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Abstract — For several decades, significant changes in bird biodiversity have been reported, especially in Europe. Agriculture, and more specifically agricultural intensification, is a major driver of these modifications. Taking into account these environmental impacts, agriculture nowadays aims at a more sustainable way of producing which would reconcile its economic and ecological functions. The objective of this paper is to give insights into the impact of public policies and financial incentives on both the conservation of biodiversity and farming production. We therefore develop a macro-regional model combining a community dynamics of 65 bird species impacted by agricultural land-use and an economic decision model for each French region. The ecological dynamic model is calibrated with the STOC (Time Survey of Common Birds) and AGRESTE (French land-uses) databases while the economic model relies on the optimization of the gross margin of the RICA (Network of Agricultural Accountant Information). We investigate different scenarios based on subsidies and taxes to study the impact of public policies on both biodiversity and agricultural economics. We show that simple economic instruments could be used to establish scenarios promoting economic performance and bird populations. The bio-economical analysis shows several solutions for the ecology-economy trade-off. These results suggest that many possibilities are available to develop multi-functional sustainable agriculture. We focus here on the impact of the innovation rigidity and we show that a too big innovation ability is not necessary favourable to the biodiversity because of the inertia of the biological systems.

Key words : Common birds, Agriculture, Bio-economic modeling, Public policy, Scenario

Résumé — Rigidité d'innovation and réconciliation écologico-economique en agriculture. Depuis quelques décennies, les populations d'oiseaux européennes ont subi de forts changements. L'agriculture, et plus spécifiquement son intensification, en est la cause majeure. Dans un tel contexte, il semble donc indispensable de developer une agriculture durable, réconciliant ses fonctions économiques et écologiques. L'objectif de ce papier est d'étudier l'impact des politiques publiques fondées sur des incitations financières sur la conservation de la biodiversité et la production agricole. Pour cela, nous avons développé un modèle macro-régional combinant la dynamique d'une communauté de 65 oiseaux communs affectée par l'utilisation des sols et un modèle économique de decision pour chaque region française. Le modèle écologique est calibré avec les bases Stoc et Agreste, tandis que la partie économique fait appel aux données du Rica. Nous explorons différents scenarios basés sur des taxes et des subventions. Nous montrons que des instruments économiques simples permettent de construire des scenarios favorables à la biodiversité et à l'économie. L'analyse bioeconomique montre un panel de solutions pour le trade-ff bioeconomique, suggérant plusieurs possibilités pour developer une agriculture multi-fonctionnelle durable. Nous nous sommes alors concentres sur le rôle de la capacité d'innovation des agriculteurs et avons montré qu'une rigidité d'innovation trop forte n'est pas favorable aux systèmes biologiques, à cause de leur inertie.

Mots clés : Oiseaux communs, Agricultre, Modélisation bioéconomique, Politique publique, Scenario

INTRODUCTION

Global changes in European agriculture in recent decades, including intensification and land abandonment, have significantly modified farmland biodiversity. The pressure is particularly strong on bird populations which have undergone severe and widespread decline (Krebs et., al 1999; Chamberlain et al., 2000; Julliard et al., 2004; Donald et al 2001 and 2006). Such erosion is mainly due to a combination of habitat loss and degradation of habitat quality altering the nesting success and/or survival rates (Benton et al., 2003). In this context, the European Union, aiming at halting biodiversity loss by 2010, has adopted the farmland bird index as an indicator of structural changes in biodiversity (Balmford et al., 2005). In this perspective, of particular interest is the need to reconcile agricultural production and biodiversity (Jackson et al., 2005). There is an extensive and increasing volume of literature concerning agri-environmental schemes and policies for multi-functional agriculture (Dobbs and Pretty, 2004). However, after 15 years of implementation of such instruments, the question whether providing habitat quality conflicts with management for agricultural production remains controversial (Vickery et al. 2004; Kleijn et al. 2006; Butler et al. 2007). To address agro-environmental sustainability, both economic and ecological criteria must be considered. As pointed out by Hughey et al. (2003) and Perrings et al. (2006), there is an urgent need for approaches that integrate economic criteria in conservation problems. Reinforcing such analyses and examining forms of farming allowing for the joint sustainability of biodiversity and agricultural production (Griffon 2006) requires interdisciplinary research. Such work relies upon the development of interdisciplinary concepts, quantitative methods and integrated models that adequately incorporate the complex interdependencies between farmland ecosystems and economic systems.

