Landscape scenarios and 3D visualisation for supporting sustainable development of mountain areas undergoing reforestation

Annick Gibon[a], Anne Mottet[b], Sylvie Ladet[a], Marc Fily[c], Patrick Caperaa[d], Gérard Balent[a]

[a]INRA, UMR 1201 DYNAFOR, Castanet Tolosan, France; [b]Institut de l'élevage, Paris, France ; [c]Direction Départementale Agriculture et Forêt, Tarbes, France; [d]Chambre d'Agriculture des Hautes Pyrénées, Tarbes, France - Annick.Gibon@toulouse.inra.fr

Abstract: *Landscape changes are currently a major concern for sustainable development in European mountains. Landscape encroachment and reforestation are widespread phenomena in these regions whose impact on future landscape functions (environmental, economical and social) remains difficult to forecast. Here, we present a landscape scenario visualisation toolkit developed in a Pyrenean valley for supporting professionals in land planning and rural development and raising the general public's awareness of changes in progress. The toolkit was built from a spatially explicit modelling of land-use and land-cover change. For this, we used the results of field assessments of (i) farmers' land-use strategies and (ii) the ecological processes involved in reforestation. The toolkit's users consider 3D visualisation of landscape scenarios very useful, provided the assumptions made are transparent.*

Keywords*: landscape change, prospective study, socio-ecological systems, sustainable development, the Pyrenees*

Introduction

Landscape multifunctionality is regarded as a topical issue of major importance for sustainable rural development, both in research and public policy circles (e.g. Wiggering & Helming, 2003). Landscape encroachment and natural reforestation, which have been widespread in European mountain areas for several decades, raise important concerns for their sustainable development (e.g. Mc Donald et al., 2000; Gibon & Balent, 2005). But the interweaving of the ecological and social processes involved, along with the landscape response time make it difficult to size up their consequences. Nowadays landscape scenarios and their 3D visualisation are regarded as useful media both for raising public awareness of landscape dynamics and for helping professionals to design land management and land planning projects. Prospective landscape studies rely on varied approaches, the most common being an expert group that sketches out 'visions' of the future landscape (e.g. Lange & Bishop, 2001). Here, we present and briefly discuss an alternative approach to the development of landscape scenarios based on a spatially-explicit modelling of change in land-use and ecological processes.

Material and methodology

The prospective study described here was carried out as a case study in a valley in the peripheral area of the Pyrenees National Park (PNP) near Lourdes (France), in the framework of the European VisuLands project (2003-2005). Locally, rural landscapes are undergoing rapid colonisation with Ash tree (*Fraxinus excelsior*), while landscape quality is of very great importance for sustainable development. Indeed, rural development objectives include concomitantly (i) the preservation of biodiversity, which is emphasised in environmental schemes; (ii) other environmental objectives, such as mitigation of fire hazards; (iii) maintenance of the pastoral resources required for sustainable livestock farming, (iv) maintenance of landscape cultural value and visual amenity for supporting both the quality of life of the permanent population and the development of tourism; (v) potential for sylviculture on reforested land, in order to consolidate the local economy. Our study group associated INRA-Toulouse researchers and regional professionals from land-planning and agricultural-development services. After having set up an agreement on agricultural land use and rural urbanisation being the main proximal drivers of landscape change in the local context – we adopted a functional approach to land-use and landscape change to explore perspectives for sustainable land

use and landscape. We built a visualisation toolkit for studying possible change in landscape functions according to 'what if' scenarios regarding socio-economic drivers on the local scale (rural urbanisation) and on the European scale (CAP and rural development policy).

Ecologists in the research team had already assessed the major role of agricultural practice at the field parcel level in the control of ecological processes of ash colonisation in the local context (Julien et al., 2006). We therefore developed landscape scenarios from a spatially-explicit modelling of relationships between agricultural land-use change and ecological processes. The approach developed relies on the fundamentals for the study of socio-ecological systems (Berkes & Folke, 1998). We carried out a spatially-exhaustive study of land-use practices and their changes at individual family farms in four villages (42 farms in all), using a socio-technical survey methodology (Mottet, 2005). Farmland and land management units worked by every farmer were mapped within a GIS (Geographic information system) at the cadaster and agricultural parcel levels, and the individual behaviour of farm families (land-use practice and farm development strategy) was classified in four farm types. We used the landscape of one of the four villages as a concrete basis for developing landscape scenarios. The visualisation was developed from a realistic GIS projection of land-use in 2030 and of land-cover change in that landscape. Family farm land layout, with the parcel as basic unit, was used as the starting point for simulating land-use decision rules according to family demographics and types of land-use strategy. Municipal urbanisation policy was simulated using an urbanisation plan. The group developed three contrasting scenarios from assumed changes in farm-development and land-use decisions at the family-farm level and simulated their results in the GIS. For landscape scenario assessment we built a set of 2D maps, 3D images (developed using a 2003 IGN orthophoto and the LandExplorer® software) and metric indicators. Toolkit evaluation is in progress.

Results and conclusion

The scenarios developed address respectively: (i) impact of 2003 family-farm demographics and land-use strategies ('Trend' scenario); (ii) impact of the 2003 CAP reform (Pillar I); (iii) impact of a significant enlargement of the village urbanisation plan. The simulation results highlight that both CAP reform and village urbanisation are likely to reduce further the quality of most landscape functions by the year 2030 (see poster). Preliminary assessments of the visualisation toolkit by ENSAT students (Ecole Nationale Supérieure d'Agronomie de Toulouse) emphasise (i) the interest of making transparent to users the assumptions made when building the toolkit, to help promote their informed awareness of sustainable development challenges in mountain areas, and (ii) the actual interest of 3D virtual images for appraising predicted change in landscape functions, especially amenity, for which 2D maps and metric indicators appear to be both too abstract and too controversial.

In conclusion we consider that landscape scenario approaches combining GIS simulation and 3D visualisation are useful tools for helping a broad range of players to improve their understanding of the dynamics of mountain socio-ecological systems and for assessing the crucial elements to be reproduced over time to sustain local development, in particular agriculture.

References

Berkes F., Folke C. (eds), 1998. *Linking social and ecological systems. Management practices and social mechanisms for building resilience.* Cambridge University Press. p. 342-362.

Gibon A., Balent G., 2005. Landscapes on the French side of western and central Pyrenees. In: *Landscape ecology and management of Atlantic mountains*. Pinto-Correia T., Bunce R. G. H., Howard D. C. (eds), London, IALE/IALE UK, p. 65-73.

Helming K., Wiggering H. (eds), 2003. *Sustainable development of multifunctional landscapes*, Berlin, Springler

Julien, M. P., Alard, D., & Balent, G. (2005). Patterns of ash (Fraxinus excelsior L.) colonization in mountain grasslands: The importance of management practices. *Plant Ecology*, 183(1), 177–189.

Lange E., Bishop I., 2001. Our visual landscape: analysis, modelling, visualization and protection. *Landscape Urban Plann.* 54 (1-4):1-3.

Mottet A. 2005. Transformations des systèmes d'élevage depuis 1950 et conséquences pour la dynamique des paysages dans les Pyrénées. Thèse INP Toulouse, Sciences agronomiques.