Issues (2003, Mojmírovce) – a working meeting of the Slovak IALE region was held. Special Suppl. of Ecology (Bratislava), 2/2003, representing contribution of Slovak and Czech landscape ecologists to the 6<sup>th</sup> World Congress IALE (Darwin, Australia, 2003) was distributed.
- 14<sup>th</sup> Symposium: Implementation of Landscape Ecology (2006, Stará Lesná) – the European IALE working meeting was organised chaired by Bob Bunce, president of IALE.

More information is in the new monograph: Landscape Ecology in the Slovak Republic, IALE-SK, Ministry of the Environment SR, 2007. See you again on the 15<sup>th</sup> Symposium in 2009.

**Proposing an empiric model of the behaviour of the main ecological functions of the human habitat (HH) in relation with the different types of landscapes (temperate regions)**

**E. Giglio, V. Ingegnoli,**

Natural Science – Univers. of Milan Via Celoria 26, 20133 Milan – Italy;  
e-mail: v.ingegnoli@virgilio.it

The Human Habitat HH can be defined as areas where human populations live or manage permanently, limiting or strongly influencing the self-regulation capability of natural systems. Thus, human population behaviour in relation to management of living-space has a high ecological importance in studying landscapes. An empiric model, based on over 40 different types of surveyed Landscape Units, has shown interesting regularities in the self-organisation of HH landscape functions on the territory in temperate regions. The model is based on the Standard Habitat per capita SH (Ingegnoli, 1993, 2002), measured as  $m^2/inhabit.$  (or ha/individual for animals): this index measures “the ‘real’ territorial surface available for humans/animals in a definite geographical territory”. It is the inverse of the ecological density DE (Odum, 1971). What is more, the SH may be detailed specifying the amount of territorial surface pertaining to each one of the most important life functions related to the considered organism: e.g. for men the residential function RSD, the subsidiary function SBS (related to human energetic and work resources), the productive function PRD (concerning a high production of biomass to support human population in an ecological sense, not in an economic&urban sense!) and the protective function PRT (referred to specific elements/parts of the mosaic giving protection to other parts, e.g. the hedgerow network in a field mosaic).

We observed that the four ecological functions of SH<sub>rsd</sub>, SH<sub>prd</sub>, SH<sub>prt</sub>, SH<sub>sbs</sub> show proper behaviours strictly related to the percentage amount of HH in the landscape. Indeed, each one of these functions presents specific thresholds where the behaviour changes abruptly. For ex., trespassing HH=65% (Fig. 1) all functions forks: a line concerns processes of transformations pertaining to rural landscapes, the other one expresses the rural technological-suburban-urban transformations. The knowledge of behaviours like these could be utilised to evidence the ‘normal’ necessity of space for human populations both in diagnostic and environmental design sense. The same method can be referred to Natural Habitat and animals.

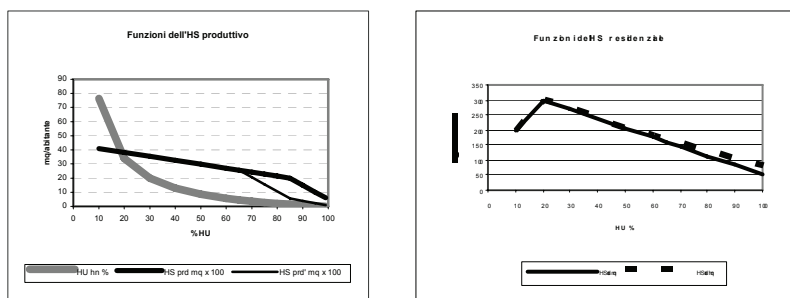


Fig. 1. On the left: function representing the behaviour of the residential SH related to HH% ( $m^2$ ). Note bifurcation for HH>65%, where in rural landscapes (HS<sub>rsd'</sub> line) we find higher values than in urbanised ones (HS<sub>rsd</sub> line). On the right: function representing behaviour of productive SH related to HH% ( $m^2 \times 100$ ). Note that rural landscapes (HS<sub>prd</sub> line) does not change until HH=85%, while urbanised landscapes (HS<sub>prd'</sub> line) assume a proper trend beginning at HH>65%, with an inflexion points at HH=85%, where a more intense technological urbanisation expels the productive function. Grey line= Natural Components% in Human habitat

**References**

Landscape Ecology: a widening foundation. Springer verlag, Heidelberg, New York, pp.358  
**Ingegnoli V & Giglio E (2005)** Ecologia del Paesaggio: manuale per conservare, gestire e pianificare l'ambiente. Sistemi Editoriali Esselibri – Simone, Napoli, pp.686

## Society, culture and people in landscape research

E. Conrad, I. Fazey, M. Christie

Institute of Rural Sciences, University of Wales, Llanbadarn Fawr, Aberystwyth, Ceredigion,  
Wales, SY23 3 AL, UK.  
e-mail: lizconrad@gmail.com

### Introduction

Landscape is a concept which straddles the natural and social sciences, bringing together a variety of physical and cultural elements. This study aims to assess the relative level of importance that physical and cultural landscape elements are attributed in academic landscape research. It is argued that if science is providing data for decision-making, then the research agenda should be relevant to policy and management concerns, and that, specifically, the important role of people in landscapes should be addressed.

### Methods

Articles published in *Landscape Ecology*, *Landscape and Urban Planning*, and *Landscape Research* over two three-year periods (1995-97 and 2004-06) were reviewed with a view to deriving data to examine three different dimensions of focus on people in landscape research. The first dimension assesses the disciplinary basis of research and topics of study, the second considers elements of participation and research methods used, whilst the third considers the nature of the research community and its activities.

### Results

#### What do researchers study?

The majority of studies emerge from disciplines rooted in the physical/biological/mathematical sciences (82.1% of studies in 1995-97 and 78.9% of studies in 2004-06). The predominant social science interest was in the planning and management discipline (50.3% in 1995-97; 37.8% in 2004-06). The latter year group also saw the inclusion of new disciplines, namely philosophy and law. There is also a trend towards a decrease in cross-disciplinary studies (57.1% in 1995-97; 43.7% in 2004-06). The dominance of the physical sciences is again clear with regard to topics of study, with 81.5% of studies in 1995-97, and 76.2% of studies in 2004-06, addressing physical attributes of the landscape.

#### To what extent does data collected reflect participatory concerns and how is it collected?

The percentage of studies involving stakeholders has increased from 13.6% in 1995-97 to 17.4% in 2004-06, although it is still limited. The majority of studies involve stakeholders in order to elicit views and opinions. Facilitative elements are very limited. The dominant research methods used to involve stakeholders are interviews and questionnaires, with some use of more novel methods in more recent years.

#### To what extent is the research community inclusive and participatory?

There is evident geographical bias in the distribution of both researchers and research, with the dominance of North America and North Western Europe in both year groups. There is also a clear correlation between income status of countries and extent of research carried out within those countries. Some degree of 'appropriation' of research is also evident in low income countries, with poor involvement of local authors.

### Conclusions

Although this study indicates that there are mixed trends in research in the field, the role of social and cultural concerns is clearly somewhat limited at present, and there is an urgent need for more integration at different levels, for more practical concerns to be addressed by research, for more stakeholder involvement, and for capacity building in many parts of the world.

**US IALE: the first twenty-five years of landscape ecology in North America (1983-2008)**

**G.W. Barrett, T.L. Barrett**

Institute of Ecology, University of Georgia, Athens, GA 30202-2202, USA.  
E-mail: gbarrett@uga.edu

Landscape ecology had its beginnings in North America during the early 1980s, when Gary W. Barrett, then serving as Ecology Program Director with the National Science Foundation (NSF), recommended funding for a workshop grant submitted to NSF by Paul G. Risser, James R. Karr, and Richard T. T. Forman. The workshop was held at Allenton Park, Piatt County, Illinois in April 1983; this workshop constituted the beginning of landscape ecology in the United States and in North America (see Risser et al. 1984 for details). The first annual meeting of the United States International Association for Landscape Ecology (US-IALE) was held at the University of Georgia, Athens, Georgia in January 1986. The first volume of the journal *Landscape Ecology* immediately followed this annual meeting with Frank B. Golley serving as Editor-In-Chief. Golley received the US-IALE Distinguished Landscape Ecologist Award in 1990 for his contribution to landscape ecology in North America, and the Outstanding Service Award in 1998 for his service as founding editor (1987-1996) of the journal *Landscape Ecology*. A brief history of landscape ecology in North America is referenced in Chapter 9 of Odum and Barrett (2005). The poster will provide a summary of the themes and sites of the US-IALE annual meetings, award recipients, and presidents of the association. In addition, the poster will inventory concepts, principles, and advances in the field of landscape ecology based on publications in the journal *Landscape Ecology*.

**References**

- Odum, E. P. & Barrett, G. W. (2005)** Landscape Ecology. E. P. Odum & G. W. Barrett. Fundamentals of Ecology, Fifth Edition. Thomson Brooks/Cole, Belmont, CA, pp. 374-411.
- Risser, P. G., Karr, J. R., & Forman, R. T. T. (1984)** Landscape Ecology: Directions and Approaches. Champaign, IL Natural History Survey Number 2:1-18. Proposing an empiric model of the behaviour of the main ecological functions of the human habitat (HH) in relation with the different types of landscapes (temperate regions)

## Theme 10: Forests, vegetation and landscape

## Theme 10: Forests, vegetation and landscape



## 10.1 Symposium 6. Forest fragmentation and biodiversity loss: The forgotten native forests

### Assessing the impacts of forest loss and fragmentation on biodiversity in the temperate landscape in south-central Chile

C. Echeverria

FORECOS-Universidad Austral de Chile, Casilla 567, Valdivia, Chile.  
e-mail: cechever@uach.cl

#### Introduction

Temperate rain forests in Chile, which are classified as a biological “hotspot” because of their high endemism, are rapidly disappearing as a result of land cover change (Myers *et al.*, 2000). Long-term analyses of the spatial patterns of deforestation and fragmentation of temperate forest ecosystems at the landscape scale have not yet been reported either in Chile or elsewhere in the southern hemisphere. Additionally, few studies have explored the impacts of fragmentation on the floristic composition in Southern Hemisphere forests.

The overall objective of this research was to develop a comprehensive analysis of the impacts of forest loss and fragmentation on biodiversity in central and southern Chile. This was conducted by i) examining the spatial and temporal patterns of forest loss and fragmentation in two study landscapes; and ii) analysing the relations between forest fragmentation and tree and shrub species communities in southern Chile.

#### Method

Spatial analyses were based on a time series of land-cover maps derived from satellite imagery acquired for the last three decades. Landscape indices such as mean patch size, patch density (per 100 ha), total core area (for a buffer edge of 100 m) and mean proximity (McGarigal *et al.*, 2002) enabled the fragmentation patterns to be described over time.

A stratified random sampling based on spatial attributes of the forest patches such as size, connectivity and isolation was used to select the forest fragments in the field. A total of 51 forest fragments were sampled using sampling plots of 20 x 25 m. In each plot, shrub and trees species were counted to estimate variables related to species richness. Basal area of trees ( $\geq 5$  cm diameter and  $> 1.3$  m height) was measured as a variable of forest structure. Ongoing anthropogenic disturbances was assessed measuring canopy cover and number of stumps along four transect of 40 m length and 2 m width oriented in each cardinal direction from the centre of the sampling plot. To assess the influence of the spatial attributes on these variables, several Generalised Linear Models (GLM) were fitted.

#### Patterns of forest loss and fragmentation

The study landscapes were affected by substantial changes in the area of native forests over time. Deforestation rates reached  $4.5 \text{ \%yr}^{-1}$  in central Chile primarily as a result of an increase in commercial exotic-species plantations, and  $1,2 \text{ \%yr}^{-1}$  in southern Chile due to clearance and forest logging. A consistent decline over the last three decades was observed for mean patch size, patch density, total core area and mean proximity. This demonstrates that the two study areas have been affected by progressive deforestation and fragmentation over the last three decades (Table 1 and Table 2). In central Chile patch density reached its maximum value in 1990 and then decreased by 2000.



**Table 1.** Changes in landscape pattern indices for the native forests in central Chile.

Landscape indices	1975	1990	2000
Mean patch size (ha)	17 ( 0.5 - 52,178 )	5 ( 0.5 - 9,842 )	4 ( 0.5 - 1,182)
Patch density	0.93	1.65	1.36
Total core area (ha)	21,138	918	839
Mean proximity	5,880 (0.0-145.119)	612 (0.0-29.276)	73 (0.0-6,032)

**Table 2.** Changes in landscape pattern indices for the native forests in southern Chile.

Landscape indices	1976	1985	1999
Mean patch size (ha)	47 (0.5 - 132,971)	24 (0.5 - 49,767)	19 (0.5 - 42,785)
Patch density	0.36	0.60	0.65
Total core area (ha)	143,428	89,007	69,900
Mean proximity	19,350 (0.0-369,603)	4,380 (0.0-152,583)	2,552 (0.0 - 120,135)

### Impacts on floristic composition

In southern Chile, abundance of interior tree and shrub species and basal area was significantly higher in large fragments (Table 3). On the other hand, abundance of edge tree and shrub species was higher in small forest fragments (Table 3). A reduction of patch size was related to a decline in the basal area of the fragments. The highest values of basal area were found in large fragments of old-growth forest, where large trees of shade-tolerant species occur. Changes in the forest structure were related to a greater occurrence of ongoing anthropogenic disturbances such as stumps and canopy cover within smaller fragments.

**Table 3.** Regression relationships between patch attributes (associated with richness, forest structure and human disturbances) and patch area in the study area of southern Chile. Estimates of the glm parameters a and b are provided and the statistical significance is shown.

Attribute of patch	a ± S.E.		b ± S.E.		P-value
Total richness (trees + shrubs)	2.67	± 0.06	-0.04	± 0.03	n.s.
Interior tree & shrub species richness	1.19	± 0.12	0.15	± 0.05	**
Edge tree & shrub species richness	1.69	± 0.12	-0.39	± 0.08	***
Total basal area (m <sup>2</sup> ha <sup>-1</sup> )	3.38	± 0.14	0.24	± 0.05	***
Canopy cover (%)	4.21	± 0.03	0.05	± 0.01	***
Number of stumps	2.82	± 0.21	-0.27	± 0.12	*

\* P< 0.05; \*\* P< 0.01; \*\*\* P<0.001; n.s., not significant; S.E standard error.

This study demonstrates that the progressive fragmentation and forest loss are associated with dramatic changes in the spatial structure of the temperate forest landscape in Chile. These changes appeared to be associated with a substantial loss of biodiversity in the temperate ecosystem.

### References

- Myers, N; Mittermeler, R.A; Mittermeler, C.G; da Fonseca, G.A.B; Kent J. (2000)** Biodiversity hotspots for conservation priorities. *Nature* **403**: 853-858.
- McGarigal, K; Cushman, S. A; Neel, M. C; Ene, E. (2002)** *Fragstats: Spatial Pattern Analysis Program for Categorical Maps*. Retrieved on January 20, 2003, from: [www.umass.edu/landeco/research/fragstats/fragstats.html](http://www.umass.edu/landeco/research/fragstats/fragstats.html).

## Testing the ecological principles of forest landscape restoration

N.C. Brouwers, A. Newton

Bournemouth University - School of Conservation Sciences, Talbot Campus, Fern Barrow,  
Poole, Dorset, BH12 5BB,  
e-mail: nbrouwers@bournemouth.ac.uk

### Introduction

In recent decades, human activities have increasingly fragmented native forest habitat in many parts of the world. This is associated with ongoing loss of natural habitat, which is increasingly recognised as the main cause of biodiversity loss (Fahrig, 2003). In several countries, conservation policy now stresses the need to preserve, expand and re-connect habitat fragments at a landscape scale to reverse the continuous loss of species.

In the United Kingdom, woodland conservation is focussing on efforts to reduce and reverse current fragmentation and habitat loss (Peterken, 2002). This has resulted in several policy initiatives focussing on the concept of creating Forest Habitat Networks (FHN) (e.g. Humphrey *et al.*, 2005). These initiatives focus on new woodland development towards linking existing woodland fragments together (Peterken, 2002; Humphrey *et al.*, 2005). This approach is based on the belief that creating new native woodland on suitable locations reduces the negative effects of habitat fragmentation on woodland biodiversity by providing links and 'stepping stones' between isolated populations of woodland species (e.g. Spellerberg and Gaywood, 1993).

Dolman and Fuller (2003) suggest that more studies are necessary on woodland specialist species to provide a firmer basis for current management strategies. To address this knowledge gap, research was undertaken on a specialist woodland invertebrate, the wood cricket (*Nemobius sylvestris*) on the Isle of Wight, UK. Wood cricket is associated with native broadleaved woodlands as its preferred habitat (Richards, 1952) and is of local conservation concern. The main objective was to determine the landscape scale distribution of this species in order to assess whether patch- and landscape-scale variables are related to its occurrence. The results of this study were used to critically examine the principles underpinning woodland restoration and evaluate current forest policy.

### Method

A survey was carried out between mid-July and mid-September 2005 focussing on the northern part of the Isle of Wight where the main fragments of native broadleaved woodlands are located. All mature broadleaf dominated woodland complexes, larger than 5 hectares, were surveyed. Wood cricket was located by recording the sound of stridulating males, which is very distinct and cannot be confused with other species. For the individual woodland fragments, wood cricket presence or absence was recorded. This data were analysed using several patch and landscape variables that were calculated within ArcGIS (version 9.1, Copyright 2005 ESRI, Redlands, California, USA).

### Results

Of the total woodland area (5123 hectares), 45.8 % (2346 ha) was surveyed in 2005, in which 43.4 % (1018 ha) wood cricket was recorded. Significant differences were found between wood cricket presence and woodland age, distance to the nearest neighbouring inhabited woodland and woodland (patch) area (table 1). Wood cricket proved to be more frequently present in old woodlands compared to younger ones, and in woodlands close to sites where wood cricket was also present. Furthermore, large woodlands were more likely to harbour a wood cricket community than smaller ones.

**Table 1.** Results summary for the relation between wood cricket presence and woodland age, distance to the nearest neighbouring inhabited woodland and woodland area.

Chi-Square	N	$\chi^2$	df	P
Age	144	4.553	1	0.033
Mann-Whitney U	N	Z	P	
Distance	215	-6.478	0.000	
Area	215	-3.175	0.001	

## Discussion

Results indicate that wood cricket presence is positively related to woodland age and patch area, and negatively related to distance between individual fragments. This is in line with common assumptions that increasing woodland age is positively related to species diversity; large habitat patches are likely to sustain more species than similar smaller patches and increasing levels of isolation are associated with a decrease in the persistence of species assemblages (e.g. Dolman and Fuller, 2003). These ecologically based assumptions are increasingly incorporated into current forest conservation policy (Defra, 2005). For wood cricket, conservation practice should focus on increasing the size of woodland patches, and reducing the distance between them. However, careful planning and targeting of suitable areas are often lacking in current restoration efforts (Lee and Thompson, 2005). Therefore the focus should be on identifying potential sites for restoration more carefully and focussing on expansion of existing woodlands rather than creating new ones.

## References

- Defra (2005)** *Keepers of time: A statement of policy for England's ancient & native woodland*. Defra/Forestry Commission, UK.
- Dolman, P.M. & Fuller, R.J. (2003)** The processes of species colonisation in wooded landscapes: a review of principles. J. Humphrey, A. Newton, J. Latham, H. Gray, K. Kirby, E. Poulson & C. Quine (Eds). *The Restoration of Wooded Landscapes*. Forestry Commission, Edinburgh, 25-36.
- Fahrig, L. (2003)** Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology, Evolution, and Systematics* **34**: 487-515.
- Humphrey, J.; Watts, K.; McCracken, D.; Shepherd, N.; Sing, L.; Poulson, L. & Ray, D. (2005)** *A review of approaches to developing Lowland Habitat Networks in Scotland*. Scottish Natural Heritage, ROAME No. F02AA102/2.
- Lee, J.T. & Thompson, S. (2005)** Targeting sites for habitat creation: an investigation into alternative scenarios. *Landscape and Urban Planning* **71**: 17-28.
- Peterken, G. (2002)** *Reversing the habitat fragmentation of British woodlands*. WWF-UK report, Godalming, Surrey.
- Richards, T.J. (1952)** *Nemobius sylvestris* in S.E. Devon. *The Entomologist* **85**: 83-87; 108-111; 136-141; 161-166.
- Spellerberg, I.F. & Gaywood, M.J. (1993)** *Linear features: linear habitats and wildlife corridors*. English Nature, Peterborough.

## Roads, fire and aggressive competitors: determinants of bird distribution in subtropical production forests

M. Maron<sup>1,2</sup>, S. Kennedy<sup>3</sup>

<sup>1</sup> Australian Centre for Sustainable Catchments, University of Southern Queensland, Toowoomba 4350, Queensland, Australia.

e-mail: maron@usq.edu.au

<sup>2</sup> Faculty of Sciences, University of Southern Queensland, Toowoomba, Queensland 4350, Australia.

<sup>3</sup> The Wilderness Society, P.O. Box 5427, West End, Queensland 4101, Australia.

### Introduction

Small passerine birds are declining in fragmented agricultural landscapes of eastern Australia, where cover of native woodland and forest vegetation is in some cases reduced to less than 5% of its original extent. These declines have typically been attributed to habitat loss and fragmentation in agricultural areas, the effects of which are often exacerbated by subsequent increases in the aggressive native honeyeater, the noisy miner *Manorina melanocephala*, which severely impacts avian assemblages through interference competition (Barrett *et al.*, 1994; Major *et al.*, 2001; Piper and Catterall, 2003).

While Queensland's Brigalow Belt forests include some of the largest contiguous areas of native forest that remain in the temperate and sub-humid zones of eastern Australia, they are currently managed for timber production, not conservation. Forestry practices such as fuel-reduction burning and maintenance of road networks can negatively impact avian assemblages (Date *et al.*, 2002; Ortega and Capen, 2002; Laurance, 2004), both directly by changing habitat structure and indirectly by creating conditions favourable for predators or competitors. Over one million hectares of Brigalow Belt forests are proposed to be converted from forestry to conservation tenure, yet the impacts on the avifauna of current and potential future forest management practices are not known. In particular, observations suggest that the noisy miner is common in the forests despite the fact that it is typically considered to be a bird of forest and woodland edges. We investigated the influence of road edges and habitat type on the avifauna of a large remnant forest in southern Queensland, with a particular focus on whether the extensive logging road network or the frequent fuel-reduction fires appeared to be facilitating noisy miner invasion of the forest.

### Methods

We surveyed the bird assemblages of 39 1-ha study plots in the 356 000-ha Barakula forest block. Survey sites were either <50m or >300m from a road, and in either cypress pine *Callitris glaucophylla* forest, spotted gum *Corymbia citriodora* forest with a regenerating cypress pine/buloke *Allocasuarina luehmannii* understorey or spotted gum forest with an open understorey due to fuel-reduction burning. Each site was surveyed five times during a twelve month period in 2005-2006.

ANOSIM in the PRIMER software package was used to test for differences in the bird assemblages of the three habitat types, between road edge and interior transects and between transects with and without noisy miners (the latter analysis run on bird assemblage data excluding noisy miners). The species richness and abundance of all birds and of small passerines, and the abundance of noisy miners, were compared among the three habitat types and between edge and interior transects using two factor ANOVA.

### Results & discussion

The avifauna differed significantly among habitat types but not with proximity to a road, with the greatest differences between cypress pine and both categories of spotted gum forest. Small passerines dominated the cypress pine forest but were at very low densities in spotted gum forest. The noisy miner appeared to be the factor mediating these assemblage-level differences. Abundance of small passerines was eight times higher in sites where < 3 noisy miners were recorded. Noisy miners were rare in cypress pine forest but were three times more numerous than any other species in spotted gum woodland. Spotted gum forest which had escaped more severe fuel-reduction fire and therefore had a regenerating understorey had fewer noisy miners than open spotted gum forest. Although total bird abundance was highest in open spotted gum forest, the species richness and abundance of passerines smaller than noisy miners was significantly lower in this forest type. However, the two spotted gum sites that were located in long-unburnt forest had exceptionally high small passerine abundance and species richness, with total abundance values of 36 and 46 compared to a mean ( $\pm$  s.e.) of  $8.8 \pm 2.2$  for all spotted gum sites and  $18.8 \pm 1.4$  for cypress pine sites, and species richness values of 14 and 13 compared to  $3.3 \pm 0.9$  for all spotted gum sites and  $7.8 \pm 0.7$  for cypress pine sites. Only one species, the area-sensitive eastern yellow robin *Eopsaltria australis*, was influenced by proximity to a road edge, and was more likely to occur > 300m from a road.

The current move by the Queensland Government to place the forests into a conservation tenure is focused on the hardwood (including spotted gum) areas, with the softwood (cypress pine) areas continuing to be harvested. However, the findings of this research suggest that from the perspective of small passerine birds, the softwood forests are of substantially greater conservation value and may potentially act as important refuges for smaller birds, enabling them to avoid noisy miner colonies.

It appears that the distribution of small passerines in this forest does not necessarily indicate their habitat preferences; rather, it reflects competitive exclusion of smaller-bodied species from all but a few forest types by a single species. These results cast doubt on the ability of Queensland's large remnants of hardwood forest as they are currently managed, even those that do not have an extensive road network, to support substantial, ecologically functioning populations of small passerines that are being lost from southern Australia. Fire regimes that reduce regeneration of the cypress pine and buloke understorey in spotted gum forest may be exacerbating the problem of noisy miner domination of the avifauna. A fire management strategy for small passerine birds in these forests should aim to maximise areas of long-unburnt spotted gum, utilising some fuel-reduction burning to protect these areas.

## References

- Barrett, G. W; Ford, H. A. & Recher, H. F. (1994)** Conservation of woodland birds in a fragmented rural landscape. *Pacific Conservation Biology* **1**: 245-256.
- Date, E. M; Ford, H. A. & Recher, H. F. (2002)** Impacts of logging, fire and grazing regimes on bird species assemblages of the Pilliga woodlands of New South Wales. *Pacific Conservation Biology* **8**: 177-195.
- Laurance, S. G. W. (2004)** Responses of understory rain forest birds to road edges in central Amazonia. *Ecological Applications* **14**: 1344-1357.
- Major, R. E; Christie, F. J. & Gowing G. (2001)** Influence of remnant and landscape attributes on Australian woodland bird communities. *Biological Conservation* **102**: 47-66.
- Ortega, Y. K. & Capen D. E. (2002)** Roads as edges: Effects on birds in forested landscapes. *Forest Science* **48**: 381-390.
- Piper, S. D. & Catterall, C. P. (2003)** A particular case and a general pattern: hyperaggressive behaviour by one species may mediate avifaunal decreases in fragmented Australian forests. *Oikos* **101**: 602-614.

## Conservation at large Scale: the Biodiversity Vision of the Atlantic Forest

M. J. Pacha

Fundación Vida Silvestre Argentina, Programa Selva Paranaense, Av. Cordoba 464- Puerto Iguazu CP 3370, Misiones, Argentina  
e-mail: proyectosmisiones@vidasilvestre.org.ar

### Introduction

Conservation efforts have evolved in the last decades to stop the worldwide loss of species and habitats and the degradation of the remaining fragments of original habitats. But conservation is proving to be more complicated than we once thought with changing policies, theoretical and technological innovations that need to be accommodated. The central questions in this quest have been about *what* exactly we are proposing to conserve, *how* we are proposing to do it and *where* the efforts should be focused (Redford *et al* 2003). In order to clarify these issues, conservation organisations around the world have tried to define both their targets and the scope of their interventions. The conservation targets represent those entities (species, ecosystems, ecological processes) whose long-term persistence the conservation efforts is attempting to ensure. The scope is the spatial scale in which the project aims to have an impact. The conservation approach (target and scope) has evolved during the last decades reflecting changing values placed on components of nature by different elements of society. These did not replace one another in a temporal sequence, but rather have tended to accumulate in a process of redefinition, absorption and addition.

In recent years the conservation community has been promoting the design and implementation of biodiversity conservation actions at larger scales. The World Wildlife Fund for Nature (WWF) has embraced this approach, focusing conservation planning and action on eco-regions. Since most ecological and evolutionary processes that sustain biodiversity occur at these larger scales, WWF has determined that eco-regions are the best units to design and implement biodiversity conservation actions. One of the key elements needed to implement WWF's approach on eco-region conservation is a Biodiversity Vision. A Biodiversity Vision is a planning tool, usually in the form of a document, aimed at guiding biodiversity conservation activities in the eco-region. A Biodiversity Vision sets a number of biodiversity conservation goals based on widely-accepted principles of conservation biology, and identifies critical areas to be either conserved, managed, or restored in order to meet those goals (Di Bitetti *et al.*, 2003). In this paper I want to present how the biodiversity Vision of the Atlantic Forest of the Upper Parana was developed.

### The Atlantic Forest Eco-region complex

The Atlantic Forest extends from Brazil, Paraguay, and Argentina, is one of the WWF Global 200 Ecoregions, being one of the most endangered tropical rainforests in the world, with just 7.4 percent of its original 1,713,535 square kilometers of native forest cover remaining. In spite of its highly fragmented condition, the Atlantic Forest remains one of Earth's most biologically diverse ecosystems, containing about 7% of the world's species (Galindo-Leal and de Gusmão Câmara, 2003). In the Atlantic Forest, there is a high proportion of endemic species: 52% of its tree species, 74% of its bromeliad species, 80% of the primate species, and 92% of its amphibians are endemic. Many of these species are now threatened with extinction. The Atlantic Forests Eco-region Complex has also been identified as a Biodiversity Hotspot, by Conservation International as one of its 25 Hotspots (Myers *et al.* 2000). The southern most eco-region of this complex is the Upper Paraná Atlantic Forest eco-region (UPAF) where the original forest covered the largest area (471,204 km<sup>2</sup>) of all the eco-region complex, extending from the western slopes of the Serra do Mar in Brazil to eastern Paraguay and the Province of Misiones of Argentina.

### How to build a Biodiversity Vision?

Underlying the Biodiversity Vision is a series of complex analyses aimed at designing a Biodiversity Conservation Landscape that if implemented will accomplish the conservation goals. From 2000 to 2003, WWF and Fundacion Vida Silvestre Argentina (FVSA) have led a tri-national participatory process involving more than 30 local organizations representing multiple sectors and disciplines. A more detailed description of the whole process can be found in Di Bitetti, Placci and Dietz (2003).

The starting point to create a tri-national Biodiversity Vision is to first identify the conservation goals that need to be accomplished in the following 50-100 years. Then various overlays of maps representing the distribution of the different biological and socio-economic variables were used. Three separate but interdependent analyses were critical to arrive at the final Biodiversity Conservation Landscape: a landscape unit's analysis, a fragmentation analysis and a threat and opportunities analysis. These analyses were then combined to produce a biodiversity potential map that represented a broad-scale cost-benefit analysis for conservation and from there the Biodiversity Conservation Landscape emerged. This Biodiversity Conservation Landscape is a central piece of the Biodiversity Vision, and its representation in a map helps to focus conservation activities on those areas and to set specific actions that would render the best results for biodiversity conservation.

### References

- Di Bitetti, M.S., Placci, G., & Dietz, L.A. (2003)** *a biodiversity vision for the Upper paran atlantic forest ecoregion: Designing a Biodiversity Conservation Landscape and Setting Priorities for Conservation Action*. World Wildlife Fund, Washington D. C.
- Dinerstein, E.; Powell, G.; Olson, D.; Wikramanayake, E.; Abell, R.; Loucks, C.; Underwood, E.; Allnutt, T.; Wettengel, W.; Ricketts, T.; Strand, H.; O'Connor, S.; Burgess, N. & Mobley, M. (2000)**. *A workbook for conducting biological assessments and developing Biodiversity Visions for ecoregion conservation. Part I: Terrestrial Ecoregions*. WWF, Conservation Science Program.
- Galindo-Leal, C., and I. de Gusmo Cmara. (2003)**. *The Atlantic Forest of South America*. Center for Applied Biodiversity Science, Island Press, Washington, D.C.
- Myers, N., Mittermeier, R.A., Mittermeier, C., Da Fonseca, G.A.B and Kent, J (2000)**. *Biodiversity hotspots for conservation priorities*. Nature 403, 853-858.
- Redford, K, H., Coppolillo, P., Sanderson, E.W., Da Fonseca, G.A.B., Dinerstein, E., Groves, C., Mace, G., Maginnis, S., Mittermeier, R.A., Noss, R., Olson, D., Robinson, J.G., Vedder, A. and Wright, M. (2003)**. Mapping the conservation landscape. Conservation Biology. 17:116-131

## Economic development and forest fragmentation in the Brazilian Amazon from 1986 to 2000

C.B.A. Bohrer<sup>1</sup>, M.C.S. Mello<sup>1</sup>, S.R. Freitas<sup>2</sup>, A.S. Pfaff<sup>3</sup>, E.J. Reis<sup>4</sup>

<sup>1</sup> Departamento de Geografia, Universidade Federal Fluminense, Campus Praia Vermelha 24210-340, Niterói, RJ, Brazil.

e-mail: [bohrer@vm.uff.br](mailto:bohrer@vm.uff.br)

<sup>2</sup> Depto. de Ecologia, Rua do Matão. Universidade de São Paulo, São Paulo, SP, Brazil

<sup>3</sup>The Earth Institute, Columbia University, Hogan Hall, 2910 Broadway New York, NY USA

<sup>4</sup> Instituto de Pesquisas Econômicas e Sociais Aplicadas, Av Pres. Antonio Carlos 51/17º andar. 20.020 Rio de Janeiro, RJ, Brazil

### Introduction

The growing concern with the amount of deforestation, and the belief that development in the Brazilian Amazon affects the region's forest biodiversity and its ecological processes, has generated significant interest in models that link drivers of human actions to forest and ecosystem outcomes at several spatial scales. The rapid development that have been occurring in the region and the likely impacts of the deforestation process on the region's biodiversity, ecological processes and global climate, have highlighted the need for the development of models that could be used to predict future changes, at different spatial scales. Modeling approaches can be quite simple, such as extrapolations of observed rates of deforestation, or quite complex, relying upon inferences from spatio-temporally disaggregated data on environment, infrastructure and society. In any such model it may be worth distinguishing between particular economic activities and land uses, such as crops and cattle ranching.

Different types of land use and economic activities have led to contrasting levels of deforestation. Cleared areas are being converted into agricultural crops, pasture are simply abandoned after logging (Andersen et al., 2002), which could lead to different forest fragmentation patterns across the region. The identification of consistent relationships between landscape patterns, socio-economic data and infra-structure development could be used in the development of models to predict the outcome of public policies planned for the region. This works aims to discuss the preliminary results of spatial pattern analyses, done by use of landscape metrics related to patch density, size and shape across the region, for the years 1986-96-92-2000, and by relating them to socioeconomic factors.

### Methodology

Land cover spatial data based on Landsat TM imagery produced by TRFIC-MSU (1986-92-96) and PRODES-INPE (2000), covering all the region, were used to extract landscape metrics (Core Area, Patch Number and Density, Largest Patch, Mean Patch Size, Average-Weighted Mean Size and Shape Indexes) by use of Fragstats\*ARC software (McGarigal & Marks, 1995), at state and municipio level. IBGE population (1991-2000) and agricultural census (1985-95) data at municipal level used were: income, total and agricultural GDP, urban and rural population, housing, literacy, life expectancy, cattle herd, farm, pasture, annual and permanent crop area, and investment in agriculture. Most variables were divided by the municipal area, and log transformation was also applied. Pearson correlation between metrics and census data. Further analyses will include PCA to reduce independent (census) variables, and linear multiple regression analyses.

### Results and Discussion

The results show an average increase of the deforested area among the Amazonian satate from 8,6% in 1986 to 29,7% in the year 2000. They also show a high correlation



between the percentage of deforested area to several landscape metrics, including patch number and density. Both deforestation and fragmentation patterns vary highly across the region. They do show a great similarity among the states with higher rates for clearing and development, such as M. Grosso, Rondonia, Pará, Acre and Maranhão.

Several socioeconomic variables, especially from the agricultural census, have shown a high degree of autocorrelation. From the demographic census, income, literacy and life expectancy were also highly correlated ( $R > 0.9$ ). These variables, which are highly related to the local level of economic development, have shown a relatively high correlation with indexes such as CA, MCAI and AWMSI

The results have shown only medium to weak correlations between fragmentation metrics (PD, MPS, MCAI) and agricultural census variables. This must be further investigated, as these values were found especially on M. Grosso and Rondonia, states where a large part of the deforestation has been occurring, combined with a faster economic growth due to logging, cattle and crop activities, which can be demonstrated by the high degree of correlation between agriculture and local GDP.

The results so far are not sufficient to give a clear and consistent view of the existence of a strong relationship between socioeconomic variables and fragmentation patterns, at least for the whole Brazilian Amazon. Nevertheless, results from some states do show that there are some relationships that could be better explored. New analysis to be carried out could clarify if these relationships are strong and consistent, in order to support the design of predictive models. These should include new approaches and perhaps further data. Environmental (climate, relief, soils) and infra-structure variables, especially roads, might also have a significant influence on the evolution of the fragmentation patterns on the region, which also should be further investigated.

Funding and support was granted by Tinker Foundation, Columbia University, LBA-Eco, Nemesis/Pronex and FEC-UFF.

## References

- Andersen, L.E., Granger, C.W.J., Reis, E.J., Weinhold, D. & Wunder. S.** (2002) *The dynamics of deforestation and economic growth in the Brazilian Amazon*. Cambridge University Press, Cambridge.
- McGarigal, K. & Marks, B.J.** (1995) *FRAGSTATS: spatial pattern analysis program for quantifying landscape structure*. Gen. Tech. Rep. PNW-GTR-351. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

## Conserving Wildlife In Fragmented Forest Landscapes Across Their Geographic Range? A Koala Case Study

C.A. Mcalpine<sup>1,2</sup>, M. Bowen<sup>1,2</sup>, D. Lunney<sup>3</sup>, J.Callaghan<sup>4</sup>, J.Rhodes<sup>1,2</sup>, D. Mitchell<sup>4</sup>, H.Possingham<sup>2</sup>

- <sup>1</sup>. Centre for Remote Sensing and Spatial Information Science, The University of Queensland, Brisbane, Australia 4072.  
e-mail: c.mcalpine@uq.edu.au
- <sup>2</sup>. The Ecology Centre, The University of Queensland, Brisbane, Australia 4072.
- <sup>3</sup>. Department of Environment and Conservation NSW, PO Box 1967, Hurstville, New South Wales, Australia 2220.
- <sup>4</sup>. Australian Koala Foundation, GPO Box 2659, Brisbane, Australia 4001.

Comparative biogeographical and ecological studies reveal considerable variation in the sizes, shapes, boundaries, and internal structures of the contemporary geographic ranges of species (Gaston, 2003). While many species have small ranges, and a few have very large ones, an important component of the world's terrestrial fauna have natural geographic ranges extending over multiple regions (e.g., neotropical birds of North America). Regional variation in habitat relationships within such broad geographic ranges has seldom been studied, even though it is potentially important for conservation management. This is particularly the case for forest fauna, whose habitat is often subject to different levels of human modification in different landscapes (e.g., Laurance & Bierregaarde, 1997). In fragmented forest landscapes, we need to understand habitat relationships within individual landscapes, while at the same time seeking general guidelines that can be applied across broad geographic ranges. This vital issue has yet to receive detailed attention from conservation practitioners, who tend to rely on simple rules, such as protecting large patches, as being obviously correct and uniformly applicable over multiple regions.

The koala (*Phascolarctos cinereus*) is an excellent animal for identifying similarities and differences in pattern-process-scale relationships within fragmented forest landscapes across a broad geographic range. It is widely distributed in eastern Australia, extending over 30 biogeographic regions from tropical Queensland (18.00 S) to temperate Victoria and southeast South Australia (38.00 S). Previous studies have reported sensitivity to both fine-scale habitat structure, its composition and landscape structure (McAlpine *et al.*, 2006a, 2006b; Rhodes *et al.*, 2006). McAlpine *et al.* (2006a; 2006b) concluded that habitat area had a strong independent effect with the interaction between habitat area and configuration also being important. The next question is: how general are these results? Do we need studies of koala habitat relationships in all regions to make well-informed management decisions, or are relationships similar across its entire geographic range? This is a conundrum for managers of all species with a broad geographic range – how much should studies in one region inform the decisions in another?

We addressed the question: can multi-scale models of species' distribution be generalised from region to region? In this study, the particular scale of observation is the presence or absence of koalas in an individual tree. This scale was chosen because it is the smallest scale at which koala habitat can be managed, and it lends itself to a hierarchical analysis of the multi-scale processes influencing patterns of occurrence. The focus is on explanation rather than prediction, although the two can be complementary. Using tree-scale data, based on the presence of koala pellets (i.e. faecal pellets on the ground under a tree), we applied a cross-regional, hierarchical modelling approach to determine the relative importance of habitat variables ranging from the individual tree (1-10s m<sup>2</sup>) to the surrounding landscape (100s-1000s ha) in three fragmented forest landscapes of eastern Australia, each separated

by 1000s of km. We also tested the cross-regional predictability of the models using the area under the receiver operator characteristic (ROC) curve.

Our results demonstrate that while some site and landscape variables are of similar importance from region to region, there is also considerable variation in the effect and relative importance of most variables. This allows the crucial management conclusion to be drawn that there is no single formula for action (such as protect the largest patch) that will suit all circumstances and locations. The presence of such cross-regional differences highlights the need for more work on wide-ranging species in different biomes in order to confidently answer the question: to what extent can multiple-scale models of species' distribution be generalised from region to region?

Adopting a uniform conservation program over a large geographic area is attractive to policy makers and conservation planners. It allows efficiencies in program development and its application. It is tempting to extrapolate species-habitat relationships derived from a single study to other regions. Our findings demonstrate that there is some hope that similar factors will influence animal distribution from region to region, particularly where environmental and land use characteristics are similar. However, we argue against adopting a uniform conservation program for species with a large geographic range. A species may experience regional differences in the spatial and historical impact of human land use pressures on its natural habitat, especially at the patch and landscape-scales where human impacts are strongest.

## References

- Gaston, K.J., ed. (2003)** *The Structure and Dynamics of Geographic Ranges*, Oxford University Press, Oxford, UK.
- Laurance, W.F. & Bierregaarde, R.O. (1997)** *Tropical forest remnants: ecology, management and conservation of fragmented communities*. University of Chicago Press, Chicago, USA.
- McAlpine, C., Bowen, M., Callaghan, J., Lunney, D., Rhodes, J., Mitchell, D., Pullar, D. & Possingham, H.P. (2006a)** Testing alternative models for the conservation of koalas in fragmented rural-urban landscapes. *Austral Ecology*, **31**, 529-44.
- McAlpine, C.A., Rhodes, J.R., Callaghan, J., Bowen, M., Lunney, D., Mitchell, D., Pullar, D. & Possingham, H.P. (2006b)** The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: a case study of koalas in Queensland, Australia. *Biological Conservation*, **132**, 153-65.
- Rhodes, J.R., Wiegand, T., McAlpine, C.A., Callaghan, J., Lunney, D., Bowen, M. & Possingham, H.P. (2006)** Modelling species distributions for improving conservation in semi-urban landscapes: a koala case study. *Conservation Biology*, **20**(2), 449-59.

## Assessment of changes in biodiversity levels of forested ecosystems by using remote sensing: a case study in Mozambique

E. Arets<sup>1</sup>, A. Vrieling<sup>2</sup>, P. van der Meer<sup>1</sup>, C.A. Múcher<sup>1</sup>

<sup>1</sup>Alterra - Wageningen UR, P.O.Box 47, 6700 AA Wageningen, The Netherlands.  
e-mail: peter.vandermeer@wur.nl

<sup>2</sup>SARVision, Agro Business Park 10, 6708 PW Wageningen, The Netherlands.

### Introduction

Forest ecosystems are under increasing pressure. The rates of forest conversion are extremely high in most tropical regions and these changes have important impacts on these ecosystems and their functioning. Remote sensing can assist in monitoring forest fires and changes in forest cover, especially when it concerns large areas that are difficult to access. However, relations between changes in forest cover and forest quality are poorly understood and need to be clarified in order to better monitor global levels of biodiversity and identify some of its potential threats.

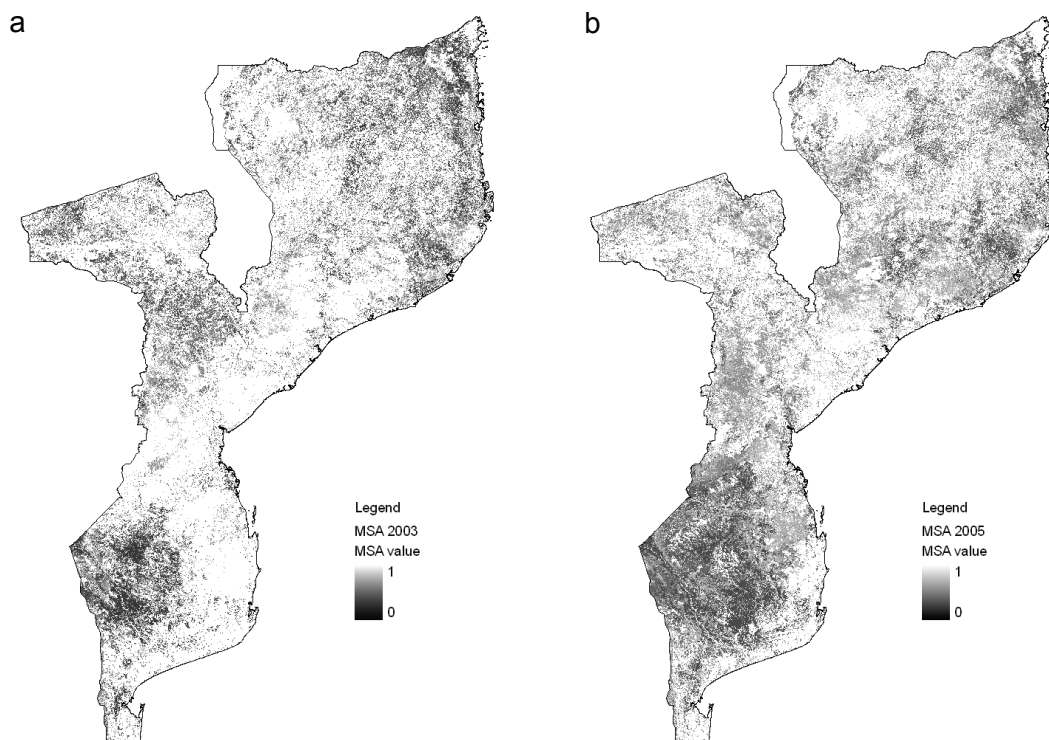
In our paper we discuss how remote sensing can be used to assess and monitor forest quality of the main forested ecosystems in Mozambique. Forest quality is assumed to be directly linked to biodiversity levels, and is expressed in terms of the Mean Species Abundance of the original species (MSA). This concept was developed by the Netherlands Environmental Assessment Agency in collaboration with other institutes, and is based on globally agreed CBD indicators to evaluate the 2010-target (change in abundance and distribution of selected species). Medium resolution satellite imagery such as MODIS (500-m resolution) was an important source of information to monitor changes for large areas of forest.