The present paper deals with such modeling issues regarding agro-environmental sustainability. A bio-economical model is developed to study the joint sustainability of agricultural land-use and bird biodiversity. This model questions the way to evaluate the ecological and economical dimensions and to rank habitat management decisions in order to assess the relevance of different policies, notably with respect to sustainability.

To deal with sustainability, approaches such as ecological economics (Dreschler et al, 2007) suggest studying environmental and economic effectiveness simultaneously, stressing the relevance of multi-criteria approaches. However, few economic studies cope with the spatial and temporal dynamics of biodiversity in this context (Hammack and Brown, 1974). In this vein, a range of spatially explicit models exist that aim at assessing consequences of different land use patterns for various environmental and economic criteria (Irwin and Geoghegan, 2001; Swihart and Moore, 2003). Nevertheless, most of these models are static, they restricts the ecological processes taken into account. Moreover, they usually do not incorporate important economic drivers (e.g. agricultural prices, subsidies) that affect the returns of different land-use patterns.

The bio-economic model proposed in the present paper is in direct line with these considerations. First the model is dynamic: it articulates ecological and economic compartments and it adopts a multi-criteria perspective. Moreover, it offers a spatialized perspective as it is built up at a macro-regional scale and its calibration relies on French regional data of both land-use and bird abundance.

The objective of this study is to analyze how we can significantly drive the bio-economic model with financial incentives and have both interesting ecological and economic performances. We focus on the bio-economic trade-off. Then we study the impact of the innovation ability on this trade-off.

The paper is organized as follows. The first section presents our bio-economical model. The second section describes the scenarios which we study here and the results. The third section is devoted to the discussion.

1. THE BIO-ECONOMIC MODEL

The ecological model

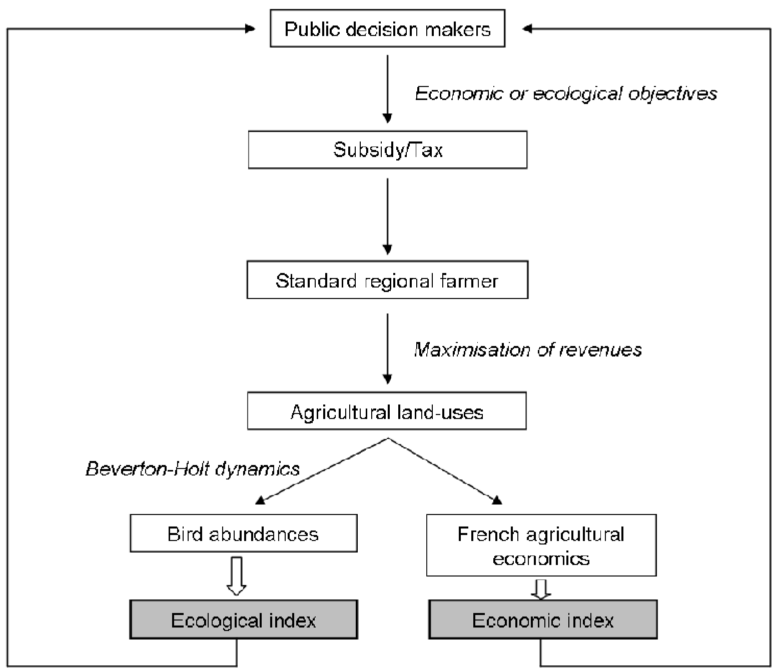
To assess the ecological performance, we here chose to focus on common bird populations and related indicators (Julliard et al., 2006). Although the metric and the characterization of biodiversity remain an open debate (LeRoux et al, 2008, MEA 2005), such a choice is justified for several reasons (Omerod et al., 2000): (i) Birds lie at a high level in the trophic food chains and thus capture the variations in the chains. (ii) Birds provide many ecological services, such as the regulation of rodent populations and pest control, thus justifying our interest in their conservation and viability (Sekercioglu et al., 2004). (iii) The availability of data and ecological knowledge: Birds belong to the most studied taxa and many databases are available. (iv) Their close vicinity to humans makes them a simple and comprehensive example of biodiversity for a large audience of citizens.
Regarding the model for bird populations, we have chosen a dynamic approach. We have adopted the Beverton-Holt model (Beverton and Holt, 1957) which accounts for the intra-specific competition for the resources and the density dependence. The carrying capacity is depending on the quality of the habitat, computing by the land-uses. So bird dynamics are dynamic and evolve function of the evolution of land-uses. Bird populations are estimated for each region. The ecological model is so implicitly spatialized.

