



A mensurative experiment to study effects of landscape heterogeneity on biodiversity

Rémi Duflot, Stéphanie Aviron, Aude Ernoult

► To cite this version:

Rémi Duflot, Stéphanie Aviron, Aude Ernoult. A mensurative experiment to study effects of landscape heterogeneity on biodiversity. Colloque IALE world “landscape ecology for sustainable environment and culture”, Aug 2011, Pekin, China. 22 p. hal-01458579

HAL Id: hal-01458579

<https://hal.science/hal-01458579>

Submitted on 6 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.



A mensurative experiment to study effects of landscape heterogeneity on biodiversity

Rémi DUFLLOT – PhD Student

20th August 2011

duflot.remi@gmail.com

Co-authors

Supervisors:

- Françoise BUREL
- Stéphanie AVIRON
- Aude ERNOULT

Master student trainees:

- Flore BALLAUD
- Romain GEORGES

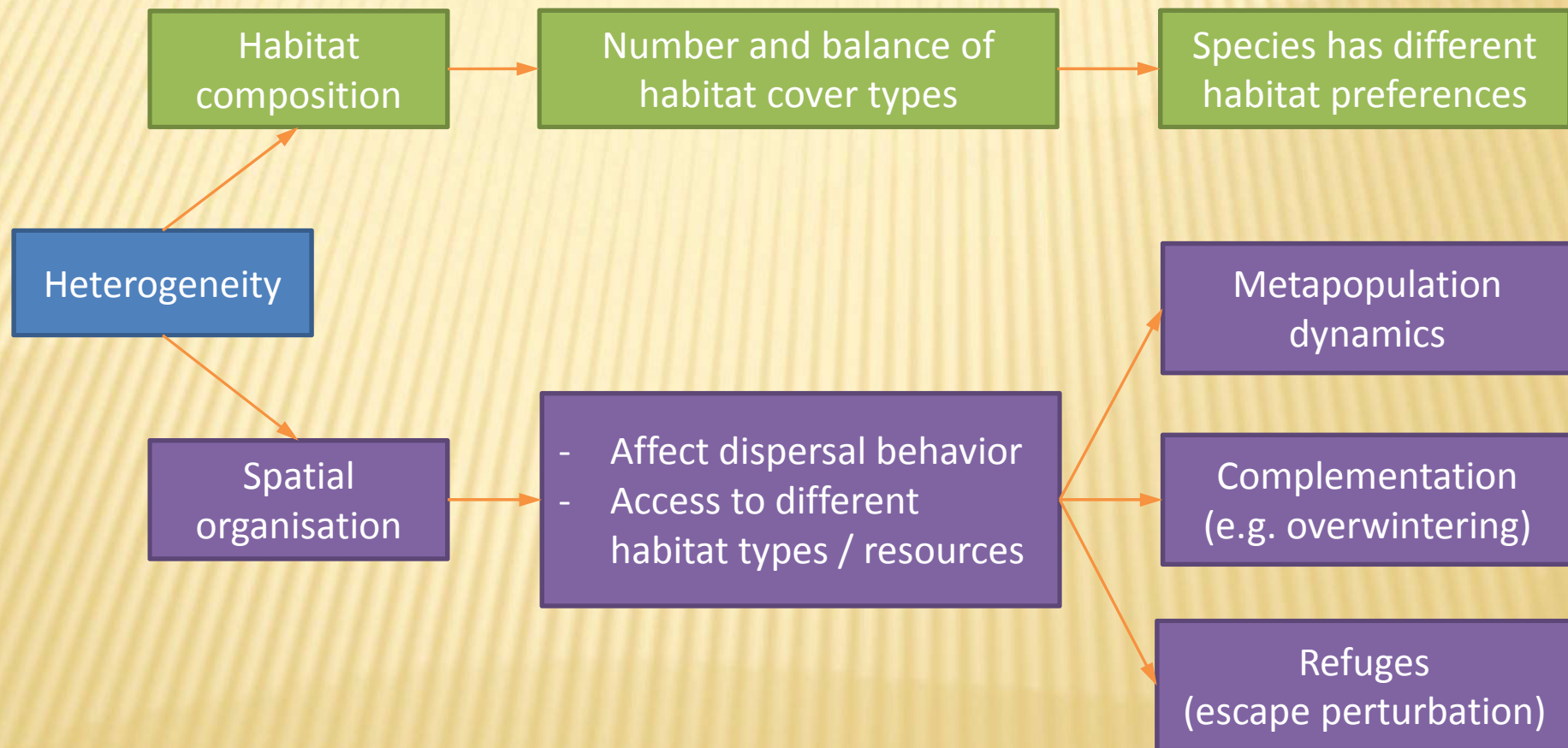


Presentation outlines

- 1/ Introduction of conceptual framework
- 2/ The experimental method
- 3/ Preliminary results

Heterogeneity and diversity

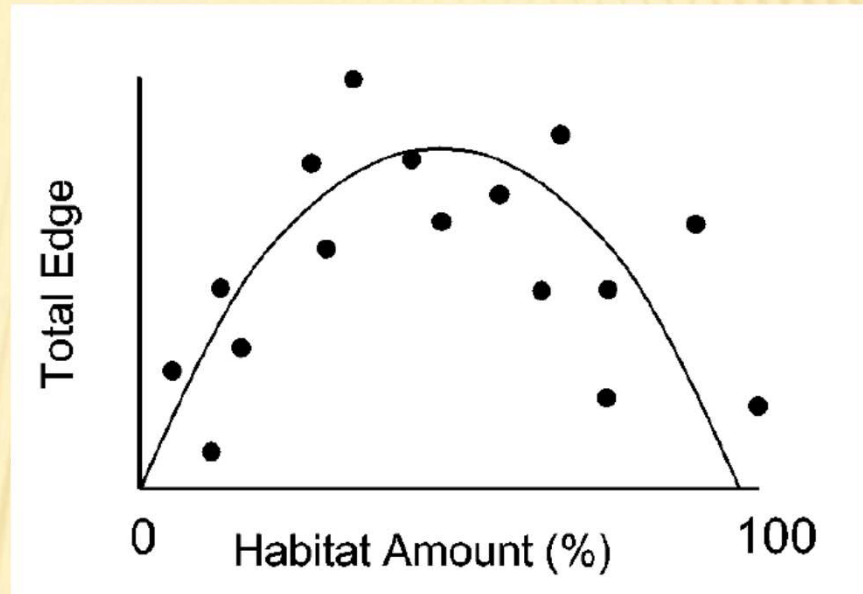
Landscape heterogeneity is a key factor in maintaining biodiversity in agricultural landscapes