### Results

Mozambique has a very complex land cover, with strong seasonal effects, characterised by a very heterogeneous vegetation mosaic with many scattered elements (trees, shrubs), small-scale agriculture and a long history of extensive human impact. At the same time hardly any ground truth data exist for calibration of the remotely sensed land-cover classification. Therefore the results may show some flaws, but the framework presented seems promising.

Automatic processing of MODIS allows for monitoring land cover. For 2000 to 2005 a strong decrease of forest quality was observed for Mozambique. Since 2000, the reference year, the average MSA value for the whole of Mozambique gradually decreased almost linearly. In 2001 it still had a value of 0.91 (i.e. 91 % of the original species abundance was left), while in 2005 it had decreased to 0.79. The reduction in MSA since 2000 is strongest in the south-western part of Mozambique (figure 1).

A good indication of fire occurrence was obtained through MODIS hotspot data, and the data show an increase in fire occurrence over the years. A time series of fire hotspots showed that most fires occur during the second half of the dry season, indicating a human influence. The occurrence of fires strongly increased from 2001-2005, both in wet and dry seasons, which is an indication for land-use changes.



**Figure 1.** Map showing the mean species abundance of original species (MSA) in Mozambique in (a) 2003 and (b) 2005. The reference year is 2000. Darker areas have a stronger reduction in MSA.

### Conclusion

Pressure on the dry forest ecosystems in Mozambique is increasing fast. Monitoring of forest cover showed that the quality of forest cover, expressed as MSA, is rapidly decreasing and that in 2005 only 79% of the MSA was left in comparison to 2000. This is likely a result of the introduction of modern agricultural practices and the eradication of tsetse flies since the end of the civil war in the mid-1990s.

The classification of the land-cover types can be significantly improved if more ground data become available. Currently a national forest inventory is carried out which is expected to be completed in the course of 2007. These data could then be used to further refine the classification of forest cover.

ASAR radar images give more detailed information than MODIS, but are only available for limited years and areas. It could be of interest for classification purposes but is currently only of limited value for monitoring forests.

## **The influence of *Prosopis*-invasions on the functioning of affected landscapes in Namibia.**

**P. Smit**

Department of Geography and Environmental Studies, University of Namibia, Private Bag  
13301, Windhoek Namibia.  
e-mail: psmit@unam.na

### **Introduction**

Plants of the *Prosopis* genus are regarded as the most widespread and most aggressive invasive species in Namibia. Labeled as transformers, they occur mainly in arid savannah landscapes, in close vicinity to drainage lines, where they multiplied and hybridized rapidly during the last three decades. In many countries *Prosopis* is perceived as valuable plants because of their high degree of tolerance to adverse geo-ecological conditions and ability to produce high yields of nutritious fodder and fuel wood, in addition to provide shelter and to combat land degradation. Research on their impact on landscapes where the plants become invasive, however, receives limited attention. In this investigation the *Prosopis*-invaded landscapes of southeast Namibia were geo-ecologically analyzed, environmental changes were indicated and patterns of connectedness and connectivity ascertained.

### **The chronological context**

Availability of seasonal surface water in the ephemeral Nossob and Auob Rivers of southeast Namibia created important corridors in the otherwise hostile and harsh Kalahari landscapes. For millennia, game migrates up and down along these drainage courses. Hunter-gatherers exploited the resources of these landscapes because of the availability of surface water, and also the seasonal accompanying wild animals. Later, these linear lifelines attracted also colonial settlers, which opened the artesian aquifer underneath, providing permanent water and converting nomadic settlements into sedentary ones. The migration of game became more limited, farms were fenced-off, infrastructure followed and new species were introduced. Ecotones become more defined, accentuating by *Prosopis*-invasions, which exaggerated much of the changeability in landscape connectedness and connectivity.

The combined drainage basin of the rivers was selected as study area to investigate the structure, functioning and connections of landscapes affected by *Prosopis*-invasions.

### **Findings of the study**

Threshold climatological, hydrological and litho-pedological prerequisites for the initiation, expansion and development of *Prosopis*-invasions were identified during the study. The plants thrive in areas unsuitable to many other xerophytes: Low and unpredictable rainfall, wide diurnal and seasonal temperature ranges, high rates of radiation, high evapotranspiration potentials; infrequent supplies of surface run-off and soils that are infertile, immature and shallow. As a result they can outnumber competitors soon after their appearance. In fact, when constraining geo-ecological conditions are coupled with irrational land use decision-making, circumstances might be considered as highly favorable to the occurrence of *Prosopis*-invasions.

Although the plants predominantly occur near drainage lines, many other ecotopes and land facets far away from landforms subject to episodic flooding are suitable to *Prosopis*. Ultimately, prominent knock-on effects on the connectedness as well as the connectivity of the landscapes were caused by the invasions. Their close proximity to drainage lines seems

to be closely associated with flowing water as dispersal agent during intermittent flooding events. Animals, which are often confined to the drainage lines, spread the seeds in addition. In turn, the continuous downstream spread of *Prosopis* caused many animal species to migrate along, much further south than before. The invasions choke the ephemeral discharge and cause serious disruptions on the local run-off regime. In addition, the plants are vigorous consumers of water when it is available and in this way affect the water balance of entire landscapes.

### Recommendations

The results of the invasions recommend clear guidelines to *Prosopis*' management on a sub-continental scale. Both rivers along which the invasions occur enter the Kgalagadi Transfrontier Park (where Namibia borders Botswana and South Africa), which implies an escalating cross-border threat of international importance. It was also found that a large part of Namibia is suitable to *Prosopis*-invasions if no control measures are in place.

If scientifically managed, a diverse range of products from *Prosopis*-plants is possible: Highly palatable pods, good quality timber, hard coal fuelwood, charcoal and pasturage to honey bees and wild silkworms. The commercial utilization of *Prosopis* is a completely undeveloped industry in Namibia, and may offer some possibilities in creating solutions to this international threat.

## Forest disturbance versus landscape metrics

S.R. Freitas<sup>1</sup>, C.B.M. Cruz<sup>2</sup>

<sup>1</sup> Universidade de São Paulo, Instituto de Biociências, Departamento de Ecologia Geral, Rua do Matão, 321, travessa 14, Cidade Universitária, 05508-090, São Paulo, SP, Brazil.  
e-mail: simonerfreitas.usp@gmail.com.

<sup>2</sup> Universidade Federal do Rio de Janeiro, Instituto de Geociências, Departamento de Geografia, Rio de Janeiro, RJ, Brazil.

### Introduction

In order to reduce uncertainty and improve predictability, future research in landscape pattern analysis must go beyond the mere quantification of landscape pattern and emphasize its relationships to ecological processes (Li and Wu, 2004). Forest fragmentation is an ecological process that affects microclimate, plants and animals (Fahrig, 2003). The effect of forest fragmentation could be studied through the ecological landscape approach, considering size and shape of forest fragments, their distribution and surroundings. Edge-effect alters canopy-gap dynamics, which influences forest structure, composition and diversity (Laurance, 2004). Some indicators of forest disturbance could include biomass loss, higher frequency of occurrence of pioneer species and lianas (Tabarelli et al., 1999; Tabanez and Viana, 2000; Laurance, 2004). This work aims to evaluate the relationships between indicators of forest disturbance and landscape metrics taken in forest fragments and their surroundings.

### Material and Methods

#### Study Site

Eleven forest fragments were studied in the Macacu River Basin (22°70'-22°36' S, 43°06'-42°55' W), in the state of Rio de Janeiro, Brazil. The main land-cover type of the study area is lowland evergreen rainforest, located in the Atlantic slope of Serra do Mar, encompassing hills and lowlands towards Guanabara Bay. The forest fragments are small ( $\leq 100$  ha) and surrounded by pastures and crop lands. These forest fragments are usually found inside small farms and sometimes within large cattle farms (Freitas et al., 2005). The forest is dense, and highly diverse, 35 m or taller, with occasional emergent trees, and understory of 5-10 m (Freitas et al., 2005).

#### Indicators of Forest Disturbance

Forest structure measurements were taken along two perpendicular transects crossing each forest fragment in north-south and east-west directions. In each transect, 5 x 10 m rectangular plots were set 30 m apart. The following measurements were taken in each plot: tree diameter at breast height (1.30 m) and tree height. The threshold used was a diameter at breast height > 5 cm. The forest structure variables estimated were: average of basal area, average of tree density, liana frequency, and two pioneer specie frequencies (*Cecropia* spp. and *Astrocaryum aculeatissimum*).

#### Landscape Metrics

Landscape metrics were taken from a 1 km buffer surroundings each forest fragment based on a classified Landsat 7 ETM+ image, using FRAGSTATS 2.0 software. The selected landscape metrics were those calculated in patch-level (forest fragment) and class-level (fragment and buffer). The landscape metrics used were: 1) AREA, size of forest fragment (hectares); 2) SHAPE, shape index of forest fragment (higher values for irregular shapes); 3)



%Pasture, proportion of pasture in the landscape; and 4) PD, patch density of forest in 100ha.

### Analysis

A Spearman correlation test was used to evaluate the relationships between indicators of forest disturbance and landscape metrics. The variables more frequently correlated were considered indicators of forest disturbance balanced to landscape metrics, which were then used to separate forest fragments in classes of disturbance through cluster analysis (Ward's method, Squared Euclidean Distances).

### **Results**

Stronger correlations were found between *Cecropia* frequency and fragment area (Spearman  $R = 0.764$ ,  $p = 0.006$ ), *Cecropia* frequency and fragment shape (Spearman  $R = 0.809$ ,  $p = 0.002$ ), and liana frequency and fragment area (Spearman  $R = -0.756$ ,  $p = 0.007$ ). Using these four strongly correlated variables (*Cecropia* and liana frequencies; and forest area and shape) in a cluster analysis, forest fragments could be separated into three classes. Two fragments included in Class A were bigger, less rounded, had more *Cecropia* and less lianas than four fragments of Class B, which were bigger, less rounded, had more *Cecropia* and less lianas than five of Class C.

### **Discussion**

The occurrence of *Cecropia* spp. and liana were strongly correlated to size and shape of forest fragment. The smaller forest fragments (19.62-30.33 ha) were infested by lianas and their more rounded edges had less *Cecropia* spp. Small fragments seem to be favourable to infestation of lianas, mainly because they are disturbed, high-light and fire vulnerable areas (Tabanez and Viana, 2000). In contrast, the bigger forest fragments had less rounded edges and a higher frequency of *Cecropia* spp. For small forest fragments, irregular shape may be a crucial measurement for determining the occurrence of shade-intolerant species, such as *Cecropia*, a pioneer tree species usually occurring in edges and treefall gaps (Hill and Curran, 2003). Concluding, in tropical forests, fragment shape and size can be used as indicators of forest disturbance, collaborating with planning and actions in conservation, management and restoration.

### **References**

- Fahrig, L. (2003) Effects of habitat fragmentation on biodiversity. *Annual Reviews in Ecology & Systematics* **34**: 487-515.
- Freitas, S.R., Mello, M.C.S. & Cruz, C.B.M. (2005) Relationships between forest structure and vegetation indices in Atlantic Rainforest. *Forest Ecology and Management* **218**: 353-362.
- Hill, J.L. & Curran, P.J. (2003) Area, shape and isolation of tropical forest fragments: effects on tree species diversity and implications for conservation. *Journal of Biogeography* **30**: 1391-1403.
- Laurance, W.F. (2004) Forest-climate interactions in fragmented tropical landscapes. *Philosophical Transactions of the Royal Society of London - B* **359**: 345-352.
- Li, H. & Wu, J. (2004) Use and misuse of landscape indices. *Landscape Ecology* **19**: 389-399.
- Tabanez, A.A.J. & Viana, V.M. (2000) Patch structure within Brazilian Atlantic Forest fragments and implications for conservation. *Biotropica* **32**: 925-933.
- Tabarelli, M., Mantovani, W. & Peres, C.A. (1999). Effects of habitat fragmentation on plant guild structure in the montane Atlantic forest of southeastern Brazil. *Biological Conservation* **91**: 119-127.

**Genetic benchmarks applied to landscape conservation and restoration, a case study of *Araucaria angustifolia* (Brazil)**

**J.V.M. Bittencourt<sup>1</sup>, A.R. Higa<sup>2</sup>, G.H. Griffiths<sup>1</sup>**

<sup>1</sup> The University of Reading, Reading, RG6 6AB, UK.  
e-mail: juvitoria@hotmail.com

<sup>2</sup> Federal University of Paraná, CIFLOMA, 80210-170, Curitiba, PR, Brazil.

## **Introduction**

*Araucaria angustifolia* is known in Brazil as *araucaria* or *parana-pine*. The mixed Ombrophilous Forest of *A. angustifolia* is one of the most important naturally occurring biomes in South and South-eastern Brazil. The extensive logging and agricultural expansion of the last century has resulted in significant fragmentation of the forest cover. Intensive logging of the natural population for high quality timber products has contributed to over-exploitation of the species. Currently, the original area of the Araucaria forest has been reduced to less than 3% of the original area, with only 0.7% being considered primary forest (FUPEF, 2001).

Currently, the landscape structure in state of Parana is a mosaic of crops, pasture, riparian zones and Araucaria forest patches. The state of Parana is one of the most important states for agricultural production in the country (Turra, 2003).

The objective of this study was to assess the genetic diversity and dynamics of remnant patches of *Araucaria angustifolia* forest, with different levels of human modification.

## **Methodology**

A sequence of satellite images (Landsat: 1978 and 2003) was used to monitor the pattern of landscape fragmentation over almost 30 years. The project compared different forest types: one is 4000 ha of continuous forest; the other is fragmented forest containing remnant forest patches varying in size from 5 to 20 ha. The last type comprises small groups of trees in an essentially non forest environment. The fragments are 15, 25, 35 and 45 km from the continuous forest area and the tree groups were chosen randomly across the landscape.

Cambium material was collected from each recorded tree. Genetic diversity was assessed for 8 microsatellite loci by Polymerase chain reaction (PCR).

## **Results and Conclusions**

Temporal analysis of Landsat satellite imagery showed that in 1978 the landscape comprised a matrix of forest interspersed with patches of agricultural land. By 2003 the opposite was evident: small patches of forest within a matrix of agricultural land.

The genetic results from the contemporary, fragmented landscape suggest evidence for mating among relatives and inbreeding in the population. For example, the population in continuous forest showed higher genetic diversity in the adult population than for the forest patches. However, the observed reduction in heterozygosity was small, possibly due to the fact that the process of forest fragmentation happened relatively recently. In addition, the results indicated that there is more inbreeding in a fragmented population than in a continuous subpopulation. Fragmentation increased the genetic divergence between isolated forest fragments. The genetic results also indicated the presence of long-distance dispersal leading to functional connectivity between isolated forest fragments. Thus, the survival of *Araucaria angustifolia* in the landscape is critically dependent upon the survival of single

trees and tree groups and is a key factor for species conservation and restoration. Any strategy for conservation should therefore, take into account the importance of gene flow within a landscape composed of continuous forest 'connected' by single trees and remnant patches (Lindenmayer and Franklin, 2002).

Integrated within landscape conservation policy, scientific results of this type can assist with an effective strategy for the protection and restoration of *A. angustifolia* forest. The successful implementation of such a strategy, requires the environmental sector to change its view of a 'hostile' agricultural matrix and to adopt a revised view that sees the *matrix as critical to maintain the functionality of an ecosystem, for example A. angustifolia*.

### References

- FUPEF, F. D. P. F. D. P. (2001).** Projeto de Conservação e Utilização Sustentável da Diversidade Biológica - PROBIO, subprojeto Conservação do Bioma Floresta com Araucária. Curitiba: 438.
- Turra, F. E. (2003).** Cooperativismo paranaense. Curitiba.
- Lindenmayer, D. B. and J. F. Franklin (2002).** Conservation forest biodiversity: a comprehensive multiscale approach. Washington, Island Press.

## 10.2 Open Session 18: Spatial vegetation modeling

### Imputation of canopy and surface fuel attributes from LiDAR and Landsat ETM+ imagery

A.J.H. Meddens<sup>1</sup>, A.T. Hudak<sup>1</sup>, J.S. Evans<sup>1</sup>, W.A. Gould<sup>2</sup> and G. González<sup>2</sup>

<sup>1</sup> USDA Forest Service Rocky Mountain Research Station, Moscow, IUSA.  
e-mail: arjan.meddens@wur.nl

<sup>2</sup> USDA Forest Service International Institute of Tropical Forestry, Río Piedras, Puerto Rico.

#### Introduction

The influence of forest fragmentation on production and decomposition processes is of special concern because these fundamental ecosystem processes constrain fuel accumulations in forests. Various studies have shown that predicting forest fuel loads regionally with multi-resolution imagery leads to acceptable results (Rollins *et al.*, 2004) but more local studies indicate that LiDAR can significantly improve these predictions (e.g. Hudak *et al.*, 2006). New methods to predict ground-measured variables are emerging; we focused on predicting canopy and surface biomass and fuels using random Forest classification algorithm (Breiman 2001). Here, we assess the ability to use randomForest to map multiple canopy and surface fuel attributes in northern Idaho.

#### Methods

##### Study site and field data

Two study landscapes were selected: Priest River (PR) and Moscow Mountain (MM), located in northern Idaho in the Interior Northwest region of the United States. The PR landscape represents the wetter end of the precipitation gradient in northern Idaho, while MM represents the drier end. The study landscapes are composed of mixed conifer forest with 12 coniferous tree species. In 2002 and 2003, field campaigns were conducted and a total of 111 sites sampled. Each site consisted of 4 variable-radius plots oriented perpendicular to the forest edge, with plots located into the forest interior at 5, 15, 35, and 55 m distances from the edge. Forest edges were sampled to best capture the fine-scale variability in fuel loads that could be expected as a consequence of fragmentation. The forest edges sampled were defined by either a road, a field, or a recent clearcut at an early stage of forest regeneration. These plot measurements were the source of several response (Y) variables of interest: basal area (BA), downed woody debris (DWD), above ground biomass (AB), trees per hectare (TPH), average tree height (THAVE), average crown base height (CHAVE), average crown diameter (CDAVE), understory canopy coverage (USCOV), height understory (HUS), shrub coverage (SHRCOV).

Landsat Enhanced Thematic Mapper Plus (ETM+) scenes were acquired in July 2002 for both study landscapes. The scenes were atmospheric corrected using the cost correction model (Chavez, 1996) to convert the scenes to top-of-atmosphere reflectance, and an adaptive image fusion model (Steinrocher, 1999) to fuse the panchromatic to the multispectral bands at an output resolution of 15 m. LiDAR data were acquired in the summers of 2002 (PR) and 2003 (MM) at a post-spacing of 2 m. The point returns were classified as ground or non-ground (Evans and Hudak, in press), and several topographic and canopy structural variables were generated from the classified returns at a mapping resolution of 15 m. Several attributes from a DEM and from polygons objectively generated using eCognition (Definiens software, 2004) were also included (Davidson *et al.*, in review). A total of 36 spatial (e.g. DEM, eCognition polygon), ETM+ or LiDAR-derived predictor (X) variables were mapped across both study landscapes.

Nearest neighbor imputation assigns reference observations, measured at the 444 discrete field plot locations, to target observations, the 15 m pixels mapped continuously across the study landscapes. The Y variables measured at the field plots were assigned to the 15m pixels using the "Yet Another Impute" (YAI) package coded in R (Crookston and

Finley, 2006). The YAI calls another R package, *randomForest* (Breiman, 2001), to classify the Y variables based on covariance relationships to the X variables and other Y variables. First, *randomForest* bootstraps the plot data to build a “forest” of classification trees. YAI then assigns the reference observation that is most similar to each target observation; similarity is calculated as one minus the proportion of classification trees where the target observation is in the same terminal node as the reference observation (Crookston and Finley, 2006). Although YAI can predict from multiple nearest neighbors, only one nearest neighbor was used in this analysis. Unlike regression, imputation leverages the covariance relationships between Y variables, which is especially useful for mapping fuel attributes difficult to characterize from remotely sensed data alone.

Y variables	LiDAR & ETM+ (MM)	LiDAR & ETM+ (PR)	ETM+ (MM)	ETM+ (PR)
<b>BA</b>	0.60	0.77	0.51	0.68
<b>DWD</b>	0.47	0.40	0.36	0.44
<b>AB</b>	0.69	0.79	0.61	0.72
<b>TPH</b>	0.33	0.30	0.28	0.29
<b>THAVE</b>	0.85	0.81	0.87	0.73
<b>CHAVE</b>	0.71	0.78	0.73	0.76
<b>CDAVE</b>	0.54	0.68	0.61	0.62
<b>USCOV</b>	0.37	0.57	0.23	0.56
<b>HUS</b>	0.17	0.36	0.35	0.42
<b>SHRCOV</b>	0.33	0.52	0.50	0.54

## Results

Most correlations between imputed and observed Y variables improved when the LiDAR-derived X variables were included, compared to when only the ETM+ variables were employed (Table 1). Using LiDAR predictors alone only slightly lowered the correlations compared to using both the LiDAR and Landsat-derived predictor variables (not shown).

## Conclusions

The use of *randomForest* in the YAI package allowed for simultaneous prediction of several canopy and surface fuel attributes of interest. The Y variables of interest were more accurately mapped from 15 m binned LiDAR-derived metrics than from the Landsat ETM+ metrics. Regional acquisition of scanning LiDAR data would permit more accurate mapping of canopy and surface fuel attributes across the region than is currently possible.

## References

- Breiman, L. (2001)** Random forests. *Machine Learning* **45**: 5-32.
- Crookston N.L. & Finley, A. (2006)**. yalmpute: an R package for *k*-NN imputation. <http://cran.r-project.org/src/contrib/Descriptions/yalmpute.html> (accessed: 24 January 2007).
- Davidson, A.; Hudak, A.T.; Evans, J.S.; Gould W. & González, G. (in review)**. Multi-resolution image segmentation for delineation of forest landscape units.
- Definiens software (2004)**. eCognition professional 4.0. <http://www.definiens.com> (accessed: 30 January 2007).
- Evans, J.S. & Hudak, A.T. (in press)** A multiscale curvature algorithm for classifying discrete return lidar in forested environments. *IEEE Transactions on Geoscience and Remote Sensing*.
- Hudak A.T.; Crookston N.L.; Evans J.S.; Falkowski M.J.; Smith A.M.S.; Gessler P.E. & Morgan, P. (2006)** Regression modelling and mapping of coniferous forest basal area and tree density from discrete-return lidar and multispectral satellite data. *Can. J. Remote Sensing* **32(2)**: 126-138.
- Rollins M.G.; Keane R.E. & Parsons R.A. (2004)** Mapping fuels and fire regimes using remote sensing, ecosystem simulation, and gradient modelling. *Ecological Applications* **14(1)**: 75-95.
- Chavez, P.S. Jr. (1996)** Image-based atmospheric corrections—revisited and revised. *Photogrammetric Engineering and Remote Sensing* **62(9)**: 1025-1036.
- Steinnocher, K. (1999)** Adaptive Fusion of Multisource Raster Data Applying Filter Techniques. *International Archives of Photogrammetry and Remote Sensing*, **32**: pp. 108-115.

## **Land surface phenologies sensed by cooler earthlight: how passive microwave image series can reveal vegetation dynamics appropriate for landscape monitoring**

**G.M. Henebry, M. Doubková**

South Dakota State University, Geographic Information Science Center of Excellence (GIScCE), 1021 Medary Ave., Wecota Hall 506B, Brookings, SD, 57007-3510, USA.  
e-mail: Geoffrey.Henebry@sdstate.edu

### **Introduction**

Although the most terrestrial radiation or earthlight is emitted in the thermal infrared, there is significant flux in the cooler microwave region. These longer wavelengths pass through clouds, smoke, and haze yielding denser observational time series of land surface dynamics. Although synoptic observations from passive microwave radiometers have been studied for as long as optical sensors, early comparative studies indicated that microwaves were less responsive to land surface dynamics than observations in the optical region. Much of the subsequent research focus in the optical community focused on developing theory, tools, and techniques to enable quasi-operational mapping and monitoring of land surface status using multispectral, multirate image series. Much of the subsequent research focus in the microwave community focused on coping with vegetation as an irksome layer that veiled observations of the real variable of interest— soil moisture. We propose that the time is ripe to revisit the synergy of passive optical and microwave image time series within the context of modeling and monitoring land surface phenology.

### **Land Surface Phenology & Landscape Ecology**

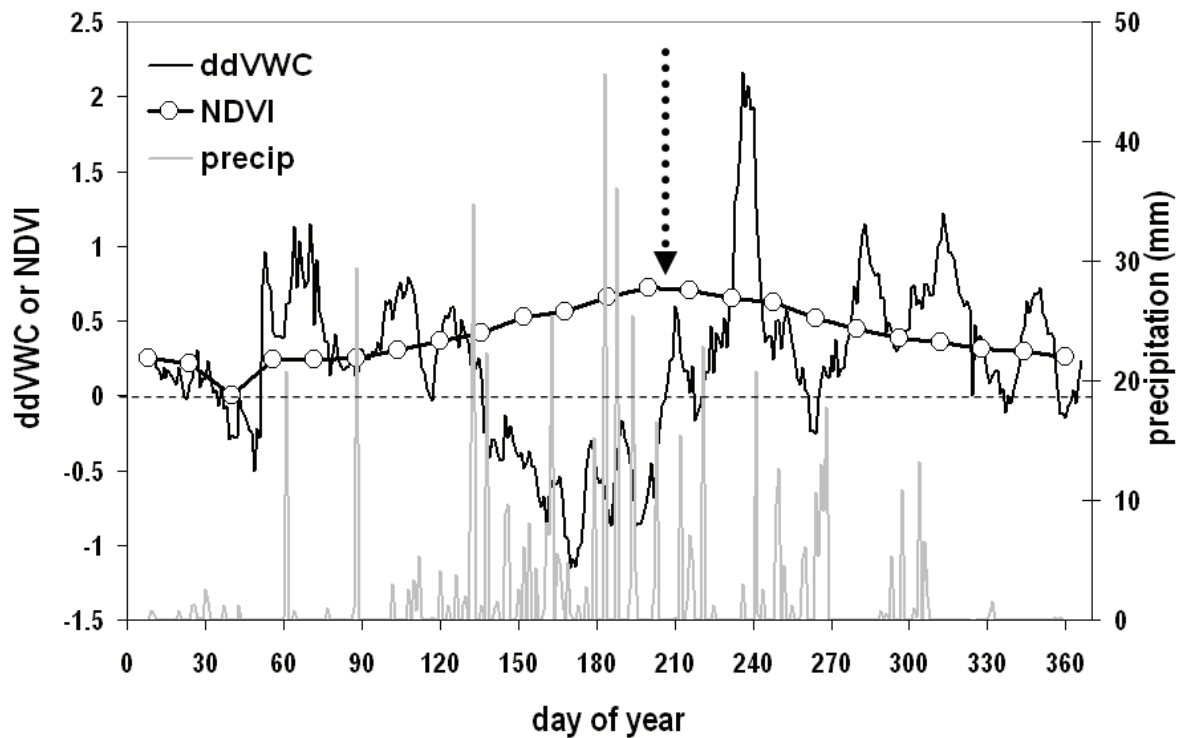
Land surface phenology (LSP) refers to the seasonal patterns of variation in vegetated land surfaces revealed by remote sensing. In contrast to the traditional concepts of phenology, which are centered on the seasonal growth and development patterns of specific organisms, LSP deals with mixtures of radiometric signals that arise from both biotic and abiotic sources. The spatial resolution of LSP studies is frequently coarse relative to landscape studies: <1m to 8km for optical sensors and ~25km for microwave radiometers. However, the significance of LSP for landscape ecology can be found in terms of the seasonal dynamics of habitat, its extent, its quality, and its movement. One environmental surrogate for habitat quality is the status of vegetation, broadly conceived. Many studies have explored how optical sensors can map habitat extent and quality by exploiting green vegetation's differential reflectance of red and near infrared light. In many landscapes habitat quality is linked to the moisture status of the surface, moisture both in soil and in vegetation. Few studies have explored how the moisture status of the vegetated land surface can be monitored using passive microwave radiometers. Here we show some preliminary results from herbaceous landscapes in North America and Northern Eurasia.

### **Sensing Cooler Earthlight at a Quick Tempo**

The current generation of passive microwave radiometers can observe the land surface twice daily (more frequently at the highest latitudes). Datastreams from the Advanced Microwave Scanning Radiometer-EOS (AMSR-E) onboard NASA's Aqua platform are processed daily at the National Snow and Ice Data Center (NSIDC) into various products, including global retrievals of surficial soil moisture and vegetation water content based on microwave brightness temperatures observed at multiple frequencies. Due to sensor orbit and swath width, gaps occur at the lower latitudes in daily products. At GIScCE we further processed the product-streams from the descending (01:30) and ascending (13:30) orbits into separate smoothed daily composites using an 8-day retrospective moving average.

Diel variations in canopy water content are routinely measured by plant ecophysiologicalists. A comparison of predawn and afternoon xylem pressure potential readings can indicate plant water status, including stress. Ecological research has shown an intimate connection between timing and variability of precipitation amounts, carbon allocation, biomass production, and species diversity. Were we able to monitoring plant water status synoptically on a daily basis, it may be possible to improve our understanding of intraseasonal dynamics of habitat quality, disturbance response, and susceptibility to invasion.

We propose that the diel difference in the AMSR-E L3 vegetation water content product may serve as a surrogate of canopy water status. We calculate the diel difference as:  $ddVWC = (\text{descending mode VWC} - \text{ascending mode VWC})$ . A positive  $ddVWC$  indicates water stress: the root zone moisture is not able to keep pace with evapotranspiration during the day, but the soil and canopy moisture equalize during the night. A negative  $ddVWC$  indicates that the water available in the root zone is meeting demands and the canopy is actively transpiring at the 13:30 overpass. The effects of precipitation (or irrigation) events and subsequent drydown are evident in Figure 1 as shifts first toward lower values (after the event) and then rising again (during drydown).



**Figure 1.** Seasonal progression of precipitation, vegetation extent (indicated by NDVI), and vegetation moisture status (indicated by  $ddVWC$ ) at Faulkton, South Dakota during 2004. Data from a single 25km AMSR-E pixel, the average of the 625 1km MODIS pixels falling within the AMSR-E pixel, and the weather station located within the AMSR-E pixel. Arrow indicates the seasonal transition from an active growth phase to chronic water-limitation.

## Diversity patterns of forest tree species (alpha, beta and gamma diversity) in the Central Andes of Colombia

J.E. Mendoza, W. Vargas, F.H. Lozano-Zambrano

Alexander von Humboldt Institute, Diag. 27 #15-09, Bogotá Colombia  
e-mail: jemendoza@humboldt.org.co

### Introduction

Spatial distribution of biodiversity changes according with the scale of analysis. The observed pattern within a local community can be different from the pattern found over broad scales such as landscapes and regions (Crist *et al.* 2003). According with Whittaker (1975) the different levels of biodiversity can be classified among ecological scales. Thus, local diversity ( $\alpha$ ); diversity among different habitats or turnover ( $\beta$ ), and diversity at landscape level ( $\gamma$ ). The last one will depend from the other two, and it will reflect the landscape heterogeneity (Pineda & Halffer, 2004). Applied to Whittaker's diversity components, gamma diversity is partitioned into the sum of the average alpha diversity and the beta diversity (Wagner *et al.* 2000). Because  $\beta$  is expressed by units of species richness, the contributions of  $\alpha$  and  $\beta$  to total species richness can be compared across spatial or temporal sampling scales (Crist *et al.* 2003). We analyzed different biodiversity levels (alpha, beta and gamma) in order to establish potential effects of habitat loss in terms of vegetal richness and diversity in Sub Andean landscapes of Colombia.

### Methods

We sampled four 2,500 ha rural landscapes with different fragmentation levels between 1,700 and 2,100 m on the western slope of the Central Andes: Mid Otún River watershed (80% native forest); Barbas River Canyon (46%), Mid Nima River watershed (25%), and Mid Chambery River watershed (20%). We analyzed different landscape elements with native forest land-cover: big forest fragments, small forest fragments and streams ( $n = 76$ ). Data of tree species (DBH  $\leq 5$ cm) abundance and richness were collected in 4 adjacent 50x4m transects.

We measured the Alpha diversity using Fisher's Alpha Index. Because we had different number of sampling sites among landscapes, Gamma diversity was measured as the number of species in each landscape using rarefaction individual-based method,  $n = 2100$  indiv. (Gotelli & Colwell, 2001). For these calculations we used PAST 1.62 (Hammer *et al.* 2001). Beta diversity was measured as the mean number of species not found in sites (Veech *et al.* 2002). We used the program PARTITON to generate expected values of beta diversity according to a null model, under the hypothesis that the observed partition of diversity could be produced by random allocation of samples (Crist *et al.* 2003; Kattan *et al.* 2006). Because we found significant spatial autocorrelation in our variables (Moran's Index between 0.55 to -0.85), and to reduce the likelihood of committing Type I errors, we used conservative level of significance in additive partitioning calculations ( $\alpha = 0.01$ ;  $P \leq 0.005$  and  $P \geq 0.995$ ).

### Results

The forest fragments had the highest alpha diversity values. Alpha values were positive correlated with patch size ( $r^2 = 0.52$ ;  $p < 0.01$ ). The species composition in tropical landscapes depends of the degree of forest cover (Halffter & Arellano, 2002).

The Filandia's landscape showed the highest richness value (204 species) followed by Nima, Otún and Chambery landscapes (201, 194 and 143 respectively). This could be explained by the middle disturbance theory (Farina, 1998). Filandia have presence of fine



timber trees (highly endangered), which are abundant in Otún, while Chambery seems to have exceeded its fragmentation threshold and is highly dominated by heliophytic pioneer species. Beta diversity accounted for 90.32% of the total gamma diversity of 410 tree species recorded at 76 localities. Most of this beta diversity was contributed by species differentiation among landscapes ( $\beta_3 = 54.83$ ;  $p = 0$ ). Beta diversity among sampling points contributed to 19.61% ( $p = 1$ ), and beta diversity among landscape elements to 15.88% ( $p = 0$ ) to gamma diversity.

## Conclusions

The sub-Andean region has a high beta diversity of trees. Most of this diversity was due to differentiation among landscapes. Species composition shows clear differences among landscapes, lack of forest interior species in highly fragmented landscapes that are present with good abundances in Otún and Filandia (80 and 46% forest respectively).

Our work is one of the first conducted regarding vegetal beta diversity in the Andes and highlight the conservation importance of remnant forests in fragmented landscapes because they preserve particular species assemblages and contribute to maintain high landscape heterogeneity.

## References

- Crist, T.O., Veech, J.A., Gering, J.C. & Summerville, K.S., (2003)**, Partitioning species diversity across landscapes and regions: a hierarchical analysis of  $\alpha$ ,  $\beta$ , and  $\gamma$  diversity, *The American Naturalist* 162:734-743.
- Farina A. (1998)**, *Principles and methods in landscape ecology*, Chapman & Hall, London UK.
- Gotelli, N. & Colwell, R. (2001)**. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* 4:379-391.
- Hammer, Ø., Harper D.A.T. & Ryan, P.D. (2001)**. PAST: paleontological statistic software package for education and data analysis. *Palaeontologia Electronica* 4(1):9pp. [http://palaeo-electronica.org/2001\\_1/past/issue1\\_01.htm](http://palaeo-electronica.org/2001_1/past/issue1_01.htm)
- Halffter, G., & L. Arellano. (2002)**. Response of dung beetle diversity to human-induced changes in a tropical landscape. *Biotropica* 34:144-154.
- Kattan, G.H., Franco, P., Saavedra, C.A, Valderrama, C., Rojas, V., Osorio, D. & Martinez, J. (2006)**. Spatial components of bird diversity in the Andes of Colombia. Implications for designing a regional reserve system. *Conservation Biology* 20:1203-1211.
- Pineda, E. & Halffter, F. (2004)**. species diversity and habitat fragmentation: frogs in a tropical montane landscape in Mexico. *Biological Conservation* 117:499-508.
- Veech, J.A, Summerville, K.S, Crist, T.O & Gering J.C. (2002)**. The additive partitioning of species diversity: recent revival of an old idea. *Oikos* 99:3-9.
- Wagner H.H., Wildi O. & Ewald C.E., (2000)**, Additive partitioning of plant species diversity in an agricultural mosaic landscape, *Landscape Ecology* 15:219-227.
- Whittaker, R.H. (1975)**. *Communities and Ecosystems*. MacMillan, New York. USA.

## Old-field succession changes along a precipitation gradient in SE Spain

J. Peña, A. Bonet, J. Bellot

Departamento de Ecología. Universidad de Alicante. Ap. Correos 99. 03080. Alicante. Spain.  
e-mail: JPL@ua.es

### Introduction

In the last decades, land use changes have experienced a dramatically rising, especially, land abandonment that represent 40% of all changes in Marina Baixa catchment (Alicante, SE Spain) (Peña *et al.*, 2007). The direct studies of successional change through time in old-fields are now yielding detailed information emerging from long-term studies of post-agricultural succession.

Most of the studies focused on successional changes have analysed extensively chronosequence plots (Pickett, 1989) in temperate climates (Myser and Pickett, 1994). However, there is a considerable lack of knowledge concerning the relationship between the dynamics of secondary succession and environmental factors (Prach, 1993) mostly in semiarid regions (Bonet, 2004).

### Study site

On Marina Baixa, strong environmental gradients occur over short distances due to elevated mountains (from 0 to 1550 meters above the sea level), e.g. with regard to precipitation. The precipitation gradient affects richness and relative abundance of groups and individual plant species. Using the Worldwide Bioclimatic Classification System proposed by Rivas-Martínez *et al.* (1999), appear three different Mediterranean ombrotypes: semiarid (200-350 mm), dry (350-600 mm) and subwet (600-1000 mm). This provides an excellent opportunity for studying how precipitation affects secondary succession in abandoned terraces.

### Methods

Plant cover was measured for all individuals of all plant species. Vegetation measurements were conducted using up to 200 plots arranged in the precipitation gradient, but in three different periods of abandonment –before 1956, 1956-1978 and 1978-2000– calculated using aerial photographs.

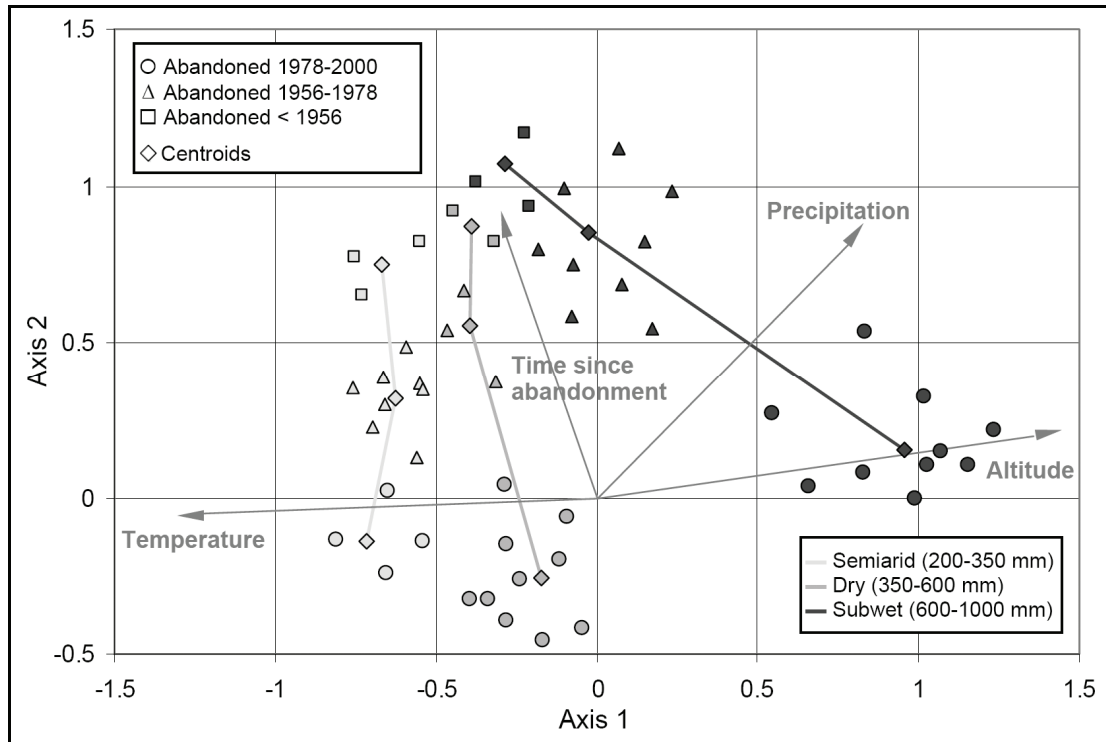
Temporal changes in floristic composition were analysed using Detrended Correspondence Analysis with detrending by segments (Hill, 1979) using CANOCO package (ter Braak and Smilauer, 1998). For ordinations, cover values were log transformed. To evaluate the importance of the factor time we ran canonical correspondence analysis (CCA) with time as the only environmental factor.

### Results

In the 200 plots studied, a total of 747 species of vascular plants were found; 24% of them were exotic. At the drier sites, total species number as well as the numbers of annuals and perennials increased with both time after abandonment and increasing precipitation reaching their maximum in the mature stands.

Species composition varied along the precipitation gradient. Herbs as well as shrubs and trees varied in abundance from the driest to the wettest places. Thus, abandoned fields at different rainfall conditions experience different succession changes through time. These results indicate that the precipitation gradient was the principal factor affecting plant species composition and time to recover land cover.

CCA ordination with four environmental variables and 9 centroids of replicates for the three Mediterranean ombrotypes is presented in **Figure 1**. The first axis showed a strong correlation with mean annual temperature, altitude and mean annual precipitation, while the second axis is correlated to time since abandonment.



**Figure 1.** CCA ordination including all three chronosequences (centroids of replicates) and four exploratory variables with the first two axes which explained 68.7% of the variance in the species data.

## References

- Bonet, A. (2004)** Secondary succession of semi-arid Mediterranean old-fields in south-eastern Spain: insights for conservation and restoration of degraded lands. *Journal of Arid Environments* 56: 213–233.
- Hill, M.O. (1979)** DECORANA a FORTRAN program for detrended correspondence analysis and reciprocal averaging. *Ecology and Systematics*. Cornell University, Ithaca, New York.
- Myster, R.W. & Pickett, S.T.A. (1994)** A comparison of the rate of succession over 18 yr in 10 contrasting old-fields. *Ecology* 75 (2), 387–392.
- Peña, J.; Bonet, A.; Bellot, J.; Sánchez, J.R.; Eisenhuth, D.; Hallett, S. & Aledo A. (2007)** Driving forces of land-use change in a cultural landscape of Spain. A preliminary assessment of the human-mediated influences. Koomen E., Bakema A., Stillwell J. and Scholten H. (Eds). *Modeling land-use change*, Springer, Netherlands, pp. 97-116.
- Pickett, S.T.A. (1989)** Space-for-time substitution as an alternative to long-term studies. Likens, G.E. (Ed.), *Long-term studies in Ecology*. Springer, New York, pp. 110–135.
- Prach, K. (1993)** On the rate of succession. *Oikos* 66 (2), 343–346.
- Rivas-Martinez S.; Sanchez-Mata D. & Costa M. (1999)** North American Boreal and Western Temperate Forest. *Itinera Geobotanica*, 12, pp. 5-16.
- ter Braak, C.J.F. & Smilauer, P. (1998)** CANOCO Reference Manual and User's Guide to Canoco for Windows: Software for Canonical Community Ordination (version 4). Microcomp. Power, Ithaca, NY, 349pp.

**Ecological values of regrowth vegetation for conserving and restoring bird communities in highly fragmented landscapes: a Brigalow case study from sub-tropical Australia**

**M.E. Bowen<sup>1,2</sup>, C.A. McAlpine<sup>1,2</sup>, A. House<sup>3</sup>, G. Smith<sup>4</sup>.**

<sup>1</sup> Centre for Remote Sensing and Spatial Information Sciences, School of Geography, Planning and Architecture, The University of Queensland, Brisbane, Australia, 4072.  
email: michiala.bowen@uq.edu.au

<sup>2</sup> The Ecology Centre, The University of Queensland, Brisbane, Australia, 4072.

<sup>3</sup> CSIRO Sustainable Ecosystems, Brisbane, Australia, 4072

<sup>4</sup> Biodiversity Sciences Unit, Environmental Sciences Division, Queensland Environmental Protection Agency, Brisbane, Australia, 4068.

Widespread habitat loss and fragmentation threaten the long term survival of fauna communities in many landscapes dominated by broad-scale agriculture. Conservation and recovery of these fauna populations is likely to rely to a large extent on landscape restoration (Young, 2000). While the task of landscape restoration can be a challenging one, in some landscapes unplanned passive restoration is already occurring as a result of land abandonment. In such landscapes, natural regeneration (regrowth) of native forests occurs following the cessation of agricultural practices such as crop production and domestic stock grazing. Land abandonment and forest regrowth is occurring in many biomes, including tropical, sub-tropical and temperate regions (Ramankutty and Foley, 1999).