1.2. The economic model of the farmer

We consider 21 regions of France. Each region is managed by a representative farmer who selects land-uses along time. The farmer makes his choice in order to maximise his revenue given rigidity and technical constraints. His revenue depends on two parameters: unit gross margin and public incentives. Implicitly the gross margin is computed from the regional output of each activity and its sale price. Here the sole reason for the direct revenue to change along time comes from the variation of surface allocated to such use. This income is affected by public incentives τ on different uses which take the form of taxes or subsidies ($\tau>0$) or taxes ($\tau<0$). We have chosen to keep the incentive or tax stable along time in this simplified prototype. It is computed as a rate τ of mean gross margin per surface unit.
When maximizing his revenue, the standard agent must comply with two constraints at every time. The first constraint corresponds to a technical constraint, which drives the rigidity (with the parameter ε) in changes. The higher ε, the larger the changes performed by the farmer at any time. This parameter could be read as the farmer innovation ability. The second constraint ensures merely that the total surface per region remains constant.
For any region, the representative farmer defines the share of his land which he dedicates to the various practices relying on a linear optimization under constraints. Certain hypotheses underlie this model. We suppose that the system is at equilibrium in various dimensions and that the farmer's choice does not alter such equilibrium. First, we consider the farmers as price-takers. Second, we admit that food consumers have changing habits, though the demand remains constant. Third, the technological level does not evolve: there is neither improvement from research nor the quest for improved productivity from the farmers. The mean yield (which this revenue per surface unit depends on) is kept flat. The same is applied to the labor market: we do not study the number of farmers, which is assumed constant.

1.3. Model coupling and public decisions

Figure 1. Model coupling:
farmers maximise their revenues and adjust theirs land-uses pending on subsidies. These choices affect French agricultural economics and bird community dynamics.



Ecological and economic models described previously are linked by the land-uses as depicted by figure 1. With the objective of maximising his revenue, the representative farmer exhibits pattern of land-uses which are injected into the ecological model through the carrying capacity: the agricultural states are the outputs of the economic model and the inputs of the ecological model. The farmer's economic choices thus condition bird biodiversity associated with the habitats.

We can therefore now add a new agent to our model: the public stakeholder. The decision-makers impact the bio-economic system through an economic instrument: they use a set of incentives and taxes which impacts the various agricultural practices, thus modifying their profitability. Thanks to their economical model, the farmers shape their land-use patterns in order to maximise their revenue. These land-use rearrangements improve the global wealth while perturbing the evolution of ecological model and bird community dynamic. Decision-makers define their incentive/tax politics depending on their ecological objectives and economic planning. For this purpose, the regulating agency must be able to evaluate the economic wealth and the biodiversity of the system it governs. It uses various performance indicators of the system. However there is no holistic criterion, representing all dimensions of the system. So we choose to focus on an economic index and ecological index to analyse the trade-off between them.
From an economic perspective, we use the national mean income per unit surface. It is computed from the mean gross margin of the 21 regions and represents a mean approach of the problem. For sake of clarity, we represent this criterion after normalisation by their current value (2008) on the next graphs (fig. 2 et 4). From an ecological point of view, we have selected the STOC index provided by the Vigie-Nature website (http://www2.mnhn.fr/vigie-nature/). This is a variation index of abundances with respect to the reference year 2005. An aggregated STOC index is built for the farmland specialist species (Julliard et al., 2006).