(Benton et al., 2003; Tscharntke, 2005; Le Roux, 2008; Fahrig, 2011)

Separating composition and spatial organisation

- Landscape composition and spatial organisation are correlated
(*Fahrig, 2003*)



- Heterogeneity is often:
 - evaluated by the proportion of habitats
 - without accounting for spatial organisation
 - or using a measure correlated with habitat amount
- The heterogeneity of crop mosaic has been poorly studied
 - > might influence species that use crops during their life cycle

Semi-natural habitat (SNH) and boundaries

-> Two important structures for biodiversity in agricultural landscapes

Semi-natural habitats (*Billeter, 2008*):

Key role in biodiversity conservation

Habitats and corridors

Refuges

Sources to re-colonize disturbed habitat

Boundaries:

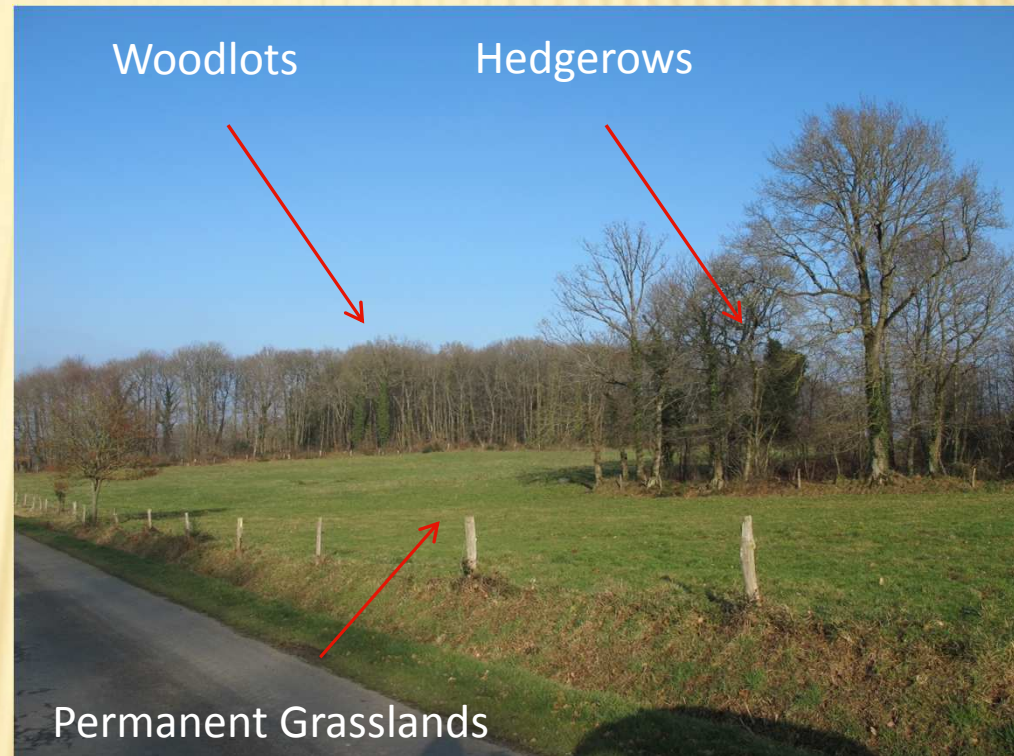
Movement between patches

A measure of spatial heterogeneity

Three types of boundaries - Crop / Crop

- SNH / SNH

- Crop / SNH



Question: How important are boundaries between SNH and cultivated land in maintaining biodiversity of agricultural landscapes ?

Creating a double gradient

-> Aim: an experimental design without correlation between % SNH and boundaries length

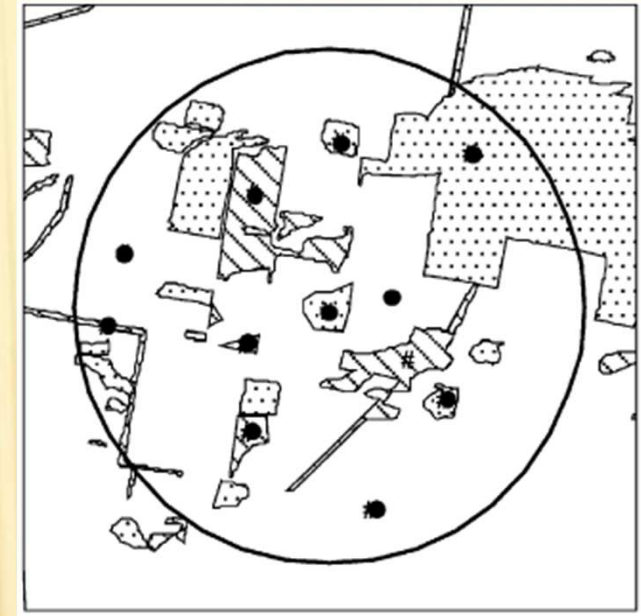
Need to:

1/ Work at landscape scale (“whole mosaic”)

2/ Sample several patches and habitat types / landscape

-> Measure diversity at landscape scale = Gamma diversity

3/ Select landscapes according to the landscape parameters to be tested



Measure other parameters of the total heterogeneity: Effect of crop mosaic?