In tropical areas, regrowth forests often result from shifting-agriculture practices. Small areas of mature forest are cleared, cultivated for a short time period (e.g., < 5 years), and then abandoned, allowing forest succession to commence (Brown and Lugo, 1994). These regrowth forests can promote relatively rapid recolonisation and recovery rates of fauna communities (Dunn, 2004). However, the low intensity of disturbance and the proximity of large tracts of undisturbed forests may be helping to accelerate recovery by providing a source of plant and animal recruits. Studies are needed in landscapes where faunal recovery in regrowth forests may be limited by more intensive land management practices and higher levels of habitat loss and fragmentation. An understanding of the ecological values of regrowth forest for fauna populations is an important step for planning a more targeted approach towards passive landscape restoration.

The distribution and abundance of animal populations can be influenced by habitat attributes at a range of spatial scales (Lindenmayer, 2000, McAlpine, *et al.*, 2006). Regrowth forests potentially have ecological values that may be considered from multiple spatial scales. Fine scale floristic or structural forest attributes may provide necessary foraging, shelter or breeding resources (e.g., Evelyn and Stiles, 2003). From a broader perspective, regrowth may play a role in buffering small remnant patches from edge effects or may improve matrix permeability for animals traversing the landscape (e.g., Antongiovanni and Metzger, 2005).

The aim of this study is to describe the relationship between bird community species richness and multi-scale spatial composition and configuration of regrowth and mature Brigalow (*Acacia harpophylla*) forests of Queensland, Australia, within a region dominated by broad-acre cereal crops and sheep/cattle grazing of native and exotic pastures.

The study area is located within the Brigalow Belt South bioregion of Queensland, Australia. The region has a semi-arid sub-tropical climate. Although less than 10% of the original Brigalow forest remains, when cultivation or intensive grazing practices are halted Brigalow regrowth develops from root suckers. However, the structural and floristic characteristics of Brigalow regrowth vary considerably from mature forest, with a far greater density of stems and lower diversity of tree, shrub and ground cover species (Johnson, 1964).

Timed-area searches were conducted for 20 minutes within a 50 m by 200 m transect at 82 survey sites. All birds heard and seen within the search area were identified and recorded. Survey sites were visited three times in summer and three times in winter. All surveys were conducted within the first four to five hours after dawn.

Within each of the bird survey sites, floristic diversity and structural components such as tree height, stem density and foliage cover were measured. Patch size, shape and landscape composition and configuration were measured from 2006 SPOT5 satellite imagery. Regrowth age and landscape history were derived from historical air photographs dating between 1945 and 2003.

Data analysis is currently ongoing. Using an information-theoretic approach (Burnham and Anderson, 2002), we are developing, testing and ranking a set of alternative generalised linear regression models to determine the influence of Brigalow regrowth on the species richness of bird communities in Brigalow landscapes. Predictors of bird species richness in the study area are arranged hierarchically, according to: forest stand habitat attributes, such as floristic diversity, structural composition and condition ( $\leq 1$  ha); forest patch composition and context (10s – 1000s ha); and the surrounding landscape structure (1000s – 10,000s ha).

## References

- Antongiovanni, M. & Metzger, J. P. (2005)** Influence of matrix habitats on the occurrence of insectivorous bird species in Amazonian forest fragments. *Biological Conservation* **122**: 441-451
- Brown, S. & Lugo, A. E. (1994)** Rehabilitation of tropical lands: a key to sustaining development. *Restoration Ecology* **2**: 97-111
- Burnham, K. P. & Anderson, D. R. (2002)** *Model selection and multi-model inference : a practical information-theoretic approach*. Springer, New York .
- Dunn, R. R. (2004)** Recovery of faunal communities during tropical forest regeneration. *Conservation Biology* **18**: 302-309
- Evelyn, M. J. & Stiles, D. A. (2003)** Roosting requirements of two frugivorous bats (*Sturnira lilium* and *Arbiteus intermedius*) in fragmented Neotropical forest. *Biotropica* **35**: 405-418
- Johnson, R. W. (1964)** *Ecology and control of brigalow in Queensland*. Queensland Department of Primary Industries Brisbane
- Lindenmayer, D. B. (2000)** Factors at multiple scales affecting distribution patterns and their implications for animal conservation: Leadbeater's Possum as a case study. *Biodiversity and Conservation* **9**: 15-35
- McAlpine, C. A., Rhodes, J. R., Callaghan, J. G., Bowen, M. E., Lunney, D., Mitchell, D. L., Pullar, D. V. & Possingham, H. P. (2006)** The importance of forest area and configuration relative to local habitat factors for conserving forest mammals: A case study of koalas in Queensland, Australia. *Biological Conservation* **132**: 153-165
- Ramankutty, N. & Foley, J. A. (1999)** Estimating historical changes in global land cover: Croplands from 1700 to 1992. *Global Biogeochemical Cycles* **13**: 997-1027
- Young, T. P. (2000)** Restoration ecology and conservation biology. *Biological Conservation* **92**: 73-83

## Landscape scale temperature predictions and vegetation models in mountainous regions

M.B. Ashcroft<sup>1,2</sup>, L.A. Chisholm<sup>1</sup> and K.O. French<sup>2</sup>

<sup>1</sup> GeoQuEST Research Centre, University of Wollongong, Wollongong, NSW, Australia.  
e-mail: mba97@uow.edu.au

<sup>2</sup> Institute for Conservation Biology, University of Wollongong, Wollongong, NSW, 2522, Australia.

### Introduction

Species Distribution Models (SDMs) can provide valuable information on the suitable habitat for plants and assist environmental managers make conservation decisions (Ferrier *et al.*, 2002). At the landscape scale a prevailing view is that the distribution of vegetation is determined by topography and land-use, with climate generally only influential at global or continental scales (Pearson and Dawson 2003). This perceived lack of a significant relationship between landscape scale vegetation patterns and temperature may be due to insufficient accuracy of temperature estimates. For example, models often utilise elevation as a surrogate for temperature or use elevation sensitive interpolations from weather stations. These methods may not be sufficiently accurate in mountainous landscapes when there are wide variations in exposure or fewer weather stations (Lookingbill and Urban, 2003).

This study aimed to improve landscape scale temperature estimates by utilising elevation, radiation, moisture, and a novel estimate of exposure to wind. The hypothesis was that more accurate temperature estimates would improve vegetation models, and provide a more meaningful explanation for the patchy mosaic of vegetation on the Illawarra Escarpment, near Sydney, Australia. Communities in the study area include moist and dry rainforests, moist and tall open eucalypt forests, and woodlands.

### Temperature estimates

Hourly temperatures were recorded at 40 sites from November 2004 until August 2006 using DS1921G iButton temperature loggers (Dallas Semiconductor/MAXIM). The daily minimum, maximum and average temperatures were calculated for each site. The data was split into seasonal periods of 3 weeks, and the average temperatures at each site during each period were related to elevation, radiation, moisture, and wind using linear regression. Wind was estimated from 24 directions (0° to 345° in 15° increments), and the direction that maximised the  $r^2$  was selected.

Elevation was found to be a reasonable predictor for average temperatures, which could be predicted with an average  $r^2$  of 0.57 ( $\pm 0.11$  s.d.) throughout the year. Minimum temperatures could be predicted reasonably well during the warmer months, but the  $r^2$  dropped to 0.43 ( $\pm 0.12$ ) in winter. Maximum temperatures were predicted quite poorly throughout the year, especially in summer where the  $r^2$  dropped to only 0.08 ( $\pm 0.04$ ).

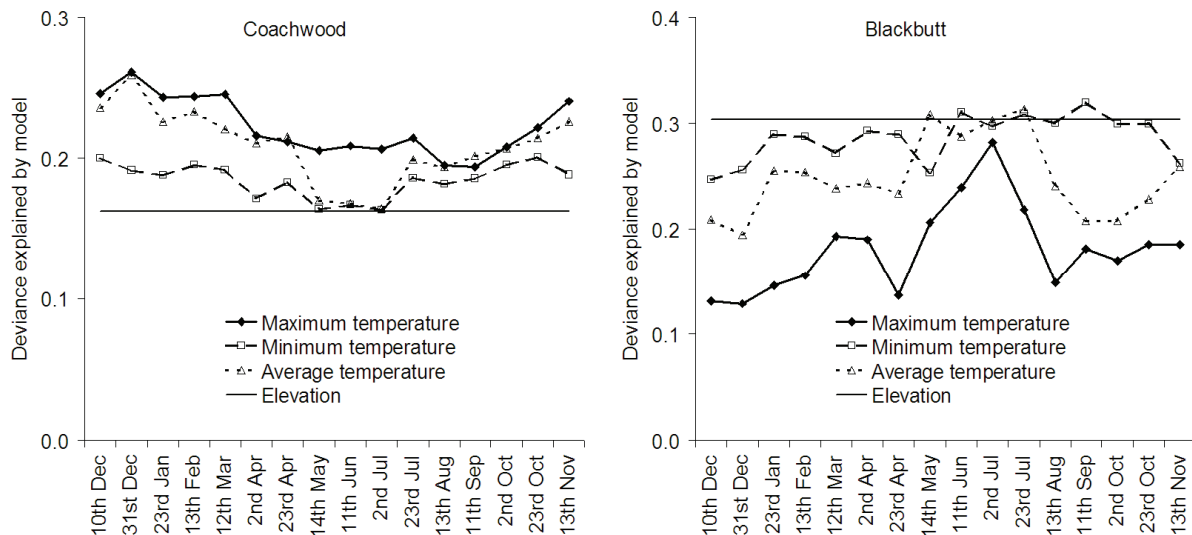
The average improvement in  $r^2$  that was achieved by including wind, radiation and moisture in the regressions for temperature was 0.17, but estimates for summer maximums were improved significantly - by an average  $r^2$  of 0.33. The improvements were largely attributed to the novel method for estimating the exposure to winds. For example, summer maximum temperatures were strongly influenced by warm-dry northwesterly winds, winter minimums were moderated by northeasterly sea breezes, and cold, moist southerly winds were influential in spring.

### Vegetation models

**Theme 10: Forests, vegetation and landscape**  
**10.2 Open Session 18: Spatial vegetation modelling**

The improved temperature estimates increased the performance of the Generalised Additive Models (Hastie and Tibshirani 1990) for the majority of species, with moist rainforest species in particular having the largest and most consistent improvements. For example, the deviance explained by the model for coachwood (*Ceratopetalum apetalum*) was increased by 61% (from 0.16 to 0.26) when summer maximum temperature was used instead of elevation (Figure 1). In contrast, eucalypts such as blackbutt (*Eucalyptus pilularis*, Figure 1) and dry rainforest species were often adequately modelled using elevation, although temperatures sometimes performed better at certain times of the year.

The results suggested that different species responded to temperatures during different seasons, and elevation did not capture the specific requirements for many species. The use of wind for temperature prediction allowed seasonal temperature patterns to vary dramatically as the influential wind directions changed and different sites became exposed or sheltered. This allowed the distributional pattern of species that responded to temperatures during one season to be different from those that respond to another time of the year. Species interactions and the varying combinations of seasonal temperatures have more potential to explain complex mosaics of vegetation than models that use only mean annual temperatures or elevation.



**Figure 1.** The performance of Generalized Additive Models for coachwood and blackbutt as assessed using the proportion of deviance that was explained. The horizontal lines illustrate the performance of a model containing elevation and geology. The other lines show the performance of models containing geology and either a minimum, maximum or average temperature from a 3-week seasonal period.

**References**

**Ferrier, S; Watson, G; Pearce, J. & Drielsma, M. (2002)** Extended statistical approaches to modelling spatial pattern in biodiversity in northeast New South Wales. I. Species-level modelling. *Biodiversity and Conservation* **11**: 2275-2307.

**Hastie, T.J. & Tibshirani, R.J. (1990)** *Generalized Additive Models*. Chapman and Hall, London.

**Lookingbill, T.R. & Urban, D.L. (2003)** Spatial estimation of air temperature differences for landscape-scale studies in montane environments. *Agricultural and Forest Meteorology* **114**: 141-151.

**Pearson, R.G. & Dawson, T.P. (2003)** Predicting the impacts of climate change on the distribution of species: are bioclimatic envelope models useful? *Global Ecology and Biogeography* **12**: 361-371.

### 10.3 Open Session 19: Vegetation and landscape fragmentation

#### How far past and present landscapes affect plant species richness depends on how landscapes change

A. Ernoult<sup>1</sup>, D. Alard<sup>2</sup>

<sup>1</sup> Université de Rennes 1, UMR CNRS 6553 ECOBIO, Ecologie du Paysage, Campus de Beaulieu, 35042 Rennes Cedex.

e-mail: aude.ernoult@univ-rennes1.fr

<sup>2</sup> Université Bordeaux I, UMR INRA 1202 BIOGECO, Ecologie des Communautés, F-33405 Talence.

#### Introduction

Landscape fragmentation, connectivity and heterogeneity around grassland communities are known to be potential drivers that contribute to variations in species richness by acting on the interchange of grasslands species between landscape elements (Soons et al. 2005). The intrinsic properties of each habitat patch *i.e.* shape and size, may also affect species richness (Krauss et al. 2004). Both kinds of drivers represent the habitat “landscape context”. However, there are still difficulties in studying the effects of this landscape context on species richness of communities, firstly because the role of local stressors is generally predominant (Palmer 1992) and secondly because the time lag that may exist between landscape and community changes is largely unknown (Lindborg and Eriksson 2004).

This paper analyses the relationships between plant richness in grassland communities, measured in 2003 and landscape variables operating at the local scale (*i.e.* landscape context) and for different dates. We intend to assess the weight of current landscape variables vs. past landscape variables with the hypothesis that different current landscape contexts as well as different histories should be responsible of richness variation.

#### Study site

This survey was conducted on the Seine valley floodplain that extends from Rouen to Le Havre estuary (France). Twenty sites (1 km×1 km) representative of the floodplain landscape were positioned along the Seine River at an altitude of less than 5 m. The landscape is a mosaic of wet grasslands, crops and orchards established on recent alluvia.

Until the beginning of the 20<sup>th</sup> century, the floodplain was mainly composed of wet grasslands surrounded with a developed hedgerow network constituting a typical “bocage” landscape. With the agricultural intensification and the setting up of drainage network, which followed the river embankment, these temporarily flooded lands dried up and the initial grassland landscape was converted into a more diverse mosaic of crops and grasslands, with a larger plot size and a decreasing hedge network (Ernoult et al. 2006).

#### Materials and methods

##### Grassland vegetation sampling

In order to study the variation of current grassland community structure, we performed a vegetation survey in May to July 2003. For each of the 168 records, we measured the Species Richness (SR).

##### Variables used for studying the “landscape context”

The past and current landscape context study was conducted on the 168 records for three dates (1963, 1985, 2003).



Three groups of variables were measured at the local scale.

- the first group characterised the intrinsic properties of each sampling grassland plot.
- the second group characterised sampling grassland plot boundaries.
- the third group of variables estimated the local environment of each vegetation record

The determination of the landscape context history was realised by multivariate analysis.

#### Relationships between the Species Richness and the “landscape context” variables

Relationships between current Species Richness (SR) and past and current landscape context variables were studied using Generalised Additive Models (GAM).

#### **Results**

Whatever the landscape history, the study confirms the link between the Species Richness and the current landscape context. The involved landscape features are mainly the permanent linear elements, i.e. the hedgerows network, roads grassy strips...

However, the results underline that the current species richness is better explained by the past landscape context. There are always the past linear elements which are involved in these correlations.

#### **Conclusion**

When considering different landscape histories, our results emphasize 1) the role of current landscape as a potential species source for grasslands. It ensures a spatial rescue-effect for grasslands communities; 2) a response delay of grassland communities to landscape dynamics. This time lag can be considered like a temporal rescue-effect which is under the control of the landscape histories.

#### **References**

- Ernault, A., S. Freire-Diaz, E. Langlois, and D. Alard. 2006.** Are similar landscapes the result of similar histories? *Landscape Ecology* **21**:631-639.
- Krauss, J., A. M. Klein, I. Steffan-Dewenter, and T. Tschardtke. 2004.** Effects of habitat area, isolation, and landscape diversity on plant species richness of calcareous grasslands. *Biodiversity and Conservation* **13**:1427-1439.
- Lindborg, R., and O. Eriksson. 2004.** Historical landscape connectivity affects present plant species diversity. *Ecology* **85**:1840-1845.
- Palmer, M. W. 1992.** The coexistence of species in fractal landscapes. *The American Naturalist* **139**:375-397.
- Soons, M. B., J. H. Messelink, E. Jongejans, and G. W. Heil. 2005.** Habitat fragmentation reduces grasslands connectivity for both short-distance and long-distance wind-dispersed forbs. *Journal of Ecology* **93**:1214-1225.

**Study on species-area relationship of small land-bridge islands and the small island effect in the Thousand Island Lake region of China**

**J. Lu<sup>1</sup>, Q. Sun<sup>1</sup>, J. Wu<sup>1,2</sup>, Z. Xu<sup>3</sup> and G. Zhao<sup>3</sup>**

<sup>1</sup>Agro-Ecology Institute, College of Life Science, Zijingang Campus, Zhejiang University, Hangzhou 310058, China.

e-mail: jianbo.lu@zjuem.zju.edu.cn

<sup>2</sup>Faculty of Ecology, Evolution, and Environmental Science, School of Life Sciences, Arizona State University, Tempe, AZ 85287-4501, USA.

<sup>3</sup>Institute of Applied Entomology, College of Agriculture and Biotechnology, Huajiachi. Campus, Zhejiang University, Hangzhou 310029, China.

### **Introduction**

The Thousand-Island Lake in China was created by a large dam constructed in 1958. Those islands in Thousand-Island Lake region were utilized as natural field proving ground and ecological “laboratory” of middle-small scale in our study (Wu *et al.*, 2003). The relationships between species richness of tree, shrub, woody plant, insect and small island areas were analyzed. We wanted to explore the quantitative relationship between plant species, insect species and small island areas in a large reservoir under the condition of a sub-tropical climate, to test the Small Island Effect (SIE), and to provide a theoretic basis for the protection of biodiversity in this area.

### **Methods**

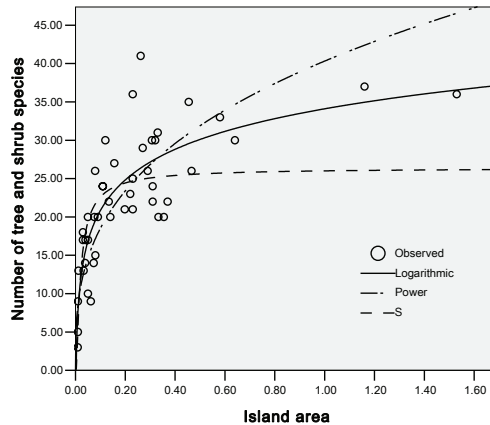
Small islands (0.001 ha < Area < 2 ha) in Thousand-Island Lake were selected as survey sites (Terborgh *et al.*, 2001). All of the species of trees and shrubs were investigated in each sample island in 2005 and 2006. Forty six islands which areas vary between 0.001 ha and 2 ha were investigated. Island areas were measured in the field with Global Positional System (GPS) and the GPS used in our study was GeoExplorer 3 produced by the Trimble Company of America.

In 2006, additional new 35 small islands (0.001 ha < Area < 2ha) were added as sampling sites, all insect species were investigated. Island areas were also measured by GPS.

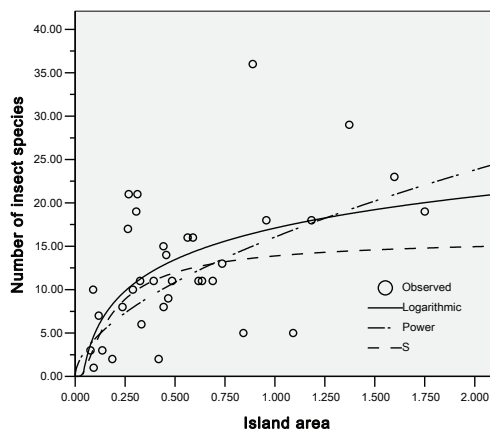
### **Results**

The species-area relationships in our study accorded with the power function curve in traditional theory toward those selected islands which areas are between 0.01 ha and 1.75 ha. The power curve showed better relationship between tree species and islands area than logarithmic and S curves. S curve could show relationship between shrub species and islands area more exactly, as well as the relationship between woody plant (tree and shrub) species and islands area (Fig. 1), also the relationship between insect species and islands area (Fig. 2).

Theme 10: Forests, vegetation and landscape  
10.3 Open Session 19: Vegetation and landscape fragmentation



**Figure 1.** Species-area relationship between total woody species and islands area (46 islands)



**Figure 2.** Species-area relationship between insect species and islands area (35 islands)

The Small Island Effect (SIE) was not obvious both on woody plant species and insect species in our study (Triantis et al., 2006). The z value of tree, shrub, woody plant, and insect species were 0.326, 0.386, 0.338 and 0.567, respectively.

### References

- Wu, J.; Huang, J.; Han, X.; Xie, Z. & Gao, X. (2003) Three Gorges Dam Experiment in habitat fragmentation? *Science*, **300**:1239-1240.
- Terborgh, J.; Lopez, L., V, P. N.; Rao, M.; Shahabuddin, G.; Orihuela, G.; Riveros, M.; Ascanio, R.; Adler, G. H.; Lambert, T. D. & Balbas, L. (2001) Ecological meltdown in predator-free forest fragments. *Science*, **294**:1923-1926.
- Triantis, K. T.; Vardinoyannis, K.; Tsolaki, E. P.; Botsaris, I.; Lila, K. & Mylonas, M. (2006) Re-approaching the small island effect. *Journal of Biogeography*, **33**: 914-923.

## Landscape structure and tropical tree seedling diversity in Atlantic rain forest, Brazil

L.F. Alves<sup>1</sup> and J.P. Metzger<sup>2</sup>

<sup>1</sup>Instituto de Botânica, Seção de Ecologia, C.P. 4005, 01061-970, São Paulo, Brasil.  
e-mail: lu\_alves@hotmail.com

<sup>2</sup>Instituto de Biociências, Departamento de Ecologia, Universidade de São Paulo, Rua do Matão, 321, trav. 14, 05508-900, São Paulo, Brasil

### Introduction

The fragmentation and spatial distribution of forest patches has consequences for tree biodiversity, at both landscape and fragment level. However, the degree to which fragmentation alters the subsequent forest regeneration and the regional biodiversity is poorly known. Connectivity and spatial arrangement of forest patches are expected to have important effects on tropical tree regeneration patterns in a regional perspective because long distances among forest fragments may limit seed dispersal, and diminish seed availability to forest regeneration.

The present study aimed to identify and evaluate the relationships among landscape structure and tree seedling diversity in a 10,000 ha fragmented area in SE Brazil. Tree seedlings were sampled from 600 1m<sup>2</sup> plots distributed across 15 forest fragments. We estimated the total number of species and seedlings, and landscape metrics for each forest patch, and then explored these relationships by applying a model selection approach (Akaike's Information Criterion; Burnham and Anderson 2002). This procedure was applied to increase our confidence to discriminate between models, without been confounded by highly inter-correlated predictor variables. We used two measures to select the best models: the delta AIC ( $\Delta_i < 2.0$ ) and evidence ratios  $< 2.7$ .

### Results

Results showed that richness and abundance were mainly influenced by the total core area (total patch size remaining after removing a specific buffer edge) and the proximity of surrounding forest areas (Table 1). The division of forest into small patches and isolation of other forest areas surrounding the focal patch have been seriously affecting the regeneration of shade-tolerant species that are dependent on biotic dispersion (Table 1). Edge density was also important for the abundance and richness of shade-tolerant and animal-dispersed species. Total core area was the unique landscape structure trait affecting the number of species and seedlings of abiotic-dispersed species, whereas isolation affected the regeneration of shade-intolerant species (Table 1).

### Conclusions

Maintaining large forest blocks surrounded by other forested areas is of importance in order to function as seed sources to forest regeneration of interior species at this Atlantic rain forest landscape. Long-term conservation of these forests may depend on the improvement of integrity of the remaining native forest fragments and its spatial arrangement across the landscape

Theme 10: Forests, vegetation and landscape  
10.3 Open Session 19: Vegetation and landscape fragmentation

**Table 1.** Akaike Information Criterion (AIC<sub>c</sub>) for the best regression models for tree seedling species richness and abundance in a fragmented landscape of Atlantic rain forest, Brazil. Core area, connectivity and proximity variables we logarithmic transformed.

Variable/Model	K	AIC <sub>c</sub>	Δ <sub>i</sub>	ω <sub>i</sub>	Evidence
<i>Total richness</i>					
core area	2	113.532	0.000	0.276	1.000
connectivity; core area	3	115.042	1.510	0.130	2.128
connectivity; core area; proximity	4	115.085	1.553	0.127	2.174
<i>Total abundance</i>					
proximity	2	183.636	0.000	0.242	1.000
core area	2	183.738	0.101	0.230	1.052
core area; proximity	3	183.813	0.177	0.222	1.092
edge density core area	3	184.047	0.410	0.197	1.228
<i>Richness biotic-dispersed species</i>					
core area	2	109.604	0.000	0.260	1.000
connectivity; core area	3	110.829	1.225	0.141	1.845
connectivity; proximity	3	111.160	1.556	1.119	2.177
connectivity; core area; proximity	4	111.305	1.700	0.111	2.340
<i>Abundance biotic-dispersed species</i>					
proximity	2	181.455	0.000	0.299	1.000
core area	2	182.170	0.716	0.209	1.430
core area; proximity	3	182.198	0.743	0.206	1.450
edge density; core area	3	182.521	1.067	0.175	1.705
<i>Richness abiotic-dispersed species</i>					
core area	2	68.680	0.000	0.713	1.000
<i>Abundance abiotic-dispersed species</i>					
core area	2	117.195	0.000	0.416	1.000
<i>Richness shade tolerant species</i>					
core area	2	106.687	0.000	0.352	1.000
connectivity; core area	3	107.270	0.582	0.263	1.338
connectivity; core area; proximity	4	107.610	0.923	0.222	1.587
<i>Abundance shade tolerant species</i>					
core area	2	181.517	0.000	0.243	1.000
core area; proximity	3	181.854	0.337	0.205	1.183
proximity	2	181.925	0.408	0.198	1.226
edge density; core area	3	181.936	0.419	0.197	1.233
<i>Richness shade intolerant species</i>					
proximity	2	63.880	0.000	0.351	1.000
<i>Abundance shade intolerant species</i>					
proximity	2	105.963	0.000	0.477	1.000

**References**

Burnham, K.P. & Anderson, D.R. (2002) *Model selection and multimodel inference: a practical information theoretic approach*. 2<sup>nd</sup> edition. Springer-Verlag, New York..

## Predicting invasion patterns of *Prunus serotina* Ehrh. in a heterogeneous forest landscape

O. Chabrerie, G. Decocq

Laboratoire de Biodiversité végétale et fongique, Université de Picardie Jules Verne, 1, rue des Louvels, 80037 Amiens Cedex 1, France.  
e-mail: olivier.chabrerie@u-picardie.fr

### Introduction

Alien plant invasions contribute significantly to global changes by often affecting biodiversity and ecosystem processes (Solbrig, 1991). Operational methods for identifying landscape attributes that promote or limit plant invasions are urgently needed to predict their future spread and manage them efficiently (With, 2002).

In this study, we explore the use of a landscape approach combining Geographic Information System (GIS) and multivariate analyses to evaluate and quantify the risk of invasion of a heterogeneous forest landscape by an exotic tree, *Prunus serotina* Ehrh.

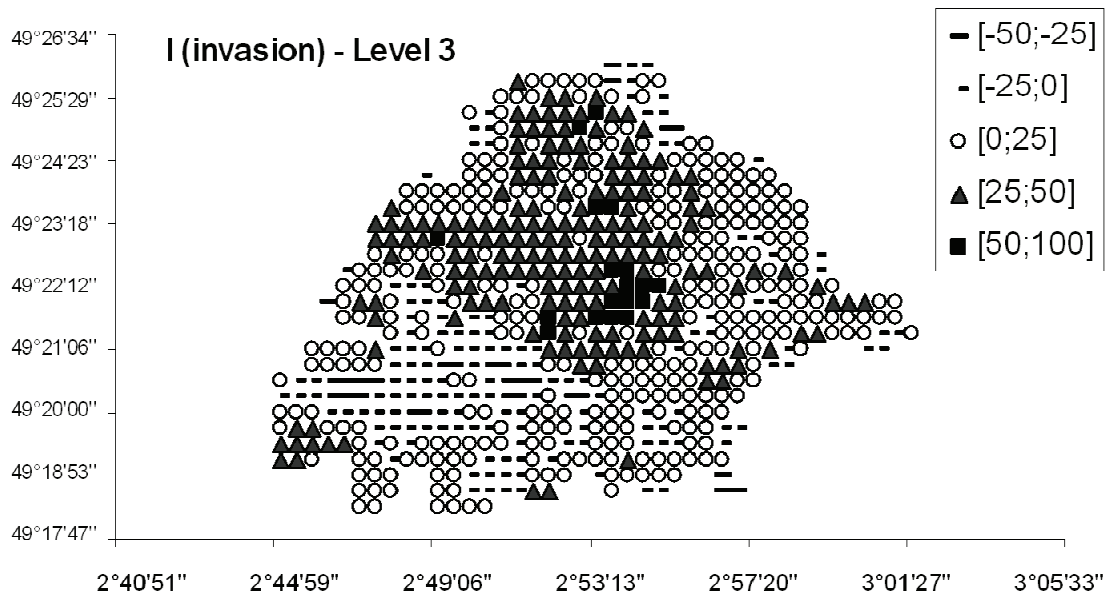
### Materials and methods

We combined landscape and functional ecology concepts (Forman & Godron, 1986; Lavorel & Garnier, 2002) to define Patch Mosaic Functional Types (PMFTs) as groups of landscape windows or cells sharing the same response to a plant invasion in a heterogeneous forest landscape (Chabrerie et al., in press). The invasion of a European temperate forest by the American black cherry (*Prunus serotina* Ehrh.) has been chosen as a case study. A set of variables was collected, mapped using a GIS, and analyzed with multivariate analyses to correlate landscape traits with *Prunus serotina* abundance in each cell of a grid which was previously overlaid on the forest map. A risk index was derived and mapped for three invasion levels: seedling colonization, tree establishment and cell invasion.

### Results and discussion

Five PMFTs were identified and characterized by a set of traits related to soil properties, land use, disturbance and invasion history. Scots pine plantations on podzols were the most invasible, while cells dominated by hydromorphic or calcareous soils were the most resistant. Most colonized patch mosaics provided suitable conditions for future establishment and invasion. Being strongly spatially connected, suitable patches provide corridors for *Prunus serotina* to colonize new parts of the forest. Conversely, the most resistant PMFTs were spatially agglomerated in the south of the forest and could act as a barrier. Colonization, establishment and invasion risk maps were finally obtained by combining partial risk associated to each landscape trait at the cell scale (Figure 1). Within a heterogeneous landscape, we defined and organized PMFTs into a hierarchy, according to their associated risk for colonization, establishment or invasion by a given invasive species. Each hierarchical level should be associated with a management strategy aiming at reducing one or more partial risk. Monitoring safe areas, extending cutting rotations, harvesting recently colonized stands tree-by-tree, promoting a multilayered understorey vegetation, cutting-down reproducing alien trees, favouring shade-tolerant, fast growing native tree species, removing alien trees at the leading edge and proposing soil enrichment or irrigation in heavily invaded areas are recommended.

Theme 10: Forests, vegetation and landscape  
 10.3 Open Session 19: Vegetation and landscape fragmentation



**Figure 1.** Spatial distribution of the invasion risk index over the Compiègne forest. Invasion level 3: *Prunus serotina* is the dominant canopy species. The map indicates forest areas resistant ( $I < 0$ ) or vulnerable ( $I > 0$ ) to *Prunus serotina* invasion. Each index can vary between  $-100\%$  to  $+100\%$ . X and Y axes correspond to longitude and latitude.

**References**

- Chabrierie, O.; Roulier, F.; Hoeblich, H.; Sebert-Cuvillier, E.; Closset-Kopp, D.; Leblanc, I.; Jaminon, J.; Decocq, G. (in press) Defining patch mosaic functional types to predict invasion patterns in a forest landscape. *Ecological Applications*.
- Forman, R.T.T. & Godron, M. (1986) *Landscape Ecology*, John Wiley & Sons (Eds), New York.
- Lavorel, S. & Garnier, E. (2002) Predicting changes in community composition and ecosystem functioning from plant traits: revisiting the Holy Grail. *Functional Ecology* **16**: 545-556.
- Solbrig, O.T. (1991) *From genes to ecosystems, a research agenda for biodiversity*. IUBS-SCOPE-UNESCO, Paris.
- With, K.A. 2002. The landscape ecology of invasive spread. *Conservation biology* **16**: 1192-1203.

## Dispersion of plant species in a scattered landscape on a regional scale; a modeling approach

G.W.W. Wamelink, J. van der Greft, R. Jochem, A.H. Prins, H.F. van Dobben & C. Grashof-Bokdam

Alterra, Wageningen University and Research centre, Wageningen the Netherlands.  
 e-mail: Wieger.wamelink@wur.nl

### Introduction

Due to human activities natural landscapes have become isolated. As a result the dispersion of plant species is hampered (Nathan *et al.* 2002). Isolated population may become extinct and cannot be re-established in a natural way. Moreover plant species may be forced to migrate to new areas due to climate change. Species survival may then depend on the connectivity of the landscape (Hanski & Ovaskainen 2000). The goal of this study was to develop a model that is able to simulate the plant species dispersion in a fragmented landscape on a regional to European scale, and to apply this model to several species.

### Model set-up

We developed a spatially explicit dispersion model (DIMO) based on dispersal capacity including wind dispersion, dispersion via animals (internal and external), vegetative dispersion, water dispersion and several forms of self inflicted dispersion. Barriers such as roads and rivers as well as unsuitable vegetation types are affecting the dispersion speed (Fig. 1). Spatially explicit data about the current and past occurrence of species is based on inventories in the Netherlands (FLORBASE/FLORON; [www.floron.nl](http://www.floron.nl) and TURBOVEG; Hennekens & Schaminée 2001). From the inventories the presence of a viable seed bank is derived. A species can (re) appear in a grid cell either by dispersion or from a viable seed bank. The establishment of a new species also depends on the biotic and abiotic quality, which is derived from other models. Species specific data to parameterize the model are derived from the LEDA-database ([www.leda-traitbase.org](http://www.leda-traitbase.org); Knevel *et al.* 2003). The dispersion capacity is corrected with a germination delay to account for predation of seeds, time to arrive in the seed bank and time till seeds are produced. All parameter values are species-specific.

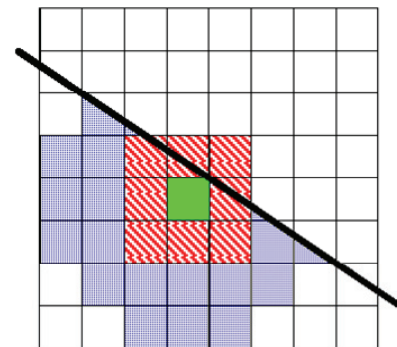


Fig. 1. Combined dispersion by wind (hatched cells) and animals (dotted cells) from one grid (solid dark grey cell) influenced by an absolute barrier (solid black line) for animals.

### Results & Discussion

For the first model runs we created a virtual plant species based on the species *Daucus carota*. The dispersion characteristics are given in Table 1.

Table 1. Dispersion characteristics used for the virtual plant species based on the plant species *Daucus carota*.

Parameter	Value	unit
Wind Dispersion - Uniform	250	$m^{-1} \cdot y^{-1}$
Animal Dispersion - Absolute Barriers	550	$m^{-1} \cdot y^{-1}$
Germination Delay	2	y
Seedbank Life Span	1	y
Run Time	120	y



We adapted the seedbank characteristics and present dispersion from *Daucus carota* (derived from FLORON/TURBOVEG), as well as the abiotic suitability from other models.

Fig. 2 shows that plant species whose survival depends on dispersal and presence in a seed bank may become isolated, and thus are not able to reach new suitable habitats due to the lack of connectivity of the landscape. In the future, populations that are not large enough may therefore become locally extinct. This process may be enhanced by climate change which may not only lead to local extinction but also to the total extinction of plant species due to the lack of suitable corridors.

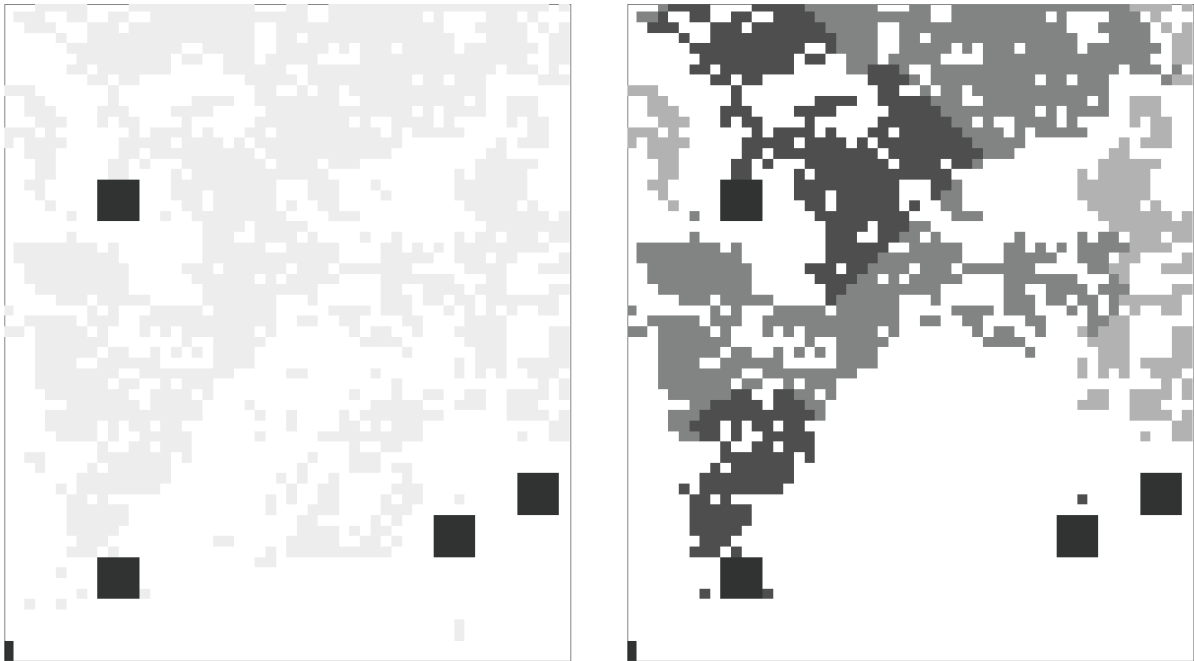


Fig. 2. Simulation of the dispersion of a virtual plant species based on data for *Daucus carota* after 120 years from present for a small part of The Netherlands (approximately 10\*10 km). Left and right the present occurrence of *Daucus carota* (solid black squares). On the left the prediction of the occurrence of *Daucus carota* based on abiotic suitability. On the right in grey scales the simulated occurrence of virtual species as dispersed from the sources. The greyer the cells, the longer the species is present. Note that in the low center of the right figure the virtual species is not present, though the abiotic circumstances are suitable.

### References

- Hanski, I. & Ovaskainen, O. (2000) The metapopulation capacity of a fragmented landscape. *Nature* 404: 755-758.
- Hennekens, S.M. & Schaminée, J.H.J. (2001) TURBOVEG, a comprehensive data base management system for vegetation data. *Journal of vegetation science* 12: 589-591.
- Knevel, I.C.; Bekker, R.M.; Bakker, J.P. & Kleyer, M. (2003) Life-history traits of the Northwest European flora: The LEDA database. *Journal of Vegetation Science* 14: 611-614.
- Nathan, R.; Katul, G.G.; Horn, H.S.; Thomas, S.M.; Oren, R.; Avissar, R.; Pacala, S.W. & Levin, S.A. (2002) Mechanisms of long-distance dispersal of seeds by wind. *Nature* 418: 409-413.

## 10.4 Open Session 20: Forest ecology and forest management

### Missing the third dimension – the missing parameters for forest birds and their habitats in forest landscape ecology

C. Purschke

Institut für Landespflege, Tennenbacher Str. 4, D- 79106 Freiburg, Germany,  
e-mail: christoph.purschke@landespflege.uni-freiburg.de

#### Introduction

Remote sensing approaches and data from thematic maps have many uses in landscape ecology. Many land cover features can be detected straightforwardly using satellite images. However, the delimitation of ecotones presents a more difficult task. The forested landscapes of central Europe are divided into discrete compartments by administrative borders, and property and management units. The vertical composition of forest stands is considered a particularly defining characteristic and forms the specific habitats of many forest species (e.g. Bauer *et al.* 2005). An effective determination of their appearance, for example, in maps, is not yet possible. Divided by age classes and the tree species mix, the forest edges are often clearly visible. In forests managed naturally the margins are less distinct; especially if they are arranged according to meta parameters (standing timber volume, tree species mixture, density of roads and tracks).

#### Birds in their forests

The differentiation of bird habitats is even more difficult than separating between neighbouring properties. Even production-oriented forests can possess a high degree of both structural and biological diversity. The height of forest stands, the branches (for cover, rest and refuge) and the foliage are multiparametric data. The vegetation cover – from the first decimetre above the forest floor up to the tree tops – forms a specific habitat and lends a seemingly chaotic structure to the birds' flight space. These spaces vary from entirely closed to less dense canopy to gaps.

As part of a study of two production forests in the southern Black Forest – one managed conventionally and the other employing a traditional form of nature-oriented management – the endowment with structures and their inhabitation by cavity nesting birds was investigated. As expected, the structural diversity of the conventionally managed forest was lower, particularly the layering.

In the forest managed according to nature-oriented principles the abundance of cavity nesting species was up to six times higher than in the conventionally managed stands (pygmy owl *Glaucidium passerinum*). The structures required by cavity nesting birds were present in greater quantities and forms than found in the ordinary forests, where these structures were restricted entirely to woodpecker holes.

#### How to generate data to reflect the vertical complexity?

Since habitats are formed by several layers of data quantitative approaches are fundamental for habitat analysis. Manually undertaken surveys of forest structure becomes prohibitive in terms of time and cost if sampling needs to be of sufficient density to incorporate small habitat structures as crucial factors to birds at the scale of large stands. Small numbers of sample points might be representative in even-aged monocultures. In contrary diverse stands as in irregular shelterwood systems or selection forests are represented by a high number in sampling plots. The more tree species form a stand the more variability in forest structure occurs. Silvicultural systems managing uneven-aged stands lead to a highly diverse structure vertically and also horizontally.

The vertical structure in forests is far more than an attribute in a horizontal extent (e.g. in GIS). Vertical structure in stands is required by woodpeckers and owls alike. Especially airborne LIDAR (Light Detection and Ranging; or Laser Imaging Detection and Ranging) is auspicious. LIDAR can be used as an effective tool for detecting detailed habitat structures including those of many birds (e.g. Bradbury *et al.* 2005).

Current systems have difficulties in receiving return pulses from the middle layers of the canopy at high density of the dominant tree layer. Maltamo *et al.* (2005) were able to classify multi-storey vertical structural classes in heterogeneous boreal forests. For central Europe with very dense canopy of beech stands (*Fagus sylvatica*) Aschoff *et al.* (2006) employed a terrestrial approach with fine grained models of bat habitats which remains laborious. Quantitatively hardly any intermediate layer of dense deciduous stands is represented correctly by current airborne systems. Undergrowth and dead trees, i.e. snags, remain hidden under dense canopy.

This study intends to show valuable data to vertical structure was gained by foliation profiles. The acquired data can easily be transformed to storey data and put into correlation to bird species demands. The smaller territories of birds are the closer the retrieved habitat structure is. Surveys on dead trees, cavities and other small sized elements lacking detectability by airborne systems are easily combined.

### Parameters for birds

Bird home ranges spanning forest stands (e.g. owls and larger woodpeckers) demand comprehensive spatial three dimensional data. Beside rare projects yielding data sets for mixed forests are hard to establish. LIDAR is an important tool and will become more so in the future.

The interpretation of the extent and density has to be adapted to every guild of focal forest species. Specific structures might occur only at several spots within the stands. All in one the mixture of a variety of vertical structure elements in their spatial arrangement are actually the true habitat to one forest bird species. Resolution has to involve the parameters of the focal bird – and its demands on the habitat – at the right scale, even in the case of regional approaches to habitat modelling for forest-dwelling birds.

### References

- Aschoff, T., Holderied, M.W. & Spiecker, H. (2006) Terrestrische Laserscanner zur Untersuchung von Wäldern als Jagdlebensräume für Fledermäuse. In: Luhmann, T. & Müller, C. (Eds): *Photogrammetrie – Laserscanning - Optische 3D-Messtechnik*. Beiträge der Oldenburger 3D-Tage 2006. Herbert Wichmann Verlag. Heidelberg. 280 - 287.
- Bauer, H.-G., Bezzel, E. & Fiedler, W. (Eds)(2005) *Das Kompendium der Vögel Mitteleuropas*. – AULA-Verlag, Wiebelsheim, 808 p. with the collaboration of: Baumann, S., Barthel, P.H., Berthold, P., Helbig, A.J., Hoi, H., Knaus, P., Ley, H.-W., Nipkow, N., Purschke, C. & Sproll, A..
- Bradbury, R.B., Hill, R.A., Mason, D.C., Hinsley, S.A., Wilson, J.D., Balzter, H., Anderson, Q.A., Whittingham, M.J., Davenport, I.J. & Bellamy, P.E. (2005) Modelling relationships between birds and vegetation structure using airborne LiDAR data: a review with case studies from agricultural and woodland environments. *Ibis*, **147**, 443-452.
- Hashimoto, H., Imanishi, J., Hagiwara, A., Morimoto, Y. & Kitada, K. (2004) Estimating forest structure indices for evaluation of forest bird habitats by an airborne laser-scanner. In: Thies, M., Koch, B., Spiecker, H. & Weinacker, H. (Eds) Laser scanners for forest and landscape assessment. Proceedings of the ISPRS working group. Freiburg, Germany, October 3-6, 2004. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences* **36** (Part 8/W2), 254-257.
- Maltamo, M., Packalén, P., Yu, X., Eerikäinen, K., Hyypä, J. & Pitkänen, J. (2005) Identifying and quantifying structural characteristics of heterogeneous boreal forests using laser scanner data. *Forest ecology and management* **216**, 41-50.