Mouysset et al. (2010) show these species are more relevant for this kind of study than the generalist habitat species. It is computed as the geometric mean of the indices of the species considered in the class. In these aggregated indices, the abundance variation of each species is taken into account similarly, independently from the abundance value.

1.4. Model calibration

We selected the metropolitan region as the unit of spatial scale. We split France into 21 regions (Corsica excluded). On the ecological side, the STOC database developed by the Museum National d'Histoire Naturelle provides the data related to the bird abundances. Among the 175 species monitored by this program, we have selected the 65 species used as a reference for the European FarmlandBird Index. The regional abundances for the years 2001 to 2007 are available for each of these species. According to their relation with the habitat, we can classify the 65 species into four main classes: generalists, farmland specialists, forest specialists, and urban specialists.
Agronomical data measuring the surfaces of the various agricultural practices are published by Agreste (Statistics Service of the Department of Agriculture) for the years 2002 to 2007. Finally the economic data relating to the gross margins are derived from RICA (Réseau d'Information Comptable Agricole). We use 10 classes of land-uses.
The first step consists in determining the Beverton-Holt parameters through a calibration. For each of the 65 species, we must estimate the growth parameter constant over the region as well as the carrying capacity specific to each region. We use a least square method to minimize errors between the observed abundances as issued from STOC and the values derived from the model. The errors of calibration are small (between 4% and 6% for the illustrated species) and the historical data do not go beyond the confidence interval (coming from the least square standard errors of calibration). Comparing the historical data with the model-generated data, we note that the model tends to smooth the variations of the observed data.

2. SCENARIOS AND RESULTS

Scenarios

Once the ecological and economic models have been calibrated, we can use them to analyse the impact of public policies. The selected timeframe runs up to 2050, i.e a 43-year forecast. Selecting a shorter timeframe could consequently hide interesting long-term effects due to the inertia of the models.
We define scenarios for various incentive/tax policies aimed at analysing the impact of governmental decisions on both the economy and agricultural biodiversity. In all scenarii described in this article, surfaces allocated to the forest and non-farming area remain steady in all times: we focus only on the evolution of the farmland use. This approach highlights the impact of the composition of farmland uses on biodiversity, the global surface remaining constant.

We have developed 3 scenarii:
- Bioenergy scenario: incentives for COP (cereal, oleaginous, proteaginous).
- High Environmental Quality (HQE) scenario: incentives for the extensive grasslands.
- Redistribution scenario: taxes on the COP, redistributed to the extensive grasslands.

The first two scenarii are very simplified variants of current policies. The first scenario represents policies which support COP, for example with the objective of developing bioenergies. The second scenario corresponds to a policy of extensification by the development of permanent grasslands. The third scenario, slightly more complex, plays at two levels: the tax on the COP and the incentive for permanent meadows. We study the synergy of these two levels. This scenario is of specific interest for the planner: the required budget is lower than for the two first scenarios, as the incentives for the permanent meadows are compensated by the taxes on the COP. This scenario is more realistic from an economical perspective in the sense that it is partially self-funded for the public stakeholder. In all three cases, this is a simplified model since the same policy is applied to all regions, whatever the economic or habitat features.

We study these 3 scenarios with a combined bio-economic approach coupling both economic and ecological outputs to better understand the trade-off. For this step, we keep the innovation ability constant. Then we analyse the impact of this parameter on the bio-economic trade-off. All graphs display the results similarly. Each trajectory is composed of 43 points, corresponding to each years of the timeframe from 2008 to 2050. All trajectories start from the same point at the lower left corner of the figure.

