

Vulnerability to land use change of services provided by alpine landscapes

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Context and objectives

Changing land use is one of the major threats to biodiversity in all regions of the world, especially in regions where, over the last few decades, societal changes (globalization) have resulted in rapid changes in agricultural systems. In Europe, mountain regions are recognized as particularly vulnerable in terms of land-use change implications for biodiversity, the maintenance of desirable ecosystem functions and ultimately the sustainability of human systems. This vulnerability results from the combination of unproductive natural conditions and marginal economic conditions which have, since the 1950s, resulted in considerable decreases in rural activities.

Semi-natural grasslands have been most strongly affected, with the abandonment of traditional fertilization and mowing, especially in steeper and less accessible areas, in contrast with the more intensive use of valley bottoms, near villages or summer farms. The sustainable use of subalpine grasslands is associated with high biodiversity, productivity and water regulation in mountain catchments. In addition to production services derived from traditional agriculture (food and fodder), they provide a wide range of ecosystem services including biodiversity conservation, recreation and spiritual value.

The VISTA project has focused on developing a conceptual framework and tools to assess the vulnerability of grassland-dominated landscapes of marginal regions to land-use change. It is proposed that ecosystem services can be quantified and modeled by linking stakeholder valuations of ecosystem services with measurable ecosystem characteristics that relate to plant functional composition. Here we will present some results for the assessment of four land-use change scenarios derived from the IPCC Special Report on Emissions Scenarios (SRES) (IPCC 2001), which were downscaled to the study site of Lautaret, Central French Alps.

Study site and methods

Study site

The study site is the south-facing slope above the village of Villar d'Arène (45.04°N, 6.34°E) which extends from 1650 to 3000 m a.s.l. The climate is sub-alpine, with a strong continental influence due to mountain ranges stopping rain coming with western winds. We studied a mosaic of fields (1900–2100 m) with varying past and present management types and intensities ('land use trajectories' hereafter) that affect fertility (mainly through manure fertilisation) and disturbance regimes (mainly mowing and seasonal grazing). Based on cadastral data and aerial photos from 1810 onwards, we selected ten different historical land use trajectories, with 3 replicate permanent plots each.

Effects of land use on ecosystem properties

Changes of ecosystem properties in response to land use were quantified by analysing simultaneous measurements of soil properties, floristic composition, plant functional traits (e.g. height, leaf specific area, dry matter, carbon and nitrogen contents, seed size) and ecosystem processes such as soil C and N pools, biomass production and litter decomposition rates. Land use effects on these parameters and covariation patterns among them were analysed to seek causal chains and feedbacks.

Land use scenarios

Projections of the four SRES scenarios for the appropriate 10' × 10' grid cell (Rounsevell *et al.* 2005) provided the overall land-use change for the study site. Complete abandonment of agriculture is projected under economic scenarios while under environmental scenarios, subalpine grasslands would still be managed. These overall trends were translated into locally relevant storylines through an iterative process involving both local and regional stakeholders. These

storylines were submitted to local people and tourists for evaluation.

Scenario projections

Ecosystem services of local interest were documented through interviews with local people and tourists. These identified the list of relevant services, along with landscape and vegetation features associated with their delivery. Changes in services provided by subalpine grasslands across the Lautaret landscape were projected for each of the four scenarios. Changes in vegetation functional composition were simulated using the LAMOS platform (Cousins *et al.* 2003). These were then translated into changes in ecosystem services using the VISTA conceptual framework (De Chazal *et al.* submitted).

Results and discussion

Effects of land use on ecosystem properties

We identified two pathways of ecosystem change. On old croplands now found on terraced grasslands, one main driver is traditional manure fertilization. Its cessation leads to a loss in fertility, slowing of biogeochemical cycles and thereby of productivity, and an overall decrease in the diversity of plant life forms with increasing dominance by grasses. A further decrease in management intensity, with conversion from mowing to grazing, exacerbates the same trends, with continued loss in biodiversity and worsening pastoral value (fodder quality and quantity). On permanent grasslands, conversion from mowing to grazing leads to a dramatic decrease in diversity due to the dominance of one tough cespitose grass, *Festuca paniculata*. The leaf properties of this species considerably modify ecosystem processes, especially increasing standing biomass of poor quality and litter accumulation. Connectivity between these first two pathways was assumed as a longer-term successional trend, which we showed, using LAMOS, to depend on recruitment limitations for *Festuca paniculata*.

Land use scenarios

The downscaling of the SRES scenarios to the Lautaret site led to four alternative futures: 1) inter-regional ranching in a context of global exchanges and no subsidies to mountain agriculture, with a prevalence of extensive grazing by long range transhumant herds; 2) summer grazing by short-range transhumant flocks for high value-added

regional products in a context of regionalization but without subsidies to mountain agriculture; 3) disappearance of agriculture and landscape gardening by specialised companies in a globalized, environmentally-oriented world, with a strong policy and subsidies to maintain non-production services; 4) locally managed agriculture within a strong subsidized multi-functional framework and linked to regional economies.

Scenario projections and ecosystem services

Seventy interviews conducted among the broad public with diverse expectations from the landscape showed an overwhelming preference for this last scenario, while the two globalized scenarios (1 and 3) were least preferred. These conclusions were partly consistent with our modeled projections of ecosystem services. Overall, the highest level of ecosystem services was maintained with multi-functional subsidized agriculture in a context of regional demand and governance. Biodiversity as well as aesthetic and cultural values are expected to be favoured under this scenario. Service provision was lower under economic scenarios where no subsidies help maintain grassland uses other than extensive grazing. However, short-range transhumant systems may provide slightly more services due to higher incentives for maintaining soil fertility and biodiversity. Based on service delivery alone, there was little difference in the value of either of the environmentally-driven scenarios. This contrast with the stakeholders' direct evaluation of scenarios highlights the importance of other cultural dimensions (e.g. impact on local communities) in determining the acceptability of alternative scenarios.

References

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