## Simulating the cumulative effects of multiple forest management strategies on landscape pattern and biodiversity

E.J. Gustafson<sup>1</sup>, D.E. Lytle<sup>2</sup>, R. Swaty<sup>3</sup>, C. Loehle<sup>4</sup>

<sup>1</sup> North Central Research Station, USDA Forest Service, 5985 Highway K, Rhinelander, WI 54501 USA.

e-mail: egustafson@fs.fed.us

<sup>2</sup> The Nature Conservancy, 6375 Riverside Dr., Suite 50, Dublin, OH 43017 USA.

<sup>3</sup> The Nature Conservancy, 125 W. Washington, Marquette, MI 49855 USA.

<sup>4</sup> National Council for Air and Stream Improvement, 552 S Washington Street, Suite 224, Naperville, IL 60540 USA.

### Introduction

While the cumulative effects of the actions of multiple owners have long been recognized as critically relevant to efforts to conserve biodiversity at the landscape scale, few studies have addressed these effects. Viable populations of many species cannot be maintained through the actions of a single landowner because these populations are sustained at much larger scales than the holdings of even the largest landowner. Population viability is a function of the combined actions of multiple landowners, which create a dynamic mosaic of forest types, stand structures and age distributions. Consequently, it is necessary to understand how the actions of individual land owners interact with the actions of others to determine the spatial pattern of the landscape mosaic, and therefore its ability to maintain biodiversity.

### Methods

We used the HARVEST timber harvest simulator to predict the cumulative effects of four owner groups (two paper companies, a state forest and non-industrial private owners) with different management objectives on landscape pattern of the forest mosaic in an upper Michigan (USA) landscape managed primarily for timber production. We quantified trends in landscape pattern metrics that were linked to Montreal Process indicators of forest sustainability, and used a simple wildlife habitat model to project habitat trends.

### Results

Our results showed that most trends were considered favorable for biodiversity, but that some were not. The proportion of all age classes (Fig. 1) and some forest types moved closer to pre-settlement conditions. The trend for the size of uneven-aged patches was essentially flat while the average size of patches of the oldest and youngest age classes increased and the size of patches of the remaining age classes decreased. Forest fragmentation generally declined (Fig. 2), but edge density of age classes increased. Habitat for animal species requiring older forests increased while species living in early successional forest declined.

### Implications

Our results challenge the conventional wisdom that uncoordinated commodity extraction activities by landowners with different objectives will lead to fragmentation, ecological simplification and an erosion of biodiversity. We found that the cumulative effects of the landowner management strategies were generally favorable for indicators of biodiversity. Each owner provides habitat conditions that cumulatively produce a positive result. Our approach provides a tool to evaluate such cumulative effects on other landscapes owned by other types of owners (e.g., national forest, timber investment companies, conservation groups). The model itself (HARVEST) is easy enough to use that conservation or landowner

Theme 10: Forests, vegetation and landscape  
 10.4 Open Session 20: Forest ecology and forest management

groups can apply it to develop and evaluate cooperative strategies to improve landscape patterns to conserve biodiversity. While our findings may be unique to this landscape, our study represents a modest but important first step in addressing the critical management issue of cumulative impacts in multiple-owner landscapes.

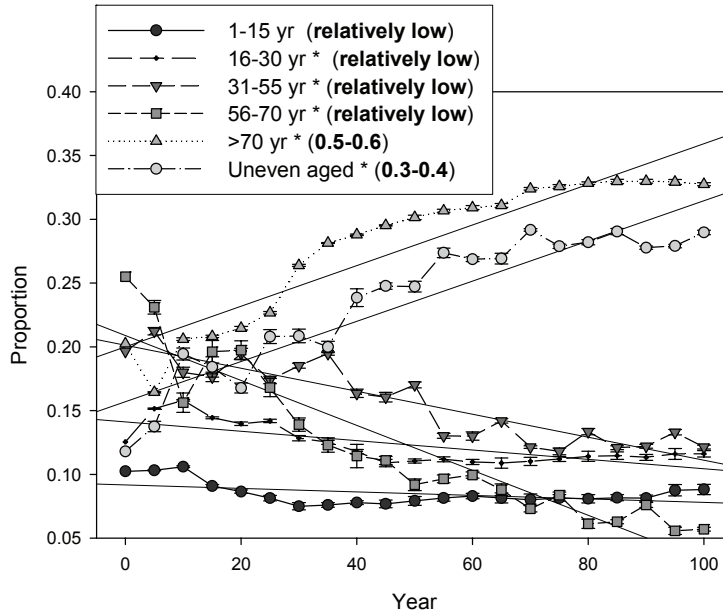


Figure 1. Proportion of age classes through simulated time. Points represent the mean of six replicates and the error bars indicate one standard error. The regression lines are fit to the points to describe the temporal trend for each forest type. An asterisk indicates a trend significantly different than zero ( $\alpha=0.05$ ). The pre-settlement proportion is in parentheses, and it is bolded if the trend is at or moving toward the pre-settlement value.

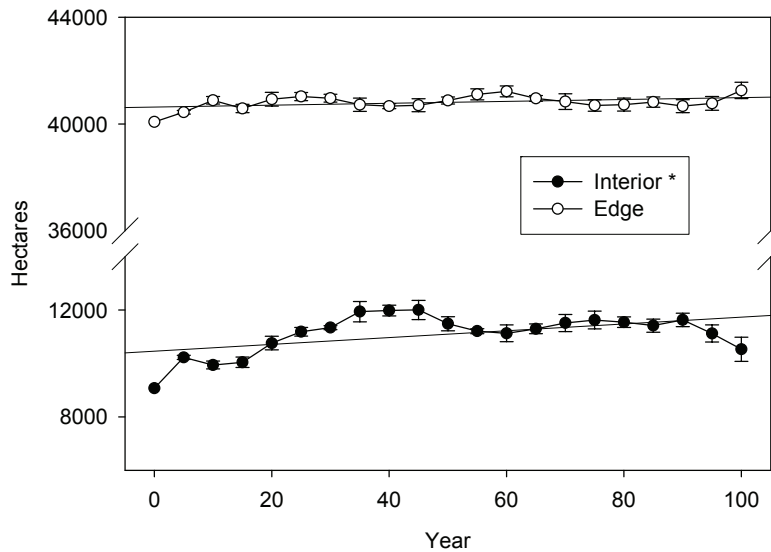


Figure 2. Mean area of forest edge and interior (forest >150 m from an opening) habitat through simulated time. Points represent the mean of six replicates and the error bars indicate one standard error (which may be smaller than the width of the symbols). An asterisk indicates significance.

## Forest landscape models: current status and challenges

H. S. He<sup>1,2</sup>

<sup>1</sup>Institute of Applied Ecology and Chinese Academy of Sciences  
<sup>2</sup>School of Natural Resources at the University of Missouri-Columbia  
203 ABNR Building, Columbia, MO 65211, USA  
e-mail: heh@missouri.edu

### Introduction

Forest landscape modeling has experienced a rapid development during the last 15 years, fueled by both technological and theoretical advances. They share common features, such as simulating (1) forest vegetation response at large spatial and temporal scales (e.g., in excess of 100,000 ha and 100 years) and (2) the outcomes of repeated, stochastic spatial processes (e.g., seed dispersal, fire, wind, insects, diseases, harvests, and fuel treatments). Depending on the model's purpose and design limitations, forest landscape models may differ in the key ecological processes incorporated, the extent to which mechanistic details are simulated for each process, and the type and scope of applications. In this paper, I provided definitions and explanations of some key terms that are commonly used in forest landscape modeling, including model entity, model object, spatially-explicit, spatial context, a general and a specific definition of forest landscape model. Based on these definitions, a general definition of forest landscape model is a model that predicts spatial characteristics (distribution, shape, abundance, etc.) of model objects, where as a specific definition of forest landscape model is a model that simulates spatiotemporal characteristics of at least one recurrent spatial process in a spatial context. Under this specific definition, a forest landscape model has the following characteristics: (a) it is a simulation model, (b) it simulates one or more spatial processes repeatedly, and (c) it operates at a large spatial and temporal extent that is adequate to simulate the spatial process. I also discussed two common modeling approaches, which are empirical and physical approaches as well as two types of models, which are deterministic models and stochastic models. The current trend has shown that physical details are increasingly being incorporated in these stochastic models

### Classification and characterization of forest landscape models

There have been a few attempts of classification and characterization of landscape models. In this paper, I opt to use a simple set of qualitative criteria to classify forest landscape models. Qualitative criteria are subjective and intuitive. These criteria are organized in a hierarchical order that creates a dichotomy tree. Each end node represents a group of models with similar traits (criteria). The criteria at and near the root level of the dichotomy tree reflect the specific definition of forest landscape models. Models that are non-spatial and models that are spatially explicit but do not require spatial context are separated from other forest landscape models.

The remaining criteria are general but fundamental to model design, modeling approaches, and consequently the scope of model applications. The most fundamental decisions include model temporal resolutions, one or multiple spatial processes included, and the method of simulating site-level succession.

The computational load of forest landscape models follows the Big O Notation and is affected by both the number of simulation entities (cell or polygon) and site-level complexity. Computational load increases with the modeling approaches that use a) spatial processes as surrogates for site-level succession, b) succession pathway approaches, and c) Vital attribute approaches.

My finding showed that forest landscape models have been developed using diverse approaches largely driven by the research or application as represented by the fact that

almost all end nodes contain a group of models. These models range from specific- tactical, strategic, and theoretical. All landscape models use both deterministic and physical approaches in certain aspects of their model simulations.

### **Applications of Forest Landscape Models**

Applications of Forest Landscape Models fall into three general categories. These are 1) the spatiotemporal patterns of spatial processes, 2) Sensitivities and uncertainties of spatial processes to input parameters, and 3) Scenario analyses. Examples are provided in discussing application examples under each category.

### **Challenges of Forest Landscape Models**

There are two dilemmas facing those using forest landscape models: result validation and circular reasoning. Independent time series data across time and space are not available and each real landscape is non-replicable and unique in nature. This difficulty renders the traditional model validation approach inapplicable to landscape models. Thus, for forest landscape models, result validations may involve the three following approaches. First, results from different simulation scenarios are compared; such comparisons reveal the magnitude and direction of change, which can provide a degree of assurance regarding the correctness of the model results. Second, simulated results can be compared with those simulated from other independently developed models. Third, results can be qualitatively or semi-quantitatively compared with those from long-term landscape scale experiments or empirical knowledge that are based on ecological principles.

In forest landscape modeling, it is often difficult to separate expected results from emergent results. A caution against circular reasoning is the caveat often encountered in this situation, where researchers discuss biological or environmental forcing (causes) of their modeled results, whereas the forcing (causes) is actually built in the model formulation to derive such results. It should be pointed out that most model simulations do not lead to new understanding of the modeled processes themselves, since the primary and subsequent results simply reflect the relationships used in building the models, which in turn reflect current understanding of the processes. The findings of these models are simply the spatiotemporal variations of the spatial process, not the mechanisms that drive the potential changes of the spatial process. Emergent results are generally those resulted from the interactions and feedbacks of model objects.

## The effects of restoration confirmed in pitch pine plantation in South Korea

H.C. Shin, C. S. Lee

Seoul Women's University, 126 Gongneung 2-dong, Nowon-gu, 139-774 Seoul, Republic of Korea,  
e-mail: leecs@swu.ac.kr

### Introduction

During the period of Japanese occupation (1910-1945) and the Korean War (1950-1953), many forests in Korea were severely degraded by over-cutting and fire. The South Korean government in the 1960s then launched large-scale tree planting campaigns to reforest these denuded mountains. Pitch pine (*Pinus rigida*) was the representative introduced species for those reforestation projects.

First of all, this study aims to clarify the nation-wide distribution pattern of pitch pine plantations and geographic characteristics of the sites. This study has another aim which is to evaluate the effects of reforestation by the introduction of pitch pine by analyzing soil properties, species composition and diversity, and vegetation dynamics based on restoration ecological principles.

### Results

Pitch pine plantations were usually set up in the western parts of South Korea, which has a low elevation and gentle slopes compared with the eastern region. The plantations were concentrated below 300m elevation above sea level and 20° degree slope. The plantation did not show any differences according to aspect. These results imply that pitch pine plantations could be set up on the degraded land by excessive land use.

Soil pH, water content, and thickness of litter layer among soil properties showed significant changes over years after reforestation. The species composition of pitch pine plantations showed differences depending on study areas, but is beginning to resemble to that of reference stands of native oak (*Quercus mongolica*). The distribution of stands in DCA ordination was usually dominated by pH, Ca<sup>2+</sup>, Soil moisture and K<sup>+</sup>.

The annual ring growth of pitch pine tended to decrease in the years following planting. However, the ring growth of oak growing in undergrowth under the canopy showed the reverse trend. The stand profile of pitch pine plantations with a reforestation age below 30 years lacks a sub-tree layer but older plantations maintain a stand profile of four layers including tree, subtree, shrub, and herb layers. In the older plantations, the cover of the sub-tree layer that replaces species compose sometimes overtakes that of pitch pine forming tree layer. As the results of analysis on frequency distribution of diameter classes of major tree species, most pitch pine plantations showed a trend of gradual replacement by native oak stands. Crown projection diagrams also showed the same trend. Based on the criterion of Aronson et al. (1993), reforestation carried out by introducing exotic plant species such as pitch pine plantation, corresponds to reallocation or replacement rather than restoration. But as is shown in the results of this study, pitch pine plantations, although formed by the introduction of an alien species, has been succeeded by native vegetation and thereby meet the restoration goal successfully. In South Korea, which experienced excessive forest exploitation under colonial rule war, reforestation has been among the top priorities of natural resource management particularly after the Korean War (1950 – 1953). Owing to those results the reforestation programs that were led by South Korean government during the past five decades are often cited as an 'exemplary model' of success around the world (Lamb and Gilmour, 2003).

### References



Theme 10: Forests, vegetation and landscape  
10.4 Open Session 20: Forest ecology and forest management

**Aronson, J.; Florest, C.; Le Floc'h, E.; Ovalle E. & Pontanier, R. (1993)** Restoration and rehabilitation of degraded ecosystems in arid and semi-arid lands. I. A view from the south. **Restoration Ecology 1**: 8-17.

**Lamb, D. & Gilmour, D. (2003)** *Rehabilitation and Restoration of Degraded Forests*. IUCN, Gland, Switzerland and Cambridge, UK and WWF, Gland, Switzerland, pp. 89-90.

## Landscape approach to sustainable forest management in post-socialist countries: Ukraine and Russia as case studies

M. Elbakidze<sup>1</sup>, P. Angelstam<sup>2</sup>

1. Ivan Franko National University of Lviv, 79000 Ukraine,  
e-mail: marine\_elbakidze@yahoo.com
2. Swedish University of Agricultural Sciences, SE-73921 Sweden

### Introduction

Europe's forest landscapes provide a vital natural capital on which human welfare and quality of life have been developed in a wide range of regions. A number of major policy processes at multiple levels have confirmed the importance of sustainable forest management concept. In order to support the implementation process at multiple levels we argue in favour of a landscape-based approach

Implementing Sustainable Forest Management (SFM) in a given landscape is highly dependent on the type of ecoregion, the environmental history, and the systems for government and governance. Europe' East and West is a unique "landscape laboratory" with steep gradients from centres for economic development to peripheral developing regions. We evaluate the wide range of regionally evolved practices for forest landscape planning and management, and the extent to which they are adapted to the natural conditions and patterns of land ownership and tenure (Angelstam and Törnblom, 2004).

### Theoretical background and methods

*A. Landscape concept as platform for integration and communication.* Working with a complex concept such as sustainability requires special emphasis on finding a common platform for communication among different elements (representing ecological, economic, socio-cultural values, including related disciplines and actors), as well as from policy to practice, and back again. We use the landscape concept to achieve this integration.

*B. Landscape concept as a tool for communication.* Landscape is an important concept within social sciences and natural sciences, and is a good interface for improving communication between them, increasing the understanding of the dependencies between social and ecological systems.

*C. Landscape approach as a tool for evaluation.* The landscape approach is an appropriate methodological tool to evaluate all dimensions of SFM. We consider a landscape as a social-ecological system which includes abiotic, biotic, social, cultural and administrative components interconnected with each other (Berkes *et al.*, 2003; Grodzinski, 2005). We evaluate how ecological, economic and socio-cultural dimensions of the sustainability are being implemented in forest landscapes in Russian Federation and Ukraine as countries in transition from a planned towards a market economy (Angelstam and Elbakidze, 2006).

Summarizing the main definitions related to SFM, we propose inserting the term landscape. The '*Sustainable Forest Landscape Management*' (SFLM) could then be defined as the stewardship and use of forests, forest lands, water and all living resources as well as cultural (human) components in a way that promotes sustainable use and conservation to fulfil, now and in the future, relevant ecological, economic and socio-cultural functions of landscapes at multiple scales through good systems of governance with the participation of all concerned stakeholders. In contrast with SFM, SFLM deals with whole forest landscapes as socio-ecological systems which are managed in the frame of a specific system of governance (Elbakidze and Angelstam, 2006, Elbakidze and Angelstam, in press).

To fully understand how the sustainability concept could be implemented under different conditions we argue that transdisciplinary research using multiple case studies should be conducted. We are currently establishing a network of transdisciplinary case studies using a suite of landscape scale management units in the Russian Federation and Ukraine. In order

to define the location of our case studies we have stratified European forest landscapes according to several factors: (a) biophysical conditions; (b) environmental history of forest use; (c) the cultural peculiarities, (d) systems of governance and planning.

## Results and discussions

Quantitative and qualitative data from multiple case studies representing different starting points and trajectories towards sustainable management of forest landscapes is an important resource for mutual learning not only in academia, but also among stakeholders, authorities and the general public. We argue that a multiple case study approach is a solution to achieve a transdisciplinary approach to landscape research. Ideally a network of transdisciplinary case studies on SFM approaches should be established in a suite of landscapes with diverse natural conditions and different settings of socio-economic development. The expected outcome of our research is a development of common toolboxes for comprehensive and flexible management for sustainable forest landscapes.

We developed the algorithm of our research in several steps: (1) to map all land users who are involved in use of forest resources; (2) to study types of forest use, the interaction among forest users in space and in time for identifying real and potential conflicts among land users and in land use; (3) to analyse and evaluate the system of governance for SFM in actual landscapes for understanding the gaps in forest policy creation and implementation process; (4) to develop indicators and tools for developing sustainable forest landscapes and scaling-up the best practises; (5) to make a gap-analysis and habitat suitability modelling for evaluation the ecological condition of forest landscapes as a result of natural dynamics and impact of land users.

We argue that the landscape approach based on multiple case studies will reveal a number of unexpected similarities between localities superficially quite different in terms of environmental, social and political features. Such similarities can be used to formulate guidelines of more general value, thus promoting the process of developing sustainable forest landscapes.

## References

- Angelstam, P. & Elbakidze, M. (2006)** Sustainable forest management in Europe's East and West: trajectories of development and the role of traditional knowledge. In: Parrotta, J. & Agnoletti, M. Johan, E. (Eds.), *Cultural heritage and sustainable forest management: the role of traditional knowledge*. MCPFE 2, 353-361.
- Angelstam, P. & Törnblom, J. (2004)** Maintaining forest biodiversity in actual landscapes – Europe gradients in history and governance systems as a “landscape lab”. In: Marchetti, M. (ed). *Monitoring and indicators of forest biodiversity in Europe – from ideas to operationality*. EFI symposium No. 51. pp. 299-313.
- Berkes, F., Colding, J. & Folke, C. (2003)** *Navigating social-ecological systems*. Cambridge University Press, Cambridge.
- Elbakidze, M. & Angelstam, P. (2006)** Role of traditional villages for sustainable forest landscapes: a case study in the Ukrainian Carpathian Mountains. In: Parrotta, J. & Agnoletti, M., Johan, E. (Eds.), *Cultural heritage and sustainable forest management: the role of traditional knowledge*. MCPFE 2, 375-384.
- Elbakidze, M. & Angelstam, P.** (In press) Interdisciplinary approach to sustainable management of forest landscapes. Lublin Catholic University.
- Grodzinski, M. (2005)** *Pisnannya landshapty: mistse I prostir*, Kiev University Press. (in Ukrainian)

## Effectiveness of protected areas in the Carpathians differs among countries in post-socialist times

T. Kuemmerle<sup>1\*</sup>, P. Hostert<sup>1</sup>, V.C. Radeloff<sup>2</sup>, and K. Perzanowski<sup>3</sup>

<sup>1</sup> Geomatics Department, Humboldt-Universität zu Berlin,  
Unter den Linden 6, 10099 Berlin, Germany

<sup>2</sup> Department of Forest Ecology and Management, University of Wisconsin-Madison,  
1630 Linden Drive, Madison WI 53706-1598, USA

<sup>3</sup> Carpathian Wildlife Research Station, MIZ, Polish Academy of Sciences,  
Ogrodowa 10, 38-700 Ustrzyki Dolne, Poland  
e-mail: tobias.kuemmerle@geo.hu-berlin.de

### Introduction

Forest ecosystems provide ecosystem services that are essential for human-wellbeing such as harbouring high biodiversity, sequestering carbon, and providing food and fibre. However, forest ecosystems are increasingly threatened by human land use. Protected areas are important to guard forest ecosystems and their biodiversity from human activities (Chape et al. 2005). However, some protected areas are less effective than others, and land-use and land-cover change in the neighbourhood of protected areas often reduces adjacent habitat (DeFries et al. 2005; Naughton-Treves et al. 2005). Measuring the effectiveness of protected areas and their management is therefore crucial (Chape et al. 2005) and commonly relies on comparing forest disturbance rates within protected areas and their neighbourhood (Naughton-Treves et al. 2005). Assessing the effectiveness of protected areas across country borders can also reveal important insights into the role of institutions, policies, and socio-economics. Transboundary protected areas in regions that are undergoing political and socioeconomic changes are particularly interesting, because they allow studying the effect of changing institutions and policies on the effectiveness of protected areas.

Eastern Europe has been undergoing dramatic changes in politics and socioeconomic since the fall of the Iron Curtain in 1989, and this has triggered forest cover change (Kuemmerle et al. 2007; Lerman et al. 2004). The Carpathians are Eastern Europe's largest contiguous forest ecosystem, provide habitat for many endangered species, and are a hotspot of biodiversity. Although several protected areas were established in the last decade to protect the region's unique forest ecosystems, the effectiveness of the protected areas during the political and economic transition remains largely unknown.

Our overarching research goal was to assess protected area effectiveness in the border triangle of Poland, Slovakia, and Ukraine (48.5-49.5N and 21.5-23.5 E) by comparing forest disturbance inside and outside protected areas. Our specific objectives were:

- (1) to derive forest disturbance maps between 1988 and 2000 using Landsat Multispectral Scanner (MSS), thematic Mapper (TM), and Enhanced Thematic Mapper data (ETM+), and
- (2) to compare forest disturbance rates inside and outside protected areas in each country

### Data & Methods

We used two Landsat TM images from the late 1980s (2<sup>nd</sup> October 1986 and 27<sup>th</sup> July 1988) to derive an initial forest/non-forest map for the initial situation before the system change based on multitemporal unsupervised clustering (ISODATA). Four Landsat MSS images (1977-79) were used to determine whether non-forest patches in 1986-88 represented disturbances such as logging, or were permanent clearings. To quantify forest change for the post-socialist period, we used three Landsat images from 1988 – 2000 (27<sup>th</sup> July 1988, 4<sup>th</sup> July 1994, and 6<sup>th</sup> June 2000). We applied the recently developed forest disturbance index (Healey et al. 2005) and composite analysis based on a hybrid

classification technique (Kuemmerle et al. 2006) to derive a forest disturbance map for each time period and calculated annual disturbance rates inside and outside protected areas.

## Results & Discussion

Our results showed increased forest disturbance rates (up to 1.8 times) in all three countries after the system change in 1989, likely due to changes in forest ownership, worsening economic conditions, and weakening of institutions. Between 1994 – 2000, disturbance rates decreased below pre-1988 rates. Protected areas generally exhibited less forest harvesting than their surrounding, but the effectiveness of protected areas differed markedly among countries. Protected area management was most effective in Poland, where disturbance rates inside protected areas were very low (annual rates of 0.02% or less). This is likely due to the low population density, the large area of the reserve, and its long history (founded already in 1977), which may have resulted in high local acceptance. In Slovakia, disturbance rates increased prior to the establishment of protected areas (with annual rates >0.4% before 1988), but dropped markedly below rates in their surrounding after protected areas were established. In Ukraine, protected area effectiveness was lowest. All protected areas experienced relatively high disturbance rates, often exceeding those in their surroundings (annual rate up to 0.86%). Disturbance rates were particularly high right before protected areas were designated, and did not decrease considerably after protected areas were established. This is likely a due to the scarcity of high-value timber, combined with the economic depression during the 1990s, a high population density in Ukrainian mountain valleys, and corruption and illegal forest harvesting (Nijnik and Van Kooten 2000).

Our results highlight that, as in other regions of the world, population density and poverty are important determinants for the effectiveness of protected areas. Yet, the strength of institutions is another crucial factor. Poland and Slovakia, where protected areas were effective, have strong institutions and were on the eve of EU accession in the late 1990s. In Ukraine, where governance is less transparent and institutions are weak, protected area effectiveness was much lower. The differences in the effectiveness of protected areas we found appear to be most closely related to differences in broad-scale socio-economic determinants, protected area management, as well as the strength of institutions, and these factors are likely to be equally important in other regions of the world.

## References

- Chape, S., Harrison, J., Spalding, M., & Lysenko, I. (2005).** Measuring the extent and effectiveness of protected areas as an indicator for meeting global biodiversity targets. *Philosophical Transactions of the Royal Society B-Biological Sciences*, **360**, 443-455
- DeFries, R., Hansen, A., Newton, A.C., & Hansen, M.C. (2005).** Increasing isolation of protected areas in tropical forests over the past twenty years. *Ecological Applications*, **15**, 19-26
- Healey, S.P., Cohen, W.B., Yang, Z.Q., & Krankina, O.N. (2005).** Comparison of Tasseled Cap-based Landsat data structures for use in forest disturbance detection. *Remote Sensing of Environment*, **97**, 301-310
- Kuemmerle, T., Hostert, P., Perzanowski, K., & Radeloff, V.C. (2006).** Cross-border comparison of land cover and landscape pattern in Eastern Europe using a hybrid classification technique. *Remote Sensing of Environment*, **103**, 449-464
- Kuemmerle, T., Hostert, P., Radeloff, V.C., Perzanowski, K., & Kruhlov, I. (2007).** Cross-border comparison of post-socialist forest disturbance in the Carpathians for the border region of Poland, Slovakia, and Ukraine. *Ecological Applications*, **in review**
- Lerman, Z., Csaki, C., & Federer, G. (2004).** Evolving farm structures and land-use patterns in former socialist countries. *Quarterly Journal of International Agriculture*, **43**, 309-335
- Naughton-Treves, L., Holland, M.B., & Brandon, K. (2005).** The role of protected areas in conserving biodiversity and sustaining local livelihoods. *Annual Review of Environment and Resources*, **30**, 219-252
- Nijnik, M., & Van Kooten, G.C. (2000).** Forestry in the Ukraine: the Road Ahead? *Forest Policy and Economics*, **1**, 139-151

## Structure, growth, and flood-induced dynamics of Tugai forests at the Tarim River in Xinjiang, NW China

S. Zerbe, N. Thevs

Institute of Botany and Landscape Ecology, University Greifswald, Grimmer Straße 88,  
D-17487 Greifswald, Germany.  
e-mail: zerbe@uni-greifswald.de

### Introduction

In the desert regions of Central Asia, Tugai forests are an important habitat for plant and animal life, contain a high biodiversity, and are a major natural resource for local people. On the other hand, vast areas of Tugai forests have been destroyed, e.g. in the Aral Sea Basin and the Tarim Basin. Tugai forests at the Tarim River are mainly built-up by *Populus euphratica*. This species is a phreatophyte, i.e. survives in the desert by growing long roots and thus establishing continuous contact to groundwater. Germination is only recorded after summer floods on freshly deposited, moist river banks. There, seeds are drifted by water and eventually germinate in lines according to the water level. On sites without flooding, *P. euphratica* reproduces vegetatively through root suckers (Wang *et al.*, 1996; Treshkin, 2001).

We investigate the structure, growth, and long-term development of these floodplain forests at the Tarim River in NW China, which are built-up by a single tree species, i.e. *Populus euphratica*. We are, in particular, interested in the age structure and regeneration of this key-stone species with regard to river dynamics.

### Study area and methods

Representative transects at the middle and lower reaches of the Tarim River (Xinjiang, NW China) are investigated in order to compare the relatively natural floodplain conditions at the middle reaches (Iminqäk) with the anthropogenically strongly altered at the lower reaches. The Tarim is fed by melt water and precipitation from the Tianshan Mountains. Thus, the Tarim carries annual floods from July to September. Each flood recharges the groundwater layer, which is the only water source for the vegetation, and changes the river course, as the floodplain is level. The annual precipitation does not exceed 50 mm.

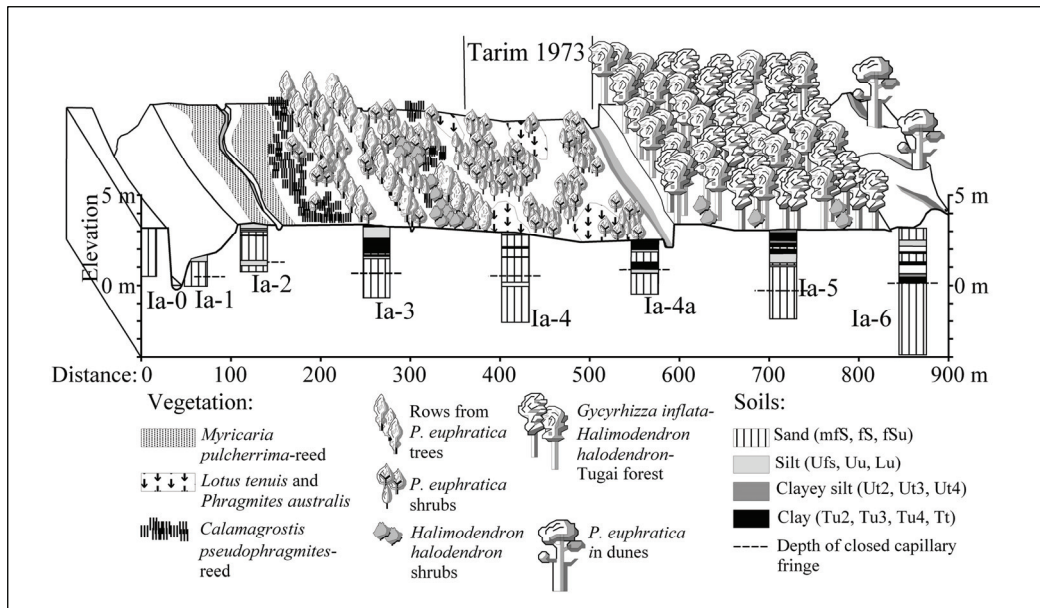
The natural river dynamics with annual summer floods and river course relocation still prevails along a 30 km stretch of the Tarim River between Yengi Bazar and Iminqäk in the Tarim Huyanglin Nature Reserve. This site serves as a model to understand the age structure and regeneration of Tugai forests. The lower reaches of the Tarim River run dry due to increasing diversion of water into irrigation since 1972. After 2000 water from the neighbouring Kaidu-Kenqi watershed and the inland delta along the middle reaches of the Tarim was diverted into the lower reaches of the Tarim River in order to preserve the Tugai forests along the lower reaches (Song *et al.*, 2000; Zhang *et al.*, 2005).

Age and growth increment are analysed applying dendrochronology and the vegetation is mapped along the transects. River course movements are traced back from Landsat and Quickbird satellite images over the past 35 years.

### Results

The research reveals that the river dynamics play an essential role for the reproduction of *Populus euphratica* and thus for the formation of Tugai forests. Within the transect at the middle reaches of the Tarim, which represents near natural conditions, saplings and young trees (age below 20 years) as a consequence of germination events are found. The trees which result from germination events appear in rows (Figure 1). Within the transect at the lower reaches, which represent the degraded forest sites, no young trees are found. An anthropogenic lowering of the groundwater table is not associated with a decrease in

average growth increment. However, the increment of the trees at the lower reaches abruptly increase after controlled flooding, thus showing signs of recovery.



**Figure 1.** Vegetation pattern, soil profiles, and elevation along a transect at Iminqäk, in the western part of the Tarim Huyanglin Nature Reserve in 2004. The transect runs from south to north (Thevs, 2006).

## Discussion

In Iminqäk, the floods and river dynamics form suitable germination sites, i.e. freshly deposited and moist river banks, where the seeds from *P. euphratica* are drifted by the water, and germinate in lines. Not every germination line is successful, as the dry period before the following summer flood hampers the establishment of seedlings. Therefore, we conclude that the bottleneck for the reproduction of the Tugai forests is the establishment and that an early onset of the flood in the year after germination is necessary for a successful establishment of seedlings.

## References

- Song, Y.; Fan, Z.; Lei, Z. & Zhang, F. (2000)** *Research on water resources and ecology of the Tarim River, China*. Xinjiang Peoples Press, Urumqi.
- Thevs, N. (2006)** *Ecology, spatial distribution, and utilization of the Tugai vegetation at the middle reaches of the Tarim River, Xinjiang, China*. PhD thesis, Greifswald University, Greifswald.
- Treshkin, S.Y. (2001)** The Tugai Forests of floodplain of the Amudarya River: ecology, dynamics and their conservation. In: Breckle, S.W.; Veste, M. & Wucherer, W. (Eds). *Sustainable Land Use in Deserts*. Springer, Heidelberg, pp. 95-102.
- Wang, S.; Chen, B. & Li, H. (1996)** *Euphrates Poplar Forest*. China Environmental Science Press, Beijing.
- Zhang, Y.; Chen, Y. & Pan, B. (2005)** Distribution and floristics of desert plant communities in the lower reaches of Tarim River, southern Xinjiang, People's Republic of China. *Journal of Arid Environments* **63**: 772-784.

## 10.5 Posters

### Searching for *Saintpaulia* - the elusive endemic of the Eastern Arcs

J. Nieminen

Department of Forest Resource Management, University of Helsinki, Latokartanonkaari 7 (PL 27), FIN-00014, Helsinki, Finland,  
e-mail: juhana.nieminen@helsinki.fi

#### Introduction

Tropical humid forests host two-thirds of all terrestrial species and regions such as the East Usambara Mountains, Tanzania, have been set aside as global biodiversity hotspots (e.g. Myers et al. 2000). Deforestation and encroachment have led to a reduction in open and dense natural forests in the region. Baseline data on endemics help to quickly and accurately delineating remaining priority forests and biodiversity patterns within these areas. The detection of forest and land cover changes at multiple scales is crucial when focusing on species distribution mapping. To ensure their future existence, knowledge on the driving forces behind the spatial patterns of species distribution and dispersion mechanisms is needed. Combining modelling methods from ecology and forestry sciences helps efforts to discover remaining habitats. This study strives to understand the spatial patterns driving the distribution of *Saintpaulia* species within the remaining forests.

#### Methods

The known localities with *Saintpaulia* were sampled firstly especially for physical geographical parameters. Vegetation information (herbaceous and woody plants) was compiled from prior larger scale inventories and updated with site specific information (i.e. vegetation structure, canopy closure). In total of 152 sites were recorded in the field. All localities with potentially suitable physical characteristics inside the Amani Nature Reserve and surrounding areas were inventoried. Field, remote sensing and ancillary data were analysed separately and together. Patterns from species abundance, diversity and richness were used as ancillary data in a non-parametric estimation method that allows the classification of satellite imagery using any number input criteria (Tokola et al. 1996). The spatial arrangement and dimensions of verified *Saintpaulia* sites were analysed to check for correlations of distribution and site characteristics, management history and relation with neighbouring patches.

#### Results and discussion

Detection of *Saintpaulia* habitats using only remote sensing data did not produce significant results. However, the use of ancillary data i.e. physical geographical parameters, gave a higher degree of predictive power. The most successful method for predicting sites was a combination of multi-criteria analysis methods and the products of a non-parametric k-NN estimation method. This study provides baseline data crucial for the mapping efforts in the surrounding mountain areas of the Eastern Arcs in the continuing search for the remnant patches of *Saintpaulia*.

#### References

- Myers, N; Mittermeier, R.A; Mittermeier, C.G; da Fonseca G.A.B. & Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature* 403: 853-858.
- Tokola, T; Pitkänen, J; Partinen, S. & Muinonen, E. (1996) Point accuracy of a non-parametric method in estimation of forest characteristics with different satellite materials. *International Journal of Remote Sensing*, 17 (12), 2333– 2351.



**CONEFOR Project - analysis of the connectivity of Spanish forested landscapes:  
implications for broad-scale forest planning and habitat conservation**

**L. Pascual-Hortal and S. Saura**

Forest Landscapes and Biodiversity Research Group. Department of Agroforestry  
Engineering. Higher Technical School of Agrarian Engineering. University of Lleida. Av.  
Rovira Roure, 191. 25198 Lleida. Spain.  
e-mail: lpascual@eagrof.udl.es

**Introduction**

The loss of connectivity of forested landscapes is one of the major threats for the conservation of the biodiversity and the ecological functions of forests. Fragmentation and isolation of habitat patches lead to a spatially structured habitat pattern in which movements of dispersing individuals may be constrained. This has led to an increasing interest in considering connectivity in broad-scale forest planning and management. However, there is a lack of operative methods that may allow adequately taking it into account in the decision-making process. So far connectivity analyses have mainly focused on obtaining an overall landscape connectivity value, but little efforts have been made in the prioritization of landscape elements, which may be more helpful.

For this purpose, we present a methodology based on graph structures, GIS analysis and new connectivity indices that enables identifying the most important patches for the maintenance of overall connectivity (Pascual-Hortal and Saura, 2006a, 2006b), which has been implemented in a specific software (CONEFOR Sensinode 2.2, a free copy can be obtained by contacting the authors) and funded by the CONEFOR project (REN2003-01628, Spanish Ministry of Science and Education). Graph structures may be used for quantitatively describing a landscape as a set of spatially or functionally interconnected patches, and are a powerful way of overcoming computational limitations that appear when dealing with large data sets and performing complex analysis regarding the intricate network of functional connections (Urban and Keitt, 2001). The new-developed indices we present improve the characteristics of existing ones, being both sensitive to all types of negative changes that can affect the landscape and effectively detecting which of those changes are more critical. We suggest approaching the connectivity problem within the wider concept of habitat availability in order to be useful for forest planning and conservation; this concept integrates topological (network) connectivity and habitat abundance and quality in a single measure.

We finally analyse the connectivity of forest cover in Spain at different spatial scales, to determine the critical sites for overall forest connectivity as well as the functionally connected subregions existing for forest-dwelling species with diverse dispersal ranges.

**References**

- Pascual-Hortal, L. & Saura, S. (2006a)** Comparison and development of new graph-based landscape connectivity indices: towards the prioritization of habitat patches and corridors for conservation. *Landscape Ecology* **21**: 959-967.
- Pascual-Hortal, L. & Saura, S. (2006b)** Integrating landscape connectivity in broad-scale forest planning: a methodology based on graph structures and habitat availability indices. R. Laforteza & G. Sanesi (Eds). *Patterns and processes in forest landscapes. Proceedings IUFRO Landscape Ecology Conference*. Academia Italiana di Scienze Forestali. Locorotondo, Bari, Italy, pp. 111-116.
- Urban, D. & Keitt, T.H. (2001)** Landscape connectivity: a graph-theoretic perspective. *Ecology* **82**: 1205-1218.

**Forest Fragmentation assessment using landscape matrices and Shannon's entropy index.**

**N. Lele<sup>1</sup>, P.K. Joshi<sup>2</sup>**

<sup>1</sup>ATREE, Bangalore.

e-mail: mail.nikhillele@gmail.com

<sup>2</sup>The Energy and Research Institute, New Delhi

The present study focuses on the importance of a landscape ecological approach for studying regional level forest cover fragmentation in one of the biodiversity hotspots - Northeast India. Till now, the region has been explored for species diversity as well as human disturbance. The present approach quantifies the landscape parameters for forest patches and fragmentation. Forest cover datasets have been generated over a multi-decadal period for the assessment of forest cover fragmentation, shape index and entropy. The study area has been under the threat of shifting cultivation, further enhanced by agriculture expansion, mining and removal of timber from forest for fuel wood and fodder collection. To encompass the degree of variability among the forest fragments, the present approach focuses on different sizes of forest patches within closed (>40% canopy density) and open (40-10% canopy density) forests for the analysis. The patches among two categories were further analyzed based on patch area into six classes; ranging from < 1 sq km to >500 sq km. It is noteworthy that patches of area between 1 sq km – 10 sq km and 10 sq km – 50 sq km have been severely fragmented. The number of forest patches with area >50 sq km area have increased owing to the break up of patches into small fragments. The shape index of small fragments varies in narrow range. An increase in open forest patches, linked to a decrease in dense forest area, indicates conversion from dense to open forest in the region. Increase in entropy values of dense forest indicates the same trend. Between 1982 and 1987, a major conversion from dense forest to other classes has been observed which is at a maximum as compared to other time series. In a spatial context, conversion of forest attributed to the shifting cultivation practice is observed in the field. It was also observed that patches of moderate size are being cultivated by groups of families. The present study gives an insight to the patch configuration and composition in terms of shape index and Shannon's entropy index.

**Forest fragmentation and its implication for biodiversity conservation in  
Xishuangbanna, SW, China**

**H-M. Li, Y-X. Ma, W-J. Liu, Z-W. Cao**

Xishuangbanna Tropical Botanical Garden, the Chinese Academy of Sciences, Kunming, China.  
e-mail: lihm@xtbg.org.cn

Disturbed by human activities, the large area of tropical forest became fragmented, which has negative effects on biodiversity. Xishuangbanna, located in the watershed of upper Mekong River, is situated in the northern margin of the tropical zone in South-East Asia. It maintains large areas of tropical rain forest and contains rich biodiversity. However, tropical rain forests are being rapidly destroyed in this region. The objective of this paper was to analyze spatial and temporal changes of forest cover and the patterns of forests fragmentation in Xishuangbanna area by comparing classified satellite images from 1976, 1988 and 2003 coupled by GIS analyses. The patterns of fragmentation and the effects of varying edge width in forests were examined using selected landscape indices. Current landscape is characterized by low forest habitat cover (from 69% in 1976 to less than 50% in 2003) in Xishuangbanna. Increase in the number of forests fragments (6096 to 8324) was associated with decreases in the mean patch size (217 to 115 ha) and a fragment size distribution strongly skewed towards small values. Forest types differ strongly in fragment size and internal habitat. Subtropical evergreen broadleaf forest was less fragmented than other types, being the dominant class in terms of surface. Fragmentation was heavier in forests occurring in agriculture-suitable areas, such as tropical seasonal rain forest and mountain rain forest. Due to the small size of fragments, the edge width was shorter in 2003 than that in 1976 when the total area of edge habitat exceeded core habitat in different forest types. Furthermore, the core area of tropical seasonal rain forest was smallest among main forest types at any edge width. The forest fragmentation within 12.5-km buffers around roads was heavier than that within total study area and nature reserves. The current forests cover within reserves in Xishuangbanna was preferentially bigger and less fragmented. However, the fragmentation of tropical seasonal rain forest and mountain rain forest was relative serious inside reserves. For conservation purposes, ways of establishing networks of forest fragments connected by corridors and stepping stone fragments are proposed. Moreover, the conservation efforts should be directed first toward the conservation of tropical rain forests at the relative altitude.

**Forest floristic indicators and landscape fragmentation in North West Lombardy (Italy): preliminary results**

**P. Digiovinazzo<sup>1</sup>, E. Ballabio, L. Bottoni<sup>1</sup>, E. Padoa-Schioppa<sup>1</sup>, C. Andreis<sup>2</sup>**

<sup>1</sup> Università degli Studi di Milano-Bicocca, Department of Environment and Landscape Sciences, Piazza della Scienza 1 – 20126 Milano Italy.  
e-mail: patrizia.giovinazzo@unimi.it

<sup>2</sup> Università degli Studi di Milano, Department of Biology, via Celoria 26 – 20133 Milano, Italy

We present ongoing research about a botanical and ecological study in woods on the morainic hills of north-west Lombardy, strongly fragmented because of the intense human impact.

The aim of the study is the determination of a group of floristic indicators significantly correlated with the environmental data. Our approach follows the concept of focal specie as “a group of species having spatial and functional requirements effectively defining environmental limits for the protection of other species present in the area” (Lambeck, 1997). We looked for a group of species linked to forests habitat and sensitive to landscape attributes like fragmentation.

In our study area (320 km<sup>2</sup>, among the metropolis of Milan, Lecco and Como Lake) there are both source elements (two natural parks largely forested) and about 216 woody fragments that may act as sink elements. The substratum is homogeneous (Würm morainic hills), with mesophyllous woods (oak-hornbeam forests). Woods are classified into *Carpinion betuli* Issler 1931, an alliance that includes hills and plain mesophyllous forests distributed on west Europe. Woody fragments have different dimension (mean size 24203,45 m<sup>2</sup> ± S.E. 3490,89 m<sup>2</sup>) and shape (A/P mean ratio 0,62 ± S.E. 0,012; Farina, 2001).

In order to obtain a group of floristic indicators we followed these criteria: we first elaborated 210 relevés coming from previous researches in a similar study area and we selected characteristic and differential species of *Fagetalia sylvaticae* Pawlowski in Pawlowski et al. 1928 and *Carpinion betuli* Iss.1931. Then we chose geophyte and hemicriptophyte, finally we selected species with Landolt L index ≤ 2 or H index ≥ 4, with frequency bigger than 20%.

These analysis allowed to determine a pool of 15 herbaceous indicators used to identify the fragments of woods better conserved: *Anemone nemorosa* L., *Aruncus dioicus* Fernald, *Brachypodium sylvaticum* Beauv., *Carex sylvatica* Huds., *Circaea lutetiana* L., *Euphorbia dulcis* L., *Geranium nodosum* L., *Lamium galeobdolon* Ehr. et Pol., *Luzula nivea* (L.) Lam et Dc., *Polygonatum multiflorum* All., *Primula vulgaris* Huds., *Pulmonaria officinalis* L., *Salvia glutinosa* L., *Symphytum tuberosus* L., *Viola reichenbachiana* Jord. ex Boreau.