Impact of scenarios on the bio-economic trade-off

Figure 2. Impact of scenarios (yellow : Bioenergy, green : HQE, blue : Redistribution) on the bio- economic trade-off between the mean revenue and the farmland bird index (τ = 50%, ε = 10%)

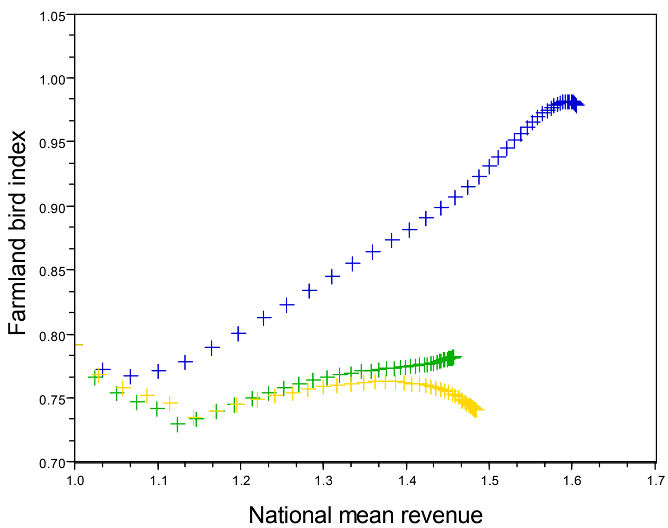


Figure 2 allows for a comparison of the 3 scenarios based on identical ε and τ parameters, set respectively at 10% and 50%. We observe that we obtain contrasted results pending on the scenarios. If all of them improve the economic index, it is not the same situation with the ecological index. The Bioenergy scenario seems to not to be favourable for the birds in a long term. From the economic perspective, the HQE scenario is the least efficient. We note that the Redistribution scenario is the one which generates the best results on both index. The marginal effect of this two-actions scenario is positive for both indicators. But it is particularly interesting for the STOC index, which goes close to the reference value. The gain with the Redistribution scenario (compare to the others) is around 7 % for the economic index while it is 30 % for the ecological indicator.

Impact of incentive's level on the bio-economic trade-off

Figure 3. Impact incentive's level τ (yellow τ = 10%, green τ = 50%, red τ = 100%, brown τ = 180%) on the bio- economic trade-off between the mean revenue and the farmland bird index (ε = 10%)

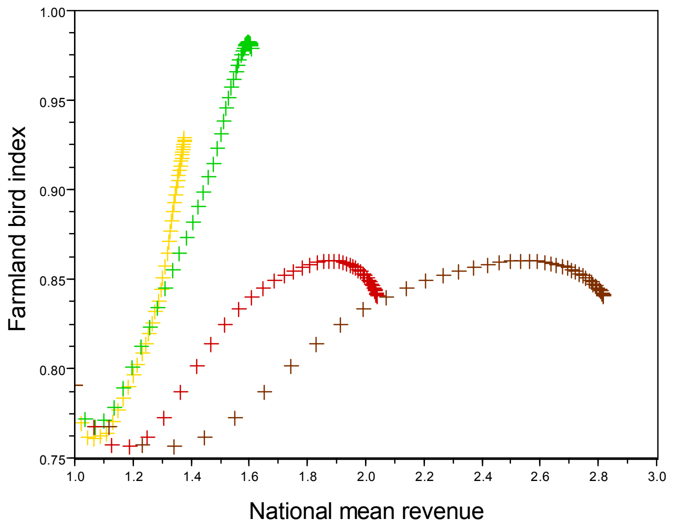
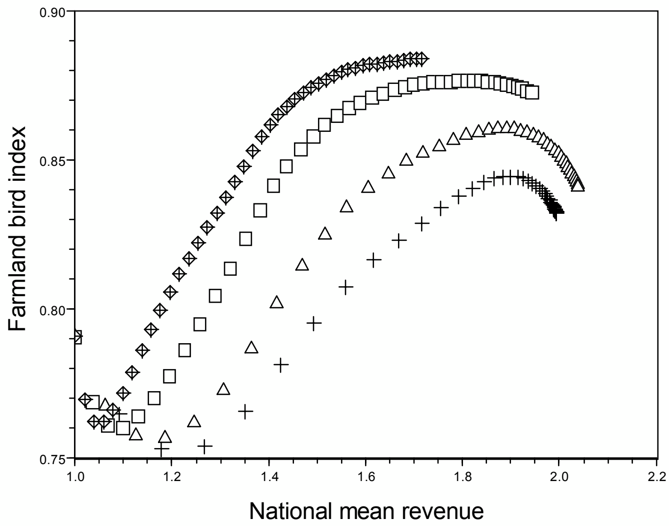


