

# Participatory modelling of social and ecological dynamics in the reforestation of mountain landscapes

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**Abstract:** Landscape encroachment and reforestation in mountain areas further to land abandonment and land-use extensification raises topical issues for sustainable development. An acknowledged challenge for the future of local agriculture is to contribute to the maintenance of a variety of landscape functions. In Pyrenean landscapes colonised by ash tree, land managers and policy makers are attempting to assess the relationships between the ecological and social processes involved in landscape dynamics in order to design land-use policies supporting constructive change. Here, we present the “companion modelling” approach we are implementing with local stakeholders in a rural district of the French Pyrenees to build a simulation model supporting the prospective analysis of change. The main conceptual aspects of the spatial multi-agent system developed in the participatory process are illustrated. This study stresses the interests and difficulties of modelling the relationships between social and ecological dynamics on the scale of agricultural landscapes within an interdisciplinary context.

**Keywords:** participatory modelling, spatialized multi-agent system, land-use/land-cover change, agricultural systems, Pyrenees.

## Context and objectives

Landscape encroachment and reforestation have been affecting most European mountain areas for the last few decades. These processes appear as a serious threat for sustainable rural development in such regions: (i) they favour environmental hazards that will be costly for society today and tomorrow such as biodiversity, erosion and fire; (ii) local economies chiefly rely on agriculture, forestry, tourism and service activities, which all greatly benefit the various functions of landscapes shaped by millenary traditional agropastoral systems.

In 2001, the Pyrenees National Park (PNP) wished to contribute to the rural development of its peripheral area where valleys are experiencing spontaneous landscape reforestation with ash tree (*Fraxinus Excelsior*). A participatory research (PR) project was set up, including scientists from our research team in ecology, agricultural sciences, GIS (Geographic Information Systems) and mathematical modelling, and Pyrenean land planners and policy decision-makers from various institutions of Hautes-Pyrénées Département. The overall goal of the project was to support reflection on local development policy orientations suited to constructive landscape change with a view to preserving landscape biodiversity and amenity, livestock farming sustainability and forestry development. The aim of the project was to (i) improve understanding of the relationships between the ecological and social processes involved in the colonisation of landscape by ash tree, and (ii) provide a provisional assessment of their future impact on sustainable development.

## Methodology

The PR project was designed as a two-step process successively addressing (i) the build-up of scientific knowledge on relationships between land-use change and ecological processes in landscape dynamics and (ii) the participatory development of models and tools for a prospective assessment of change in landscape functions according to variations in societal pressure. A joint study was set up with an expert in natural resource management to explore modelling methods and prepare the second step. This led the PR group to revise the project plan and launch the second step while step-one research operations were on-going, in order to enhance interactivity between research and

development partners. Our approach is currently based on the application of the “companion modelling” methodology (ComMod collective, 2005) for developing a spatial multi-agent model (SMAS) for simulating scenarios for change in land-use and landscape.

## Results

The crucial role of past change in agricultural land-use on landscape dynamics in the study area was assessed from a field survey (Mottet et al., 2006). The ecological study of ash tree colonization processes and their consequences on landscape and biodiversity highlighted the major role played by agricultural abandonment and grazing intensity below a given threshold at the parcel level in landscape reforestation (Julien et al., 2006). Agricultural land-use decisions taken by local farmers were considered as key factors and modelled at the individual farm level according to their types of farming style (Gibon et al., 2006). Decision rules in the computer model encompass year-round land management at the parcel level (in two-week steps) through to long-term farmland development (Monteil et al., in press). Change scenarios currently under development address the impact of EU and local development policies (CAP reform; village urbanisation) on farming population demographics, farm viability and farmer land-use strategy. Preliminary results obtained by running the prototype computer tool for the “trend” scenario are presented on the poster

## Conclusions

Sustainable rural development in mountain areas appears closely tied in with the capacity of local agriculture to support a variety of landscape functions over time. Topical concerns of local policy stakeholders are the capacity of family farms to develop innovative and multifunctional land-use systems able to meet sustainable rural development objectives. Stakeholders' requirements challenge current know-how with regard to application of SMAS simulation methodology in companion modelling approaches, it being important to make available an integrated view of the long-term dynamics of family farms in order to meet the objectives of the prospective study. Such an approach appears of special interest for fostering interdisciplinarity in a research group, and supporting local societies in their search for paths towards sustainable development.

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