First results in 20 patches already examined show the relationship between the number of floristic indicators and the dimension of the woody patches: Mann-Whitney U test (U = 21; p<0,05) and Spearman correlation coefficient (ρ = 0,484; p<0,05) show that the number of indicators is significantly higher for patch areas bigger than 20.000 m<sup>2</sup>.

Next steps will be the assessment of the relationship between the number of indicators and the remaining patches and among other environmental parameters as woody structure, shape of the patch, distance between the patches.

## References

- Lambeck R.J., (1997).** Focal species: A multi-species umbrella for nature conservation. *Conservation Biology* **11** (4): 849-856.
- Farina A., (2001).** *Ecologia del paesaggio: principi, metodi, applicazioni*. UTET, Torino.

## Modelling vegetation change in the British countryside

A.P. Blain<sup>1</sup>, L.G. Firbank<sup>1</sup>, S. Smart<sup>1</sup>, S.P. Rushton<sup>2</sup>

<sup>1</sup>Centre for Ecology and Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster, LA1 4AP, United Kingdom.

e-mail: [albl@ceh.ac.uk](mailto:albl@ceh.ac.uk)

<sup>2</sup>Centre for Life Sciences Modelling, University of Newcastle Upon Tyne, Devonshire Building, Newcastle upon Tyne, Tyne and Wear, NE1 7RU, United Kingdom.

### The Countryside Survey Series

The Countryside Survey is a series of surveys designed to measure and evaluate stock and change of land cover, landscape features, freshwaters, habitats and the vegetation of Great Britain (Haines-Young *et al.*, 2000). Data are available for 1978, 1990 and 1998 surveys, covering over 500 one kilometre square replicated sampling sites, selected at random using environmental stratification. Within each kilometre square a number of replicated vegetation surveys were carried out at a variety of plot types. The vegetation survey allocates plots to one of eight major vegetation classes based upon the species composition of the sample sites. These can be further divided into 100 subclasses for more specific analysis.

### Analysis

#### Multivariate analysis and modelling

Markov modelling techniques are applied to the vegetation datasets, with the broad aim of predicting the results of the next survey, due in 2007. Multivariate techniques have been used to identify links between the observed changes in vegetation and the known drivers of vegetation change. Predictions are made on a plot by plot basis using various general linear models.

#### Visualisation

The results are presented on a national scale using CIS (Countryside Information Service) software. The relative impacts of known drivers of vegetation change are presented according to their predicted impact on the results of the next survey.

### References

Haines-Young, R.H; Barr, C.J; Black, H.I.J; Briggs, D.J; Bunce, R.G.H; Clarke, R.T; Cooper, A; Dawson, F.H; Firbank, L.G; Fuller, R.M; Furse, M.T; Gillespie, M.K; Hill, R; Hornung, M; Howard, D.C; McCann, T; Morecroft, M.D; Petit, S; Sier, A.R.J; Smart, S.M; Smith, G.M; Stott, A.P; Stuart, R.C. & Watkins, J.W. (2000) *Accounting for nature: assessing habitats in the UK countryside*. DETR, London ISBN 1 85112 460 8.

**How well do pollen samples reflect changes in grazing pressure in heterogeneous landscapes?**

**H.H. Wagner<sup>1,2\*</sup>, F. Gillet<sup>3,4</sup>, F. Mazier<sup>5</sup>, P. Sjögren<sup>6</sup>, B. Ammann<sup>6</sup>, A. Buttler<sup>3,4</sup>, C. Scheidegger<sup>1</sup>**

<sup>1\*</sup> Swiss Federal Research Institute WSL, Zürcherstrasse 111, CH-8903 Birmensdorf, Switzerland,

e-mail: helene.wagner@wsl.ch

<sup>2</sup>University of Toronto at Mississauga, Mississauga, ON, L5L 1C6, Canada.

<sup>3</sup>Swiss Federal Research Institute WSL, Antenne romande, 1015 Lausanne, Switzerland.

<sup>4</sup>EPFL, Swiss Federal Institute of Technology, 1015 Lausanne, Switzerland.

<sup>5</sup>University of Franche-Comté, 25030 Besançon, France.

<sup>6</sup>University of Bern, 3000 Bern, Switzerland.

Fossil pollen records provide an excellent archive of historic vegetation. However, local vegetation typically results from a combination of processes, including (i) local climate, (ii) past or present human land use and landscape management, (iii) topography, geology and edaphic site conditions, and (iv) ecological processes relating to succession and plant – herbivore interactions. Successful reconstruction of climate or land-use change needs to account for these confounding effects. We combined a spatially explicit, process-based model of landscape management and vegetation dynamics (WOODPAM) with a model of pollen flow based on pollen productivity estimates and simulated pollen dispersal (POLFLOW) in order to assess how changes in grazing intensity in a heterogeneous landscape are reflected in pollen deposits. Preliminary results suggest that a single pollen profile may reflect overall grazing intensity in a landscape with little topography and high grazing intensity only. In a heterogeneous landscape, the landscape pattern introduces gradients of grazing pressure, especially at lower stocking rates, and may lead to a systematic nutrient shift. This results in a divergence of vegetation dynamics within the management unit, so that the assessment of land-use intensity from pollen deposits becomes highly dependent on the sampling location.

### Landscape ecology analyses in a critical coastal area of Southern Italy

M.T. Carone<sup>1</sup>, T. Simoniello<sup>2</sup>, A. Acampora<sup>1</sup>, M.P. Vaccaro<sup>1</sup>

<sup>1</sup>ARPAB, via della Fisica 18, 85100 Potenza – Italy;

e-mail: mariateresa.carone@arpab.it

<sup>2</sup>IMAA-CNR, C.da S. Loja, Z.na Ind. 85050 Tito (PZ) – Italy

The need to preserve precious ecosystems in areas critical because of human activities has become a topical challenge in the last decades. Such a need continuously forces the decision makers towards the finding of a correct balance between human and natural environment. This balance can be achieved only when management decisions are based upon a deep knowledge of the landscape temporal dynamics.

Landscape Ecology can be a powerful tool for understanding such dynamics since it analyzes landscape patterns and their changing in time by considering natural and anthropical environments as a unique integrated system (Farina, 1998; Leitão and Ahern, 2002).

In this work a critical coastal area of Southern Italy has been studied by using a chosen set of landscape ecology indices (Landscape metrics).

The area is characterized by the presence of peculiar evergreen forested ecosystems, protected by the European community, and by a strong incidence of human activities that has been expressed, besides agriculture, through the construction of an important tourist port at the outlet of the Agri River. Furthermore, forested areas are frequently affected by fire events.

The landscape metrics have been computed over multi-temporal land-cover maps of the area obtained from classifications of three Landsat-TM sub-scenes (1987, 1996, 2004).

The analyses show that the agricultural matrix does not present important changes during the observed period. On the contrary metrics concerning wooded and transitional areas point out two important phenomena of the adopted management: a significant dynamic on the first ones and a trend towards the isolation for the second ones, which may suggest an increase of their sensitivity.

The forthcoming of the present work aims to evidence the best sites for environmental interventions useful to increase the connectivity among forested and shrub patches and thus, for a general improvement of landscape functioning.

#### References

**Farina A. (1998)** *Principles and Methods in Landscape Ecology*. Chapman and Hall.

**Leitão & Ahern (2002)** Applying landscape ecological concepts and metrics in sustainable landscape planning. *Landscape and Urban Planning* **59**: 65-93.

## Landscape changes due to native forest loss along a precipitation gradient in the Chaco region, Argentina

M. G. Parmuchi, J. Bono, M. Stamati, C. Montenegro, M. Brouver, E. Manghi, M. Strada

Unidad de Manejo del Sistema de Evaluación Forestal (UMSEF) – Dirección de Bosques – Secretaría de Ambiente y Desarrollo Sustentable de la Nación (Forest Evaluation System Management Unit - Native Forest Division - Secretariat for the Environment and Sustainable Development), San Martín 451 – (1004) Ciudad de Buenos Aires – Argentina.  
umsef@medioambiente.gov.ar,

### Introduction

The analysis of native forest loss and its spatial distribution in Chaco, Selva Tucumano Boliviana and Selva Misionera forest regions is one of the objectives carried out by UMSEF. From 1998 to 2002, an important landscape transformation occurred in the Chaco region as a consequence of the expansion of the agricultural frontier mainly for culture of soybean. It produced not only a loss of forest ecosystems but also an increase of fragmentation and decrease of connectivity. Then the landscape ecology frame through its theories and methodological tools, is essential to study these processes (Forman and Godron, 1986; Gustafson, 1998; Turner *et al.*, 2001). In this context, the objective of this work is to analyse landscape pattern changes in the Chaco region in Argentina along a precipitation gradient including the provinces of Chaco, Formosa, Santiago del Estero, Salta and Tucumán.

### Methods

We analysed three 550 km-length transects in east-west direction, from the 1,100 to the 600 mm annual rain isohyets, and established 6 circular equidistant sample units of 100,000 ha in each transect. We calculated landscape indexes for the years 1998 and 2002 using land coverage obtained by UMSEF through visual interpretation of Landsat 5 TM and 7 ETM satellite images. Land classes were based on FAO classification and adapted to the Argentinean characteristics and include Forest Land, Other Wooded Land and Other Land classes. We computed the area, number of fragments, average and maximum size of fragments and medium length between the nearest fragments for each year. Moreover, we obtained the annual deforestation rate and diversity index for each sample unit.

### Conclusions

Along transects different landscape patterns were evident showing association with natural and anthropic factors. Deforestation is an evident process in some samples situated between 700-900 mm but there is not a clear pattern associated with the rain gradient. In areas with high deforestation, indexes allow us to detect more remarkable landscape changes, that are reflected in an increase in forest patches fragmentation and reduction, affecting their connectivity.

### References

- Forman, R. T. T. & Godron, M. (1986) *Landscape Ecology*. John Wiley & Sons. New York.  
Gustafson, E. F. (1998) Quantifying Landscape Spatial Pattern: What is the State of the Art?. *Ecosystems*, 1: 143-156.  
Turner, M. G.; Gardner, R. H. & O'Neill, R. V. (2001) *Landscape ecology in theory and practice: pattern and process.*, Springer-Verlag, New York.



**Examining the role of spatial pattern in understanding the implications of forest management policy within the Angkor World Heritage Site, Cambodia**

**N. Wales, E. Bruce<sup>1</sup>**

School of Geosciences, University of Sydney, 2006, NSW, Australia.  
e-mail: nwal8800@mail.usyd.edu.au

Vegetation communities within the Angkor World Heritage Site in Cambodia have been subject to human disturbance both historically and more recently through agricultural encroachment, logging and fire. Despite the resulting implications including habitat fragmentation, simplification of forest structure and loss of biodiversity the modified forest environments of Angkor are integrally linked to values held by local communities. This connection is reinforced through subsistence use of forest resources for activities such as the harvesting of firewood, resin collection and cattle grazing (Ballard, 2003). Restrictions on forest use have been imposed on local villagers under various policies for forest protection and management since the involvement of French conservators in the early 20<sup>th</sup> century and more recently as a consequence of the inscription of Angkor on the World Heritage List in the early 1990s (Miura, 2005).

The purpose of this research is to examine vegetation response to changing use levels enforced through forest management policy within the Angkor park. If the communal heritage status of these forest environments is to be maintained, greater insight into the implications for subsistence use for forest communities is required. In examining the ecological integrity and cultural value of remnant vegetation there is a need to understand the spatial and temporal pattern of change. A combination of remote sensing techniques, field botanical surveys and interviews with local community was adopted to investigate vegetation change.

Change in the extent and type of vegetation cover was identified from remotely sensed imagery for a ten year period following World Heritage listing from 1992 to 2002. Mapping and change analysis of vegetation was performed using Multivariate Alteration Detection (MAD) methods and Landsat imagery. Results derived from analysis of high resolution SPOT imagery were then integrated with local knowledge to compare vegetation change patterns with local perceptions of change identified through semi-structured interviews and geo-referenced transect walks based on Participatory Rural Appraisal approaches. Further, qualitative information derived from interviews with villagers and the local management authority (APSARA) provided insight into the social processes associated with changes to forest composition, local environmental management systems and the issue of effective regulation of the use of forests at the village level while large scale forest clearing continues unabated.

**References**

- Ballard, B. M. (2003)** Employment and Trade in Angkor Park: Some Preliminary Observations on the Impact of Tourism. *Cambodia Development Review* 7(1): 5-7, 16.
- Miura, K. (2005)** Conservation of a 'living heritage site': a contradiction in terms? A case study of Angkor World Heritage Site. *Conservation and Management of Archaeological Sites* 7(1).

## **A Bayesian MCMC approach to reconstruct spatial vegetation dynamics from sparse vegetation maps**

**I. Somodi<sup>1</sup>, I. Miklós<sup>2</sup>, K. Virágh<sup>3</sup>**

<sup>1</sup> Department of Plant Ecology and Taxonomy, Eötvös Loránd University, 1/C Pázmány Péter promenade, 1117 Budapest, Hungary.

e-mail: somodiimelda@freemail.hu

<sup>2</sup> Alfréd Rényi Institute of Mathematics, Hungarian Academy of Sciences, 13 Reáltanoda street, 1053 Budapest, Hungary.

<sup>3</sup> Institute for Ecology and Botany of the Hungarian Academy of Sciences, 2-4. Alkotmány road, 2163 Vácrátót, Hungary.

### **Introduction**

In studies of vegetation dynamics, data of the changes are often sparse, because changes were not recognized in early stages or investigations were part of different projects. The snapshots at hand then often leave the nature of the dynamics unrevealed and only give a rough estimation of the directions of changes. Extrapolation of the dynamics with traditional cellular automaton modelling is also complicated in such cases, because rules often cannot be deduced from field data for each interaction.

### **The proposed method and sample data**

We developed a Bayesian MCMC method (Liu 2001), using a discrete time stochastic cellular automaton model to reconstruct vegetation dynamics between vegetation maps available. Spread capability of each vegetation type was characterized by a lateral spread parameter and another for establishment from species pool. We tested our method on a series of three vegetation maps depicting vegetation change at a grassland site following abandonment of grazing in north-eastern Hungary. Uninformative priors were used as prior distributions of parameters. The posterior distribution was defined as the product of the prior probabilities of the rules' parameters and the probability of the particular series of maps under the set of parameters. The Markov chain explored the missing data space (missing maps) as well as the parameter space.

### **Major results and importance of the invention**

Vegetative spread capability was generally larger than establishment from species pool for our site. We estimated the trajectory of change for each vegetation type, which bore a considerable non-linear element in most cases. Large volume expansions during relatively short periods also occurred and it was possible to trace their timing. To our best knowledge, this is the first work that tries to estimate vegetation transition parameters in a stochastic cellular automaton based on field measurements and so gives a tool to reconstruct past dynamics. It can give an estimate of when changes occurred, and also provides a mechanism-based extrapolation possibility.

### **References**

**Liu, J.S. (2001)** *Monte Carlo strategies in scientific computing*. Springer series in statistics. Springer-Verlag, New York, New York, USA.

**Modeling the dynamics of Mediterranean landscapes under various disturbance regimes**

**A. Bar-Massada<sup>1</sup>, G. Koniak<sup>2</sup>, Y. Carmel<sup>1</sup>, I. Noy-Meir<sup>2</sup>**

<sup>1</sup>Division of Environmental, Water and Agricultural Engineering, Faculty of Civil and Environmental Engineering, Technion -- Israel Institute of Technology, Haifa 32000, Israel.  
e-mail: agavi@tx.technion.ac.il

<sup>2</sup>Faculty of Agricultural, Food and Environmental Quality Sciences, The Hebrew University of Jerusalem, Rehovot 76100, Israel.

East Mediterranean ecosystems have been disturbed by clearing, burning and grazing for more than 10,000 years (Naveh and Dan, 1973). Consequently, the landscape was shaped into fine-grained vegetation mosaics, consisting of patches of vegetation states at different regeneration stages, with high structural and species diversity. Recent land use changes allowed spontaneous succession processes to transform large areas in the Mediterranean basin into continuous dense scrub forest, with reduced biodiversity and high fire risk. Grazing, clearing and fire could possibly be managed to conserve or restore mosaic landscapes (Perevolotsky and Seligman, 1998). However, the long term interactions between these disturbances and spontaneous vegetation processes are not fully understood, hindering the development of management programs.

In order to understand and predict the spatiotemporal dynamics of Mediterranean vegetation under multiple disturbances, we are developing a hybrid ecological model, combining Markov, gap, and cellular automata formulations. The model operates simultaneously on four hierarchical spatial scales: patch, site, macro-site and landscape. At the patch scale (1 m<sup>2</sup>), ecological processes of recruitment, expansion, and mortality determine the dominant woody vegetation state. The site scale (100 m<sup>2</sup>) is the grain size for disturbance processes (grazing, fire, clearing) and seed rain. The macro-site (10000 m<sup>2</sup>) represents a territory of avian seed dispersers, and is used to derive the amount of seeds available for dispersal. At the landscape scale (>10000 m<sup>2</sup>), disturbance events and dispersal processes are the driving forces of ecological heterogeneity.

Model simulations successfully mimic general trends in Mediterranean vegetation observed over past decades (Carmel and Kadmon, 1998, Perevolotsky *et al.*, 2003). Without disturbance, grassland with few shrubs transforms into dense scrub forest within 100 years. Under intense goat grazing, dwarf shrubs gain dominance after 30 years, while other woody types remain stable. Burning or clearing are followed by full regeneration of woody vegetation within 25 years. Model simulations show that application of a mixed disturbance regime can re-establish and preserve the mosaic structure of Mediterranean landscapes.

**References**  
EN.REFLIST

## The effects of landscape structure on the vegetation of field boundaries in Estonia

T. Aavik, M. Zobel, J. Liira

Institute of Botany and Ecology, University of Tartu, 40 Lai St, Tartu 51005, Estonia.  
e-mail: tsipe.aavik@ut.ee

### Introduction

Field margins are often the last and only semi-natural habitats in contemporary agricultural landscapes. They are considered to be important contributors for the maintenance of biodiversity of these landscapes. The aim of our study was to compare the vegetation composition of fields and field boundaries and to analyze the importance of surrounding landscape structure on the field boundary plant species composition.

### Methods

We studied the vegetation composition of fields and field margins of six Estonian agricultural landscapes that differed in regard to land use intensity and small-scale landscape structure (ditches, roads, or tree and bush layer). We used Detrended Correspondence Analysis (DCA) to analyze the variation in plant species composition in relation to local landscape structure and environmental conditions, and indicator species analysis to detect species characteristic to particular EUNIS-types of field boundaries.

### Results and discussion

We have to note that field margin classification into four broad EUNIS-types did not describe objectively the habitat conditions in linear green veining elements. The landscape features of close neighbourhood around field margins should be treated as independent environmental factors and the effect of surrounding landscapes structure on the vegetation composition of field boundaries should be seen as factorial complex.

We recorded nearly 1/5 of Estonian flora of vascular plant species. Hence, the habitats in agricultural landscapes seem to support a considerable proportion of biodiversity. However, we found that species being most abundant in the field margins were the same species that were also frequent in rotational grasslands and crop-fields. About 45 % of the flora of field boundaries comprised species found in agricultural land. Road verges were characterised by annuals and other disturbance-tolerant species. The vegetation of ditch banks consisted of species typical of semi-natural grasslands. Tree-lines and hedgerows or forest edges were characterised by generalist species. Few threatened or protected species were noted.

We suggest that while assessing the influence of land use intensity and landscape structure on plant biodiversity, species should be distinguished on the basis of their different tolerance to agricultural disturbance. The species in agricultural landscapes could be classified into two wide emergent groups – agro-tolerant species and nature-value species (nature conservation-demanding species). The first group includes species supported by human activities in agricultural landscapes. The second group includes rare weeds and habitat specialist species.

## Landscape dynamics in Armação dos Búzios (RJ - Brazil) in the 1976-2002 period

H.G.R. Dantas<sup>1</sup>, C.B.A. Bohrer<sup>1</sup> and H.C. Lima<sup>2</sup>

<sup>1</sup> Depto. de Geografia, I. Geociências, Universidade Federal Fluminense, Campus Praia Vermelha 24210-340 Niterói RJ, Brazil  
Email: heloisa.normando@gmail.com

<sup>2</sup> Jardim Botânico do Rio de Janeiro, Rio de Janeiro, RJ, Brazil

### Introduction

The characterization of land units, ecologically homogeneous parts of the terrain, can be used as a framework for the quantitative analysis of heterogeneous landscape dynamics, integrated with the use of fragmentation indexes. This approach was adopted in the analysis of the changes in Armação de Búzios, a município located on a Center of Plant Diversity on SE Brazilian coast (Fig. 1), which has been experimenting a fast development and population growth in the last decades, due mainly to tourism. It has a dry climate (Bsh), with average temperature of 25° C and annual rainfall of 800mm.

### Method

Land and vegetation cover mapping was based on interpretation of detailed aerial photographs, complemented by woody vegetation structural and floristic data collected on 10 sampling plots, plus transects on shrub vegetation and floristic data from previous surveys. Geologic, relief, soil and land cover data were integrated in a GIS environment. The geologic formations were assumed as the higher hierarchical level. Cluster classification and CCA were used to analyze the vegetation-environment relationships. ArcView 3.2 and Fragstats software were used to extract eleven metrics (Area, NP, LPI, PD, MPS, TE, DLF, MPFD, FRACT, Disturbance) at landscape and land unit level, for the years 1976 and 2003.

### Results

Five main land covers classes (natural vegetation, wetlands, water corps, altered vegetation and urban areas) were identified. Arboreal vegetation corresponds to 92% of the original vegetation cover. The land cover patterns were linked to five landscape units, according to geology, relief and soils types (Fig. 3). Vegetation physiognomy varied from grasslands, low xerophyte thorn thicket to semideciduous forest, with a relatively high plant diversity, according to the interaction of natural (relief, soil, water table, wind, salt) and human factors. There was a 15% loss of natural vegetation cover in the period, with altered areas becoming dominant in the landscape (Table 1; Fig. 4). Quaternary plains were mostly impacted by urban and agriculture land use.

Natural habitat fragmentation also increased (Tab.2), which is shown by the increase of path density and changes on patch size distribution. Patch shape indexes reveal the complexity of the changes, varying among the land units. This could be related to the different patterns of land use changes, especially on areas that were open to urban use (with intensive road building), but with a low cover change rate, due to a high number of plots still covered by natural vegetation.

It can be concluded that the município of Armação de Búzios has suffered a process of intensive changes on its landscape, due a high population increase, and consequent conversion of natural areas to agriculture and urban land use. This process has resulted in a net loss of natural habitat area and also in a higher fragmentation of the remaining natural vegetation, especially on the Quaternary plains, considered to be more attractive for human use, due to the relief and the proximity to the beaches.

**Landscape sustainable management and the Atlantic Forest Biosphere Reserve: an ecologic and human study approach of the rain forest remnants from Morro Ferrabrás and Serra Geral, RS, Brazil**

**J. Konrath<sup>1</sup>, M.D. Bitencourt<sup>2</sup>, W. Mantovani<sup>2</sup>**

<sup>1</sup> Education School of Taquara Faculties, Oscar Martins Rangel Avenue, 4500, Taquara, RS, Brazil, Cep: 95600-000;  
e-mail: konrathj@terra.com.br

<sup>2</sup> Ecology Department - São Paulo University, São Paulo, Brazil.

**Introduction**

The main objective of this work is to present the ecologic and human study method employed in approaching the land use and conservation of the rain forest remnants under the Brazilian Atlantic Forest Biosphere Reserve by the local landholders, and discuss the results contributions in the context of the landscape sustainable management. The Atlantic Forest remnants of Morro Ferrabrás and Serra Geral are located in a South Brazil old foreign immigration region, ranging from 29°15'S to 29°45'S and 50°40'W to 51°05'W and covers about 2.893,5ha of the last rain forest fragments of the Rio dos Sinos hydrographic region. Tables, figures and references are shown in the poster.

**Methods**

The study was developed by an assembled qualitative, geoprocessing and applied ecology research tools, performed to support an integrated analysis of the relationships between the landholder socioenvironmental profile and the forest remnants conservation status. This work focalize only the preliminary qualitative research made with the aim of to realize an environmental inventory and to know the environmental perception and management context of the study area landscape, to construct the rapid study method further employed to analyse the land use and conservation of the rain forest remnants by the local landholders.

**Results and discussion**

The analysis of documents of former landscape descriptions and images allowed inferring a high biological diversity in the primal of the territory occupation. However the high disturbance level and scarcity of biological diversity data of the original landscape, contributed to the lack of awareness with the conservation priority of these Atlantic Forest remnants in spite of his highest urbanization degree and human population density. The content analysis of the journal research showed that the sierras and forests are public perceived as cultural values connected with the colonization history of the region and the expressive secondary forest recover is public perceived as a critical factor for the region sustainable development. The interviews with the local inhabitants indicate a clear perception of landscape change that have strong impacts over their local life conditions, and that there is a lack of knowledge of the environmental protection objectives, the land use regulations and the alternative resource management of the rain forest remnants, in spite of the institutionalization of environmental management programs (Rio Grande do Sul, 1990 and 1998) and the geographical location of the study area at less than 100 km of the Brazilian Atlantic Coast.

**Conclusion**

The results highlighted the need of more integrated and locally supported environmental management programs and effective tools for biodiversity conservation of the Brazilian Atlantic Forest remnants.

## Non-timber utilization and Landscape value of Pistachio-Almond mixture stand

E. Kouhgardi<sup>1</sup>, O. Rafyeian<sup>2</sup>, P. Ahmadpour<sup>1</sup>, F. Ahmadpour<sup>1</sup>

<sup>1</sup> Islamic Azad University, Boushehr Branch, Alishahr, Boushehr, Iran.  
e-mail: kouhgardi@yahoo.com

<sup>2</sup> Islamic Azad University, Science & Research Branch, Tehran, Iran.

### Introduction

For many years, the Iranian Forest Service has been implementing forest management plans in Zagros forests using a number of different approaches. These have met with limited success owing to conflicts of interest and expectations between the local communities and the forest service, but we see a wide range of degradation in these forests. It seems that traditional forest application would be changing to multiple use management for achieve to sustainable development.

### Summary

Main species of this stand are Almond (*Rosaceae: Amygdalus scoparia*) and Pistachio (*Anacardiaceae: Pistachia atlantica*) and growth in arid and semi-arid area often. Almond has edible seed that could be use as desserts or use for almond oil exploitation, this oil could be employ for medical and hygienic use. Nowadays, the almond oil produces the different kinds of the soap. Almond branches use for basketry and its seed bark use for animal feeding. Pistachio has edible seed and sappy stem. This sap include 25 % worthy oil (Turpentine), that be exude from stem if the stem bark is scratched. The sap color is green-white and it has very plentiful use in chemical and medical industries. Time of sap extraction is the beginning of the summer until middle part of this season and removes it by two ways: classic & new method. In classic method, all parts of stand area and in new method 1/3 of this area were be used at each year. The sap of pistachio is processing by two ways: classic & technical method. In classic method that carried out in stand area, only product the raw chewing gum (Persian turpentine). The economic value of the chewing gum is very lower than actual potential. However, in technical method, products the different materials such as turpentine alpha penine, beta penine, clophane and raw material for making gum. These materials have plenty use in medicinal and foodstuffs industries. Utilization of galipot and resin from these stands is about 1000 t in each year.

### Conclusion

With regard to research parameters, this mixture stand have high capacity for landscape planning in mountain area and developing the ecotourism, also the area is near the biggest oil and gas field (South Pars field) in the world, therefore we would be keep a balance between nature and industries. So, in spite of these various applications and suitable income, cutting trees to obtaining wood and land would be prohibiting.

### References

- Beede R. H. (2004) sample costs to establish and produce pistachios. *Pistachios cost and return study*, university of California cooperative extension, pp 1-25.
- Hamadeh, S. (1999) *Sustainable improvement of marginal lands in Lebanon*. The American university of Beirut. A final report.
- Iran Nejad M. H. (1996) Investigation of natural communities of Almond in Kerman province. *MSc. Thesis*, Natural resources faculty, university of Tarbiat Modares, Iran.

## Temporal and spatial dynamics in abandoned chestnut coppice forests

J. Vogt<sup>1</sup>, P. Fonti<sup>2</sup>, M. Conedera<sup>3</sup>, B. Schröder<sup>1</sup>.

<sup>1</sup> Institute of Geoecology, University Potsdam, Germany.  
e-mail: boris.schroeder@uni-potsdam.de

<sup>2</sup> WSL, Swiss Federal Research Institute, Birmensdorf, Switzerland.

<sup>3</sup> WSL, Swiss Federal Research Institute, Bellinzona, Switzerland.

### Content

Chestnut coppice is a man-made forest type that has been managed for centuries in short rotations to produce woody biomass. These forests, which nowadays cover significant areas within Europe, experience a general neglect and are subsequently being abandoned. Most of them are now over-aged, very dense, strongly monotone. An increasing frequency of uprooting events is raising concern among forest managers who fear a progressive expansion of the phenomenon.

The present research is aimed at describing temporal and spatial patterns of the ongoing uprooting processes in order to identify causes and to estimate future progression. We analyzed the stool uprooting dynamics in an abandoned chestnut coppice and built an empirical predictive model to estimate uprooting probability based on topographic, stand and stool characteristics.

Results indicate that uprooting is primarily caused by precarious tree static rather than external forcing agents. The empirical model clearly states that tall stools located in pits and steep depressions are the most likely to deracinate (Vogt et al., 2006). We expect a progressive increase of this phenomenon with the ageing of abandoned coppices, due to the endogenous process of uprooting. From the forest manager's perspective, this situation favors a progressive rejuvenation and diversification of the forest structure.

### References

Vogt, J.; Fonti, P.; Conedera, M. & Schröder, B. (2006) Temporal and spatial dynamics of stool uprooting in abandoned chestnut coppice forests. *Forest Ecology and Management* **235**: 88-95.



## Forest quality in southwest Mexico City, assessment towards ecological restoration of ecosystem services

V. Avila-Akerberg<sup>1</sup>

<sup>1</sup> Landespflege Institute– Tennenbacher Str. 4, Freiburg im Breisgau, Germany  
e-mail: vicaviak@gmail.com

Mexico City is the central, urban core of the Federal District, which occupies an area of 1,547 km<sup>2</sup>. However, the larger metropolitan area of the capital extends well into other neighboring states. The population of the Federal District proper was 13,096,686 in 2000. The population of the metropolitan area reached 18.7 million in 2003.

The Federal District, although it contains one of the biggest cities of the world, it still has important forested areas on its southwestern part, which represent more than half of its territory and provide several environmental benefits to the people living in the city. These forests have already been modified by people: complete ecological integrity (Westra and Lemons, 1995) is already an historical concept in most forests. The distinction between "natural" and "disturbed" forests is less important than the *degree* and *type* of disturbance (UNEP, 1997).

During the 1990s there have been numerous attempts to define criteria and indicators (C + I) for sustainable forest management on a global, regional, national and forest management unit levels. C+I are tools which can be used to collect and organize information in a manner that is useful in conceptualizing, evaluating and implementing sustainable forest management. The value of information lies in the way it is organized.

In 1998, the WWF (World Wide Fund for Nature) and the IUCN (International Union for the Conservation of Nature) developed an initiative to evaluate the forest quality at the landscape level. The concept proposed by WWF and IUCN (1999) utilizes the forest quality as the principle and subdivides criteria in three overlapping categories: *forest authenticity, environmental benefits and social and economic benefits*. These criteria, at the same time, contain indicators and verifiers of what can be evaluated in field to recognize the quality and present condition of a given forest ecosystem. Forest quality is defined as the "significance and value of all ecological, social and economic components of the forest landscape". It measures forest conditions at the landscape level, giving more scope for considering the way in which people, forests and ecology interact in a region.

This project aims to follow the concept of forest quality, in order to make an assessment of the forests in the southwest of Mexico City. The objectives of this PhD project are:

1. Design a methodology for the assessment of "forest quality" at the landscape level.
2. Generate an assessment of the forest quality in the southwest of Mexico City.
3. Give management proposals towards ecological restoration and conservation of the forests and their environmental services.

For this, a hard field work has been made, interviews and questionnaires with the main stakeholders of the area are being made, and it is intended to analyze and synthesize all this information using multivariate and multicriteria methods.

### References

- UNEP. (1997)** Convention on Biological Diversity: Indicators of Forest Biodiversity, Montreal.
- Westra, L. & J. Lemons. (1995)** Perspectives on Ecological Integrity, Kluwer Academic Publishers, Amsterdam.
- WWF and IUCN. 1999.** Evaluation of Forest Quality: Towards a Landscape Scale Assessment. Forest Innovations: a Joint Project Between IUCN and WWF.

**Associations between vegetation and geomorphic units as a basis for predictive vegetation mapping and conservation assessment**

**E.J.B. van Etten**

Centre for Ecosystem Management, School of Natural Sciences, Edith Cowan University,  
100 Joondalup Drive, Joondalup 6027, Perth, Australia.  
e-mail: e.van\_etten@ecu.edu.au.

**Background**

Strong association between vegetation types and geomorphic units has often been reported for arid and semi-arid lands at landscape scales, but not often formally tested. In Australia, this association has been hypothesised as stemming from long-term weathering and sorting of surface soils and associated geological stability. In this poster, levels and significance of association between vegetation units derived from a numeric classification of floristic data and mapped elements of the physical environment are investigated for an area of arid Western Australia. The use of such associations in predicting spatial distributions of vegetation units across the landscape are then evaluated. A successful approach to such predictive vegetation mapping is of considerable interest to those managing inland Australia, as well as many other arid and semi-arid regions, given the large expanses of unmapped native vegetation and reasonably thorough coverages of geological and landform maps.

**Methods**

The study area was located immediately north of Kalgoorlie, Western Australia (30.5°S; 121°E). Over four discrete areas (varying from 43 to 90 km<sup>2</sup> in size), the cover of all plant species was recorded at 95 sites. Numerical classification of sites was performed and yielded 12 "plant communities" within 5 broad vegetation types. Association between these communities/types of vegetation and classes of geomorphology (12 landforms within 4 broad regolith units) were explored using two-way contingency tables, chi-squared test statistics and Ochiai Index (a measure of degree of association). Analysis of similarity (ANOSIM) was used to detect any differences in floristic composition between landform and regolith units, as well as the four areas. Strong, unambiguous associations were used to produce predictive vegetation maps within a GIS.

**Results & Discussion**

Eight of the 12 plant communities were positively associated with particular landforms significantly greater than that expected by random association. Similarly the majority of landforms were associated with particular communities. Associations were generally stronger at the higher levels of abstraction (i.e. between broad vegetation types and regolith units). However they were no unambiguous associations with communities typically linked to 2-5 landforms; landforms were also spread over a number of communities. Fortunately, a number of communities were predominantly associated with one particular landform; an example being that 9 of the 12 mixed *Acacia* – *Casuarina* shrubland sites occurred on 9 out of the 13 rocky hills studied. Such generalised and simple relationships were used to produce predicted vegetation maps for the region. The value and accuracy of such maps are of limited value for land management and conservation assessment and suggestions for improvement are given. Importantly, floristic differences were found between the four areas, particularly within regolith units. This suggests that other factors are influential in controlling broad floristic patterns and suggests more complex modelling and mapping approaches are warranted.

**Landscape change and habitat suitability for chimpanzees (*Pan troglodytes verus*) in Guinea-Bissau (Western Africa)**

**J. Torres<sup>1,2</sup>, M.J. Vasconcelos<sup>3,4</sup>, L. Catarino<sup>3</sup>, J. Honrado<sup>1,2</sup>**

<sup>1</sup> CIBIO - Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto. Rua do Campo Alegre 1191, 4150-181 Porto, Portugal.

e-mail: joao.torres@fc.up.pt

<sup>2</sup> Faculdade de Ciências, Universidade do Porto. Rua do Campo Alegre 1191, 4150-181 Porto, Portugal. <sup>3</sup> Instituto de Investigação Científica Tropical. Tv. Conde da Ribeira, 9, 1300 Lisboa <sup>4</sup> Centro de Estudos Florestais, Instituto Superior de Agronomia. Tapada da Ajuda, 1349 – 017 Lisboa, Portugal

Recent international policies and conventions on biodiversity conservation have pointed species and ecosystems as the biological scales on which to base conservation efforts (Pereira & Cooper 2006). Landscape-scale spatial data, obtained from remote sensing sources, provide new opportunities for biologists to model and evaluate wildlife habitat quality. Furthermore, landscape analyses and wildlife population priorities are common features of land management decision processes (Larson, *et al.*, 2003).

In the present study, we make an assessment of landscape change in a remote area (Cantanhez) of Guinea-Bissau throughout 17 years (1986-2003), with the purpose of identifying trends and assessing their impact on regional habitat suitability for chimpanzees (*Pan troglodytes verus*). For the landscape analyses, we used land cover maps derived from Landsat imagery (30x30 m pixel). Landscape metrics (both for specific classes and for the whole landscape) were computed through the use of the FRAGSTATS software (McGarigal, 2002). In the habitat suitability analysis, we used data derived from field work, Landsat<sup>ETM</sup>, land cover maps and altimetry. Habitat suitability maps were obtained through an Ecological Niche Factor Analysis, performed in the Biomapper software (Hirzel *et al.*, 2002, 2004).

Results show that the landscape didn't suffer dramatic changes in the analysed time period, showing a global trend for patch agglutination and a growing area of dense forest cover. Habitat suitability analyses revealed the preference of *Pan troglodytes* for forest patches, particularly of climax forest. It also shows that about 30% of the study area provides highly suitable habitat for chimpanzees. The study area appears to exhibit a low landscape transformation rate, with the forest land cover classes increasing in area. Considering both the habitat preferences of the species and the recent landscape evolution, future perspectives for chimpanzees in the study area are rather positive, making the Cantanhez region a priority area for wildlife conservation in Western Africa.

J. Torres is supported by grant SFRH/BD/24560/2005 from the Portuguese Science and Technology Foundation (FCT).

**References:**

- Hirzel, A. H., Hausser, J., Chessel, D. & Perrin, N. (2002)** Ecological-niche factor analysis: how to compute habitat-suitability maps without absence data? *Ecology* 83: 2027–2036.
- Hirzel, A. H., Hausser, J. & Perrin, N. (2004)** Biomapper 3.1. Division of Conservation Biology, University of Bern. Available from: <<http://www.unil.ch/biomapper>>.
- Larson, M. A., Dijak, W. D., Thompson, F. R. & Millsbaugh, J. J. (2003)** *Landscape-level Habitat Suitability Models For Twelve Wildlife Species In Southern Missouri*. United States Department of Agriculture, Forest Service, North Central Research Station.
- McGarigal, K., Cushman, S. A., Neel, M. C. & Ene, E. (2002)** FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Computer software program produced by the authors at the University of Massachusetts, Amherst.
- Pereira, H. M. & Cooper, H.D. (2006)** Towards the global monitoring of biodiversity change. *Trends in Ecology and Evolution* 21(3): 123-129.

### Coastal Landscapes and the Gradient Concept in Landscape Ecology

J. Vicente<sup>1,2</sup>, A. Lomba<sup>1,2</sup>, P. Alves<sup>1,2</sup>, R. Henriques<sup>3</sup>, H. Granja<sup>3</sup>, F.B. Caldas<sup>1,2</sup> & J. Honrado<sup>1,2</sup>

<sup>1</sup> CIBIO-Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto. Rua do Campo Alegre 1191, 4150-181 Porto, Portugal.

e-mail: jvicente@alunos.fc.up.pt

<sup>2</sup> Faculdade de Ciências, Universidade do Porto. Rua do Campo Alegre, Porto, Portugal.

<sup>3</sup> CCT-Centro de Ciências da Terra, Universidade do Minho. Campus de Gualtar, Braga, Portugal.

The organization of coastal landscapes is driven by strong, directional environmental gradients. Under these conditions, vegetation occurs in the form of complex mosaics arranged in strands which are parallel to the shoreline (Lomba et al., 2005). McGarigal & Cushman (2005) recently proposed an important conceptual shift in landscape ecology, from categorical representations of environmental variables (the “patch-mosaic paradigm”) to continuous mappings based on a gradient analysis of landscape structure. Coastal landscapes can thus be viewed as particularly suitable to address this new paradigm, to establish new methodologies and to assess the quantitative behaviour of “gradient landscapes”. However, the conceptual shift to gradient analysis is still to be made e.g. in the study of the relation between geomorphology and vegetation in sand-dune systems, therefore we present data from a recent gradient-driven analysis of geomorphology and vegetation in coastal dune landscapes of Northern Portugal.

The most significant features of geomorphology and vegetation in coastal sand dune landscapes of the study area were assessed along gradient transects perpendicular to the shoreline (Lomba et al., 2006). Morphological profiles were built through the use of a total station for topographic data acquisition. Point data on the occurrence of each plant species were collected at regular distances along transects and transformed to relative abundances for the calculation of diversity indices. Environmental gradients in coastal sand-dune systems are driven by the distance to the shoreline and were found to reflect strongly on both dune morphology and vegetation. Sand mobility decreases and plant cover increases as the distance to the sea increases, allowing the structuring of characteristic morpho-ecological features such as embryonic foredunes, foredunes and interior dunes. Plant species tend to occupy specific positions along gradients and to replace each other from the upper beach inwards, with species richness, overall plant biomass and vegetation cover showing an increase from the beach inwards. Due to their structuring along directional environmental gradients operating at a local scale, coastal landscapes are true “gradient landscapes” which provide a suitable stage for assessing the theoretical and methodological impact of the paradigm shift proposed by McGarigal & Cushman (2005).

This research was partially funded by the Portuguese Science and Technology Foundation (FCT) through grant POCI/AMB/58047/2004. A. Lomba is supported by grant SFRH/BD/31576/2006 from the Portuguese Science and Technology Foundation (FCT).

#### References

- Lomba, A., J. Honrado, H. Granja, J. Favennec & J. Vidal-Romani (2005). Geomorphology and Vegetation: A Contribution for a Synthesis on Erosion vs. Stability Bioindicators of the Coastal Zone. *Proceedings Book of ICCCM'05*, 495-501.
- Lomba, A., J. Vicente, H. Granja, F. Fidalgo, A. Santos, F. B. Caldas & J. Honrado (2006) Towards an interdisciplinary methodology for the indication of stability conditions in coastal areas. *Littoral 2006-8th International Conference, Coastal Innovations and Initiatives. Poland* 142-146.
- McGarigal, K. & Cushman, S. A. (2005). The gradient concept of landscape structure. In J. Wiens & M. Moss (eds.), *Issues and Perspectives in Ecology*. Cambridge Univ. Press, Cambridge, 112-119.

**Influence of landscape features on biotic patterns of bryophyte communities - two case-studies from Northern Portugal**

**C. Vieira<sup>1,2</sup>, H. Hespanhol<sup>1,2</sup>, A. Séneca<sup>1,2</sup>**

<sup>1</sup> CIBIO-Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto. Rua do Campo Alegre 1191, 4150-181 Porto, Portugal.

e-mail: ccvieira@fc.up.pt

<sup>2</sup> Faculdade de Ciências, Universidade do Porto. Rua do Campo Alegre, 4169-007 Porto, Portugal.

The lack of information on biodiversity patterns and on the underlying ecological processes is often an obstacle in management plans for natural and semi-natural landscapes and biotic communities.

The ecological study of the influence of the landscape context on biotic patterns of bryophyte communities explores the influence of larger scale gradients on communities known to depend greatly on local or micro-habitat gradients.

The evaluation of the variation of communities (particularly regarding their richness and diversity) which is correlated with certain landscape features is an important tool to identify circumstances in which a landscape perspective is important to consider, such as in the development of methodologies regarding the protection and management of biological diversity.

The data used in this study were collected within the framework of two PhD projects developed in Northern Portugal, in two contrasting mountain ecologies: riverine habitats and dry, exposed rocky outcrops. Both sampling procedures were performed on rock substrate. Both GIS-based spatial analyses and statistical techniques were used to analyse landscape and bryophyte data, since they have been proved to be powerful tools on the establishment of relationships between the variation of ecological factors in the landscape context and biodiversity patterns of the studied communities.

The two case-studies presented illustrate the influence of the surrounding landscape features and structure on bryophyte communities and a synthetic model relating bryophyte species richness and diversity and landscape variables is proposed. The significance of this model for management purposes of Northern Portugal territories is also discussed.

C. Vieira and H. Hespanhol are supported by grants SFRH/BD/6969/2001 and SFRH/BD/13058/2003, respectively, from the Portuguese Science and Technology Foundation (FCT).

## Effects of trees on spatial heterogeneity of soil properties in a tropical rainforest in Western Kenya and its implication on plant species diversity

W.M. Musila<sup>1,2</sup>, H. Todt<sup>2</sup>, R. Gliniars<sup>2</sup>, M. Oesker<sup>2</sup>, H. Dalitz<sup>2</sup>

<sup>1</sup>National Museums of Kenya, P.O. Box 40658 00100, Nairobi, Kenya.  
e-mail: wmusila@yahoo.com

<sup>2</sup>University of Hohenheim, Institute of Botany (210), 70593 Stuttgart, Germany

### Introduction

Spatial variability of soil properties was compared to tree distribution in order to establish whether tree distribution was associated with soil spatial pattern. The hypothesis was that soil properties in tropical forests are patterned at a scale that might be expected to affect plant population dynamics within the community. In order to test this, biogenic soil properties (such as pH, electrical conductivity (EC), C and water extractable base cations i.e. K, Ca and Mg) easily influenced by plants through plant cycling were compared with geogenic properties (such as Al, Si and Fe), which are more stable soil characteristics unlikely to be influenced by vegetation. Biogenic soil properties are expected to vary over short scales and their spatial patterns are expected to show association with tree distribution, while geogenic soil properties are likely to vary over longer ranges and to show less association with the tree distribution. The study objectives were: 1) Characterize spatial patterns of surface soil properties. 2) Evaluate whether there are relationships between soil spatial patterns and tree distribution.

### Materials and Methods

A plot of 70 m by 70 m grid was established in Colobus site in Kakamega rainforest in Western Kenya. All trees within the plot with diameter at breast height (DBH) of more than 5 cm were recorded, identified, and mapped. A grid sampling approach was used whereby soil samples were collected at 5 m interval (225 sample points) within the first 10 cm depth. Soil samples were dried, sieved and analyzed for pH, EC, C and water extractable K, Ca and Mg following standard laboratory methods. Spatial variability of soil properties was assessed using geostatistical techniques. Block kriging was used to produce spatial maps of soil properties. The concordance between the soil spatial patterns and tree species distribution was assessed by comparing the kriging maps of the soil properties and distribution of the tree species at different size classes.