Figure 3 displays the trajectories of the Redistribution scenario for 4 levels of incentive. We remark that depending on the value given to τ, we get a full range of trajectories covering the set of possibilities. No trajectory exhibits an improvement of the system for either ecological or economic dimensions. However, some trajectories are more eco-efficient (for example with τ = 0.1 and 0.5), while others show a better economic effectiveness (τ = 1 and 1.8). We note that certain values of the national mean income can be obtained for all trajectories (for example revenue = 1.3). This value is not reached at the same speed for the four trajectories: with τ = respectively 1.8 (1, 0.5, 0.1), this income is obtained respectively after 4 years (6 years, 11 years, 40 years). The more drastic the policies (higher level of tax and incentive), the faster the income. However, for a given income, the slowest trajectory is the most eco-effective: for a national mean income of 1.3, the STOC index of farmland specialists provides a level of 0.93 with τ = 0.1, against only 0.77 for τ = 1.

Impact of the innovation ability on the bio-economic trade-off

With the figure 4, we illustrate trajectories of the Redistribution scenario for 4 levels of innovation ability for one level of incentive. We find exactly the same kind of results for the other levels of incentive. This graph shows an impact of farmer rigidity of changes on the bio-economic trade-off. On the economic side, the smaller is the ε parameter, the smaller is the speed of the revenue. But for all the cases, the model converges to the same long-term revenue. On the ecological side, the rigidity affects also the speed of growth of the STOC index, but there is a second effect, more interesting. The level of ε can not stop the bird decrease at the end of the trajectories, but still drives the ecological optimum. The smaller the rigidity, the higher is the optimum reached along the projection. To obtain good ecological results with a bird favourable scenario, it is not necessary to have too big innovation ability.

Figure 4. Impact of innovation ability parameter ε (diamond ε = 3%, square ε = 5%, triangle ε = 10%, plus ε = 15%) on the bio-economic trade-off between the farmland bird index and the national mean revenue for the Redistribution scenario (τ = 100%)



3. DISCUSSION

Ecological-economic reconciliation

With this simplified bio-economic prototype, we have shown that both the ecological and economic performances are impacted by the public policies for agriculture and land-use. A basic economical instrument (incentive/tax) separates policies according to the two criteria. In line with the bio-economic literature (Dreschler et al, 2007), it suggests that managing the agricultural practices in bio-economic terms is possible thanks to a simple economic distortion of the marginal revenues.
The model illustrates how it is possible to build scenarios which appear favourable on the long term to both ecological and economic criteria. It should therefore be possible to define public strategies improving both farmer incomes and the avifauna. Our study suggests that the most favourable case occurs with the Redistribution scenario. This observation highlights that acting simultaneously on various incentives can improve performance from both the ecological and economic points of view.

The ecology-economy trade-off

As depicted by the figure 3, no unique pareto optimum arises: even if both criteria are improved, it is always necessary to prioritise ecological and economical objectives. Consequently, a set of admissible strategies is available to bring together ecological and economic performances.
The challenge consists in selecting which farming activities should be subsidised or taxed and which magnitude of incentive/tax is the most adequate in order to optimise trajectories for the set of selected ecological and economic criteria. However, along these trajectories, we have seen that the speed of change is very fluctuating. This variation gives another level of trade-off in terms of timeframe: how fast the public agency wants to reach the objectives. The growth rate is linked to the level changes requiring a larger budget. The total budget of the regulating agency is another key element of his strategy. In our model, we have not

