Integrative simulation of agricultural and landscape changes

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Abstract: Patterns and functions of European landscapes should be strongly modified by the changes of agricultural activities and by the way they will react to the new European agricultural policies after 2013 and the CAP redefinition. In that context, models of interactions between agricultural practices and ecological dynamics are of great relevance for considering the potential changes in landscape structures. In previous research actions, our team developed scenarios of landscape and policy change, as well as simulations of landscape change. At that stage, we wanted to develop a more integrative and participatory approach for simulating landscape ecological dynamics and farms socio economic changes in order to allow stakeholders to build their own scenarios according to their identified needs. The first objective of this text is to explain why our models have properties that make them simulators adapted to participatory approaches for scenario building. The cellular automaton *Genevrier* simulates the evolution of land cover. All transition rules can be displayed and modified by stakeholders during working sessions. The socio-economic simulator *Larzac* allows simulating the consequences on farm income of scenarios defined with stakeholders and

based on information describing the farming system. The second objective is to present the potentialities of using both simulators as complementary tools for considering alternative agro-environmental policies.

Keywords: landscape; breeding systems; biodiversity; agricultural policies

Introduction

Patterns and functions of European landscapes should be strongly modified by the changes of agricultural activities and by the way they will react to the new European agricultural policies after 2013 and the CAP redefinition.

Maintenance of agriculture is subject to strong uncertainties in many European rural areas. In 1975, 30% of the total UAA was classified as Less favoured areas (LFA, Council Regulation (EC) 1257/99), especially mountain areas and areas with low productivity. In 2005, LFAs represent 55% of the total UAA of the EU-15 Member States and +/- 69 millions of ha (IEEP 2006). Among these areas are those where agricultural maintenance is a key factor for social cohesion and preservation of rural landscape. In those areas facing land abandonment and agricultural decline, the strategies and practices of agricultural stakeholders have to take into account new economic and policy contexts and a redistribution of constraints and opportunities. In the same way, the evolution of agricultural policies has begun: decrease of direct supports, increase of differentiated supports for rural development like support for local projects, increasing attention paid to environmental issues and to alternative agricultural practices through agro-environmental schemes, High Natural Value Farmland and organic agriculture.

In that context, models of interactions between agricultural practices and ecological dynamics are of great relevance for considering the potential changes in landscape structures. In previous research actions, our team developed scenarios of landscape and policy change, as well as simulations of landscape change and analysis of agricultural practices (Quétier et al. 2005; Caplat et al. 2006 ; Fonderflick et al. in press). We looked for develop a more integrative and participatory approach for simulating landscape ecological dynamics and farms socio economic changes. As there is a strong demand from stakeholders and extension officers for models that take into account the interactions between agricultural systems and environmental variables, we aimed at building simulation tools allowing to get a better understanding of how different farm strategies impact on the environment at landscape level.

We developed these tools in close cooperation with local partners (extension officers and officers in charge of local development: Service d'Utilité Agricole Montagne Méditerranéenne Elevage – SUAMME, Chambre d'agriculture de l'Hérault, Centre Permanent d'Initiation à l'Environnement - CPIE Larzac and Institut de l'élevage). During this collaboration process, local partners were able to validate the models and to start to use

them. Those models allow 1) simulating land cover and landscape dynamics depending on agricultural practices, 2) analysing the consequences of changes in the factors of agricultural income (flock size, surfaces, hay resources, public supports…) on farm survival. We designed those tools so that local actors could as easily as possible, appropriate and use them.

This paper has two main objectives: 1) to explain why these models have properties that make them simulators adapted to participatory approaches for scenario building and 2) to present the potentialities of using both simulators as complementary tools.

1. Study area

The study area is the southern part of the Causse du Larzac ("Larzac héraultais"). Semi-natural grasslands, potentially used for sheep and livestock grazing, are the most important component of that landscape. Cropped areas account for less than 10%. This area is identified as of high biodiversity value because of the open semi-natural calcareous grasslands and rangelands. It is almost entirely included in a Natura 2000 site (FR9101385, 29 619 ha). The main factor of change is a massive dynamic of tree and shrub encroachment threatening the most valuable natural habitats. This process started in the second half of the 19th century when cultivation decreased and when breeding became the main agricultural activity. However, local actors continue to analyze this process as the result of a decrease in grazing pressure linked to farm management models who give less importance to semi-natural grassland resource. This study area is composed by 23000 ha used by 66 farms for which we have obtained detailed data, thanks to our collaboration with local partners. Thanks to almost ten years of research on woody plants ecological dynamics and on resource use by local farmers, our team has a correct knowledge of the plant / human activities interactions.