### Results and Discussion

A total number of 398 trees with over 5 cm DBH were recorded. Sixty percent of the trees in the plot were small trees with DBH between 5 and 9 cm. However, one tree had exceptionally large DBH, i.e. *Ficus lutea* with a DBH of 323 cm. Kriging maps of the soil properties showed that each parameter had a specific spatial pattern. All the biogenic soil properties showed a patchy distribution while the geogenic soil properties depicted a gradient distribution. The patchy distribution of the biogenic soil properties confirms that they are influenced by biotic factors such as vegetation while the geogenic factors are as a result of the parent material. A comparison of the kriging maps of the soil properties and spatial distribution of the trees showed that the biggest tree, *Ficus lutea* coincided with high C, P, K, EC, Ca and Mg maxima at South East corner of the plot. This co-occurrence of spatial patterns of soils and trees species indicates that the tree species influence or promote soil heterogeneity. Tree induced soil heterogeneity results in more niches for seedling establishment, which in turn promote coexistence of plant species and consequently higher levels of species diversity and may consequently contribute to maintenance of biodiversity in tropical rain forests.

## Spatial pattern of native forests at Córdoba Mountains (central Argentina)

M. Menghi, R. del Sueldo

Centro de Ecología y Recursos Naturales Renovables (CERNAR), Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba. Ciudad Universitaria-X5016GCA Córdoba, Argentina. CONICET, e-mail: mmenghi@efn.uncor.edu

The growth of man's activities in mountainous areas displacing native ecosystems, particularly forests, is causing world wide concern. In the Córdoba Mountains, plantations with exotics, as well as urbanization, are expanding without an integrated plan to protect biodiversity preservation and the sustainable use of natural resources. In addition, there are very few integrated studies done aiming to support the development of resource use programs at a territorial scale. The present work, is focused mainly on diagnosis and hypothesis exploration, and analyzes the current landscape spatial pattern and habitat status (*sensu* Forman and Godron, 1986) of natives *Polylepis australis* "tabaquillo" and *Lithraea ternifolia* "molle" wood.

The study area (31°50'S/64°50'W) is included in the Chacoan region. The *L. ternifolia* "molle" wood covers lower mountain areas, from 700 to 900 m. a. s. l. approximately, and the *P. australis* "tabaquillo" wood is included in the upland grassland domain, over 1500 m. a. s. l. According to physiognomic criteria, the authors previous experience and ground control, the native woodland potential area (Luti *et al.*, 1979) within 60.000 ha, was analyzed. The supervised classification (Envi, 3.5) of a subset of a LandSat TM (30 x) image (Path Row 229/83) (CONAE) dated September 2002, and landscape analysis at habitat, patch (McGarigal *et al.*, 2002) and boundary levels, were carried out.

The current land cover of native woodland represents from 10 to 19 % of their potential areas in the analyzed watershed. The "molle" wood covers 3140 ha fragmented into 2812 patches. The main ones include one patch of 400 ha, two of 100 ha, and the rest have 1.12 ha on average. Most (13.000 ha) of the original wood was replaced by tall and spiny shrublands, with a predominance of *Acacia* spp. ("espinillo"). These disturbed areas maintain transitional boundaries with well preserved "molle" wood areas and are being notably invaded by woody exotic species. At the opposite elevation end, only 282 ha of well preserved "tabaquillo" wood were detected. That total area, is fragmented into 1016 patches restricted to ravines, with a mean patch area of 0.26 ha  $\pm$  0.45, or 0.14 ha  $\pm$  0.8, depending on altitude; sharp native/native boundaries among the patches are typical. Both physical and human factors could explain that spatial pattern. The disturbance of "tabaquillo" wood has promoted the development of shrubby growth forms of the same species, as well as woody habitats giving way to the growth of secondary grasslands, or of eroded soil and rock outcrops. With respect to human impacts, up to present the native woodlands habitat status detected would be mainly related to traditional land-uses. Currently, the deforestation process with urbanization and/or plantation goals has sustainable growth, and the "molle" wood is particularly endangered.

### References

- Forman, R.T.T. & Godron, M. (1986) *Landscape Ecology*. John Wiley and Sons, New York, USA.
- Luti, R.; Solís, M.A.B.; Galera, F.M.; Ferreyra, N.M.; Berzal, M.; Nores, M.; Herrera, M.A. & Barrera, J.C. (1979) Vegetación. J.B. Vázquez; R.A. Miatello & M.E. Roqué (Eds.), *Geografía Física de la Provincia de Córdoba*. Editorial Boldt, Bs.As, Argentina. pp. 297-368.
- McGarigal, K.; Cushman, S.A.; Neel, M.C. & Ene, E. (2002) *FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps*. Computer software program produced by the authors at the University of Massachusetts, Amherst. Available at the following web site: [www.umass.edu/landeco/research/fragstats/fragstats.html](http://www.umass.edu/landeco/research/fragstats/fragstats.html).

## Ecological change in British woodland 1971-2001

K.J. Kirby

Natural England, Northminster House, Peterborough, PE1 1UA, UK.,  
Keith.kirby@naturalengland.org.uk

### Introduction

Differences recorded in forest vegetation between woods or stands may reflect underlying spatial variation, but also different stages in the forest growth cycle.

In 1971 103 woods across Great Britain were selected from a sample of 2,500 that were surveyed in the 1960s. Association analyses (and primitive computers!) were used to divide up the woods into clusters and then the central wood of the cluster was subject to more detail survey. Sixteen 200m<sup>2</sup> plots were set out at random locations in each wood and standardised data collected on soils, trees and shrubs, habitat features and ground flora. The plots were re-recorded in 2000-2003 ('2001 results').

Correlations were explored between the changes observed and the expected major drivers of woodland change over the period 1971 and 2001, in particular impacts of changes in climate change, nutrient regimes, grazing levels and stand growth.

### Results

Overall there was a decline in the richness of the ground flora at both plot and site level. Individual species showed varying responses to the climate change variables, with mainly decreases in cover, but also increases in frequency, correlated with changes in growing season length and mean Jan. – Mar. temperatures. *Ilex aquifolium* increased in abundance.

Soil pH increased, particularly in the more acid soils. While there was no increase in mean Ellenberg fertility (N) score, there was a tendency for N scores to increase in woods that were surrounded by intensive agricultural land use and some species with high N scores also showed increases in cover.

Signs of increased deer activity were detected in woods in lowland Britain, but little change in the uplands where grazing, particularly by sheep, was already high in 1971. Deer browsing may be implicated in declines in the density of the understorey.

The decline in species richness was correlated with increased basal area of trees and shrubs; stands disturbed by the 1987 storm tended to increase in species richness. There was a shift towards more shaded assemblages of plants and loss of open habitats.

Overall a major factor driving change appears to be the regrowth of British woodland following major fellings during the period 1939-45.

### References

Kirby, K.J., Smart, S.M., Black, H.I.J., Bunce, R.G.H., Corney, P.M. & Smithers, R.J. (2005) *Long term ecological change in British woodland (1971-2001)*. Peterborough: English Nature (Research Report 653).

Hopkins, J.H. & Kirby, K.J. (in press) Ecological change in British broadleaved woodland since 1947. *Ibis*.



## Does seed dispersal of late-successional species drive secondary succession in the Swiss National Park?

M. Iravani<sup>1</sup>, H.H. Wagner<sup>1,2</sup>, A.C. Risch<sup>1</sup>, C. Scheidegger<sup>1</sup>, P.J. Edwards<sup>3</sup> and M. Schuetz<sup>1</sup>

<sup>1</sup>WSL Swiss Federal Research Institute, 8903 Birmensdorf, Switzerland.  
e-mail: majid.iravani@wsl.ch

<sup>2</sup>University of Toronto at Mississauga, Mississauga, ON, L5L 1C6, Canada.

<sup>3</sup>Swiss Federal Institute of Technology Zurich, 8092 Zurich, Switzerland.

### Introduction

The composition and dynamics of the seed bank can strongly influence the rate and direction of secondary succession, and knowledge of the seed bank is therefore important for understanding local vegetation dynamics. The rate of succession on subalpine grasslands (former cattle pastures) of the Swiss National Park, as documented by vegetation development on permanent plots and by long-term enclosure experiments, has been very low in international comparison for reasons that are not well understood. We hypothesize that the low rate of succession may be due to seed limitation of late-successional plant species. We assessed the relative importance of local seed rain, seed dispersal from adjacent late successional vegetation (forest), and internal seed dispersal by red deer (*Cervus elaphus* L.) as main vectors to compensate this lack, using an existing experimental setup with a grid of 268 cells (20 m x 20 m). The soil seed bank composition was assessed in a greenhouse germination experiment for a total of 24 cells, with three replicates for each combination of two successional stages, two levels of deer dung density, and two levels of distance from the forest edge.

### Main results

A comparison of species composition between seed bank and vegetation showed that the seed bank was mostly composed of earlier successional species. ANOVA of the overall successional age of the three layers indicated that the vegetation was significantly older than the seed bank in both soil layers. Successional age of the vegetation increased significantly from early to late stage, while it was approximately constant for the seed bank in both the organic and mineral soil layer. The distance from forest edge had a larger effect on the successional age of the vegetation (increasing) than on that of the seed bank of both soil layers, where no significant effect was found.

### Conclusion

The results suggest that the seed bank was not the driving force of successional changes in the vegetation. Even in the later stages of grassland succession, seeds of late-successional species were not abundant in the soil seed bank. Seed dispersal therefore may play an important role for the secondary succession on such sites. This study indicated that few seeds from adjacent forest dispersed into the grassland and that red deer were not an important vector for seed dispersal of late successional species, so that the low rate of succession is likely to be due to the lack of seeds of late successional species.

## Effect of Landscape Fragmentation on Diversity of Avifauna in the Edwards Plateau of Texas

E. González<sup>1</sup>, W. Grant<sup>2</sup>, N. Wilkins<sup>2</sup>, X. Wu<sup>3</sup>, M. Kjelland<sup>2</sup>

<sup>1</sup> Universidad Nacional de Colombia, Escuela de Diseño Industrial.  
e-mail: egonzala@neo.tamu.edu

<sup>2</sup>Texas A&M University. Wildlife and Fisheries Sciences

<sup>3</sup>Texas A&M University. Rangeland Department

The Edwards Plateau is one of the areas of highest biological diversity in the State of Texas. However, its biodiversity may be endangered by shifts in the landscape mosaic resulting from continued fragmentation of rural properties, associated with urbanization processes. This study addressed the relationship among land fragmentation, landscape structure and avian diversity.

The effect of landscape fragmentation associated with urbanization processes on diversity of avifauna in the Edwards Plateau ecoregion and surrounding area was studied using spatial analysis. Urban influence, ownership property sizes, landscape structure, and avian diversity were quantified for 31 North American Breeding Bird Survey (BBS) transects, 12 located within the Edwards Plateau ecoregion and 18 in contiguous ecoregions. Direct and spatial correlations between these indices were examined using Modified t-Test (Dutilleul *et al.*, 1993) and Cross Mantel test (Fortin and Gurevitch. 1993). The spatial analysis revealed an apparent "threshold of habitat fragmentation" at an ownership property size of 500 acres at an intermediate level of urban influence. The results showed that property sizes lower than 500 acres produce habitat fragmentation characterized by a significant decrease in mean patch size and proximity among habitat patches. Consequently, avian  $\alpha$ -diversity (richness) decreased because mean patch size and proximity among habitat patches were related to availability and connectivity of suitable habitat for avian populations. The spatial analysis also made possible the prioritization of ecological subregions of the Edwards Plateau for conservation or restoration based on the threshold of habitat fragmentation and avian  $\alpha$  and  $\beta$ -diversity.

### References

- Dutilleul, P; Clifford, P; Richardson, S; Hemmon, D. (1993) Modifying the t-Test for assessing the correlation between two spatial processes. *Biometrics* 49(1): 305-314.
- Fortin, M. & Gurevitch, J. (1993) Mantel tests: Spatial structure in field experiments. Scheiner, S.M., Gurevitch, J., (Eds.), *Design and Ecological Experiments*. Chapman & Hall, New York. pp 343-359.

## Potential habitat map of endangered hygrophytes for conservation planning

E.Harada<sup>1</sup>, M.Ogawa<sup>2</sup>, H.Mitsubishi<sup>3</sup>, M.Kamada<sup>1</sup>

<sup>1</sup> Dept. of Civil and Environmental Engineering, Tokushima University, Tokushima, Japan.  
e-mail: castanea1996@yahoo.co.jp

<sup>2</sup> Tokushima Prefectural Museum, Japan

<sup>3</sup> Museum of Nature and Human Activities, Hyogo, Japan

### Introduction

Mapping potential habitat of rare species is very effective for broad scale conservation planning for regions that contain no actual data. Based on existing distributional data, we can obtain such environment factors as topographic characteristics, temperature and precipitation, which can then be used to predict potential habitats and species occurrences. The potential habitat distributions of rare species are useful for deciding the regions for conservation plans. This study proposes the method of detecting and mapping the potential habitat of rare hygrophytes in the whole area of Tokushima Prefecture (4144km), Japan.

### Method

#### Data set

##### *Species occurrence data*

There are 107 rare hygrophytes listed in the Red Data Book of Tokushima Prefecture. Two data sources of species locality data were used: one was a specimen labels from the Tokushima Prefectural Museum; and the other was based on data obtained by field survey. These distributional data were included in 1 kilometer square grids.

##### *Environmental parameter data*

Environment parameters were topographic wetness index, stream power index, elevation, slope inclination, warmth index and precipitation. These environmental parameters and species occurrence data were converted into 1 kilometer square meshes.

#### Procedure for mapping potential habitat of endangered hygrophytes species

##### *Step 1: Classifying species by functional type*

Target species were classified into some functional types by CCA and cluster analysis, using environment variables of the areas where the species were found.

##### *Step 2: Finding environmental range preferred by species groups*

Factors which limit the occurrence of species groups are identified from the environmental variables by calculating the electivity of each group for each environmental variable.

##### *Step 3: Mapping potential habitats*

Areas with the same environmental variables to those preferred by each functional type were searched from the entire region of Tokushima, and potential habitat maps of the groups are produced.

**Spatial heterogeneity of nutrient and organic carbon storage under a fragmented landscape of Atlantic Forest, Brazil: the influence of human activities on decomposition processes**

**F. Noronha<sup>1</sup>, I. Garay<sup>1</sup> & D. Perez<sup>2</sup>**

<sup>1</sup> Department of Botany, Institute of Biology, CCS, Federal University of Rio de Janeiro, Ilha do Fundão, 21941-590, Rio de Janeiro, RJ, Brazil.

e-mail: noronha@biologia.ufrj.br

<sup>2</sup> Embrapa-Solos, Jardim Botânico street, 1024, Jardim Botânico, 22460-000, Rio de Janeiro, RJ, Brazil.

The influence of land-use history is receiving increased attention in research dealing with ecological process responses. Habitat fragmentation by human activities is considered the leading process of environmental change. The current trend is that ecological studies focus on the resolution of questions such as conserving ecosystem's diversity in a more integrative approach (Younés & Garay, 2006). Thus, given the complexity of this issue, ecological indicators are essential to synthesize ecosystem functioning at multiple scales (Niemi & McDonald, 2004). This work aims to evaluate if variability of humus form (organic matter and nutrient contents and pools parameters) are indicators of fragmentation impacts at landscape and within fragments scales.

The study site is located in an Atlantic Table-land Forest, at Sooretama Municipality, southeastern Brazil. Litter biomass, nutrients (N, P and Ca<sup>2+</sup>) and organic carbon (C) concentration and stock in the hemiorganic horizons of soils (0-2cm and 2-12cm) were examined according to Garay *et al.* (1995). Samples were collected in two fragments of secondary Atlantic Forest (15 and 80ha) and one primary Atlantic Forest site in Sooretama Biological Preserve (25.000ha – control site). Each fragment was sampled in forest and pathway plots, which indirectly represent humans' intensity usage.

In landscape level comparison (fragments x control site), litter accumulation was near twice higher within primary forest (5,0 Mg.ha<sup>-1</sup> versus 3,8 Mg.ha<sup>-1</sup> in the 80ha fragment and 1,8 Mg.ha<sup>-1</sup> in the 15ha fragment). At local level (forest x pathway plots), litter accumulation was near six times higher in forest plots. Forest plots in fragments displayed a higher immobilization of C and N concentrations, leading to lower nutrient contents, compared to control sites, but a similar degree of immobilization compared with pathway plots. Conversely, spatial heterogeneity was more pronounced for nutrients and C stocks within both kinds of fragment plots. Thus, it seems that differences between soil nutrient and C concentrations (qualitative indicators) are more adequate for discriminating anthropic effects at the landscape level. In contrast, litter accumulation and stocks of nutrients and C (quantitative indicators) are more reliable to assess responses of ecological processes to human impacts at local ecosystem level.

### References

- Garay, I; Kindel, A. & Jesus, R.M. (1995) Diversity of humus forms in the Atlantic Forest ecosystems (Brazil): The Table-land Atlantic Forest. *Acta Oecologica* (16): 553-570.
- Niemi, G.J. & McDonald, M.E. (2004) Application of ecological indicators. *Annual Review of Ecology, Evolution and Systematics* (35): 89-111.
- Yonés, T. & Garay, I. (2006) As dimensões humanas da biodiversidade: o imperativo das abordagens integrativas. In: Garay, I. & Becker, B. (Eds). *Dimensões humanas da biodiversidade: o desafio de novas relações sociedade-natureza no século XXI*. Ed. Vozes, Petrópolis, Rio de Janeiro, pp.57-72.

**Biological forest ecosystem diversity and their impact in semi arid land: analysis followed by remote sensing (Alsat-1 data, Steppe of Algeria)**

**Z. Ahmed**

National Center of Spaces Technics, BP 13, 1 avenue de la Palestine, 31200 Arzew , Algeria  
e-mail: z\_ahmed65@yahoo.fr

The Algerian forests present an important ecological diversity, due to the different type of climate, from the sub humid to arid. These types of climate have a direct influence on the forest ecosystems and condition the floristic composition of these forests as well as their regeneration. The ecological diversity of some forests as part as its constitution, plays an important role in the natural regeneration, following some natural problems as forest fire (windblow). The conservation of biological diversity and the maintenance of permanent value of some forest ecosystems are important. Forest ecosystems can unite the biological wealth of the systems. Research in ecology progressed the knowledge on the working of the forest ecosystems and the impact of the human activities (fires, windblow, deforestation and recovery). Man can improve his practices consequently and enable to repair the degraded surroundings. In this survey, the utilization of remote sensing data respectively satellite ALSAT-1 and satellite LANDSAT TM in different dates, inform us about impact of arid weather on the ecological diversity in the middle of some vegetal steppe formations and in particular on the regressive evolution of some forest ecosystems under the name of the DEFORESTATION. We have used in this survey the data of satellite LANDSAT TM of the year 1989 and those of satellite ALSAT-1 of the year 2005, for a multistage study of the regressive evolution of forest ecosystems. An application of specific treatments especially classification supervised by the method of maximum of verisimilitude was used in order to identify the most important formations of the zone of survey. The index: NDVI, MSAVI2 and the index of IV verdure is used for characterized and determined the forests formations changes. The arithmetic combinations are used in the system of information geographical IDRISI. And after application of the method of the rations we obtained a picture of the changes. A map of the Vulnerability of the forests ecosystem was realized and this map informs us of the process of deforestation in natural forests following the different pressure and anable us a possible perspectives of harnessing.

## Landscape change in the *Austrocedrus chilensis* forest ecosystems: the role of the restoration in Patagonia, Argentina

E. Rovere

Laboratorio Ecotono, CRUB-Universidad Nacional de Comahue. Quintral 1250, 8400 Bariloche, RN, Argentina.

e-mail: arovere@crub.uncoma.edu.ar

### Introduction

The forest landscape in north-west Patagonia region has been strongly influenced by human and natural disturbances. The main driver of ecological change in this region is the fire (Veblen, *et al.* 1995). Thus the current state of the forest landscape is the result of centuries and/or decades of burning, logging, grazing and conversion of native forests to exotic pine plantations. The progressive fragmentation is causing dramatic changes in the structure and composition of the temperate forests. Ecological restoration as an activity, initiates the recovery of an degraded ecosystem with structure, composition and functioning to its original structure (SER, 2002).

### Focal species and study area

*Austrocedrus chilensis* is a dioecious endemic conifer tree native to the temperate forest of southern South America and an important local timber (Rovere, *et al.* 2003). *Austrocedrus* is found on the eastern slopes of the Patagonian Andes between 39°30' and 43°35' S, forming a more or less continuous forest strip 20-30 km wide, with approximately 135.000 ha (Bran, *et al.* 2002). The region inhabited by *Austrocedrus* is characterized by an abrupt decrease in precipitation due to the orographic effect of the Andes on westerly moisture. This environmental gradient is reflected in a west-east spatial succession of montane forest types from temperate rainforest, through *Nothofagus dombeyi* mono-specific forests, *Nothofagus-Austrocedrus* mixed forests, pure *Austrocedrus* forests and finally to open *Austrocedrus* woodlands and Patagonian steppe in the east. The main urban centers in north-west Patagonia are in the distribution area of *Austrocedrus*.

### Trial and results

Since 2004 we have been conducting restoration surveys in 5 ha of hillside originally covered in pure *Austrocedrus* forest, located near the Nahuel Huapi National Park. The entire area had been burnt and then illegally felled. In collaboration with a land owner and with a Provincial Forest Service, we planted 3000 seedlings of *Austrocedrus* propagated from seeds collected in the local area in order to promote the conservation of the local genotypes. The experience was successful with survival rates > 80% after 2 years. Its recovery is important, particularly due to its location, in order to halt soil erosion and prevent landslides, protects the basins, and connected the landscape. Specifically our study area is a buffer region, between Nahuel Huapi National Park and Bariloche city, one of the longer cities in Patagonia (200000 habitants). This case study was exposing like an example of the restoration of degraded area. Fortunately, since January 2007 by our participation the new law "*Carta Orgánica*" by the Bariloche city includes an article for restoration ecology in the city and its surroundings, as well as in land use planning.

### References

- Bran, D., A. Pérez, D. Barrios, M. Patorino & J. Ayesa (2002). Eco-región valdiviana: distribución actual de los bosques de ciprés de la Cordillera (*A. chilensis*). INTA, APN, FVSA: Informe preliminar, Bariloche, Argentina. 12 p.
- Rovere, A., M. Aizen & T. Kitzberger (2003). Growth and climatic response of male and female trees of *Austrocedrus chilensis*, a dioecious conifer from the Temperate Forests of southern South America. *Ecoscience* 10 (2): 195-203.
- SER (2002). The SER Primer on Ecological Restoration. Science & Policy Working Group, Society for Ecological Restoration International, Tucson, Arizona, E.U.A.

**Community Based Perpetuation of Deforestation: The Case of Forests Mongu District,  
Western Province, Zambia**

**K. Mbikusita Lewanika**

Diocese of Mongu Development Centre, P. O. Box 910177, Mongu, Zambia  
e-mail: kusiyoml@hotmail.com

Mongu District hosts both the headquarters of Western Province and Barotse Royal Establishment. Lealui the summer capital and Limulunga the winter capital are both located in the district. Mongu is the economic, political, cultural, social and administrative hub of the Western Province.

The economy of Mongu district is based on natural resources related activities (agriculture, fishing, timber exploitation, crafts, livestock) and trading. The district has considerable amount of natural resources (rivers, lakes, grass, timber, fish, etc.), which have not been exploited to full potential yet for the benefit of the local people. Most of the natural resources are exported from the district in (semi) processed form (timber, fish, cattle, etc.) thereby reducing the "value added" to the local economy. Most of the economic activities carried out in the district provide an important source of revenue for the district.

Forestry in the district plays a very important role, both direct and indirect. Direct benefits relate to those benefits that accrue to individuals directly while indirect benefits relate to those that have direct impacts on rivers, soils and climate. The district has one National and 27 Local Forests. There are also open or customary forest areas that are managed by the traditional leadership (since they are outside protected areas). In National and Local forests, logging and firewood collection is controlled by the Department of Forestry through licenses. In the open areas firewood collection is not controlled. The district has a total of 68,985 hectares of forest estate (both National and Local). This accounts for 6.85% of the total land area for the entire district. Apart from the gazetted forests there are also plantations in Kaande, Limulunga and Namushakende.

Some actions and activities by community are speeding up the process of deforestation. The posters will show four common actions and activities undertaken by communities that perpetuate deforestation. The four are shifting cultivation, arson, human settlement and charcoal burning.

## Theme 11: Landscapes for Life



## Theme 11: Landscape for Life

## Rehabilitation of the Baltic Coastal Lagoon Habitat Complexes (*BaltCoast*)

B. Küper

Stiftung Naturschutz Schleswig-Holstein, Eschenbrook 4, D-24113 Molfsee  
Germany.  
e-mail: [kueper@sn-sh.de](mailto:kueper@sn-sh.de)

Coastal lagoon is a priority habitat for the EC Habitats Directive. In the Baltic region coastal lagoons are particularly well developed. Together with various dune habitats, cliffs and stone beaches, salt meadows and various types of grasslands, the Baltic coastal lagoons form an extremely varied habitat complex, associated with high levels of biodiversity. Many coastal lagoons have either been destroyed already or are still losing their ecological distinctiveness because of hydrological changes, overgrowth and eutrophication.

The LIFE Project *BaltCoast* focuses upon the restoration and improvement of several characteristic habitat types within the Lagoon-Dune-Habitat-Complex. These areas are important for breeding populations of the ruff (*Philomachus pugnax*) and a distinctive subspecies of the dunlin (*Calidris alpina schinzii*), two wading bird species listed in the Birds Directive. The project covers some of the last Baltic strongholds for creeping marshwort (*Apium repens*), European green toad (*Bufo viridis*), natterjack toad (*Bufo calamita*) and avocet (*Recurvirostra avosetta*).

Actions foreseen are, among others, the restoration of natural hydrology of lagoons and salt meadows by drainages blocking and reducing unnatural lagoon discharge. Water bodies will be improved by dredging accumulated mud and the removal of dense reed. Often, these habitats are invaded by unnatural overgrowth of bushes and trees including alien invasive species (e.g. *Rosa rugosa*) which displace natural plants and animals. Through conservation action this process will be stopped and reversed by the introduction of an appropriate mowing and grazing regime. Finally a natural morphology of depressions and dells in dunes and meadows will be re-created. These activities will be accompanied by a number of public awareness raising activities and a scientific best practice guideline based on the knowledge of this project and the expert network created by it.

The main tool for the sustainable long term management of the lagoon complex will be the introduction and extension of hardy cattle and horse grazing. In particular, winter grazing or grazing including early spring and late autumn which has been shown to have a positive impact on site vegetation and structure.

With a partnership of 21 organisations from 5 EU countries (Germany, Denmark, Sweden, Estonia and Lithuania) the project will run from 2005 to 2011. The total project budget will be cofinanced by LIFE Nature. The code of this unit is LIFE05 NAT/D/000152 ([www.life-baltcoast.eu](http://www.life-baltcoast.eu)).

## Conservation of *Bombina bombina* in the Baltic Sea Region (*Bombina*)

H. Drews

Stiftung Naturschutz Schleswig-Holstein, Eschenbrook 4, D-24113 Molfsee, Germany.  
e-mail: drews@sn-sh.de

The fire-bellied toad (*Bombina bombina*), was once a common inhabitant of the agricultural landscape around the Baltic Sea, but recent intensification and land consolidation in the arable fields affected it severely. The sunny pools it vitally needed were filled to make way for productive land, or else the fields the species were in were abandoned so that the pools became overgrown and shaded. Natural protection for the toads' hibernation during the wet and cold wintertime was cleared away, so that these rather helpless creatures became an easy prey for any predator.

While numbers of fire-bellied toads underwent a severe decline during the last few decades overall, not all populations suffered to the same degree. Individual circumstances on-site gave no clear indication for the reasons for such different population trends. A previous LIFE project, focussing on *Bombina bombina* in Denmark, made some progress towards solving these puzzles, but at the same time it exposed other weak spots in toad management.

The LIFE Project *Bombina* aims to safeguard the north-western population of the fire-bellied toad *Bombina bombina* in the Baltic Sea region. A set of tools has been introduced to provide a long term sustainable management of fire bellied toad populations around the Baltic and including genetic analysis, habitat management and population management.

Of these three actions genetic analysis is being employed to detect genetic diversity and to evaluate populations in respect of population management activities (management demanding or self-sustainable populations). Habitat management is seen as essential and habitat quality will be improved by converting arable fields into grassland; creating new ponds and the restoration of eutrophicated ponds (150 in total); the building hibernation sites and the establishment of a whole grazing regime by the introduction of hardy cattle and horses in areas surrounding the ponds. Winter grazing or grazing including early spring and late autumn has positive impacts on vegetation and structure of ponds and the surrounding grasslands. Finally, population management is carried out to secure the survival of small populations (less than 50 adult toads), to build up new mixed populations based on recommendations of the genetic survey at sites where fire-bellied toads went extinct and to build up mirror/preserve populations as a genetic reservoir of unique, isolated populations. The population management will be carried out by the rearing of eggs to metamorphosing tadpoles and releasing young toads at home sites as well as at the newly created and restored sites.

As part of the project, other actions include the establishment of an international expert exchange and initiatives to raise public awareness about the species.

The project comprises 7 partners from 4 EU countries surrounding the Baltic Sea including Germany, Denmark, Sweden and Latvia. The project will run from 2004 to 2009 and part will be co-financed by LIFE-Nature programme. The project code unit is LIFE04 NAT/D/000028 ([www.life-bombina.de](http://www.life-bombina.de)).

**Restoration of ponds as landscape elements and habitat for amphibians - an Estonian experience from LIFE-Nature project**

**R. Rannap, P. Pappel**

Ministry of the Environment of the Republic of Estonia, Narva mnt. 7A, 15172 Tallinn  
Estonia.

e-mail: riinu.rannap@ekm.envir.ee

The great crested newt (*Triturus cristatus*) has a widespread distribution in Europe but has suffered from habitat decline over large parts of its range, which is why the species is listed in Annex II of the Habitats Directive. The problems facing the species include the loss of small water bodies and ponds, natural succession as well as the introduction of fish (which feed on newt eggs and larvae). For hibernation, the newt is dependant on terrestrial habitats which may be negatively affected by commercial forestry and intensive agriculture.

In various parts of Europe, programmes for the protection and restoration of habitats for various amphibian species have been launched. These experiences can be of considerable use to other countries, such as Estonia and Finland, that have yet to start a co-ordinated recovery programme for the species. These two countries harbour small isolated populations along the north eastern border of the range of the species so it will be important for the management and restoration techniques to be adjusted to the regional and local conditions. In Western Europe a main issue is the impact from intensive farming, whilst in north eastern locations it is a lack of appropriate management of semi-natural grasslands and forest habitats that are the main causes of species decline.

In the project area, the distribution of amphibians is largely influenced by availability of suitable aquatic habitats. Some species like *Triturus cristatus* and common spadefoot toad (*Pelobates fuscus*) have high demands to the breeding waters: clear water, suitable plants for egg-laying, absence of fish, shallow zones with high water temperature for development of tadpoles. In the second half of 20<sup>th</sup> century the number of such water bodies has decreased tremendously in several countries around Baltic Sea, causing decline of great crested newt and the common spadefoot, leading several populations to extinction. Thus, saving small isolated populations of both species from extinction, especially in the northern edge of their distribution range (Estonia and Finland), and securing the long-term viability of those species in the Baltic Region, LIFE-Nature project "Conservation of *Triturus cristatus* in Eastern Baltic region" was launched in 2004. This four year project is carried out in Estonia, Finland and Denmark, where the restoration and creation of small water bodies is one of the main actions to improve breeding conditions for those species. In addition, to stop the decline of the target species and re-establish the structure of meta-populations, the restoration of small water bodies creates esthetical value of the landscapes.

The project code for this unit is LIFE04NAT/EE000070.

## Restoring Active Blanket Bog in Ireland

**K. Donnellan, P. Murphy**

Coillte Teoranta (The Irish Forestry Board), Leeson Lane, Dublin 2, Ireland.  
e-mail: philip.murphy@coillte.ie

The peatlands in the West of Ireland are among the most important intact areas of active blanket bog to be found in Europe. Along with the bogs of the Flow Country and the Isle of Lewis in Scotland these form the heartland of the world's blanket mire resource. Since 1997 more than 135,000 hectares of active blanket bog, located mainly in the Atlantic seaboard counties of Ireland, have been proposed for inclusion in the Natura 2000 network. However, significant areas had already disappeared under a canopy of commercial forest plantations whilst the open areas, being unfenced, suffered from ever increasing grazing pressures. The result has been an extensive degradation and drying out of the habitat. The tide is however now turning, Coillte (the Irish Forestry Board) for instance have set aside 15% of its landholding for biodiversity. This creates a unique opportunity to reverse past activities and begin to restore key afforested bog areas.

This strategic five year project is the first of its kind in Ireland to be run by a key Natura 2000 landowner and stakeholder. Using its own land, the Irish Forestry Board will carry out an extensive restoration programme on 14 sites involving over 1989 hectares. Principal actions involve:

- Fencing to gain control of 718.6 hectares of open bog areas;
- Removal of trees on up to 982.27 ha to enlarge the blanket bog area;
- Drain blocking to restore the integrity of the bog hydrological systems;
- Removal of naturally regenerated trees from the open bogs.

Special emphasis is given to sites in County Mayo where the full range of bog types occur from lowland to mountain blanket bog. Five sites have been selected as demonstration sites where there will be a focus on public awareness through demonstration days, interpretation and boardwalk access.

Following achievement of all the main targets on our 14 original project sites, operational work is now progressing on the six additional sites. The main operational targets are felling to waste of conifers, with windrowing of these felled conifers in areas where there is significant tree cover, in order to clear the peat surface for vegetation regeneration. Any significant drains will also be blocked in order to raise the water levels in the peat. This work will continue until the end of 2007.

An end of project conference will be held in late 2007.

The project code for this unit is LIFE02 NAT/IRL8490 ([www.irishbogrestorationproject.ie](http://www.irishbogrestorationproject.ie)).

## Restoring Raised Bog in Ireland

**M. Delaney, P. Murphy**

Coillte Teoranta (The Irish Forestry Board), Leeson Lane, Dublin 2, Ireland.  
email: philip.murphy@coillte.ie

The peatlands of the Irish Midlands are among the most important raised bog systems remaining in Europe. Raised bog habitat was once extensive in Ireland, covering an estimated 310,000 hectares, but this has been reduced to a mere 18,000 hectares of high conservation value, 10,000 hectares of which has been proposed for Natura 2000 designation. Most of the loss has been through the harvesting of peat for household fuel, electricity production and the manufacture of horticultural products. Afforestation has also resulted in habitat loss, but on a smaller scale, with about 2% of the original area planted.

This four year project focuses on the removal of forestry plantations within 14 pSCIs and will be carried out by the Irish Forestry Board (Coillte Teoranta) in line with its objectives to manage 15% of its estate for biodiversity. The project will address the main ecological threats which affect 570 ha of raised bog habitats through the following actions:

- Removal of 450 ha of plantation forest;
- Blocking forestry drains in order to elevate water levels and hence restore the hydrological balance of the peatland areas;
- Removal of naturally regenerated trees from open, unplanted bogs;
- Perimeter protection of vulnerable raised bog sites against fire;
- Consultations to secure control of turbary (turf-cutting) rights.

This work will restore raised bog habitat in Natura 2000 sites across five counties. The project sites were selected as examples of the largest and best raised bog areas owned by the Irish Forestry Board. It will also work closely with the statutory agency on securing the control of peat-cutting rights. The project will build on the restoration techniques pioneered in earlier LIFE-Nature projects in the UK and Ireland (including LIFE02NAT/IRL/8490) and, as the largest single raised bog restoration project to be undertaken in Ireland, it will have a key demonstration element. Two sites will be used as demonstration sites for restoration techniques and for general awareness raising. The project sites will be incorporated into the Irish Forestry Board's biodiversity programme and will continue to be managed with nature conservation as the primary objective.

Approaching the midpoint, the main tree removal actions are close to 100% complete while the drain blocking action is close to 50% complete.

The project code for this unit is: LIFE04 NAT/IE000121 ([www.raisedbogrestoration.ie](http://www.raisedbogrestoration.ie))

## Restoring Priority Woodland Habitats in Ireland

S. Quealy, P. Murphy

Coillte Teorante (Irish Forestry Board), Leeson Lane, Dublin 2, Ireland. email: philip.murphy@coillte.ie

Coillte Teoranta is Ireland's leading forestry company, established in 1988 to manage state owned forests commercially. It currently employs around 920 people and owns 440,000 ha of forest, which it manages with sustainability as a key objective. Coillte has committed to managing 15% of its estate primarily for biodiversity purposes and in 2001 it was awarded the Forest Stewardship Council (FSC) Certificate for good forest management.

In Ireland, four native woodland habitats are recognised in the Habitats Directive as being critically rare and restricted in their distribution across the EU. These habitats are alluvial woodland, yew woodland, bog woodland, and woodland associated with limestone pavement, which is a glaciated karst feature of very limited distribution in Europe and largely restricted to the north-west of the continent. These priority woodland habitats are threatened by issues such as: afforestation with exotic tree species; natural regeneration and spread of exotic species; trespass and damage caused by animals such as feral goat, livestock and deer; artificial drainage; and illegal dumping of domestic and commercial waste.

The main objective of the project is to restore 550.8 ha of alluvial woodland, yew woodland, bog woodland, and woodland with limestone pavement. The project encompasses nine Natura 2000 sites, owned and managed by Coillte, and located in nine different counties across Ireland. The diversity, quantity and quality of the areas make them sites of considerable national and European significance. The project aims to improve the conservation status of the sites and to restore the natural vegetation, as far as possible. The principal protective and restorative actions of the project include removal of exotic species; planting of native and habitat specific species; and installation of fences, dams and dip wells.

On many of the sites, the presence of rare habitats was previously unknown and the project will therefore mean a significant increase in the national area of managed habitats of these types. Three of the sites will be LIFE Project Demonstration Sites, where there will be a focus on public awareness and education over the four-year project period. The project will encourage co-operation between NGOs and statutory bodies involved with protecting the Irish natural environment, making results available for a broad group of stakeholders. Under Coillte's programme for Sustainable Forest Management, the project sites will be managed with nature conservation as the primary objective after the LIFE project ends. This four year project is the newest of our three LIFE projects, and is still largely in the preparatory stage of implementation; removal of invasive exotics such as *rhododendron* has begun. Expected results during the life-time of the project include a significant improvement in woodland habitat quality and the aim is to put in place conditions which will allow priority woodland to regenerate in future years.

The project code for this unit is LIFE05 NAT/IRL000182 ([www.coillte.ie](http://www.coillte.ie)).

## Restoration of the Wetlands of Zahorie Lowland

**J. Šibl**

State Nature Conservancy of the Slovak Republic, Lazovná, 10, 97400 Branská Bystrica,  
Slovakia.  
email: sibl@broz.sk

In Slovakia, wetlands are among the most seriously threatened natural ecosystems. They represent unique habitats for many plant and animal species. They are important for biodiversity conservation and for stabilising the water regime of the landscape. During the last two decades, the total wetland area in Slovakia has declined dramatically and the vast majority of remaining natural and semi-natural wetlands are seriously threatened by human activities.

The main cause of the decline is changes in the natural water regime, brought about by extensive drainage, peat extraction and land reclamation schemes. The changes have led to a decline in habitats and species associated with the wetlands and a reduction of the retention capacity of the areas concerned. One of the most valuable remaining wetlands is located in the Zahorie Lowland, which is also one of the most important regions in Slovakia for biodiversity in general.

The overall objective of the project is to contribute to the development of the Natura 2000 network in Slovakia and the conservation of habitats and species at national level. The project aims to restore eight proposed Sites of Community Interest (pSCI) in the Zahorie Lowland. The proposed activities target a network of mountain rivers and ponds, bogs, dunes, and riparian and alder forests. To respond to the lack of appropriate management, the project will elaborate long term management plans and restoration projects and the existing forest management plans will be amended. This process will involve extensive stakeholder concertation.

The project foresees the construction of a system of fish bypasses and the restoration of river banks to enhance the quality of the river and adjacent habitats. This will include installing 5 small weirs and filling in over a kilometre of drainage ditches, and should improve the conservation status of some 1800 ha, as well as of a number of species. There are also plans to re-establish traditional use on 165 ha of lowland hay meadows in order to restore their ecosystem functions. This will involve cutting and regular mowing and grazing. Finally, the project aims to block ditches and drains to improve the hydrological conditions of the wet habitats in the project area.

The project code for this unit is LIFE05NAT/SK000112 ([www.broz.sk](http://www.broz.sk)).



## Restoration and Management of Sand Dunes Habitats in Zahorie Military Training Area

**P. Frantisek**

Military Technical and Testing Institute Záhorie, VTSÚ Zánorie, 905 24 Senica,  
Slovakia.

e-mail: petras@vtsu.sk

In Slovakia the pannonic inland sand dunes and dry heaths are among the most seriously threatened natural ecosystems. They represent rather unique habitats for many rare plant and animal species, and therefore they are considered of special importance for the biodiversity conservation. During the last few centuries the total area of these habitats in Slovakia has been dramatically reduced and the vast majority of remaining natural and semi-natural sand dunes and dry heaths have been seriously threatened by human interventions. The most significant have been the changes in their natural character, caused by the extensive afforestation and land reclamation schemes, abandonment of their traditional land uses and sand extraction. These changes have led to the substantial reduction of the areas covered by these habitats and to the dramatic decline of their biodiversity. Therefore the project is focused on the restoration of suitable habitat conditions and introduction of appropriate management on the most valuable remaining pannonic inland sand dunes and dry heaths at the territory of Military Training Area Zahorie, which is the most important area in Slovakia for these particular habitats. The project shall contribute to the development of NATURA 2000 network through the conservation, restoration and management of important sand dunes and dry heaths habitats and species at the territory of Military Training Area Zahorie on Zahorie Lowland (West Slovakia).

The specific project objectives are:

- elaborate and test management planning to reconcile Natura 2000 conservation requirements with military use
- reach and maintain favourable conservation status of the habitats and species targeted (pannonic inland sand dunes and dry heaths that have been degraded by the abandonment and vegetation succession) at 3 proposed Sites of Community Importance (pSCIs)
- carry out habitat restoration work, notably against succession, which is a major problem on the sites concerned
- build up the framework for lasting recurring management after the project
- raise awareness of the military staff and local communities about the sand dunes and dry heaths conservation issues and about the importance of military training areas for nature conservation
- continue and strengthen the cooperation between the military and nature conservation institutions on nature conservation management on military training areas

The project code for this unit is LIFE06NAT/SK/000115.

**Restoration of the habitat of the European otter (*Lutra lutra*) in the valleys of Our, Ourthe and Sûre (Belgium, Luxemburg)**

**C. Leclercq**

Parc Naturel Haute-Sûre et de la Forêt d'Anlier, Commission de gestion du Parc Naturel de la Haute-Sûre et de la Forêt d'Anlier, Chemin du Moulin, 2, 6630 Martelange, Belgium.  
e-mail: [christine@parcnaturel.be](mailto:christine@parcnaturel.be)

The Walloon Government established the Parc Naturel Haute-Sûre Forêt d'Anlier in 2001. The park covers 70,000 hectares and is managed by a steering committee with representatives of regional and local administrations, NGOs, conservationists, hunters, fishers, farmers and other stakeholders.

The European otter (*Lutra lutra*) was present in almost every river till the late 1950's. Its regression began during the second part of the past century and all over Europe. The centre of the continent particularly suffered. Nowadays, cores of population living in France and East Germany are slowly increasing, taking back their place. In Belgium and Luxemburg, footprints are regularly found on the banks of several rivers of this border area. The species still present generally without the knowledge of the inhabitants. Although the number of individuals is estimated about 20 to 40 individuals, this population are very important link at the European scale.

This LIFE Nature project aims to restore the habitat in order to preserve the otters living in those valleys. Another objective is to help on the further recolonisation of expanding populations. In order to safeguard the existing otter population and encourage recolonisation, the project will restore the otter (*Lutra lutra*) habitat in a cross-border area between Belgium and the Grand Duché de Luxembourg, including the basins of the rivers Our, Sûre and Ourthe, covering approximately 300,000 ha. The aim is for the habitat restoration to improve the possibility for contact and genetic exchanges between the currently separated populations.

In order to provide long-term protection and appropriate conservation management for key sites, some 50 ha will be purchased and management agreements with landowners will be put in place for a further 50 ha. In agreement with the local farmers, a narrow strip of land along the stream and river banks will be restored to a natural state. This will involve planting deciduous species over 26 km and installing some 45 km of fencing to protect the banks from cattle, as well as installing more than 50 watering troughs to allow them access to water. In order to make the habitats in the valleys more favourable to otters, some 150 ha of conifer plantations along the river valley bottoms will be cut and either replaced by mixed deciduous trees or else left open. Various invasive species will be removed from about 35 ha. Some 25-30 safe refuge zones will be put in place in areas favourable to reproduction, and 9 road-bridges will be equipped with passageways for otters to allow them to cross roads with dense traffic safely. Various actions will be carried out to increase the natural supply of fishes, including restoring 20 cutoffs. To help reconnect the populations in different river basins, and in agreement with local farmers, some 24 km of hedges will be planted along the ridges some 30 small ponds dug. As this conservation programme has so many different aspects and concerns such a large area, the involvement, awareness and approval of numerous local stakeholders are of vital importance. To address this challenge a wide-ranging communication effort will be made with specific actions toward different target groups.

The code of this unit is: LIFE05 NAT/B/000085  
([www.parcnaturel.be/fr/projets/life\\_nature.html](http://www.parcnaturel.be/fr/projets/life_nature.html)).