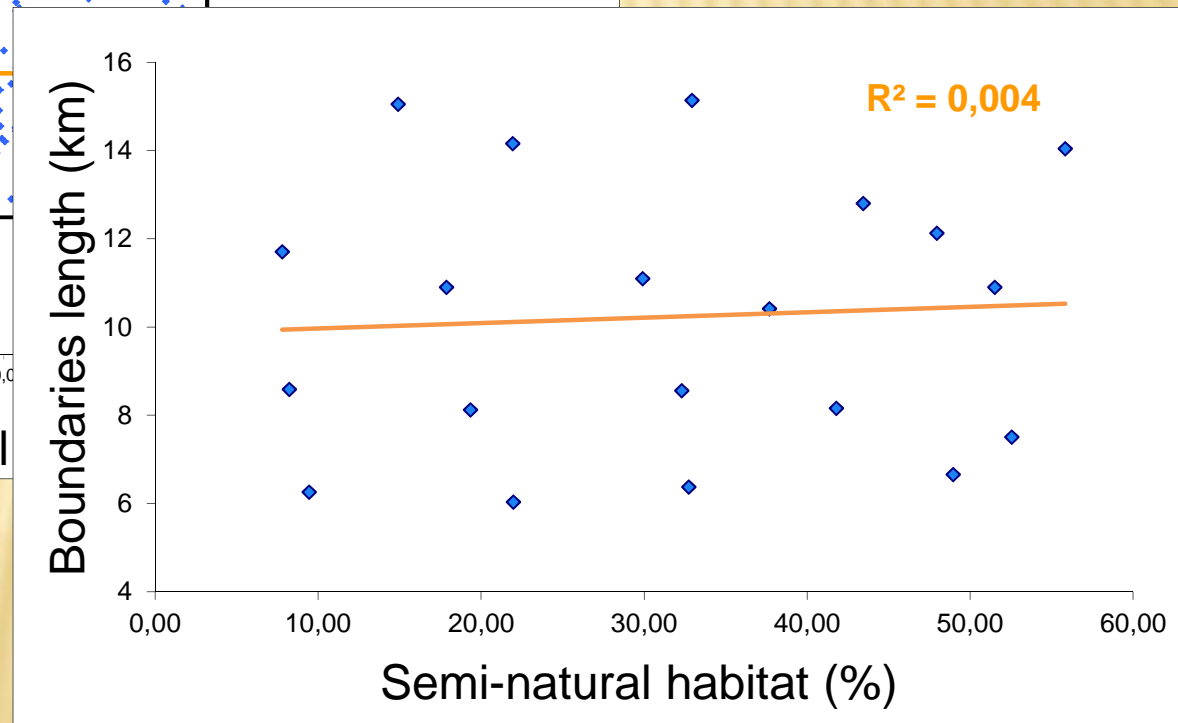
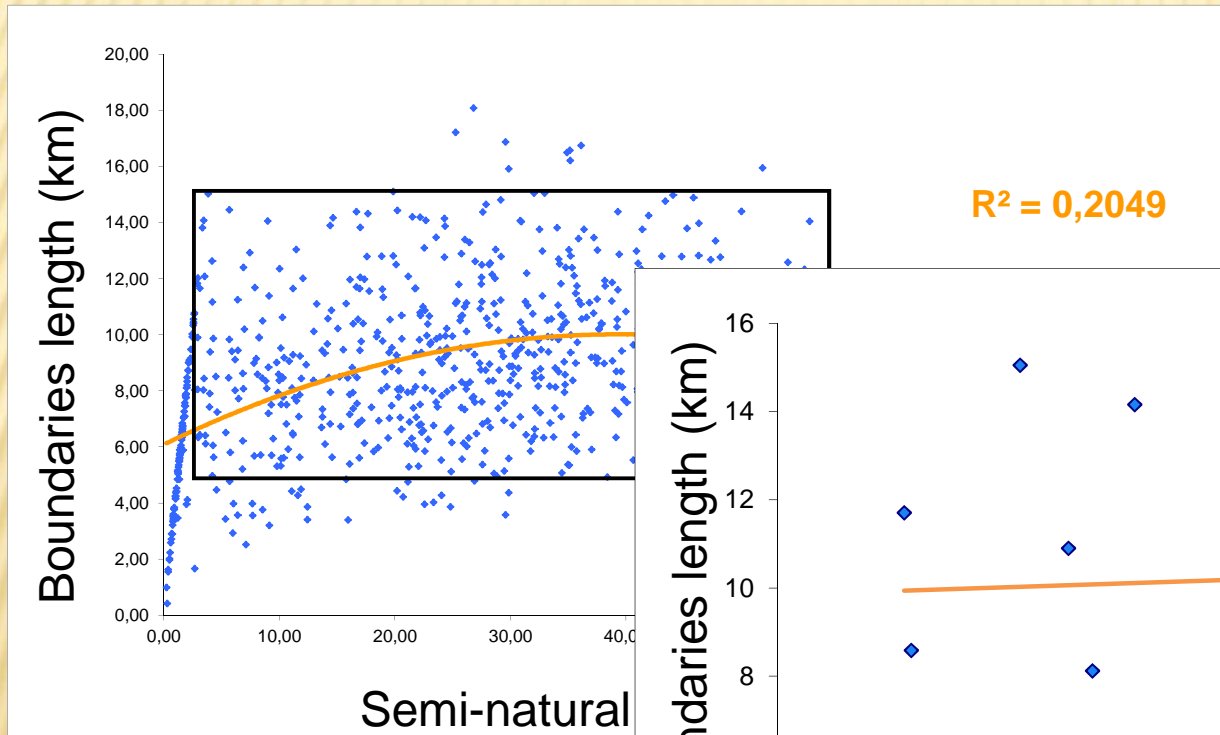
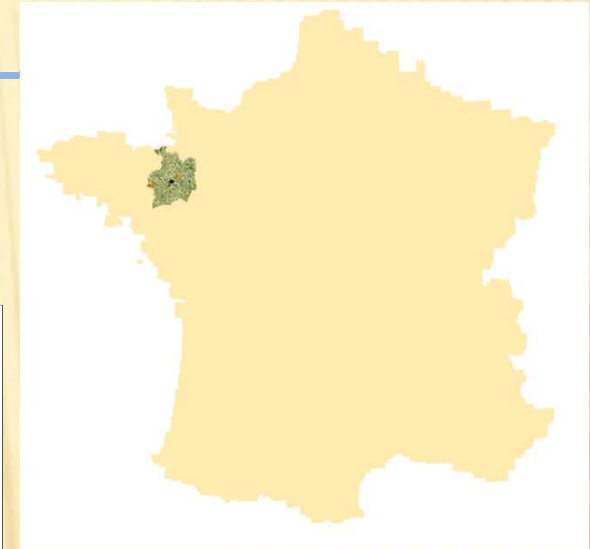
- Cover of crop types
- Total heterogeneity