imposed budgetary constraint. However, in a larger perspective, decision-making support requires the integration of this budgetary limitation in the model. Indeed, some policies may be attractive from ecological and economic perspectives but not feasible in terms of public balance. Considering this global budget limitation raises the question of budget allocation to the regions. The answer to such a question is highly dependent on the selection of the economical indicator. Does the objective consist in reaching a maximal national mean, a maximal level for the poorest region or a minimal variability over the regions? This spatial share of the global budget highly conditions the economical and ecological performance of each region, as well as for the whole country.

Importance of the innovation rigidity for the ecological performances

As expected, the innovation rigidity has an impact on the speed of changes for the ecological and economic performances. But a strong rigidity has also a positive effect on the ecological results. The farmer's changes in land-uses modify the carrying capacity in the Beverton-Holt dynamic, but do not directly alter the population size. Under relevant public incentives, farmers adjust their land-uses in an eco-friendly way. So the carrying capacity increases, as well as the populations with a delay. If farmers do not stop, they keep changing their activities over time: they reach the optimal land-use repartition but continue their changes to optimise their revenue. Over the optimal repartition, the carrying capacity decreases leading, with the delay, the decrease of the bird population. The faster the changes (low rigidity), the faster optimal repartition; thus the shorter the growth period for bird populations, the lower the optimum reached by the ecosystem. Biological dynamics show stronger inertia than the economic system and we illustrate here that it is no useful to promote scenarios which develop a too big innovation rigidity. Biodiversity needs time to take benefits of eco-friendly activities. It will be particularly necessary to elaborate a dynamic policy, which changes when the optimum repartition is achieved. We can note that the optimal repartition is compiled with a set of land-uses: a bigger proportion is allocated to eco-friendly land-uses, but it is necessary to keep a diversification in the activities as shown by Benton et al (2003).

CONCLUSION

This interdisciplinary model illustrates that reconciliation between agricultural production and conservation is possible. The research approaches using optimisation under constraints are more widely used in interdisciplinary problems, as the multi-functionality of agriculture. The objective of these methods is to build a plausible model to predict the impact of public policies on bio-economic performances. We develop a dynamic, spatialized and empirically rich model to study the links between bird biodiversity and agricultural policies. This kind of models can be an interesting aid to the decision, promoting interactions between research and society. The ex-ante analysis of public policies allows to test innovating scenarios, that we cannot directly test in reality, and to analyse strategic features of these policies to enhance their sustainability. We show that reconciliation between ecological and economic efficiency is possible using relevant public policies. We focus here on the impact of the innovation rigidity and we show that a too big innovation ability is not favourable to the biodiversity because of the inertia of the biological system.

REFERENCES

Balmford A. et al., 2005. The Convention on Biological Diversity's 2010 Target. Science, 307, 5707, 212 - 213.

Benton T.G, Vickery J.A., Wilson J.D., 2003. Farmland biodiversity: is habitat heterogeneity the key? Trends in ecology and evolution, vol 18, No 4, 182-188.

Beverton R. J. H., Holt S. J. (1957), On the Dynamics of Exploited Fish Populations, Fishery Investigations Series II Volume XIX, Ministry of Agriculture, Fisheries and Food.

Butler S.J., J. A. Vickery, K. Norris, 2007 Farmland Biodiversity and the Footprint of Agriculture Science Vol. 315. no. 5810, pp. 381 - 384

Chamberlain D.E., Fuller R.J., Bunges R.G.H., Duckworth J.C. and Shrubb M., 2000. Changes in the abundance of farmland birds in relation to the timing of agricultural intensification in England and Wales. JAE, vol 37.

Dobbs, T. and Pretty, J.N. 2004. Agri-Environmental Stewardship Schemes and "Multifunctionality". Review of Agricultural Economics 26: 220-237.

Donald P.F., Green R.E., Heath M.F., 2001. Agricultural intensification and the collapse of Europe's farmland bird populations. Proc. R. Soc. Lond. B, 268, 25-29.