## Jovsi – the cultural landscape with endangered species

M. Galičič, A. Hudoklin

Institute of the Republic of Slovenia for Nature Conservation  
Dunajska 22, SI-1000 Ljubljana, Slovenia.  
e-mail: mirjam.galicic@zrsvn.si

Slovenia, encompassing two biogeographical regions, Mediterranean and Alpine, has a significant value in biodiversity. This has led the Slovenian government to propose thirty-five percent of the national territory as Natura 2000 sites. However, as in the rest of Europe, newly introduced intensive farming practices, together with rural depopulation and the consequent abandonment of pastures and meadows, is having a negative impact upon habitats and species whose conservation is considered as a priority by the Habitats and Birds Directives. Over half of the national territory is covered by forest and Slovenia is the third most forested country in Europe. However, afforestation practice has witnessed the planting of exotic conifers which have had a drastic impact upon native tree species and habitats for forest bird species.

The Slovenian government intends to address these problems and meet the challenge of contributing to the European network of protected areas. But Natura 2000 sites can be managed successfully only if local administrations are aware of the biodiversity values included in the territory they are responsible for and on the best way to protect and conserve these values. The main objective of the project is to provide local administrations with a model on which to base the actions aimed at the conservation of habitats and species of EU interest. The Institute for Nature Conservation of the Republic of Slovenia, beneficiary of the project, will prepare the official "Guidelines for preparation of management plans for Natura 2000 sites in Slovenia" and will produce and implement five specific management plans, covering a total area of over 67.000 ha. Three priority species and 19 habitats, 6 of which priority, according to the Habitats directive, two priority birds and 20 other species listed in Annex I of the Birds directive will be targeted through the project.

Specific actions will be carried out within all five Natura 2000 sites, including buying trees important for woodpeckers, owls and other forest birds, so as to prevent their destruction, mowing of at least 100 ha of meadows, so as to prevent the disappearance of *Molinia* and lowland hay meadows, fencing of an area with *Pulsatilla grandis*, improving hydrological conditions, creating new educational trails, building of a bird watching tower. Additionally, there will be a national campaign to raise awareness and this will include the setting up a Natura 2000 information system and the organization of numerous workshops, both at local and national level.

In the south-eastern part of Slovenia, along the Sotla River, and next to the border with Croatia, an almost 3000 hectares Natura 2000 site represents a unique cultural landscape. Partially wet meadows and partially a low-altitude inundated forests resort at least 18 Annex I Bird Directive species (including *Crex crex*), as well as other protected and endangered animal (e.g. *Lutra lutra*, *Bombina bombina*, *Lucanus cervus*, *Callimorpha quadripunctata*) and natural habitat types (e. g. Erythronio-Carpinion). Centuries of traditional farming have shaped and preserved Jovsi. In spite of the natural monument status, the region is nowadays endangered by a number of threats, e.g. land abandonment and overgrowing, intensification of agriculture (where farming is still present), intensive forestry practices, disturbance due to increased human access, low public awareness. With the project LIFE04NAT/SI/000240 "NATURA 2000 in Slovenia – management Models and Information System" (2005 – 2007), the project will address the listed threats by a number of actions of which some have already been successfully completed.

The project code of this unit is LIFE04 NAT/SL/000240 ([www.zrsvn.si/life/sl](http://www.zrsvn.si/life/sl))

**Complex program to save the Hungarian meadow vipers (*Vipera ursinii rakosiensis*)  
from extinction.**

**B. Halpern, T. Pechy**

MME BirdLife Hungary, Költő u. 21, 1121 Budapest, Hungary.  
e-mail: balint.halpern@freemail.hu

At present time this small venomous snake can only be found in Hungary. During the last century the subspecies lost most of its previous area in the Carpathian-basin, remaining only in small and isolated populations. Recent estimations put its numbers below 500 individuals. MME BirdLife Hungary with Kiskunság and Duna-Ipoly National Parks started a complex program to establish the background of preserving this unique subspecies for the future.

The four-year program is funded by the Ministry of Environment and Water Affairs and the EU LIFE-Nature programme. The programme consists of four major pillars: habitat reconstruction, monitoring and related studies, publicity campaign and the start of the Viper Conservation and Breeding Centre. Habitat reconstruction is urgently needed to turn forests, planted some 30 years ago on elevated parts of certain habitats, into grasslands providing safe hibernating places. Monitoring of recent populations will try to describe recent habitats with objective parameters, to prepare guidelines for their management. The active protection of a venomous snake can be difficult to accept for the general public, therefore we use every opportunity overcome this problem. Experts fear that some isolated population due to their size are unable to grow whilst the best management effort either and their reinforcement is inevitable in order to keep them. The Viper Conservation and Breeding Centre was started with 10 adult individuals, collected from different populations. The minimised predation and maximised food abundance provided by the Centre's seminatural conditions should result higher recruitment rate than in wild populations. Since the Centre started operating in 2004 we had 103 vipers born from 14 females (2004: 25 from 2 females, 2005: 43 from 4 females, 2006: 35 from 4 females). In the future their repatriation can take place step by step to the selected habitat, enlarged by that time thanks to the grassland restoration.

In addition to the practical conservation work, information panels, leaflets and public fora will try to persuade the local community to understand and accept the conservation of this rare, but unpopular snake.

The project code for this unit is LIFE04 NAT/HU/000116 ([www.mme.hu/rakosivipera](http://www.mme.hu/rakosivipera)).

## Improving coexistence of large carnivores and agriculture in Southern Europe

**A. Mertens, V. Salvatori, S. Ricci, J. Glikman**

Istituto di Ecologia Applicata, Via Cremona 71, 00161 Rome, Italy.  
e-mail: coex@ieaitaly.org

Italy, France, Spain, Portugal, and Croatia have been involved in the past in projects dealing with actions aimed at reducing the conflict between large carnivores and human activities. Now, for the first time, these countries have joined together in a coordinated effort to save their bear and wolf populations.

The population size of these predators in the five Mediterranean countries has experienced a dramatic decline over the last century, mainly due to human persecution and habitat loss. As a result, although once present throughout most of the region, bears and wolves are now characterized by small and fragmented populations, some of which (i.e. bears in central and north-eastern Italy and in central and eastern Pyrenees, and wolves in France), are so reduced in number as to risk extinction. Notwithstanding this decline, large carnivores are still accused by farmers of causing damage to livestock and agriculture. Traditional atavistic antagonism and fears in rural areas also contribute to a negative public attitude towards the two predators.

The project is aimed at the development of the necessary legal and socio-economic conditions for the conservation of bear and wolf, reducing actual and potential conflict situations through a number of measures implemented within a coordinated strategy. As a first step, studies on bear and wolf population size and distribution, are carried out with the support of a Geographic Information System. Studies on damage caused by carnivores, damage prevention methods and causes of vulnerability of agricultural activities are also performed, together with surveys on public perception toward large carnivores. Other actions include the implementation of effective damage prevention methods, such as traditional and electric fences and use of guarding dogs, the improvement of damage compensation and insurance systems and monitoring actions aimed at verifying the effectiveness of these measures and how to fit them to local conditions.

Actions and studies targeting stray dogs, whose recurring damages on livestock are often ascribed to other wild carnivores, are also carried out (i.e. development of a specific management plan and implementation of vaccination campaigns). The project foresees also a wide information campaign directed to the general public and to the rural communities, aimed at raising awareness on ways to improve the coexistence between large carnivores and human activities, emphasizing the potential economic benefit of conserving carnivores, for instance developing eco-tourism.

The main thread of the project is the cooperation and the use of common working methods across the five countries, as well as the exchange of experience and knowledge of all involved parties and other on-the-ground conservation actors.

The project code for this unit is LIFE04 NAT/IT/000144 ([www.life-coex.net](http://www.life-coex.net)).

## Restoration of Latvian Floodplains for EU priority species and habitats

A. Aunins, J. Reihmanis and I. Račinska,

This large and strategic 45 month project targets 16 floodplain areas in Latvia covering 14,085 hectares. All these areas are Natura 2000 sites and they harbour the best floodplain meadows in the country, including 50% of the national resource of fennoscandian wooded meadows. They also host the highest breeding densities of the priority species *Crex crex*, *Aquila pomarina*, as well as a third of the Latvian *Gallinago media* population. Five of the project sites contain etalon habitats for *Osmoderma eremita*. The main threat to these floodplains comes from a lack of management and fragmentation; most have been abandoned and are gradually being invaded by scrub. Changes in the water regime from past drainage works are also taking their toll as is the overall lack of awareness over the natural and socio-economic value of these areas.

The Latvian Fund for Nature is the project beneficiary, and is working in partnership with 24 other organisations, including 21 local municipalities, Latvian Ornithological society, North Vidzeme Biosphere reserve and Nature Protection Board. This partnership will ensure not only a coordinated and coherent approach to floodplain management that is accepted and supported locally, but it will also provide valuable capacity building: be it for the preparation of management plans, use of agri-environmental support or understanding the conservation management needs of species and habitats in the floodplains. In this context, the project will use its experiences to write up a comprehensive best practice manual on floodplain management which will be of relevance also outside Latvia.

A significant part of project budget is located to support local farmers in the restoration of the most important and presently abandoned floodplain areas. All farmers that receive project funding for restoration of their floodplains are obliged to apply for EU agri-environment schemes to ensure further management of restored lands. The objective of this project is to initiate a coordinated restoration and long term management of these important floodplains. Thus, management plans have been prepared for 15 sites in close consultation with stakeholders and works are on the way to restore around 4000 ha of meadows. Since the long-term management is highly dependent on agricultural stakeholders, the project is promoting and training farmers in applying for the new agri-environment schemes in Latvia. Over 800 farmers have been contacted and study tours, educational seminars as well as one to one discussions organized as appropriate to initiate interest and active participation. To date, the project has contracted works for approximately 3000 hectares, and 140 contracts have been signed with farmers (individual and farm contracts). Project staff has encountered a wide range of difficulties including a lack of interest from local farmers to the requirements of the national Rural Development plan, which does not favour the maintenance of floodplain meadows. In order to overcome these difficulties a series of tools are being used including: more emphasis on public awareness building on Natura 2000 network, education seminars, individual meetings, involvement in the development of Rural Development plan for planning period 2007 – 2013, an analysis of current legislation and recommendations to State Institutions.

The project code for this unit is LIFE04 NAT/LV/000198 ([www.lmf.lv](http://www.lmf.lv))

## Conservation and development of inland salt meadows in Brandenburg, Germany

H. Roessling, H. Lengsfeld

Landesumweltamt Brandenburg, Seeburger Chaussee 2, 14476 Potsdam, Germany.  
e-mail: holger.roessling@lua.brandenburg.de

From a bio-geographical point of view, the salt marshes in Brandenburg are an important link between the salt meadows of Northern and Western Europe and those of the more eastern continental areas. The project area comprises the most significant of the Brandenburgian salt marshes, including several plant species endemic to Central Europe. The salt marshes in the project area are generally of small size, but relatively numerous. They are threatened on one hand by the abandonment of extensive grazing, leading to overgrowth, and on the other hand by intensification, leading to a conversion into agricultural lands. Furthermore, the salt marshes are suffering from salt imbalances due to changes in the hydrological conditions, traditionally regulated by the irrigation and drainage system in the project area. Especially during the 20<sup>th</sup> century most sites were damaged by intensive agriculture practice with intensely drainage of wetlands. Moreover, in recent years fen meadows suffer from invasion by reed and wood due to abandonment of the sites.

The project area is located in north-eastern Germany. It covers about 900 ha at around 20 sites. Several sites in Brandenburg are known where deep salt water intrudes into pleistocenic layers and discharges at the surface. The project aims at restoring inland salt meadows and ensuring long term conservation of this priority habitat type of the NATURA 2000 network. Salt plant communities are partially subendemic and endemic in Central Europe.

The measures are intended to cause a distinct improvement of the preservation conditions for salt-affected plant associations. Main actions are:

- Stop of reed and wood invasion
- Restoration of water regime
- Establishment of a sustainable, extensive, land use
- Monitoring
- PR

Salt meadows will benefit from the reestablishment of conditions favourable for an extensive land use and the restoration of local watersheds. The very close cooperation with land owners, land users, local authorities and nature associations will establish an increased awareness of this habitat type and an adapted land use in the project area.

The project code for this unit is LIFE05 NAT/D/000111  
([www.mluv.brandenburg.de/info/salzstellen](http://www.mluv.brandenburg.de/info/salzstellen)).

## **Restoration of the Core Ravine Woodlands of England and Wales: The Ravine WoodLIFE Project**

**M. Brocklehurst**

Natural England, Northminster House, Peterborough, PE1 1UA, UK.  
e-mail: Matt.Brocklehurst@naturalengland.org.uk

The remaining natural Tilio-acerion woodland of the British Isles includes mosaics of woodland habitats associated with steep-sided limestone valleys. Two such sites, the Wye Valley Woodlands cSAC along the border of England and Wales and the Peak District Dales cSAC in northern England, have been chosen for this project due to their size and complex conservation requirements. These woodlands suffer from a range of threats, not least from their fragmentation into different ownerships and a lack of an overall strategy for management, but also from a wide range of progressively negative trends. Work is urgently required to combat woodland fragmentation, the degradation of woodland structure, the decline of woodland species and the lack of community involvement in management.

The project aims to protect, restore and de-fragment the two ravine woodland complexes, to bring them under co-ordinated management and to find innovative solutions to ensure their long-term viability. To do this the project will establish local management groups at each site to develop management plans and to undertake a range of practical measures to improve the quality of the overall woodland mosaic. These will include silvicultural operations to restructure the woodland, boundary repairs to control grazing and the co-ordinated management of deer populations. Additional monitoring work and the use of GIS will establish a clear overview of each site to guide long-term management decisions.

Linked to this practical work will be socio-economic studies such as assessing the markets for venison and charcoal as by-products of woodland management. Overall the project will enhance the condition of some 3000 ha of woodland habitats and will secure their conservation in perpetuity through local partnerships and plans. As a case study in supporting the development of forest habitat networks and core forest sites, the project could have considerable demonstration value. The project will develop networks with similar projects in Europe and will prepare a series of technical notes to support the publication of a ravine woodland management handbook. Finally, awareness will be raised about the importance of these woodland habitats within the Natura 2000 network and share experience gained.

The Ravine WoodLIFE Project, is a partnership between the Countryside Council for Wales, Derbyshire Wildlife Trust, English Nature, Forestry Commission, the National Trust, Wye Valley Area of Outstanding Natural Beauty (AONB) and WWF, and is part funded by the European Commission's LIFE-Nature programme. Running from October 2003 to June 2007, £1.3 million has been targeted at ensuring the long term ecological viability of 2,845 ha of the UK's most important native woodland Tilio-Acerion habitats and associated non-woodland habitats within both the Peak District and Wye Valley on the English – Welsh border.

The project code for this unit is LIFE03 NAT/UK/000044 ([www.ravinewoodlife.org.uk/](http://www.ravinewoodlife.org.uk/)).



## BurrenLife - Farming for Conservation in the Burren

### B. Dunford

National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, 7 Ely Place, Ely Court, Dublin 2, Ireland.  
e-mail: [brendan@burrenlife.com](mailto:brendan@burrenlife.com)

Located along Ireland's Atlantic coastline, the Burren region is one of the most remarkable limestone areas in Europe. Within its boundaries, five pSCIs now cover a total of 47,000 ha, encompassing a range of habitats including the priority habitats limestone pavements, orchid-rich grasslands, petrifying springs, turloughs and *Cladium fens*.

Agricultural use of the area can be traced back over 6,000 years. The Burren landscape has been deeply influenced by this agricultural activity and recent research has shown that traditional pastoral systems, in particular the reverse-transhumance 'winter grazing' regime, are integral to ensuring the presence of over 70% of Ireland's native flora in the region. Furthermore, the exploitation of the land by generations of farmers has ensured that large areas of limestone pavements have remained free of scrub, creating a dramatic landscape. In spite of this long tradition of agriculture in the Burren, recent years have seen the withdrawal, restructuring and reduction of farming activity. This has led to the slow degradation of priority habitats through under-grazing, abandonment and the loss of land management traditions.

A new, integrated, system for the agricultural management of the Burren urgently needs to be developed, one that will secure a bright future for its people and their heritage. Funded through the EU LIFE Nature fund, BurrenLIFE -*Farming for Conservation in the Burren*, aims to develop a new model for the sustainable agricultural management of the priority habitats of the Burren. With the support of the Burren Irish Farmers Association, Teagasc, National Parks and Wildlife Service and local communities, the project is running pilot schemes on 2,400 ha of the Burren. Project actions include the use of new feeding systems, the redeployment of existing livestock and targeted scrub removal. When fully tested, the land use stipulations will be used to develop new support mechanisms through the revision of existing agri-environment schemes and other methods.

A pilot project of this nature requires a considerable amount of preparation and monitoring in order to be confident that the new mechanisms are transferable to the whole 56,000 ha of Burren farmland. Studies addressing the impact of the land use stipulations on habitat quality, soils and water quality are to be matched with data on the condition of livestock and the costs of management. In the end, support for new initiatives must come from the farmers themselves. Thus the project intends to work closely with the farming community to develop a pragmatic scheme which satisfies environmental, agricultural, economic and social criteria.

The project code for this unit is LIFE04 NAT/IE/000125 ([www.burrenlife.com](http://www.burrenlife.com)).

**Conservation through plant micro-reserves in the Valencian Community: experiences from the LIFE programme**

**E. Laguna**

Generalitat Valenciana, Conselleria de Territorio y Vivienda. CIEF – Servicio de Conservacion de la Biodiversidad. c/ Francesc Cubells, 7. E-46011 Valencia, Spain.  
e-mail: laguna\_emi@gva.es

The Mediterranean rim of Spain numbers over 300 endemic plant species, 50 of which are found exclusively in the Valencia region. Unique plantscapes are frequent in this region, with its wide variety of habitats. A total of 62 habitat types of Community interest have been identified, 17 of which are classified as priorities. Under the European legislation, the regional government has therefore proposed 38 sites for inclusion in the Natura 2000 network - equivalent to designating almost 16% of its territory for protection of habitats and of the species living there.

With the loss of biodiversity and degradation of the plant communities some of these habitats have virtually disappeared, principally because of urban expansion, overgrazing, quarrying. Since 1991, the government of the Valencian Community (Spain) has developed a project to establish a network of Plant Micro-Reserves (PMRs), a new legal and technical figure for plant monitoring and active conservation. Its development was initially supported through two earlier LIFE-Nature projects (1994-99; 1999-2003). Nowadays, the Valencian Community (region of Valencia) holds 257 officially protected PMRs, housing representative samples of 60 habitats of community interest; more than 1000 populations of 450 selected species have been targeted to develop active conservation tasks in this network; 275 of these species are Spanish endemic plants. The Valencian PMR is particularly concerned with the protection of micro-landscapes and plant communities which cover small surfaces, such as Mediterranean temporary ponds, petrifying springs, relict Eurosibiric forests –yew woods, and Tilio-Acerion ravine forests.

The principal objective of the project is conservation of the vegetation which forms 17 priority habitats in the 38 sites proposed for inclusion in the Natura 2000 network. The action planned to restore some of the priority habitats includes reproduction of plant species to reinforce the existing population and reintroduction at sites where they are now extinct. At the same time, following on from the earlier Life-Nature projects, this project will complement the network of flora microreserves set up to protect the most valuable species and habitats in the Valencia region. Technical seminars will be held to disseminate information on activities on the project and an educational campaign has been designed, including production of a video and the establishment of guided trails, both in the natural environment and in gardens reproducing the habitats covered by the project.

Due to its contribution for plant and habitats conservation, the Valencian PMR project has been promoted and sponsored by several institutions (European Commission, Council of Europe, Planta Europa, Europarc, Eurosite) and programmes (IPAs, MaB-UNESCO). The European Commission has also promoted the enlargement of the PMR through 3 more LIFE projects in Menorca (Spain), the future regional park of the Slovenian Karst (Slovenia) and the prefecture of Chania (Crete, Greece).

The project code for this unit is LIFE99 NAT/E/006417.

## Optimisation of the pSCI Lippe flood plain between Hamm and Hangfort

### O. Schmidt-Formann

Dipl.-Landschaftsökologe, Stadt Hamm, Umweltamt, Caldenhofer Weg 10  
D- 59065 Hamm, Germany.  
e-mail: schmidtformann@stadt.hamm.de

The city of Hamm is located east of the Ruhr area in Germany and has around 190,000 inhabitants. The Umweltamt (environmental county) is the local authority responsible for issues concerning environment, water protection and nature conservation. A successful application was made to the Life Nature programme to part fund a project for the optimisation of the proposed site of community importance (pSCI) "Lippe flood plain between Hamm and Hangfort". The proposal was funded in 2005.

The River Lippe, a tributary of the Rhine, is running along the southern edge of the Westfalian lowlands. Its floodplain connects the biotopes of the Lower Rhine in the West and of the Teutoburger Wald and the Eggegebirge in the East. The river system has been heavily modified by water engineering works and agricultural use, but has still some areas with high conservation value. One of these areas is the proposed Site of Community Interest (pSCI) "Lippeaue zwischen Hamm and Hangfort". This pSCI is characterised by grassland, backwaters and oxbows, and small pockets of alluvial forests, a priority habitat under the EU Habitats Directive. Part of the area is also designated as Special Protection Area (SPA, "Lippeaue zwischen Hamm und Lippstadt mit den Ahsewiesen") with breeding populations of corncrake (*Crex crex*), kingfisher (*Alcedo atthis*) and marsh harrier (*Circus aeruginosus*).

One of the most important aims of this project is to protect and to promote habitats and species contained within the EU Habitats and Birds Directives. Additionally, the project would support the restoration of active floodplain by connecting river and meadow and optimising the natural water balance.

In the transition area between the Central Münsterland and the Hellwegbörde, the Lippe is a lowland river. Its meadows and tributaries constitute a mosaic of different biotopes with unique biocoenoses, which have retained their natural appearance despite increasing stress mainly induced by intensive land farming. However, commercial demands on the Lippe meadows increased continuously during the last century. The river was straightened in sections, and most of the banks were reinforced with rock beddings. This resulted in a deepening of the riverbed, a lowering of the surrounding water levels and in connection with man-made embankments an associated isolation of river and flood plain. In addition, amelioration measures and the construction of drainage ditches in the meadows resulted in widespread changes to the water balance.

The project will serve the sustainable protection and improvement of biotopes according to Annex I of the Habitats Directive. Several measures will stabilise the populations of highly endangered animal and plant species. The Lippe flood plain also serves as a connection axis for the biotope network of migrating animal species.

The project code for this unit is: LIFE05 NAT/D/000057 ([www.life-lippeaue.de/](http://www.life-lippeaue.de/)),

## Conservation and management of Danube floodplain forests

T. Kušík

BROZ - Regional Association for Nature Conservation and Sustainable Development  
Šancová 96, 83104 Bratislava, Slovakia.  
e-mail: kusik@broz.sk

South of Bratislava, the Danube forms the largest inland river delta in Europe. Here, at the border with Hungary, its floodplain landscape comprises a wide range of shifting interdependent habitats: forests, river channels and alluvial aquifers. The dynamics of river hydrology, geomorphology, vegetation and ecological gradients between aquatic and terrestrial habitats have resulted in a unique environment. The area was designated a Ramsar site in 1993 and qualifies as a Natura 2000 area for its floodplain forests (the alluvial alder, willow formations and the mixed oak-elm-ash stands). This species-rich area (over 100 mollusc species and 1800 beetle species) is also home to the black stork (*Ciconia nigra*), the white-tailed eagle (*Haliaeetus albicilla*) and several bat species.

Like most rivers in Europe, the Danube floodplain has been drastically altered. The building of the Gabčíkovo dam and canal strongly affected this inland river delta. Forest management as pursued in the 1990s was not sustainable and did not take the potential natural forest into consideration. Finally, pollution, eutrophication and increasing intensification of the nearby agricultural environment were also having a negative effect on fauna and flora. The territory of Danube river floodplain in Slovakia consists of well-developed branch system, oxbow lakes, river islands, sand and gravel banks. A large part of the area is covered by floodplain forests. Diverse system of aquatic and wetland ecosystems represents the largest inland delta in the Central Europe.

Many decades of unsustainable forestry practice, large scale clear cuts and planting of plantations of hybrid poplars has led to major destruction of natural floodplain forest habitats. NGO BROZ - Regional Association for Nature Conservation and Sustainable Development is leading the LIFE project with the objective to preserve last remaining natural floodplain forests in Slovak part of the Danube floodplain, which were under threat of clear cutting and replacing by plantations. Due to new forest management plans and cooperation with foresters, further loss of natural floodplain forests habitats by forestry is no more possible. Other project actions included elimination of invasive tree species, designation of new nature reserves land purchase and long-term lease, etc. BROZ has acquired 250 ha of the land where natural habitats will be restored. After the project implementation conservation actions are continuing in restoration of river branches and looking for resources for purchasing of more valuable floodplain areas. Model forest management would be carried out as a practical demonstration, with measures for the control and elimination of invasive plant species, the promotion of natural regeneration and selective tree cutting. Finally, education and training of personnel from the forest and nature conservation administration would help the most important stakeholders to apply sustainable forestry and to protect the threatened habitat types and species of this unique landscape.

The project code for this unit is LIFE03NAT/SK/000097 ([www.broz.sk](http://www.broz.sk)).

## Ecological restoration of the Lower Prut floodplain natural park

<sup>1</sup> C. Sandu, <sup>1</sup> G. A Radu, <sup>2</sup> I. Şandric

<sup>1</sup> Regional Environmental Protection Agency, 2 Regiment 11 Siret, Galati, RO-800322, Romania.

e-mail: office@arpmgl.ro

<sup>2</sup> University of Bucharest – Centre for Environmental Reserach and Impact Studies, 36-46 Mihail Kogălniceanu, Bucuresti, RO-050107, Romania.

The Lower Prut Floodplain Natural Park is the entrance of the Danube Delta Biosphere Reserve. It lies on the flyway route of hundreds of migratory birds. It is the nesting site for more than a hundred bird species, and also a resting/wintering place for many of the passing migratory birds. More than 50 of these birds are listed in the EU Birds Directive and in the Bern Convention. The target area of the project furthermore comprises three priority habitats under the Habitats Directive. The ecological importance of the park has been recognised at national as well as international levels. For example, it is included in the Lower Danube Green Corridor programme, developed with the support of WWF, and signed by representatives of Romania, Bulgaria, Moldova, and Ukraine in 2000. In 1999-2000 a project on nature rehabilitation and international wetlands management, financed in the PHARE scheme, was implemented in the park.

The natural park is characterised by average to low levels of rural settlements, affected by accelerated population decrease. Fishing and agriculture represent the main activities generating incomes for the local inhabitants. Lower Prut Floodplain Natural Park, including 8247ha, is located in Galati County in the eastern border of Romania with Moldavian Republic along Prut River. The objective of the project is to improve the conservation status of aquatic bird species in Lower Prut Floodplain Natural Park, Galati County, through a series of strategic interventions involving scientific inventory, monitoring activities, sites restoration, raising awareness activities, implementation of the park management plan and designating Special Protected Area - Romanian Nature 2000 sites.

The implementation of actions is focused on the improvement of the conservation status of the important aquatic bird species, their inclusion in the management plan of park, contributing to the sustainability of the sites. The public awareness component will involve the production of a set of promotional materials, films and pictures, activities with the mass media, web site publishing and informational panels and displays throughout the sites and in the information points. In the park area some lakes will be carried a set of reconstruction activities in order to prevent birds' habitat destruction. The wetlands are included in the ecological-fragile areas category, their dynamic being mainly influenced by the qualitative and quantitative parameters of the water from the watershed they are extending in. For this reason, the conservation measures promoted in these areas are accompanied by a severe control of the *entropic activities/arrangements* that use the water for different usages or as a way to discharge some wastes.

Satellite image and pictures have been identified for the spatial unitary representation of the ecological elements from the Lower Prut Floodplain, in order to analyse the area of project in the past and at the present day, and to understand the relationship between landscape and the dynamic nature of wetlands.

The project code for this unit is LIFE05NAT/RO/000155.

## Amphibian Biotope Improvement in the Netherlands (AMBITION)

R. Heringa

Staatsbosbeheer, Princenhof Park, 1, 3972 NG Driebergen, Netherlands.  
e-mail: r.heringa@staatsbosbeheer.nl

Staatsbosbeheer is the Dutch State Forestry Service, which has been in existence for well over a century. In recent decades its tasks have extended beyond forestry work to include broader areas of nature conservation.

Amphibians rely on the presence of small wetlands and small landscape features such as hedges, ditches and small pockets of woodland. The large scale rural land consolidation schemes in the Netherlands have resulted in the loss of many of these habitats with the result that amphibians, too, are rapidly disappearing. This project tackles the conservation of five particularly vulnerable amphibian species including *Triturus cristatus* (great crested newt); *Bombina variegata* (yellow bellied toad); *Alytes obstetricans* (midwife toad); *Hyla arborea* (tree frog); and, *Pelobates fuscus* (common spadefoot toad).

Before the project began, national recovery plans had been designed for the midwife toad and tree frog. A four step approach had been developed to restore the populations of these species and improve the conservation of their habitats:

- Protect the existing populations
- Enlarge the size of habitats around the core areas
- Provide ecological corridors between the populations and,
- Create metapopulation structures.

Partnership is particularly important in this project. The beneficiary (Staatsbosbeheer) collaborates with provincial landscape foundations (Overijssel, Gelderland, Limburg), an NGO with considerable herpetological experience (RAVON) and the largest conservation NGO in the Netherlands (Natuurmonumenten).

A total of 14 subsites have been selected and in each of these, the partners are to carry out small-scale conservation works to protect the existing populations and expand their habitats. Pools will be dug, ditches will be restored, depressions will be created, hedges will be planted (or removed where they are detrimental to the target species).

An 'AMBITION' website has been set up to promote the collaboration between the partners and exchange information. Special measures are also being taken to raise public awareness about the project.

The project code for this unit is LIFE04 NAT/NL/000201 ([www.life-ambition.com/](http://www.life-ambition.com/)).

## Protection of *Emys orbicularis* and amphibians in the north European lowlands

**P. Mierauskas**

Lithuanian Fund for Nature, Algirdo st. 22-3, LT-03218 Vilnius, Lithuania.  
e-mail: [pranas.m@glis.lt](mailto:pranas.m@glis.lt)

The Lithuanian Fund for Nature (LGF) is a non governmental organisation in charge of five programmes: environment policy and management, nature protection and site management, agriculture and rural development, ecological education, Baltic coastal conservation and protection of the Curonian Lagoon. The Nature Protection and Site Management Programme covers the conservation of biodiversity and its status assessment, protection of rare and endangered species, the drawing up and implementation of site management and species action plans, and the selection and management of protected areas.

Considerable knowledge has been acquired on the design and improvement of pond landscapes of high value for amphibians, thanks mainly to three LIFE projects. The first project dealt with the consolidation of the European fire-bellied toad (*Bombina bombina*) in Denmark (LIFE99NAT/DK/006454). The two other projects, still ongoing, focus on the protection of the great crested newt (*Triturus cristatus*) in the Eastern Baltic region and on the management of the *Bombina bombina* in the entire Baltic region (LIFE04NAT/EE/000070) and (LIFE04NAT/DE/000028). With basic experience on turtle conservation in Lithuania, Poland and Germany, there are enough data available to implement protection measures on herpetological (reptiles and amphibians) sites of European interest and to develop a concept of active protection of sites of high herpetological diversity in the North European lowlands.

The main objective of the project is to ensure the favourable conservation status of the European pond turtle (*Emys orbicularis*) in the North European lowlands. The project also foresees to ensure a favourable conservation status for the European fire-bellied toad (*Bombina bombina*) and the great crested newt (*Triturus cristatus*) in the areas where they occur together with *Emys orbicularis*. The project will furthermore demonstrate how to protect *Bombina bombina* in artificial and drained lowland meadows of Brandenburg in Germany and in the large natural swamps and fenland of Zuvintas Biosphere Reserve, Meteliai and Veisiejai regional parks in Lithuania. The aim is to protect more than 90% of the *Emys orbicularis* individuals in the north European lowlands and to demonstrate the validity of protection measures for *Bombina bombina* and *Triturus cristatus* as well as other amphibian species such as *Hyla arborea* and *Pelobates fuscus*.

The project code for this unit is LIFE05 NAT/LT/000094 ([www.glis.lv](http://www.glis.lv)).

## Habitat improvement for *Microtus oeconomus* in Alde Feanen

H. de Vries

Provinciale vereniging voor natuurbescherming It Fryske Gea, Van Harinxmaweg, 173  
Beetsterzwaag, The Netherlands.  
e-mail: [h.j.de.vries@fryskegea.nl](mailto:h.j.de.vries@fryskegea.nl)

The endemic root vole *Microtus oeconomus* var. *arenicola* occurs only in the The Netherlands and is listed as a priority species in Annex II of the Habitats Directive. The root vole thrives in wet reedlands and grasslands along lakes and rivulets. It has a fragile existence and can only exist where the Common Vole (*Microtus arvalis*) and the Field Vole (*Microtus agrestis*) are absent - it cannot compete with these more competitive species. The project aims at increasing the optimal habitat of the root vole in its core area in the province of Friesland at a site managed by "It Fryske Gea" called the Alde Feanen (the old peatlands). Here, the species still occurs but is vulnerable because of its limited population size.

The aim of the project is to strengthen and develop a healthy core population, by recreating a suitable habitat on recently acquired farmlands and by installing a variable water level management regime in the existing nature area. This cyclic water management will allow the beneficiary to decrease the water level inside one area (Jan Durkspolder) where it is currently too high, while increasing the water level in another area (Wolwarren), so that competition of the Field Vole will be excluded. In practical terms, this involves significant structural engineering works such as excavation works, filling in of existing ditches, reconstruction of a micro-relief, strengthening of the canal banks in the surrounding area and securing roads and buildings.

A secondary objective is to enable other rare species to benefit from the project. This applies mainly to the animals found in marshland vegetation, such as the Bittern. The beneficiary will also provide ample publicity (sign-posting, exhibition, publications) to the project and its plight to save this small endemic rodent from extinction.

The project code for this unit is LIFE04 NAT/NL/000203 ([www.fryskeagea.nl](http://www.fryskeagea.nl)).



## **Ecological military area management: no beating about the bush, please!**

**H. Jochems**

Ministerie van de Vlaamse Gemeenschap, AMINAL (afdeling Natuur), Ferrarisgebouw, 4de verd.Koning Albert II-laan, 20/8, Brussels, Belgium.  
e-mail:hans.jochems@lin.vlaanderen.be

### **Introduction**

Military areas are undoubtedly of the utmost importance for the conservation of wildlife. Within the framework of the largest European LIFE Nature project DANAH, the aim is to make effective area management plans by end 2008 for 12 Military areas with a total surface of close to 10.000 hectares in Flanders, Belgium.

The situation in Flanders is unique. Due to the fact that open spaces are becoming ever rarer, the social pressure for recreational use of military domains increases.

Combining Nature Management and Military training is a challenge on its own. Adding recreation as a third relevant form of land use is the only way to maintain sustainable and social acceptable results.

### **Story Content**

The system has three simple steps: 1. Approve every former management attempt on a high hierarchical level, 2. Build Area Direction Plans on top of the former management attempts, 3. Use the Direction Plans to build uniform Area Management Plans. These are summarized below. The target is sustainability.

1. Within every Commission for the Nature and Forestry of the Flemish military areas the management attempts before LIFE project DANAH were gathered (step 1).
2. Then workshops were set to work to make inventories of the ecological and military values of the areas. These geographical inventories were compared and where necessary adapted inside a GIS-system. From this point the guidelines for recreation will be listed for every area, and this will happen between March and September 2007 (step 2).
3. Parallel with this last discussion, step 3 (Area Management Plans) will be carried out. These will include an ecological, cultural and historical inventory, a listing of ecological and economical targets, followed by management measures to reach these targets and the monitoring of ecological status. This step 3 will run until December 2008.

The idea is to reach the aims of the NATURA 2000 concept by carrying out landscape architecture with the two project partners, the Ministries of Defence and Environment in order to integrate the three most important types of land uses known in Flanders on military domains.

This system includes qualitative (e.g. what kind of vegetation is present?) as well as quantitative data (e.g. how rare is this vegetation within Flanders and Europe?). This is done in a uniform way for the complete surface of the NATURA 2000-network in Flanders, and the data are listed inside a GIS-tool (internet-based) and a simple relational database.

Together with step 2 a think-tank works out the best way to communicate the idea behind the system a broader public. This will try to take away at least some of the recreational pressure that is present within such military areas.

The project code for this unit is LIFE03 NAT/B/000024 ([www.danah.be](http://www.danah.be)).

## Rehabilitation of peat and wet habitats on the Saint-Hubert Plateau, Belgium

G. Jadoul

Unité de Gestion Cynégétique du Massif Forestier de St-Hubert ASBL  
C/o Cantonnement de la Division Nature et Forêt, Rue de Lahaut 3, 6950 Nassogne,  
Belgium.  
e-mail: gerard.jadoul@skynet.be

The Unité de Gestion Cynégétique du Massif forestier de Saint-Hubert, asbl (Unit for Hunting Management of the Saint-Hubert Forest Block) was one of the first voluntary associations of hunting estates in the Walloon region of Belgium. Created in 1985 around the royal hunting estate of Saint-Michel, Freyr et Libin, it currently regroups more than 134 hunting estates (ranging from 50ha to 4000ha).

Strategically located in the centre of the Ardennes, between other natural areas with similar ecosystems, the 10,000 hectare plateau of Saint-Hubert formerly consisted of a complex of beech forests, bog woodlands, alder forests, transition mires and raised bogs with interesting fringe vegetations along the watercourses. Most of the natural wetlands have now disappeared as large parts of the 2,500 ha peaty and wet soils on the plateau were afforested with spruce.

Because of the difficult soil conditions, this afforestation effort did not prove very successful and is certainly not sustainable. It also caused a lot of problems with soil structure, hydrology and the availability of suitable vegetation for browsing deer, icons of this forest where Saint Hubert was miraculously converted. Purple moor-grass is invading the open areas as the wetlands further desiccate. Nevertheless, these degraded forests offered a great potential for nature conservation and as much detailed information on biodiversity, soils, ownership structure and socio-economic context existed, the local hunters' association, in collaboration with the Wallonian authorities, developed a master plan to restore this area.

A priority work area covering 842 ha was identified, covering the main zones where peaty areas or very wet soils overlap with degraded spruce plantations. The owners (public authorities and private land owners) are known and have already agreed to participate in the project. The first action is to identify the most suitable 300 ha where spruce plantations should be abandoned in order to restore the natural habitats. Up to 50 ha of land is to be bought and at least 150 ha is to be restored by cutting and exporting trees and by restoring a more natural water regime (filling drains, building little dams). Tree and purple moor-grass colonisation will be controlled by cutting young trees and, above all, by putting a flock of 400 sheep on at least 100 ha of restored land. The project will invest in a stable and other infrastructure; grazing management is designed to be financially self-sustaining after the project.

This project intends to be a model for similar restoration efforts in the other high plateaus of the Ardennes region and the project's public awareness-raising efforts should create support for such conservation initiatives. As non-sustainable forestry has caused conservation problems in such wetlands elsewhere in Europe, the beneficiary intends to network and disseminate information about the habitat restoration measures of this LIFE-Nature project.

The project code for this unit is LIFE03 NAT/B/000019  
([http://mrw.wallonie.be/dgrne/sibw/offh/life\\_tourbieres/](http://mrw.wallonie.be/dgrne/sibw/offh/life_tourbieres/)).

## Cross-border restoration of heathland on continental dunes

I. Ledegen, P. Muijsers<sup>1,2</sup>

<sup>1</sup> Cross-border park 'De Zoom – Kalmthoutse Heide', Nieuwstraat 77, 2910 Essen, Belgium.  
e-mail: info@grensparkzk.be

<sup>2</sup> Four partners in this project: Vereniging Natuurmonumenten, Agentschap voor Natuur en Bos, gemeente Woensdrecht, Natuureducatief Centrum De Vroente'

The De Zoom – Kalmthoutse Heide consists of 3,750 ha of heathland that extends over the Dutch-Belgian border. It is made up of continental dunes, dry and wet heath, pools and woods and transitions between them. The park is both privately and publicly, and partnerships are necessary to maintain the land, to provide information, education and recreation and to coordinate wood production and fauna management. The project site of 180 ha is situated in the centre of the cross-border park, on Dutch and Belgian land. Human impact, such as afforestation and soil desiccation, combined with a lack of nature management has led to degradation of the habitat. There is an acute need to invest in nature restoration in this part of the cross-border park.

This LIFE-project aims to restore and develop a varied heathland landscape, paying special attention to the following Annex I habitats of the Habitats Directive : dry sand heaths with *Calluna* and *Genista*, inland dunes with open *Corynephorus* and *Agrostis* grasslands, oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*, northern Atlantic wet heaths with *Erica tetralix*, European dry heaths and depressions on peat substrates of the *Rhynchosporion*. The long term objective is to create an open landscape, merging gradually into adjacent woodland.

As a first step, 52 ha will be purchased with a view to carrying out nature management on the whole project site. Felling of trees will be carried out over an area of 65 ha. An open area of 120 ha will be created alongside present open terrain to connect open heathlands on the Dutch and Belgian part of the park. Together with sod cutting on different locations (total surface of 41 ha), this activity will create the optimal conditions for the restoration of the special habitats listed above. Between this open heathland and the remaining wood, an area of 20 ha will be reserved for half open landscape. The long-term objective is to create an open landscape that merges gradually into close woods in the south of the project site. The open heathland will include a mosaic of different habitats: bare shifting sand, carpets of mosses and lichens in the pioneer phase, pioneer grasslands with *Corynephorus*, dry heaths with a varied age structure, well-developed wet heaths and pools.

The restoration measures will promote the establishment in the area of species of the Habitats Directive, such as the Water-Plantain (*Luronium natans*), the large white-faced darter dragonfly (*Leucorrhinia pectoralis*), and the crested newt (*Triturus cristatus*) and will improve the habitat for birds already breeding in the area, such as the nightjar (*Caprimulgus europaeus*) and the woodlark (*Lullula arborea*). New walking paths will be created and the public statute of a road in the centre of the border park will be abrogated.

The project code for this unit is LIFE06 NAT/B/000085.

## Natural meadows and pastures of Östergötland - restoration and maintenance

D. Nilsson

The County Administrative Board of Östergötland, Östgötagatan 3, 581 86 Linköping, Sweden.

e-mail: dan.nilsson@e.lst.se

Meadows and grasslands contain a broad diversity of plant species, which provide the conditions for a wealth of insect life while grazed shore meadows provide habitats for many species of birds.

During the past decades, the modernization of agriculture has resulted in a drastic reduction in the acreage of natural hay meadows and grazing land as small land plots were abandoned or incorporated into large intensified agricultural units. Where small plots still exist, lack of management has resulted in overgrowth of the plots and caused many connected species of flora and fauna to become rare or even disappear.

The county of Östergötland holds a considerable proportion of Sweden's acreage of natural hay meadows and grazed pastures. Östergötland is also an important region for many species connected with old oaks. These old, often hollow, trees host a myriad of insects, lichen and moss species. For example, the hermit beetle (*Osmoderma eremite*), a priority species in the Habitats Directive, has its largest populations in Östergötland and occurs in no less than eight of the project sites.

The project targets natural meadows, wooded pastures and shore meadows typical for extensive agricultural landscapes. It aims to restore natural meadows and pastures on 41 Natura 2000 sites in Östergötland. The habitats typically require continuous management in the form of haymaking or extensive grazing. Within the framework of the project, 398 hectares of meadow and wooded pasture will be cleared of overgrowth. Grazing by horses and cattle will be introduced, or grazing conditions improved, on 392 hectares, and natural hay meadows will be restored on six hectares. Pasture will be established on an additional 433 hectares of shore meadows to encourage the rich bird life of these areas.

In one area, pollarding of old deciduous trees will be resumed to benefit the many species of flora and fauna that need old trees for their survival. Oak trees will be planted to encourage, in a long-term perspective, the many species dependent on old oaks.

The project code for this unit is LIFE05 NAT/S/000108.

**A LIFE-Nature project on restoration of Priority Habitats for Amphibians within the Natura 2000 Network in Valencian Community (East Spain).**

**I. Lacomba<sup>1</sup>, V.Sancho<sup>2</sup>**

<sup>1</sup>Conselleria de Territori i Habitatge. c/ Gregorio Gea, 27 (Edif. PROP 1). Valencia, Spain.  
e-mail: lacomba\_ign@gva.es

<sup>2</sup>Conselleria de Territori i Habitatge. CRF La Granja del Saler. Av. Los Pinares 106. 46012 El Saler (Valencia, Spain).

Owing to the widespread abandonment of traditional management practices, the small inland freshwater bodies of the Valencia Region are rapidly disappearing. Small freshwater bodies are vital habitats for a range of threatened amphibians as well as some rare plant and animal species. Eight different amphibians are currently found in the freshwater bodies in Valencia.

In 1998, a preliminary inventory of water bodies of interest was developed with a view to the protection of their biodiversity. Based on interviews with environmental managers and field visits, more than 4,600 water bodies across Valencia were inventoried. At the same time, it was established that actions are necessary to ensure the restoration, protection and management of many of these water habitats. Amongst the habitats are Mediterranean temporary ponds and petrifying springs with tufa formations, which are prioritized by the European Community.

The project targets the preservation of a network of 55 small freshwater pools, part of a vast complex of 4,612 ponds (or water retention sites) of small and medium-size in Valencia. The project aims to improve the conservation status of eight amphibians found in the pools. Amongst these are the Spanish painted frog (*Discoglossus jeannea*), a priority species for the European Community, as well as three other rare species: the midwife toad (*Alytes obstetricans*); the natterjack toad (*Bufo calamita*); and the Western spadefoot (*Pelobates cultripes*), a toad which is only found on the Iberian peninsula and in southern France.

Management plans will be elaborated for individual habitat types and two of the targeted amphibian species. To encourage an increase in the habitat-specific vegetation, the propagation of hydrophitic and helophytic plants will be carried out. Further concrete restoration actions that are planned include the eradication of invasive species, erosion control, and restoration of hydrological features.

The project code for this unit is LIFE05 NAT/E/000060.