$$\text{Heterogeneity} = - \sum_{q=1}^{na} P_q \times \ln(P_q)$$

(Bennett, 2006 ; Crist, 2003; Burel & Baudry, 2003)

Selection of study sites

- > Screening of up to 8000 squared landscapes 1km x 1km:
 - Selection of 20 sites without correlation between % SNH and boundaries length



Diversity survey

Two study groups

- Carabid beetles
- Vascular plants

Sampling methods

- Plants: squared plots
- Carabids: pitfall traps

Stratified sampling design

Two replicates of five habitat types

- Woodlot
- Hedgerow
- Permanent grassland
- Temporary grassland
- Winter cereal fields (wheat)

-> 10 sampling points / landscape



Hypotheses

- I. Percentage of SNH increases Gamma diversity
 - More suitable habitat available
- II. Boundaries length increases Gamma diversity
 - Promote exchanges between patches and habitats
- III. Important role of crops for some species
 - Crop-specialist carabid beetles, plant weeds
- IV. Heterogeneity
 - a) Heterogeneity reduces dispersal rates, limits competition and increases biodiversity
 - b) Heterogeneity limits metapopulation dynamics, fragmentation effect, decreases biodiversity



Ranunculus repens L.



-> Heterogeneity might have different impact according to other parameters

Preliminary results

Results include

- 10 sites along the gradient
 - > Landscapes that have more cereals also have more heterogeneity
- No survey of plant in wheat fields
- Only the first two trapping periods (pooled) of carabid beetles (out of 6)
 - 4 periods in May / June
 - 2 periods in September
- Gamma diversity analyzed with Multiple Linear Models
 - > % SNH / Boundaries length / % Cereals / Heterogeneity

General overview

-> The effects of variables on species are well estimated

Coinertia RV-coefficient = 63% (carabids) / 56% (Plants)

Carabid beetles : 73 species ; 30 % appeared in less then 3 sites

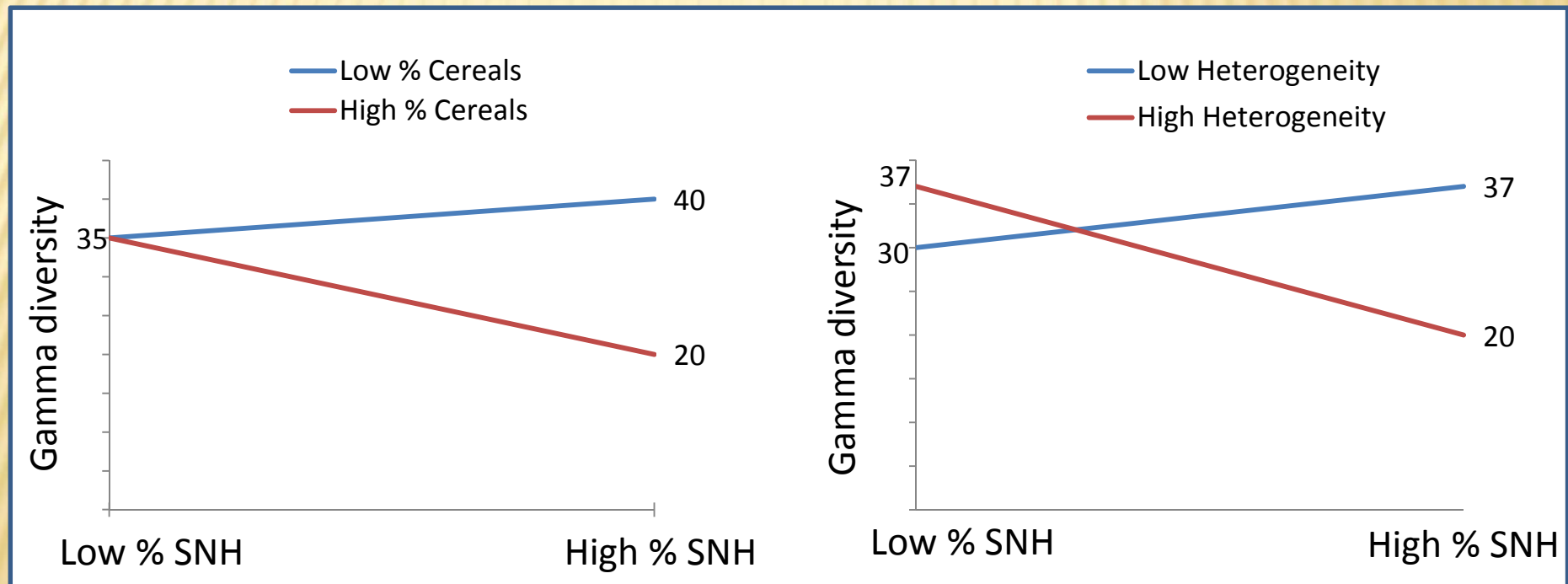
Plants: 227 species ; 52 % appeared in less then 3 sites