2. Two models suitable for participatory approaches

As we designed them, these two simulation tools have properties that make them suitable for participatory approaches for scenario building (Le Bars and Le Grusse 2008).

Genévrier is a cellular automaton. It contains a data base and a simulator. In the data base are information on species (Box, oak, juniper, pine…) and vegetation types (crops, grassland), on vegetation cover types based on 1 or 2 species and a density mode (e.g. : sparse box, sparse oak with sparse box), grazing (heavy, light, no grazing), 130 evolution rules for each cover type.

Figure 1. Land cover types evolution rules in Genévrier

ceci	Voisinage	Paturage	devient	dans
genévrier clair	pin dense*	fort	pin clair/genévrier clair	30
		lâche		20
		nul		10
	pin clair*	fort	pin clair/genévrier clair	30
		lâche		25

The cellular automaton *Genevrier* simulates the evolution of land cover. It is based on spatial diffusion of woody plants patches. This spatial diffusion follows a set of transition rules that takes into account neighbourhood and grazing pressure as a factor affecting colonization. It has two main participatory properties. First it is a model without black box and where transition rules can be displayed and modified by stakeholders during working sessions. This property is essential in order to have a validation of the model and its functions by stakeholders. This model allows showing, for any step of the simulation, the corresponding rules. In that sense it is an auto-explanatory model. Additionally we developed a module for data acquisition that allows simulating any landscape structure relevant for stakeholders and users: maps, aerial photographs or even basic hand-made sketches.

The second model, the socio-economic simulator *Larzac* contains a data base with technical and economic information (margin, public payments, flock size…) for each farm of our study area (N=62). *Larzac*, allows simulating the consequences of scenarios to be defined with stakeholders (Hadjem 2009). It allows examining how these scenarios could affect the total area used by agriculture, through a farm viability threshold defined by stakeholders. Like *Genevrier*, *Larzac* is an open model where data and rules can be shown, challenged and corrected at any moment by stakeholders during working sessions. Stakeholders checked the consistency of data and validated this model.

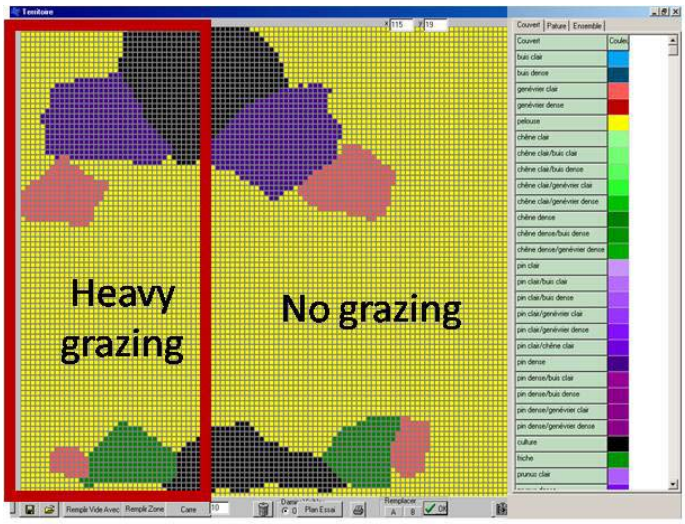
3. Two complementary tools for building landscape scenarios