## Monitoring the Mediterranean Temporary Ponds in Crete

I.N. Vogiatzakis<sup>1</sup>, G.Kazakis<sup>2</sup>, D. Ghosn<sup>2</sup>

<sup>1</sup>Centre for Agri-Environmental Research, School of Agriculture Policy and Development, University of Reading, UK.

e-mail: [i.n.vogiatzakis@reading.ac.uk](mailto:i.n.vogiatzakis@reading.ac.uk)

<sup>2</sup>Department of Environmental Management, Mediterranean Agronomic Institute of Chania (MAICH), Greece

Mediterranean Temporary Ponds (MTPs) are a priority habitat of the 'Habitat Directive' 92/43/EEC. Being a particularly vulnerable and dynamic habitat, MTPs are frequently threatened from anthropogenic activities and the concurrent lack of natural dynamics.

This LIFE project will focus on a number of M.T.P. on the island of Crete, all located within four different pSCIs. The MTPs of the first site are found in the areas of Imeri and Agria Gramvousa-Tigani kai Falasarna-Podikonisi (112 ha) 2.5 km south of the Falasarna beach of the western coast of Crete; the second is Nisos Elafonisos and its opposite beach from Chrysoskalitissa to Akrothrio Krios (87 ha); the third is Drapano (NW coasts)- Georgioupolis beach-Limni Kourna (3ha); and the fourth the islands of Gavdos and Gavdopoula (45 ha).

The total surface of the MTPs in the project area extends thus to 247 ha. Although these four sites are still in a relatively good state, they are increasingly affected by human activities, including water over extraction, artificial drainage and recharge, overgrazing, water eutrophication, solid waste disposal and high visitor pressure.

The aim of this LIFE project is restoring the MTP habitat in Western Crete to the favourable status that existed prior to human interference in the area. This will notably be done through the set-up of an adequate management system and by implementing the following actions: restoring the habitats' natural hydroperiod and reducing the negative impact of overgrazing impact by re-establishing the habitats' original grazing management system.

The impact of polluted run-off from unsustainable agricultural practices will be quantified through a water quality survey and through the set-up of a monitoring system on a site-by-site base. The concrete actions that will be undertaken as result of the recommendations of this survey are expected to bring the ponds' water quality back into a favourable status. To support the aforementioned actions and to diminish visitors' pressure on the sites, public awareness and environmental education through participatory approaches is anticipated, along with the designation of non-access area and an eco-tourism development.

The project code for this unit is LIFE04 NAT/GR/000105 ([www.life-kriti.gr](http://www.life-kriti.gr)).

## **GrassHabit – a LIFE project dedicated to the proper management of Pannonian grasslands**

**R. Szabó<sup>1</sup>, E. Illyés<sup>1</sup>, A. Horváth<sup>1</sup>, Z. Molnár<sup>1</sup>, Z. Szilvacsku<sup>2</sup>, Á. Egyházy<sup>2</sup>, Gy. Fülöp<sup>2</sup>, B. Szabó<sup>2</sup>, S. Rév<sup>2</sup>, K. Sipos<sup>3</sup>, T. Parrag<sup>4</sup>, L. Viszló<sup>3,5</sup>**

<sup>1</sup>Institute of Ecology and Botany of the HAS, Alkotmány u. 2-4., H-2163 Vácrátót, Hungary.  
e-mail: rebeka@botanika.hu

<sup>2</sup>Land Stewardship Advisory Service of BirdLife Hungary, Lőportár u. 16. H-1134 Budapest, Hungary.

<sup>3</sup>Duna-Ipoly National Park Directorate, Hűvösvölgyi út 52. H-1021 Budapest, Hungary.

<sup>4</sup>Duna-Dráva National Park Directorate, Tettye tér 9., H-7625 Pécs, Hungary.

<sup>5</sup>Pro Vértes Foundation Kenderesi u. 33. H-8083, Csákvár, Hungary.

### **Introduction**

The dry and semi-dry grassland habitats of the Pannonian region represent high nature conservation value at the European level. The majority of their area can be found in Hungary, often as a part of the Natura 2000 Network, where the traditional land use practices are the focus of the management. Developing applicable and accessible methods for the proper management is essential for the long term maintenance and preservation of these diverse dry and semi-dry grasslands; thus this is the main goal of the GrassHabit Life project.

### **Project structure**

#### Aims and timescale

The project is aiming to (1) manage, restore and conserve different dry and semi-dry grassland habitats characteristic to the Pannonian region; (2) gather available information on the management of Pannonian grasslands and its monitoring in a searchable database open for conservation society; (3) develop and (4) disseminate best practise of grassland management to land managers and the overall public. The timescale of the project is 2006-2010.

#### Sites and management measures

We manage six sites ranging from 30 to 300 hectares located in different regions of the country, dominated by Pannonic salt steppes, loess steppes, slope steppes, open sandy grasslands and sand steppes. Grazing by traditional Hungarian breeds of sheep and mowing are the most important treatments, but regular cutting of invasive herbs or spreading shrubs and water regulation are also parts of the management. Standardized monitoring methods based on comparison of managed and control plots were developed to follow up the effect of the management on the structural and compositional characteristics of the vegetation

### **First experiences**

In the first year of the project several infrastructural changes were accomplished on the sites to provide proper conditions for the management. Vegetation and soil samples were taken as baseline data prior to the new management. Apparent changes in the abundance of plant species can be seen due to the first treatments, but significant results are expected only after several years. As the sites differ in their history, past management and actual threats as well, we will be able to draw general conclusions at the end of the project and give recommendations for the best practice of grassland management on the landscape level.

## Workshops

### Workshop: Landscape Ecology Education Network (LE-Net)

#### M. Potschin and LE-Net Members

Centre for Environmental Management, School of Geography, University of Nottingham,  
Nottingham NG7 2RD, UK  
e-mail: Marion.Potschin@Nottingham.ac.uk

**The aims** of this working group are to:

- achieve an overview of existing courses in landscape ecology;
- link to existing teaching projects/initiatives;
- co-ordinate and assess teaching and training in the field on an international platform;
- to assess the existing and co-ordinate the credit point system;
- promote the needs for teaching and training in our field; and
- to set up funding sources which allow students to attend PhD courses linked to IALE congresses/research activities.

The **purpose of this workshop** is to gather working group members for the first time

- to nominate and elect a chair, secretary and other relevant positions;
- to discuss and decide on the level of training and education (undergrad, master, PhD, consulting?)
- to discuss and possibly amend the aims; and
- to discuss the next steps/activities.



## Workshops

### Workshop: The Global Earth Observation System of Systems (GEOSS) EC-06-02 Global Ecosystem Mapping Task

R. Sayre

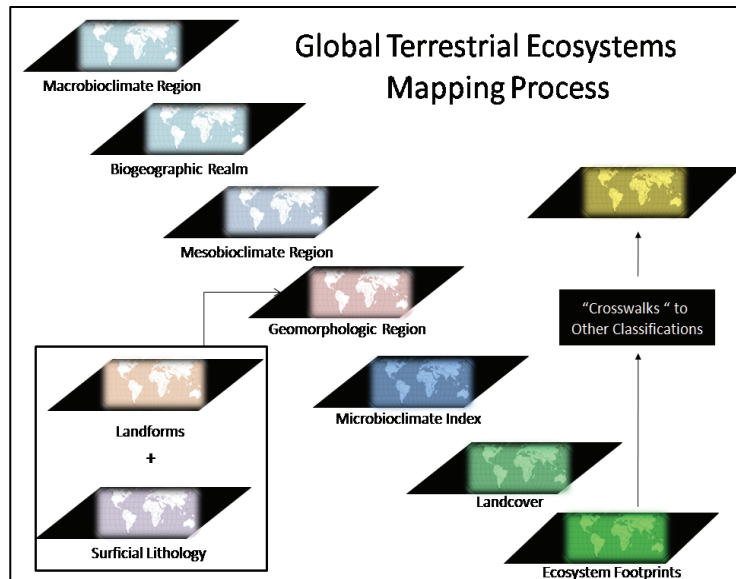
e-mail: roger.sayre@usgs.gov

U.S. Geological Survey and Task Lead for GEOSS EC-06-02

Proposed Session: Special Session on GEOSS EC-06-02

The intergovernmental *Group on Earth Observations* (GEO) is leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS) to provide comprehensive, coordinated Earth observations from thousands of space-, water-, and ground-based instruments worldwide, transforming the data they collect into vital information for society. GEOSS is programmatically organized into the following societal benefit areas: disasters, health, energy, climate, water, weather, ecosystems, agriculture, and biodiversity. A number of priority tasks have been developed for each of the societal benefit areas, and these tasks collectively represent the GEOSS Workplan. One of these tasks, EC-06-02, in the ecosystems societal benefit area, calls for the development of a robust, practical, standardized classification and map of global terrestrial, freshwater, and marine ecosystems.

The GEOSS approach for this global ecosystem mapping effort advocates a physical stratification of the planet's terrestrial, freshwater, and marine domains into a set of increasingly finer, unique abiotic environments and their associated biota. These "ecosystem footprints" will be produced at meso-scales (10s to 1000s of hectares) through a combination of earth observation-derived datasets (land cover from imagery, landforms/seaforms from DEMs, bioclimate regions from meteorological sampling, etc.) and other interpretive datasets (e.g. lithology). These standardized ecosystem footprints will be developed at a finer spatial resolution (90m to 450m) than any existing ecoregionalization of the planet. This approach, prototyped for South America, and currently being implemented for the United States, will be described in detail. The GEOSS global ecosystem mapping effort will be characterized as a nexus of earth observation and landscape modeling.



**Workshop: Methods of quantifying, valuing and mapping landscape functions to support integrated impact assessment of land cover change**

**R. de Groot, M. Metzger**

Environmental Systems Analysis Group, Wageningen University, The Netherlands.  
e-mail: [dolf.degroot@wur.nl](mailto:dolf.degroot@wur.nl)

*Background*

Landscapes provide important functions and services to society with considerable ecological, cultural and economic value. These services include provisioning (e.g. food, timber, and fuels), regulating (e.g. climate regulation and water purification), cultural (e.g. aesthetic values, sense of place) and supporting services (e.g. wildlife habitat, nutrient cycling) (Millennium Ecosystem Assessment, 2005). Increasingly, integrated assessments attempt to translate projected changes in landscapes (e.g. changes in land use, landscape structure, and habitats) into their effects on landscape functions, services and values. In spite of the progress made, there are still considerable challenges to be overcome in methods to quantify, value and map landscape functions and associated services, both spatially and economically.

*The workshop*

The principal aim of this workshop will be to explore methods to better quantify and value landscape functions and services across spatial scales. Results of the workshop will be summarized in a scientific paper that will discuss current limitations and challenges as well as providing several suggestions, or possible strategies, to improve quantification, valuation and mapping of landscape functions over the coming decade.

Well before the workshop, a first draft discussing the current state-of-the-art, will be written by the organizers in collaboration with several key players in the field. During the workshop this overview will be presented in 1 or 2 short keynote-addresses, followed by an interactive discussion on current limitations, and possible suggestions and recommendations to improve future research. Discussion will be stimulated by various participatory techniques and representatives of some related symposia (notably 18, 23 and 25) have been asked to be part of the advisory group to this workshop to enhance synergy.

*The scientific paper*

All participants of the workshop who agree to invest time in writing the resulting manuscript will become co-authors of the scientific paper. Suitable journals will be contacted at an early stage of the preparation (in agreement with the main authors).

Structure of the paper:

1. Introduction linking land cover and landscape functions and services, and illustrating potential global change impacts on the functions (*prepared before the workshop*)
2. Overview of existing methods for quantification and valuation of these functions, perhaps with some examples as case studies ( *prepared before the workshop, but to be expanded with participant contributions*)
3. Discussion on current limitations and challenges (*outcome of the workshop*)
4. A short list of recommendations / suggestions for the future (*outcome of the workshop*).

**Workshop: Landscape Ecology and Sustainable Management of Natural Resources: A New Paradigm for Environmental Management in Africa in the 21<sup>st</sup> Century**

**H.N.N. Bulley<sup>1</sup>, M.G. Turner<sup>2</sup>**

<sup>1</sup>Department of Geography/Geology, University of Nebraska-Omaha, NE, USA,  
e-mail: hbulley@mail.unomaha.edu

<sup>2</sup>Department of Zoology, University of Wisconsin, Madison, WI, USA

The wealth of Africa's diverse natural resources has been exploited over the last couple of centuries without any significant improvement socio-economic wellbeing of the people. In many African countries, political boundaries limit effective consideration of landscape implications of natural resource management initiatives. However, a landscape perspective is imperative to maintain biodiversity and ecological function as part of any sustainable resource management effort. A recent UNEP report, "*Our Environment, Our Wealth*", highlights how the enormous natural resources may constitute the basis for economic renaissance in Africa. There is an urgent need to ensure minimal human impact on the environment in the process of utilizing and transforming these natural resources. Hence, it is necessary to enhance the adoption of emerging science and technologies for sustainable development in African countries.

This presentation provides a context for the emerging discipline of ecology in Africa. We assess the potential for integrating ecology into sustainable management of natural resources in African countries, in such areas as water resources, disaster mitigation, forest and wildlife biodiversity, urban development, and recreation. To be successful, there is a need for a paradigm shift from only local considerations to include the implications development and research initiatives on broader landscape scales such as watershed or trans-boundary perspective. There is particularly true of sustainable water management and drought mitigation. In particular, we examine how landscape ecology could natural resource management and assert that it offers a conceptual framework for understanding spatial heterogeneity and scale. Finally, we highlight some of the training, infrastructure and institutional issues that need to be addressed in order to gap between the science of Landscape ecology and resource management in African countries.

**Workshop “Karst landscapes in Europe: conservation of cave ecosystems in an integrated landscape approach” during IALE Congress 8-12 July 2007**

**P. Veen and J Nooteboom**

e-mail: peter.veen@veenecology.nl

Karst landscapes cover about 10% of the land surface in the world, but some 25% of the world's populations lives in these landscapes. Functioning of these landscapes is characterised by the predominantly subterranean drainage and a morphology and pedology strongly influenced by the dissolution of carbonate rocks. Conservation and management of these landscapes require profound understanding of their specific features, incomparable to any other landscape type. Especially, cave conservation is an important issue because integration of cave conservation in an integrated landscape approach is not well developed. The workshop will detail the ecological relationships within karst lands and the links to the ecology of the 'unseen' subterranean cave systems, with special attention to cave habitat conservation. The aim of the workshop is to bring the various aspects of karst landscapes (hydrology, geomorphology, speleobiology, phytosociology) together in a single landscape ecological setting as a basis to discuss conservation strategies. Topics to be discussed are:

- Hydrology and habitat diversity
- Karst land ecology and cave fauna conservation
- Anthropogenic aspects
- Conservation strategies

Organisations involved in the organisation of this workshop are the Royal Dutch Society for Nature Conservation (KNNV), the International Society for Subterranean Biology (SIBIOS), and the Walloon Committee for the Study and Protection of Subterranean Sites (CWEPPS).

*Proposed programme for workshop*

1. Presentation Karstic landscapes in Europe: location, geology, processes in hydrology, common land use by Peter Veen
2. Presentation Cave biology by Jos Nootenboom
3. Presentation Protection and management of karst landscapes in Southern Europe – experiences from Dinaric Alps by Nikola Tvrtkovic
4. Presentation Protection and management of karst landscapes in Central Europe – experiences from .....
5. Discussion based on prepared recommendations

*Chair of the workshop:* Proposed Peter Skoverne from Slovenia

*List of potential threats and impacts for karst landscapes in Europe:*

- changes in water systems
- accessibility of caves
- over-visiting of caves
- pollution aspects in watersystem and caves
- introduction not-autochthonous species from outside cave-system
- destruction like through quarries, road construction, limestone quarries, changes in water flows
- intensification through conversion of grassland in arable fields, olive gardens etc with impacts of soil quality (changes in carbonium household)

*Measures for protection and reconstruction:*

- Habitats Directive application
- Water Framework Directive

**From landscape ecology to functional biodiversity – possibilities to improve the situation of wildlife**

**C. Schlatter, H. Luka and L. Pfiffner**

Research Institute of Organic Farming (FiBL), Ackerstrasse, CH-5070 Frick, Switzerland,  
e-mail: christian.schlatter@fibl.org

**Background**

Functional biodiversity and wildlife conservation in the context of agriculture are both important trends in EU project funding within the next years. Both themes demand interdisciplinary research and should involve experts of agriculture, biology, landscape ecology, sociology and economy.

Agriculture as the dominating land use form in Europe and construction activities (infrastructure and settlement) in the second half of the 20th century led to a severe loss of biodiversity. To stop this trend, in 1993 the Swiss government established a national ecological compensation programme in agriculture, which financially supports less intensive cultivation and promotes typical landscape elements like hedge-rows, low-intensity meadows and wild flower strips. Today, more than 10% of the agricultural land is ecological compensation area and farmers are indemnified through this programme. Nevertheless, the aim of stopping the loss of species has not been achieved. Reasons for this are often low quality of these compensation areas and the intensification of production on the rest of the farmland which itself leads as well to new types of problems caused by agricultural practices (pesticides, fertilisers, mechanisation, etc.).

Obviously there is a missing link between the creation of ecological compensation areas and their benefits for agricultural production or at least the benefits for agriculture are not yet sufficiently known.

However, many possibilities to improve biodiversity are already implemented in organic farming and some of them can even be linked to the improvement of biodiversity in cultivated areas, such as functional biodiversity. Functional biodiversity includes measures like sowing wildflower strips to increase the level of natural antagonists of agricultural pests.

**Goals**

The workshop aims to discuss a proposed way and find other ways of linking the regional approach of promoting sufficient areas for wildlife with the field-based side of improving the benefits from landscape features for agricultural production. After having defined the rough conceptual frame by introducing the main idea and existing concepts, the discussion will be lead on this base.

## Workshops

### **Landscape changes in the Brazilian tropical rain forest: patterns and processes of fragmentation and transition**

**M. Batistella**

e-mail: mb@cnpqm.embrapa.br

Brazil is home to the world's largest tropical rain forest (the Brazilian Amazon) and to the remnants of the Atlantic forest. Forest matrices in the Amazon have been fragmented as colonization processes advance; approximately 18% of these forests have already been cleared, mainly after the 1970's. Atlantic forest remnants have been relatively stable at approximately 6% of its pristine area as they were systematically cleared since the 1500's. Considerable progress has been made in understanding the dynamics of tropical deforestation and landscape change. It is recognized that processes of regrowth can take place simultaneously with deforestation but when, where, and how these processes occur is not well understood. The conditions under which a region transitions from a phase of deforestation to one of reforestation is largely an untapped research frontier.

This workshop proposes to review some results and lessons produced by integrative research dedicated to understand processes and patterns of change in both biomes. The workshop will also be an opportunity for discussion of controversial topics, such as:

- Evaluation methods for landscape change in the Amazon and the Atlantic Forests
- Thresholds defining forest fragmentation and transition
- Human drivers behind landscape change
- Modeling landscape change

Experiences pertinent to the workshop may draw upon data from local to regional scales, from satellite imagery to ground data, and from qualitative to quantitative methods of data collection, analysis, and synthesis. The workshop will be coordinated by members of the Brazilian Chapter of the International Association for Landscape Ecology (IALE-BR) and informal presentations will be designed to allow inputs from the audience.

Chair: Mateus Batistella (Embrapa Satellite Monitoring)

Participants already contacted: Jean Paul Metzger (University of São Paulo)  
Emilio F. Moran (Indiana University)  
Diógenes Alves (National Institute for Space Research)  
Britaldo Soares Filho (University of Minas Gerais)

## Workshops

### **Simulation model validation workshop**

**R.G. Pontius Jr, Organizer and Chair**

Clark University, School of Geography  
Department of International Development, Community, and Environment  
950 Main Street, Worcester MA 01610-1477, USA  
e-mail: [rpontius@clarku.edu](mailto:rpontius@clarku.edu)

This workshop examines the role of validation in simulation modeling. In order to begin the dialog among participants, the workshop presents a recent collaboration among land change modelers in which twenty scientists agreed to subject their land change projections to straight-forward, rigorous validation. Results show that only one of the thirteen case studies showed more correctly predicted change than error at the fine resolution of the maps. We share the published results at the workshop, where some of the authors will be available for discussion. Workshop participants are invited to share their thoughts and perhaps to share authorship on the next paper concerning the role of validation in the assessment of simulation models. The discussion will examine the reason why a culture among scientists has developed that encourages some modelers to create extremely complex models, while ignoring the fundamental scientific step of validation.

## Workshops

### **Can we measure the global impacts of fine-scale changes within anthropogenic landscapes?**

**E.C. Ellis**

Department of Geography & Environmental Systems, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, USA  
e-mail: ece@umbc.edu

Densely populated anthropogenic landscapes now cover more than 10% of Earth's terrestrial surface (populations  $>10$  persons  $\text{km}^{-2}$  cover  $>20$  million  $\text{km}^2$ ). These intensively managed and highly dynamic rural, urban and suburban landscapes are profoundly transformed by human activities ranging from the construction of buildings and roads, to agriculture, horticulture and forestry, and by the impacts of these and other activities on neighboring ecosystems. Despite their high degree of disturbance and their vast extent, the causes and consequences of long-term ecological changes within anthropogenic landscapes are poorly understood at global scale, in part because ecological changes within anthropogenic landscapes tend to occur at fine spatial scales, beneath the threshold for precise measurement by global and regional remote sensing platforms ( $<30$  m).

The goal of this workshop is to discuss approaches toward the global measurement and monitoring of fine-scale changes within anthropogenic landscapes based on combining global, regional, and local measurements using multi-scale sampling and upscaling designs.

#### Key topics for discussion include:

- Scales of change in different types of anthropogenic landscapes.
- Statistical designs for sampling fine-scale changes at global scale.
- Use of remote sensing for local change detection at global scale: combining global data with local data (MODIS/ASTER, Landsat, IKONOS, Quickbird, aerial photography, LiDar, etc.)
- The need for field measurements.
- Historical data sources.
- National and international obstacles to global measurements at local scales.



## Author list

Aavik, T, 1117  
 Abdullah, S.A, 840  
 Acampora, A, 1112  
 Aguilera Benavente, F, 1016  
 Ahmadpour, F, 1120  
 Ahmadpour, P, 1120  
 Ahmed, Z, 1134  
 Akbarzadeh, M, 1039  
 Alard, D, 1081  
 Alberti, M, 888  
 Alcaraz-Segura, D, 873  
 Alfò, M, 911  
 Alves, L.F, 1085  
 Alves, P, 1125  
 Ammann, B, 1111  
 Andreis, C, 1109  
 Andresen, M.T, 698  
 Angélibert, S, 764  
 Angelstam, P, 1099  
 Arets, E, 1061  
 Arsalan, M.H, 799  
 Ashcroft, M.B, 1079  
 Aspinall, R.J, 953  
 Attorre, F, 911  
 Auclair, D, 893  
 Aunap, R, 821  
 Aunins, A, 1151  
 Austad, I, 712  
 Avelar, A.S, 850  
 Avila-Akerberg, V, 1122  
 Aviron, S, 702  
 Ayeni, A.I, 738  
 Babaei Kafaki, S, 1039  
 Bach, M, 750  
 Badia, A, 684  
 Bakker, M.M, 775, 791  
 Báldi, A, 773  
 Ballabio, E, 1109  
 Barao, T, 1008  
 Barczy, A, 749, 883  
 Barendregt, A, 919  
 Barkova, B, 878  
 Bar-Massada, A, 1116  
 Barredo, J.I, 1030  
 Barrett, G.W, 1045  
 Barrett, T.L, 1045  
 Barriocanal, C, 716  
 Bastian, O, 700, 998  
 Batistella, M, 981, 1175  
 Baudry, J, 690, 977  
 Baveco, J.M, 909  
 Bellamy, P.E, 895, 979  
 Bellot, J, 1075  
 Belonovskaya, E, 682, 714  
 Bemigisha, J, 742  
 Bennett, A.F, 959  
 Berry, P.M, 909  
 Bezák, P, 1036  
 Bezemer, T.M, 781  
 Biggs, J, 764  
 Birrer, S, 702  
 Bitencourt, M.D, 1119  
 Bittencourt, J.V.M, 1067  
 Blain, A.P, 1110  
 Blaschke, T, 819  
 Boada, M, 684, 875  
 Bobra, T.V, 1040  
 Boehmer, H.J, 670  
 Bohnet, I, 1028  
 Bohrer, C.B.A, 1057, 1118  
 Bolliger, J, 779, 963, 983  
 Boltižiar, M, 1036  
 Bonari, E, 805  
 Bonet, A, 1075  
 Bono, J, 1113  
 Bosshard, A, 706  
 Bottoni, L, 1109  
 Bouchard, A, 887  
 Bowen, M, 1059, 1077  
 Bożętko, B, 680  
 Bradstock, R.A, 666  
 Brandt, J, 795  
 Branscomb, A, 941  
 Broadmeadow, M, 913  
 Brocklehurst, M, 1153  
 Brouwer, M, 1113  
 Brouwers, N.C, 1051  
 Bruce, E, 1114  
 Brůna, V, 881  
 Bruno, F, 911  
 Bryan, B.A, 973  
 Bu, R, 726  
 Bucsi, T, 761  
 Bulley, H.N.N, 1172  
 Bunce, R.G.H, 708, 712, 758, 765, 873,  
 Burel, F, 690, 977  
 Burgholzer, R, 967  
 Bürgi, M, 793  
 Burton, O.J, 907  
 Busch, G, 975  
 Buttler, A, 1111  
 Cabello-Pinar, J, 873  
 Cacho, O, 1034  
 Caldas, F.B, 1125  
 Callaghan, J., 1059  
 Campbell, B, 1012  
 Caravello, G, 741  
 Carmel, Y, 1116  
 Carone, M.T, 1112  
 Carranza, E.J.M , 742  
 Carreira, J.A, 724  
 Carriero, A, 783

## Author list

Cary, G.J, 666  
Castellanos, E, 704  
Catarino, L, 1124  
Centeri, Cs, 749  
Céréghino, R, 764  
Chabrierie, O, 1087  
Chang, C-Y, 1010, 1037  
Chang, Y-T, 1037  
Chartko, M.K, 733  
Chen, H, 726, 866  
Chen, L, 838  
Chiou, C-R, 831  
Chirol, A.A, 762  
Chisholm, L.A, 1079  
Choi, J.U, 755  
Christie, M, 1044  
Claggett, P.R, 967  
Cobo, M.C, 724  
Coelho Netto, A.L, 745, 762, 850  
Coles, R.W, 799  
Conedera, M, 1121  
Conrad, E, 1044  
Conradin, H, 759  
Cormont, A, 931  
Cousins, S.A.O, 688  
Craft, C, 919  
Criscuolo, C, 981  
Crompvoets, J, 873  
Crossman, N.D, 973  
Cruz, C.B.M, 1065  
Da, L, 752, 889  
Dalchow, C, 817  
Dalitz, H, 1127  
Dantas, H.G.R, 1118  
Dawelbait, N, 787  
de Bello, F, 722  
de Blaeij, A.T, 1002  
De Groot, R.S, 963, 1171  
De las Heras, P, 736  
De Natale, F, 783  
De Pablo, C.L, 885  
de Torres Curth, M, 720  
de Vries, H, 1161  
Deadman, P.J, 886  
Decocq, G, 1087  
del Sueldo, R, 1128  
Delaney, M, 1143  
Delattre, T, 977  
Devecchi, M, 1026  
Digiovinazzo, P, 1109  
Dimböck, T, 905  
Domon, G, 887  
Donnellan, K, 1142  
Dorrough, J.W, 965  
Doubková, M, 1071  
Drăguț, L, 819  
Dramstad, W, 823  
Dreier, S, 702  
Drews, H, 1140  
Dullinger, S, 905  
Duncan, D.H, 965  
Dunford, B, 1154  
Duttmann, R, 750  
Dyakonov, K.N., 1014  
Dykes, N.T, 758  
Echeverria, C, 1049  
Edwards, P.J, 1130  
Edwards Jr, T.C, 975  
Egyházy, Á, 1168  
Elbakidze, M, 1099  
Ellis, E.C, 852, 1177  
Engstová, B, 756  
Enright, C, 941  
Ernoul, A, 977, 1081  
Estreguil, C, 813  
Etter, A, 923  
Evans, J.S, 1069  
Eycott, A.E, 913  
Falusi, E, 749  
Fang, W-T, 844  
Farina, A, 668  
Fazey, I, 1044  
Fedyeva, M.V, 751, 934  
Fernández-Sañudo, P, 736  
Ferns, P.N, 979  
Firbank, L.G, 1110  
Fischer, M, 706  
Fjellstad, W, 823  
Flannigan, M.D, 666  
Fonti, P, 1121  
Francesconi, F, 911  
Frantisek, P, 1146  
Franzese, J, 720  
Freire, M.R, 813  
Freitas, S.R, 1057, 1065  
French, K.O, 1079  
Fu, B, 838  
Fujihara, M, 752, 889  
Fujita, N, 678  
Fülöp, Gy, 1168  
Galičić, M, 1148  
Galli, M, 805  
Gao, Q, 728  
Garay, I, 1133  
Gardner, R.H, 665  
Garrabou, J, 935  
Gasparini, P, 783  
Gaucherel, C, 1038  
Geertsema, W, 987, 1002  
Gehrig-Fasel, J, 779  
Gehring, K, 983  
Gellrich, M, 779  
Gherardi, M, 882  
Ghermandi, L, 720  
Ghosn, D, 1167  
Giętkowski, T, 874  
Giglio, E, 1022, 1024, 1043  
Gillet, F, 1111  
Gimeno, J, 885  
Gimona, A, 961

## Author list

Glemnitz, M , 817  
Glikman, J, 1150  
Gliniars, R, 1127  
Gómez, F.J, 875  
Gómez Sal, A, 712  
Gong, J, 838  
Gonzalez, S, 720  
González, E, 1131  
González, G, 1069  
González, J.R, 785  
Gorman, J.T, 985, 1012  
Gould, W.A, 1069  
Grabaum, R, 971  
Gracheva, R, 682  
Granja, H, 1125  
Grant, W, 1131  
Grashof-Bokdam, C, 1089  
Griffon, S, 893  
Griffths, G.H, 1067  
Grónás, V, 883  
Grünig, A, 759  
Guntenspergen, G.R, 917  
Guofu, L, 842  
Gustafson, E.J, 1093  
Hagen-Zanker, A, 870  
Haines-Young, R.H, 955, 963, 995  
Halada, L, 696, 1036  
Hall, S.J.G, 765  
Halpern, B, 1149  
Hara, K, 752, 753, 889  
Harada, E, 833, 1132  
Harmelin, J.G, 935  
Harrison, N.M, 979  
He, S.H, 1095  
Hehl-Lange, S, 1006  
Heiland, S, 877  
Hein, L, 957  
Heller, I, 963  
Helming, K , 817  
Henebry, G.M, 1071  
Henriques, R, 1125  
Hepinstall, J.A, 888  
Heringa, R, 1159  
Hersperger, A.M, 793  
Herzog, F, 702, 712  
Hespanhol, H, 1126  
Higa, A.R, 1067  
Hill, R.A, 979  
Hinsley, S.A, 979  
Hofer, G, 708  
Holmes, E, 795  
Holzkämper, A, 969  
Hong, S.K, 829, 836  
Honrado, J, 1124, 1125  
Hopkins, K, 967  
Horváth, A, 1168  
Hostert, P, 1101  
Hott, M.C, 981  
Houet, T, 1038  
House, A, 1077  
Hrnčiarová, T, 1042  
Hsueh, I-C, 831  
Hu, H.B, 890  
Huang, W-M, 1037  
Huang, Z, 838  
Hudak, A.T, 1069  
Hudoklin, A, 1148  
Hull, A.P, 764  
Hulse, D.W, 941  
Hunziker, M, 983  
Idrisov, I.R, 879  
Ihm, B-S, 836  
Ihse, M, 710  
Illyés, E, 1168  
Imanishi, A, 744  
Imanishi, J, 744  
Imola, S, 880  
Ingegnoli, V, 1022, 1024, 1043  
Irvani, M, 1130  
Isozaki, Y, 835  
Ituen, U.J, 740  
Iverson, L.R, 925  
Iverson Nassauer, J., 947, 996  
Izakovičová, Z, 801, 884, 1036  
Jadoul, G, 1163  
Jancura, P, 884  
Jantz, C.A, 967  
Javelle, A, 977  
Jeanneret, P, 702  
Jedicke, E, 670  
Jia, H.K, 728  
Jiang, Y, 827  
Jochem, R, 1089  
Jochems, H, 1162  
Johnson, W.C, 917  
Jones, K.B, 809  
Jones-Walters, L, 797  
Jongman, R.H.G, 712  
Joó, K, 761  
Jopp, F, 663  
Joseph-Haynes, M, 704  
Joshi, P.K, 1107  
Juying, J, 746  
Kamada, M, 833, 1132  
Kamagata, N, 753  
Kanal, A, 821  
Karanja, F, 1034  
Kardol, P, 781  
Karpichenka, A.A, 733  
Kasanko, M, 1030  
Kasimov, N.S., 1014  
Käyhkö, N., 876  
Kazakis, G., 1167  
Keane, R.J, 666  
Kennedy, S, 1053  
Khoroshev, A.V., 1014  
Kienast, F, 779, 963, 983  
Kikuchi, A, 835  
Kim, D.Y, 755  
Kim, J.-E, 829

## Author list

Kindlmann, P, 977  
King, K.J, 666  
Kirby, K.J, 1129  
Kjelland, M, 1131  
Klaus, G, 706  
Klug, H, 991  
Koike, F, 757  
Kong, Z.H., 846  
Koniak, G, 1116  
Konrath, J, 1119  
Koolstra, B.J.H, 939  
Koomen, E, 864  
Kouhgardi, E, 1120  
Kovář, P, 694  
Kozin, V.V, 879  
Kozlov, D.N, 751, 763, 927, 933, 934, 1020  
Kozová, M, 884, 1042  
Křováková, K, 881  
Krsakova, A, 884  
Kuemmerle, T, 1101  
Kumagai, Y, 678  
Kumar, L, 1034  
Küper, B, 1139  
Kušík, T, 1157  
Lacomba, I, 1166  
Laguna, E, 1155  
Lang, S, 819  
Lange, E, 1006  
Larcher, F, 1026  
Lascurain, J, 880  
Latham, J, 913  
Lavalle, C, 1030  
Leclercq, C, 1147  
Ledegen, I, 1164  
Lee, C.S, 777, 1097  
Leemans, R, 957  
Lele, N, 1107  
Lemmey, R.P, 758  
Lengsfeld, H, 1152  
Lertxundi, A, 716  
Levin, G, 795  
Li, H.M., 890, 1108  
Li, Y, 726  
Liepiņš, I, 735  
Liira, J, 1117  
Liliehalm, R.J, 975  
Lima, H.C, 1118  
Lin, Y-H, 1010, 1037  
Lindborg, R, 789  
Lindsay, K.F, 932  
Lingua, E, 771  
Lioubimtseva, E, 936  
Lipský, Z, 803  
Liu, W.J, 890, 1108  
Liu, Y.H, 728  
Llausàs, A, 676, 716  
Loehle, C, 1093  
Lomba, A, 1125  
López Estébanez, N, 736  
Lozano-Zambrano, F.H, 1073  
Lu, J, 1083  
Luckert, M, 1012  
Luka, H, 1174  
Lunney, D, 1059  
Lütz, M, 998  
Lychak, A.I, 1040  
Lytle, D.E, 1093  
Ma, Y.X., 890, 1108  
Maessen, R, 797  
Mander, Ü, 821  
Manghi, E, 1113  
Mantovani, W, 1119  
Marchenko, N.A, 1018  
Marguerie, D, 690  
Mariani, M.C, 882  
Marinskikh, D.M, 743, 879  
Maron, M, 1053  
Marshinin, A.V, 879  
Martín de Agar, P, 885  
Matarán Ruiz., A, 1016  
Matthews, S.N, 925  
Maurer, K, 706  
Mazier, F, 1111  
Mbikusita Lewanika, K, 1136  
Mcalpine, C.A, 1059, 1077  
McCall, M, 742  
McCollin, D, 739  
Meddens, A.J.H, 1069  
Mello, M.C.S, 1057  
Ménadier, L, 747  
Mendoza, J.E, 1073  
Menghi, M, 1128  
Mertens, A, 1150  
Metzger, J.P, 1085  
Metzger, M.J, 708, 1171  
Meyer, B.C, 971  
Mierauskas, P, 1160  
Miklós, I, 1115  
Miklós, L, 801  
Miller, M, 704  
Misikova, P, 884  
Mitchell, D, 1059  
Mitchley, J, 746  
Mitsubishi, H, 833  
Mitsubishi, H., 1132  
Molnár, Z, 1168  
Montenegro, C, 1113  
Moorfeld, M, 877  
Moretti, M, 722  
Morimoto, Y, 744  
Morri, D, 668  
Moylan, E.A, 854  
Moyzeová, M, 1036  
Mücher, C.A, 1032, 1061  
Muijsers, P, 1164  
Mulkova, M, 892  
Müller, F, 809  
Müller, K, 817  
Muñoz-Márquez, T.R.A, 886  
Murphy, P, 1142, 1143, 1144

## Author list

Murray-Hudson, M, 915  
Musacchio, L.R, 945  
Musila, W.M, 1127  
Myshliakou, S.H, 760  
Nagata, T, 835  
Nakagoshi, N, 754, 829, 835, 840  
Negreiros, A.B, 745  
Neubauer, S, 919  
Neubert, M, 858  
Newton, A, 1051  
Nicolet, P, 764  
Nieminen, J, 1105  
Nilsson, D, 1165  
Nizovcev, V.A., 686  
Nootboom, J, 1173  
Noronha, F, 1133  
Novelly, P, 951  
Nowicki, P, 797  
Noy-Meir, I, 1116  
Oertli, B, 764  
Oesker, M, 1127  
Ogawa, M, 833, 1132  
Ollerton, J, 739  
Olsen, M, 795  
Olson, L.T, 932  
Opdam, P, 947, 996  
Oszlányi, J, 692, 1036  
Otero, I, 684  
Ott, J, 921  
Overmars, K.P, 672, 775  
Pacha, M.J, 1055  
Padoa-Schioppa, E, 1109  
Palahí, M, 785  
Palang, H, 1000  
Palmer, M.W, 724  
Pappel, P, 1141  
Park, J-W, 836  
Parmentier, B, 868  
Parmuchi, M.G, 1113  
Parodi, P, 720  
Parrag, T, 1168  
Pascual-Hortal, L, 1106  
Pauditsova, E, 872  
Pavlickova, K, 872, 878  
Pearson, D.M, 985  
Pechy, T, 1149  
Peña, J, 1075  
Penksza, K, 749  
Perera, A.H, 718, 886  
Perez, D, 1133  
Pérez Campaña, R, 1016  
Pérez-Soba, M, 712  
Perotto-Baldivieso, H, 704  
Perzanowski, K, 1101  
Peters, M.P, 925  
Peterseil, J, 905  
Pető, Á, 761  
Petříček, V, 756  
Petrosillo, I, 825  
Petrov, L.O, 1030  
Petrovič, F, 1036  
Pettenella, D, 769  
Pezzatti, B, 722  
Pfaff, A.S, 1057  
Pfiffner, L, 702, 1174  
Pichancourt, J.B, 977  
Pillai, R.B, 771  
Piper, J, 903  
Piqueras, S, 684  
Piquer-Rodriguez, M, 873  
Pitt, D.G, 1004  
Pivotto, B, 741  
Pontius Jr, R.G, 866, 868, 1176  
Possingham, H., 1059  
Potschin, M.B, 955, 963, 995, 1169  
Potts, S, 722  
Prasad, A.M, 925  
Prince, H.E, 758  
Prins, A.H, 1089  
Printsmann, A, 848  
Pukkala, T, 785  
Purschke, C, 1091  
Puzachenko, M.Y., 751, 763  
Puzachenko, Y.G, 729, 927, 933, 934, 1014, 1020  
Quealy, S, 1144  
Qureshi, S, 799  
Račinska,, I, 1151  
Radeloff, V.C, 1101  
Radford, J.Q, 959  
Radu, G.A, 1158  
Rafyeian, O, 1120  
Rahman, M.L, 739  
Ramos, I.L, 891, 993  
Rannap, R, 1141  
Ray, D, 913  
Reid, N, 1034  
Reihmanis, J, 1151  
Reilly, J, 967  
Reis, E.J, 1057  
Rommel, T.K, 718  
Renetzeder, C, 1032  
Restrepo, C, 704  
Retsios, V, 742  
Retzer, V, 670  
Rév, S, 1168  
Rhodes, J., 1059  
Ribas, A, 676, 716  
Ribeiro, L, 1008  
Ricci, S, 1150  
Riitters, K.H, 807, 811, 825  
Risch, A.C, 1130  
Ritsema van Eck, J, 864  
Rizzo, D, 805  
Roessling, H, 1152  
Roldán Martín, M.J, 736, 885  
Romanova, E.P, 731  
Roosaare, J, 821  
Rovere, E, 1135  
Rushton, S.P, 1110

## Author list

Rutherford, G.N, 779  
Ružička, M, 1042  
Sabbatini, T, 805  
Saez, M, 716  
Sage, R, 895  
Sagris, V, 1030  
Sajaloli, B, 764  
Salvatori, V, 1150  
Sánchez, S, 875  
Sancho, V., 1166  
Sandlerskiy, R.B, 927  
Šandric, I, 1158  
Sandu, C, 1158  
Sankovski, A.G, 933  
Santos, C.I.F, 891  
Sarmiento, A, 923  
Saura, S, 1106  
Sayler, K.L, 862  
Sayre, R, 1170  
Scheidegger, C, 1111, 1130  
Schippers, P, 899  
Schlatter, C, 1174  
Schmidt-Formann, O, 1156  
Schmidt-Vogt, D, 827  
Schöpfer, E, 819  
Schrestha, R.P, 827  
Schröder, B, 1121  
Schuetz, M, 1130  
Schultz, A, 817  
Schüpbach, B, 759  
Scott, D, 886  
Sedlarikova, R, 892  
Selman, P.H, 860  
Séneca, A, 1126  
Seppelt, R, 815, 969  
Shahcheraghi, A, 674  
Shengyan, D, 842  
Shin, H.C, 1097  
Short, K, 753  
Šíbl, J, 1145  
Simoniello, T, 1112  
Sing, L, 913  
Sipos, K, 1168  
Sitzia, T, 783  
Siunova, E.V., 763, 933  
Sjögren, P, 1111  
Skånes, H, 876  
Skidmore, A.K, 742  
Skokanova, H, 856  
Smart, S, 1110  
Smit, P, 1063  
Smith, G, 1077  
Soares, V.P, 981  
Sohl, T.L, 862  
Soliva, R, 983  
Somodi, I, 1115  
Speranza, M, 882  
Stachow, U, 817  
Stamati, M, 1113  
Stanková, E, 884  
Steingröver, E.G, 939, 987  
Stöcklin, J., 706  
Strada, M, 1113  
Su, W-C, 1010, 1037  
Suffling, R, 886  
Sun, Q, 1083  
Suzuki, S, 754  
Swaty, R, 1093  
Swetnam, R.D, 895  
Syrbe, R-U, 1041  
Szabó, B, 1168  
Szabó, R, 1168  
Szerencsits, E, 759  
Szilvacsku, Z, 1168  
Tang, H-F, 1010  
Teixeira, T.M, 891  
Teixidó, N, 935  
Thevs, N, 1103  
Thontteh, O, 866  
Tiede, D, 819  
Tischendorf, L, 932  
Todt, H, 1127  
Tomita, M, 752, 889  
Torres, J, 1124  
Toth, R.E, 975  
Trapeznikova, O.N, 737, 929  
Travis, J.M.J, 907  
Turner, M.G, 1172  
Uuemaa, E, 821  
Vaccaro, M.P, 1112  
Valenzuela Montes, L.M, 1016  
Valverde, V, 885  
van der Greft, J, 1089  
van der Heide, C.M, 1002  
van der Horst, D, 961  
van der Meer, P, 1061  
van der Putten, W.H, 781  
van der Valk, A.G, 917  
van Dobben, H.F, 1089  
van Doorn, A.M, 791  
van Etten, E.J.B, 1123  
van Eupen, M, 1032  
Van Marwijk, R.B.M, 1004  
van Mensvoort, M, 957  
van Wingerden, W, 987  
Varga, D, 676, 716  
Vargas, W, 1073  
Vasconcelos, M.J, 1124  
Veen, P, 1173  
Veldkamp, A, 672, 957  
Verboom, J, 899, 901  
Verburg, P.H, 672, 775, 957  
Verhulst, J, 773  
Vianello, G., 882  
Vicente, J, 1125  
Vieira, C, 1126  
Vila, J, 676, 716  
Viola, F, 783  
Virágh, K, 1115  
Viszló, L, 1168

## Author list

Vogiatzakis, I.N, 1167  
Vogt, J, 1121  
Vogt, P, 813  
Von Haaren, C., 989  
Vona, M, 749  
Vos, C.C, 899, 901, 939  
Vrieling, A, 1061  
Waarts, Y.R, 797  
Wade, T.G, 807  
Wagner, H.H, 670, 724, 1111, 1130  
Wales, N, 1114  
Walter, T, 702, 759  
Walz, U, 858  
Wamelink, G.W.W, 1089  
Watts, K, 913  
Wei, W, 838  
Weisberg, P, 771  
Wenjuan, B, 746  
Whigham, D.F, 919  
Whitehead, P, 951  
Wickham, J.D, 807, 811  
Wiens, J.A, 943  
Wiggering, H, 817  
Wilkins, N, 1131  
Willemen, L, 957  
Wolf, T, 971  
Wolski, P, 915  
Wolynski, A, 783  
Wrbka, T, 708, 1032  
Wu, J, 949, 1083  
Wu, X, 1131  
Xu, H.M, 728  
Xu, Z, 1083  
Yang, Y, 752, 889  
Yasuda, M, 757  
Yatsukhno, V.M, 894  
Yoshida, S, 744  
Yu, M, 728  
Yuman Hu, Y.C, 726  
Zaccarelli, N, 825  
Zander, P, 817  
Zanini, F, 722  
Zariņa, A, 735  
Zerbe, S, 1103  
Zhang, X.S, 728, 846  
Zhao, G, 1083  
Zhao, Y, 752, 889  
Zhoomar, P.V, 733  
Zhou, N, 967  
Zimmermann, N.E, 779  
Zobel, M, 1117  
Zurita-Milla, R, 873  
Zurlini, G, 809, 825