-> Our results are sensitive to rare species

Gamma Diversity / Carabid beetles

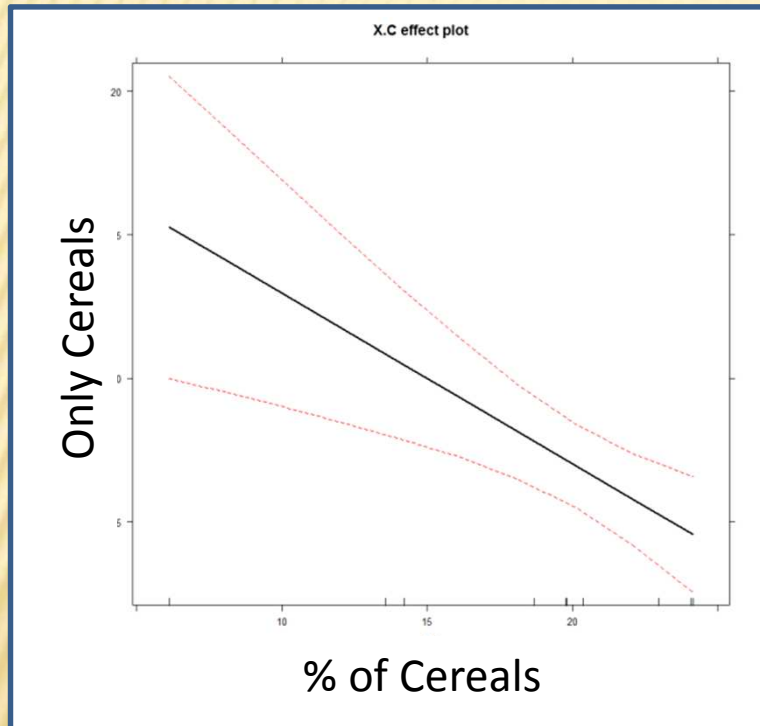
-> No effect of boundaries length on Gamma Diversity

-> The effect of % SNH depends greatly on the % of cereals and heterogeneity levels

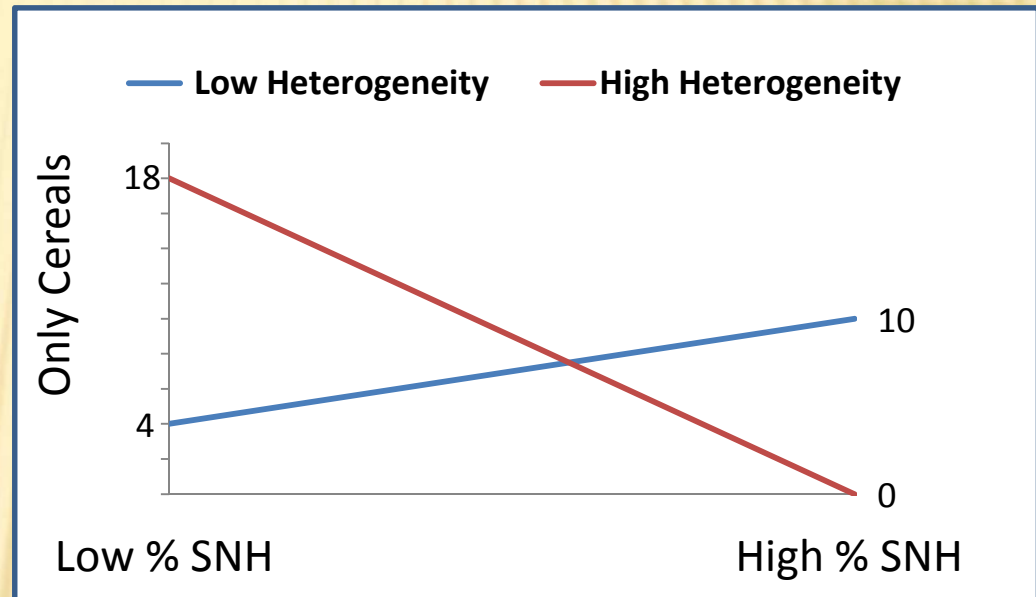


* Estimated values from Multiple Regression analysis

Species present only in cereal habitats



Interaction % SNH x Heterogeneity



The number of species present only in cereal fields decreases with decreasing % of Cereals

Interaction % SNH x Heterogeneity has the same pattern as for the Gamma diversity

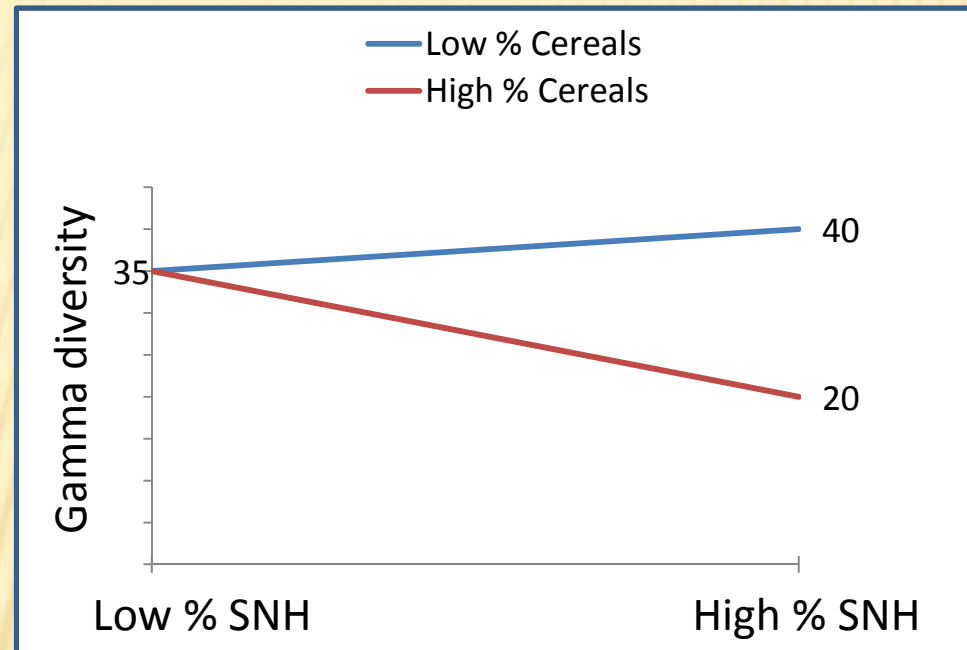
* Estimated values from Multiple Regression analysis

