Modelling Regional Land Change Scenarios to Assess Land Abandonment and Reforestation Dynamics in the Pyrenees (France)

Laure A. VACQUIE1 http://orcid.org/0000-0003-1752-6183; e-mail: laure.vacquie@univ-tlse2.fr
Thomas HOUET1 http://orcid.org/0000-0001-5890-6145; e-mail: thomas.houet@univ-tlse2.fr
Terry L. SOHL2 http://orcid.org/0000-0002-9771-4231; e-mail: sohl@usgs.gov
Ryan REKER3 http://orcid.org/0000-0001-7524-0082; e-mail: rreker@usgs.gov
Kristi L. SAYLER3 http://orcid.org/0000-0003-2514-242X; e-mail: sayler@usgs.gov

1 GEODE Laboratory, Toulouse Jean Jaurès University, 5 allées Antonio Machado, 31000 Toulouse, France
2 U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA
3 ASRC Federal – ImTeq, Contractor to U.S. Geological Survey, Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD 57198, USA


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Abstract: Over the last decades and centuries, European mountain landscapes have experienced substantial transformations. Natural and anthropogenic LULC changes (land use and land cover changes), especially agro-pastoral activities, have directly influenced the spatial organization and composition of European mountain landscapes. For the past sixty years, natural reforestation has been occurring due to a decline in both agricultural production activities and rural population. Stakeholders, to better anticipate future changes, need spatially and temporally explicit models to identify areas at risk of land change and possible abandonment. This paper presents an integrated approach combining forecasting scenarios and a LULC changes simulation model to assess where LULC changes may occur in the Pyrenees Mountains, based on historical LULC trends and a range of future socio-economic drivers. The proposed methodology considers local specificities of the Pyrenean valleys, sub-regional climate and topographical properties, and regional economic policies. Results indicate that some regions are projected to face strong abandonment, regardless of the scenario conditions. Overall, high rates of change are associated with administrative regions where land productivity is highly dependent on socio-economic drivers and climatic and environmental conditions limit intensive (agricultural and/or pastoral) production and profitability. The combination of the results for the four scenarios allows assessments of where encroachment (e.g. colonization by shrublands) and reforestation are the most probable. This assessment intends to provide insight into the potential future development of the Pyrenees to help identify areas that are the most sensitive to change and to guide decision makers to help their management decisions.

Keywords: Pyrenees; Land use change; Land cover change; Land abandonment; Mountain landscape;

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Introduction

Land use and land cover (LULC) change processes are an important part of global environmental changes affecting biodiversity, climate and environmental services (UNEP 2002; Lambin et al. 2006). In Europe, land use is dominated by agriculture and forestry which covers 45% and 36% of the EU-25 states, respectively (FAO 2003), with 34% of terrestrial area used for crop production and 14% for grassland (Verburg et al. 2006a). For centuries, agriculture has shaped a variety of landscapes across Europe as the result of various management strategies and policies, local human decision-making and physical factors.

In the last century, LULC of European mountains has experienced substantial transformations. Supporting competitive agriculture, the Common Agricultural Policy (CAP) has favored intensification and specialization of agriculture production neglecting less favored areas such as mountain lands (ACAP 2011). Moreover, constant modifications of regulations and management policies (e.g. CAP reforms, regulation measures for consumer and environment protection, quotas for food production, incentives for specific land management) have caused rapid changes in agricultural practices influencing land management. Concurrently, the decreasing number of agricultural employees and aging of farmers have led to agropastoral land abandonment and fewer farm holdings (Mottet et al. 2006). The socio-ecological and cultural richness of mountainous regions relies on an anthropogenic heritage, where landscapes were built and maintained by farmers and foresters. Thus, agro-pastoral and logging activities have historically played a key role in shaping and maintaining mountain landscapes (Mitchley 2006). The critical situation affecting agricultural sectors, combined with the recent introduction of competing activities (e.g. tourism, recreation activities), have raised major concerns for politicians, planners and local stakeholders (Busch 2006) dealing with mountain land use.

Over the next decades, many European regions will face major demographic, economic and technological modifications (Renwick et al. 2013). Many studies have proposed that rapid changes are to be expected, and predicted a massive decrease in agricultural areas (Rounsevell et al. 2005; van Meijl et al. 2006) and increase in encroachment (i.e. colonization by shrublands) and spontaneous reforestation on formerly open-lands (Garbarino et al. 2014). Such dynamics have been predominant in the French Pyrenees Mountain over the past 60 years and are expected to intensify at the expense of agro-pastoral lands in the upcoming decades (Métailié and Paegelow 2004; Galop et al. 2013).

However, LULC changes (Land Use and land Cover Change) processes in the Pyrenees are complex, occurring at various temporal and spatial scales, with interlinked environmental, societal and economic impacts (Houet et al. 2012; Grandjean et al. 2013). The extents of these changes are difficult to predict as are their impact on the environment, landscapes and rural societies. The uncertainties in future landscape evolution lie in the fact that they result from driving factors occurring at various spatial scales, affecting current and future landscape organization at different levels of intensity (Turner II et al. 1995).

Scenarios, representing a variety of potential future outcomes, have become popular tools in a number of research projects to inform spatially and temporally explicit models assessing LULC changes. Starting from a known initial situation and exploring the future to illustrate feasible trends of evolution, scenarios can help to understand the complexity of driving factors and distinguish their respective and combined effects on landscape evolution (Verburg et al. 2006b; Houet et al. 2010).

Scenario exercises exist at the global level and focus on the impact of anthropogenic activities on natural resources (IPCC 2000; UNEP 2002; MEA 2005). Using global drivers of change (e.g. demographic changes, economic growth and technological development) they describe alternative futures of the world for impact, adaptation and vulnerability assessments (Alcamo et al. 2006). However, because they are conducted at coarse spatial and temporal scales, they fail to provide insights into the consequences of changes at the landscape level. Concurrently, several