Donald P. F., Sanderson F. J., Burfield I.J., van Bommel .F P. J., 2006. Further evidence of continent-wide impacts of agricultural intensification on European farmland birds, 1990-2000. Agriculture Ecosystems and environment, 116 (3-4): 189-196.

Dreschler M., Wätzold F., 2007. Ecological-economic modelling for the sustainable use and conservation of biodiversity, Ecological Economics, 62,2,203-206.

Griffon M., 2006. Nourrir la planète. Paris, Odile Jacob, 456p.

Hammack, J. and Brown, G.M., Jr. (1974). Waterfowl and Wetlands: Toward Bioeconomic Analysis. Baltimore: Johns Hopkins University Press.

Hughey K.F.D., Cullen R., Moran E., 2003. Integrating economics into priority setting and evaluation in conservation management, Conservation Biology, 17, 1, 93-103.

Irwin E.G., Geoghegan J. 2001. Theory, data, methods: developing spatially explicit economic models of land use change. Agriculture Ecosystem Environment, 85, 7-23.

Jackson L., Bawa, K., Pascual, U., and Perrings, C. 2005. Agrobiodiversity: A new science agenda for biodiversity in support of sustainable agroecosystems. DIVERSITAS report. N. 4. 40 pp.

Julliard R., Jiguet F., Couvet D., 2004, Common bird facing global changes: what makes a species at risk ?, Global Change Biology, 10, 1, 148-154.

Julliard R., Clavel J., Devictor V., Jiguet F., Couvet D., 2006. Spatial segregation of specialists and generalists in bird communities. Ecology Letters 9 : 1237-1244.

Kleijn R. A., Baquero Y., Clough M., Díaz J., De Esteban F., Fernández D., Gabriel F., Herzog A., Holzschuh R., Jöhl E., Knop A., Kruess E.J.P., Marshall I., Steffan-Dewenter T., Tscharntke J., Verhulst T.M., West J., L. Yela, 2006. Mixed biodiversity benefits of agri-environment schemes in five European countries, Ecology Letters 9 (3), 243-254.

Krebs J.R., Wilson J.D., Bradbury R.B., Siriwardena G.M., 1999. The second silent spring ? Nature, 400, 611-612.

Le Roux X., Barbault R., Baudry J., Burel F., Doussan I., Garnier E., Herzog F., Lavorel S., Lifran R., Roger-Estrade J., Sarthou J.P., Trometter M. (éditeurs), 2008. Agriculture et biodiversité, valoriser les synergies. Expertise scientifique collective, synthèse du rapport, INRA (France).

Millenium Ecosystem Assessment, 2005. Ecosystems and human well being: current state and trends. Chapter 26 : cultivated systems. Pp 745-794. Island Press, Washington.

Mouysset L., Doyen L., Jiguet F., Allaire G., Leger F. Bioeconomic modelling for sustainable management of agriculture and biodiversity. Ecological economics (submitted).

Ormerod S.J., Watkinson A.R., 2000. Editor' s introduction: Birds and agriculture. Journal of applied ecology, n°37, 699-705.

Perrings, C. P., L. Jackson, K. S. Bawa, L. Brussaard, S. Brush, T. Gavin, R. Papa, U. Pascual, and P. de Ruttier., 2006. Biodiversity in agricultural landscapes: saving natural capital without losing interest. Conservation Biology 20:263-264.

Sekercioglu C., Daily G.C., Ehrlich P., 2004. Ecosystem consequences of bird declines. PNAS, 101: 18042 - 18047.

Swihart, R. K. Moore and Jeffrey E., 2003, Conserving Biodiversity in Agricultural Landscapes Model-Based Planning Tools , Purdue University press.

Vickery J. A., Bradbury R. B. and Henderson I. G., Eaton M. A. and Grice P. V., 2004. The role of agri-environment schemes and farm management practices in reversing the decline of farmland birds in England, Biological Conservation, 119, 19-39.