Gamma Diversity / Carabid beetles

Positive effect of
Heterogeneity



Negative effect
of % Cereals



Negative effect
of % Cereals



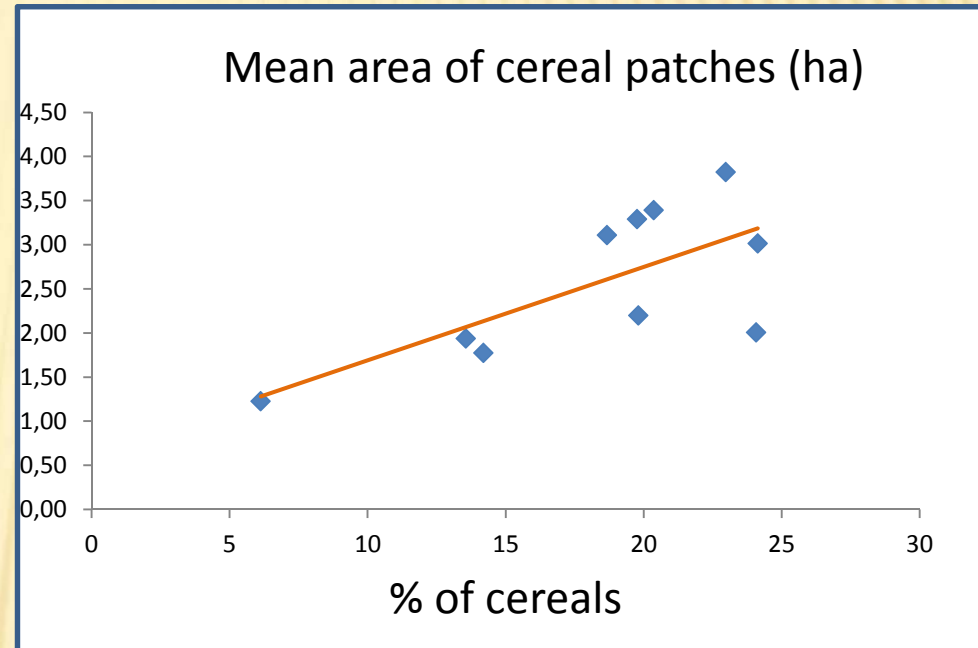
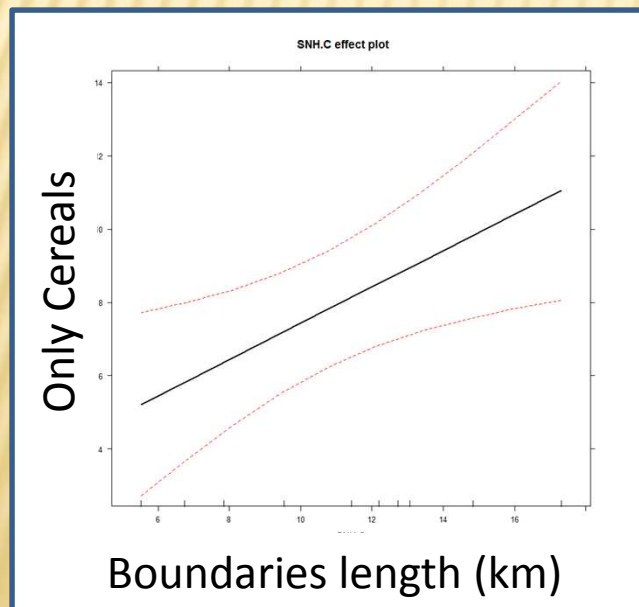
-> Gamma diversity variation is related to the number of species present only in cereals

At low % SNH the negative effect of % Cereals balance the positive effect of heterogeneity