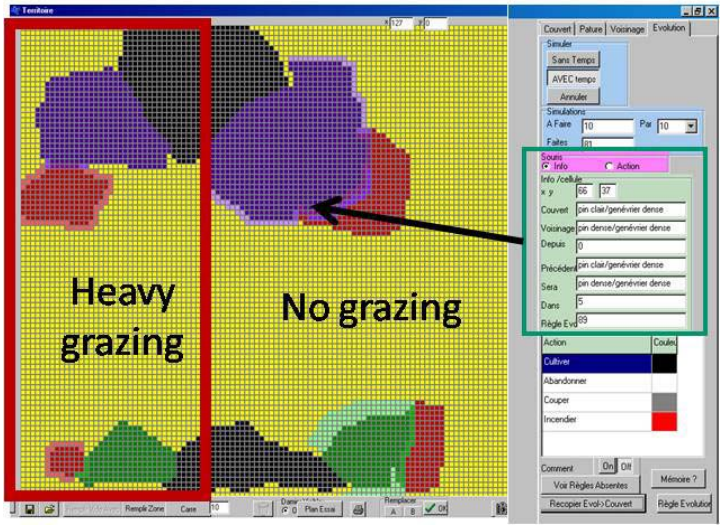
Both tools are complementary. They allow visualizing how landscape structure can be affected by changes in farmers' practices (increasing or decreasing grazing pressure, using or not local rangeland resources, development of sylvo-pastoralism…) and in public support to agriculture (following different scenarios in incentives attribution). Each different landscape structure produces different contexts both for agriculture and biodiversity.

3.1. *Genévrier*: visualisation of the effects of grazing practices

Following the vegetation transition rules validated by our local partners, *Genevrier*'s simulations show that breeding systems, as far as they use rangeland resources through grazing practices considered as "heavy grazing", can limit the extent of tree and shrub encroachment (figure 2).

Figure 2. Initial state (up) and simulation of landscape change (down) under two grazing regimes.





Furthermore, simulations in *Genevrier* lead users (farmers, extensions officers, decision makers, landscape ecologists) to question their knowledge and to put their practices in discussion. One essential question is to find out under which conditions farming systems involving heavy grazing practices are sustainable.

3.2. *Larzac*: farm dependence on public supports

From a data set of 62 farms, we simulated the effects of five scenarios of change in public support and payments (table 1) and we observed how these changes affected two indicators: 1) farm in critical state and 2) area potentially abandoned. A farm is "in critical state" when margins do not allow an income for a person at the minimum legal French salary. The area potentially abandoned is the sum of the area of the farms in critical state.

Table 1. Five scenarios of change in public agricultural support

	Balance Indicator				
	No change in CAP	1st pillar: -20%	1st pillar: -50%	1st pillar: -80%	Suppression of CAP
Ovine meat farms threatened	**9**	**9**	**10**	**11**	**11**
Ovine milk farms threatened	**0**	**0**	**0**	**0**	**0**
Bovine farms threatened	**5**	**5**	**6**	**9**	**9**
Mixed farms threatened	**3**	**3**	**4**	**4**	**4**
AWU threatened	**19**	**19**	**23**	**28**	**28**
Causse (ha) under risk of agricultural abandonment	**5527**	**5527**	**7543**	**10513**	**10513**

The results displayed in table 1 show firs that the breeding systems of the study area have a delicate but contrasted economic balance. Ovine milk farms should be little affected even by a strong decrease in public support. But public payments are necessary for the survival of 1/3 of the farms included in our data set. Decrease in public support should increase the number of farms in critical position and thus the area under risk of agricultural abandonment. In the 4th and 5th columns of table 1, almost half of the study area is likely to be abandoned by agriculture. Abandoned agricultural areas are prone to be colonized by trees and shrubs.

As for *Genévrier*, the outputs of *Larzac* do not give management solutions but help farmers and policy makers to conduct a more informed and more reflexive debate on agricultural landscape issues.

Conclusion

These simulation tools can be used for considering alternative agro-environmental policies. Our results showed that the Larzac breeding systems depend strongly on public support to agriculture through the CAP payments. However these supports do not take enough into account that farmers are not only food producers but that they are essential actors for maintaining environmental amenities at landscape level (i.e. for our case study the maintenance of open semi-natural landscapes providing habitats for priority species). Our first working sessions showed that stakeholders are strongly interested by using those simulators. These tools having being validated by stakeholders, the next step will be to use those models as a tool for a collective reflection with focus groups gathering farmers, extension officers and decision makers.

Acknowledgments

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