At high % SNH the negative effect of % Cereals is dominant

* Estimated values from Multiple Regression analysis

Cereals Negative Effects



More cereals = larger cereal patches

-> lower boundary / area ratio

-> Boundaries influence the number of species present only in cereals

Heterogeneity Effects

Cereal-specialist carabid beetles usually have high dispersal abilities

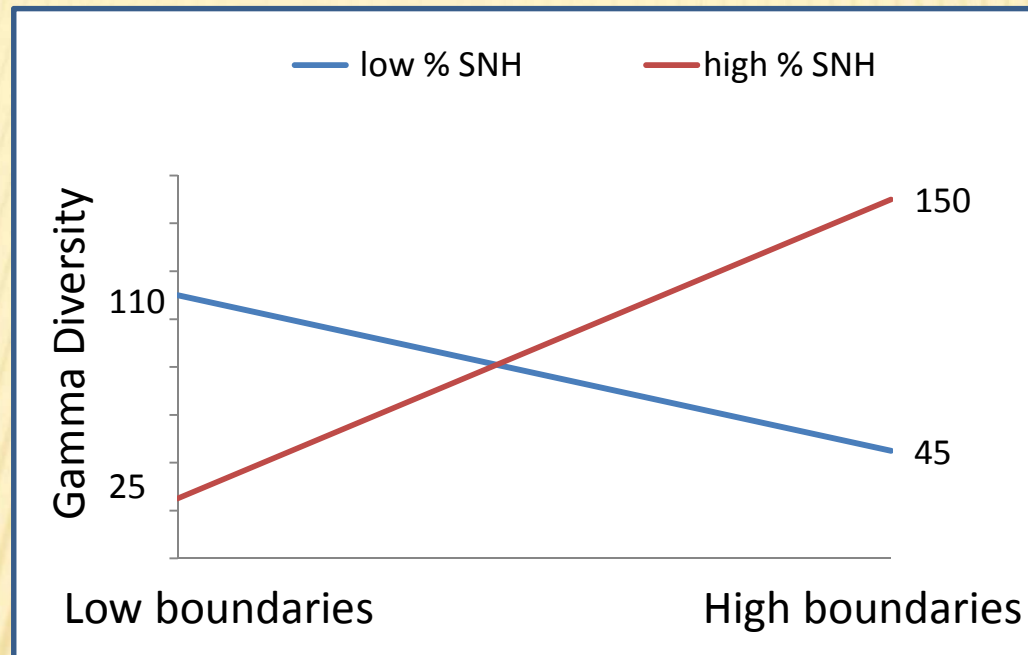


Huston, 1994. The coexistence of species on changing landscapes
-> high competition and low diversity

Heterogeneity increases -> less dispersal -> less competition
(explains results for low % SNH)

Heterogeneity increases -> more fragmentation -> less complementation / refuges...
(explains results for high % SNH)

Gamma Diversity / Flora



- > At high % SNH : boundaries are favorable (hypothesis : enhanced dispersal)
- > At low % SNH : boundaries are unfavorable (hypothesis : Fragmentation effect)

The direct effect of SNH on plant diversity is not reliable because of lack of replicates

* Estimated values from Multiple Regression analysis

Next steps of the research



1/ Make analysis with:

- 20 landscapes
- all trapping periods
- Include flora data of cereal fields

2/ Improve the understanding of results by studying α and β diversity

3/ Study differences between functional groups

- various habitat preferences
- various dispersal abilities

Acknowledgement to

IALE for invitation and financial support

Britany Region for financial support



International Association
for Landscape Ecology



Région
BRETAGNE



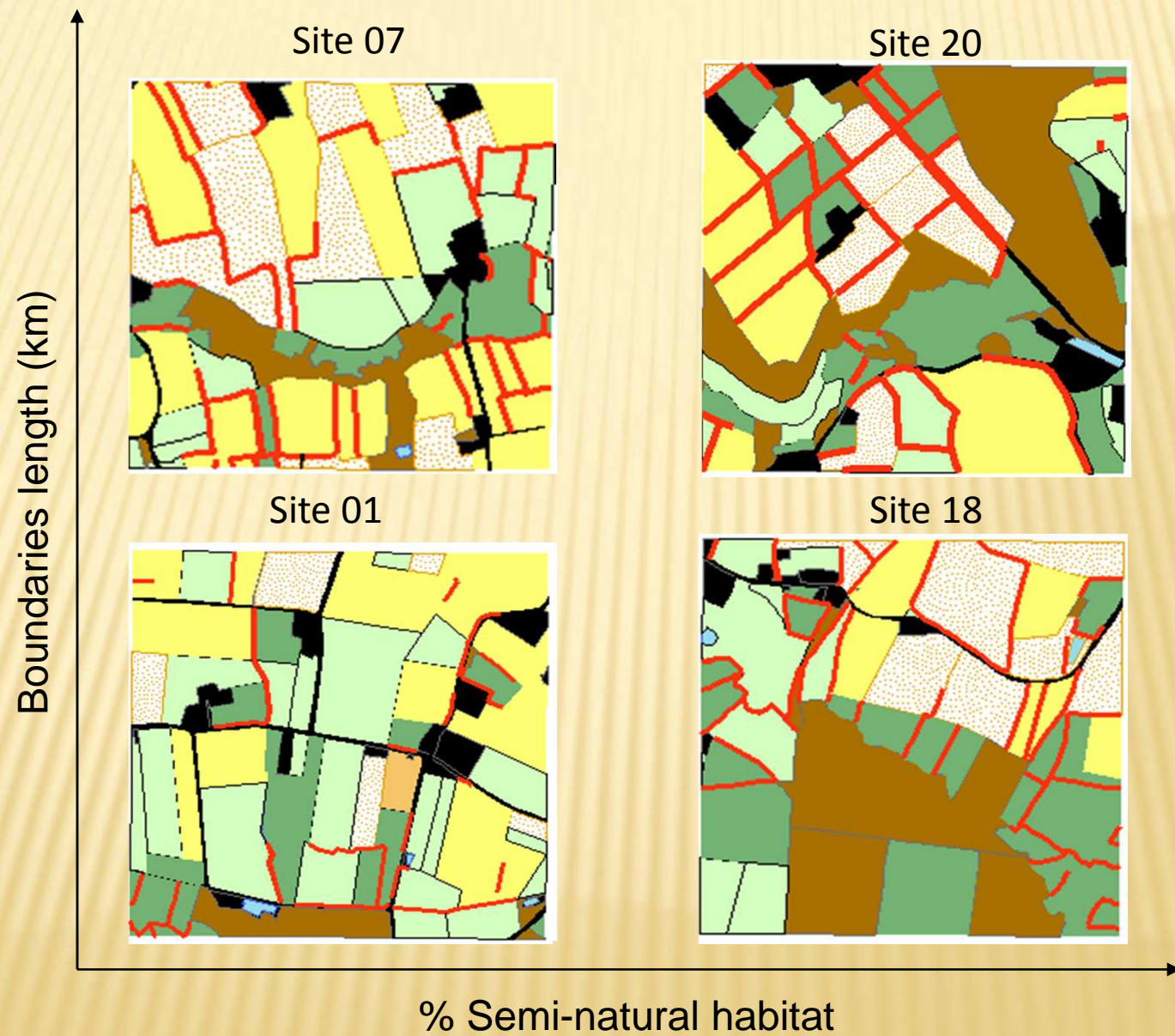
References

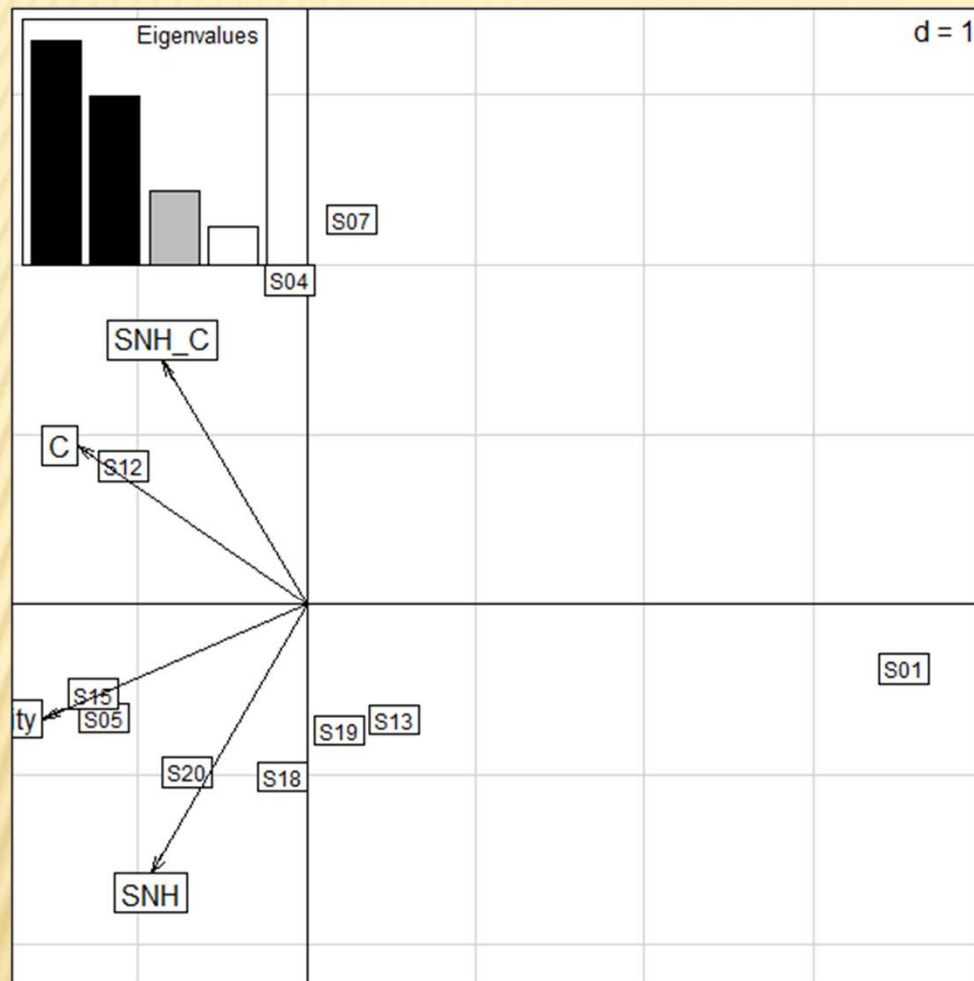
- Benton *et al.*, 2003. Farmland biodiversity: is habitat heterogeneity the key? *Trends in Ecology & Evolution*
- Tscharntke *et al.*, 2005. Landscape perspectives on agricultural intensification and biodiversity - ecosystem service management. *Ecology Letters*
- Le Roux *et al.*, 2008. Agriculture et biodiversité. Valoriser les synergies: Expertise scientifique collective, rapport, INRA
- Fahrig, 2003. Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology Evolution and Systematics*
- Fahrig *et al.*, 2011. Functional landscape heterogeneity and animal biodiversity in agricultural landscapes. *Ecology letters*
- Boitani *et al.*, 2007. Ecological networks as conceptual frameworks or operational tools in conservation. *Conservation Biology*
- Billeter *et al.*, 2008. Indicators for biodiversity in agricultural landscapes: a pan-European study. *Journal of Applied Ecology*
- Bennett, 2006. Properties of land mosaics: Implications for nature conservation in agricultural environments. *Biological Conservation*
- Crist, 2003. Partitioning Species Diversity across Landscapes and Regions: A Hierarchical Analysis of α , β , and γ Diversity. *The American Naturalist*
- Burel & Baudry, 2003. Landscape ecology : Concepts, methods and applications. Science Publishers, Inc. Enfield, NH, USA
- Huston, 1994. Biological Diversity, the coexistence of species on changing landscapes. Cambridge University Press. p 95

Heterogeneity Effects

		Actual Physical Heterogeneity of the Environment	
		LOW	HIGH
Mobility/Perception/Size of Organism	LOW	Effective Heterogeneity: LOW Competition Intensity: HIGH Species Diversity: LOW	Effective Heterogeneity: HIGH Competition Intensity: LOW Species Diversity: HIGHEST
	HIGH	Effective Heterogeneity: LOW Competition Intensity: HIGH Species Diversity: LOWEST	Effective Heterogeneity: LOW Competition Intensity: HIGH Species Diversity: LOW

Huston, 1994





PCA on environmental variables

Axis 1 : 44%

Axis 2 : 33% (cumulated 77%)

Heterogeneity and Cereals are the main variable of Axis 1.

Site S01 has low X.C and low Heterogeneity

S04 et S18 medium / medium

S15, S05 and S11 have high X.C and high heterogeneity

(07/13/19/20)

-> The effect of heterogeneity and cereals are partially mixed