

# Agroforestry landscapes and global change: landscape ecology tools for management and conservation

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**Abstract** Forest ecosystems are impacted by multiple uses under the influence of global drivers, and where landscape ecology tools may substantially facilitate the management and conservation of the agroforestry ecosystems. The use of landscape ecology tools was described in the eight papers of the present special issue, including changes in forested landscapes due to agricultural and forestry activities, landscape changes due to recent intensification of agriculture, and the impacts of agroforestry as compared to natural forest ecosystems. Landscape ecology can improve the economic, environmental and social values of agroforestry, and this knowledge should help

to develop new management alternatives for agroforestry. We believe that these papers will inform management at the landscape level, especially in agroforestry landscapes, offering new tools for management and conservation.

**Keywords** Landscape ecology · Forest management · Agroforestry · Biodiversity conservation · Global changes

## Introduction

Forest ecosystems are both impacted by multiple uses and influenced by global drivers. Wide-ranging effects on the condition of forest ecosystems and their potential services are to be expected based on several factors (Luque et al. 2010). Climate change, urban sprawl, agriculture abandonment, intensification of forestry and agriculture, invasion of exotics, changes in energy generation and use, expanding infrastructure networks, increased habitat destruction and degradation, and other drivers of change are often occurring at increasingly faster rates. They affect, in turn, ecosystem processes (disturbance regimes, productivity, carbon sequestration), structure, and biodiversity in forest ecosystems and landscapes. Rapidly changing landscapes therefore expand the frontiers of both current and future activities of scientists and managers. At a local scale, multi-functionality of forests (wood harvesting, hunting, pasture, wildlife conservation,

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recreational) means that many different and sometimes conflicting goals exist regarding their management purposes. To achieve sustainable forest management, tools for assessing the forest system as a whole are thus needed. Recently, several studies have demonstrated that management of forest ecosystems should not exclusively occur at a single scale (e.g., Spies et al. 2002). On the contrary, the hierarchical and pluralistic framework of landscape ecology (Naveh and Lieberman 1994) may substantially facilitate the management and conservation of the forests (Luque et al. 2010). For this, a landscape perspective is needed whenever landscape spatial patterns can be expected to have a significant effect on forest use efficiency and sustainability (Fahrig 2005).

A conference on these topics was organized by IUFRO Landscape Ecology Working Group (IUFRO 8.01.02) and took place in Bragança (Portugal) during 21–24 September 2010. This meeting recognised the role of landscape ecology in the advancement of science and management, particularly within the context of emerging physical, social, and political drivers of change which influence forest systems and the services they provide (Azevedo et al. 2010). The science of landscape ecology must consider the enormous ecological and economic changes occurring across the globe, primarily driven by the increasing demands of people and their intensified activities. These challenges were the primary reasons to have the theme of this last conference as “Forest Landscapes and Global Change: New Frontiers in Management, Conservation and Restoration”. The conference based their discussion in the analysis of the ongoing changes driven by environmental, technological, political, economic, and social factors, which produce additional challenges for forest landscape ecologists and managers by creating new and multiple contexts for their activities.

This thematic issue of Agroforestry Systems consists of eight papers dealing with studies in agroforestry around the world, which collectively propose using various tools in landscape ecology to help achieve simultaneous improvements in both management and conservation. We highlight the importance of a landscape ecology perspective towards managing forests. Managing forest landscapes is therefore a complex practice of understanding the critical patterns of the landscape and their reciprocal interrelationship through processes. Managing forests at a landscape

level implies focusing on mosaics of patches and long-term changes in these mosaics to integrate ecological values (e.g., biodiversity conservation), yet still conserve the economic and social purposes of the forests (e.g., timber and recreation) (Luque et al. 2010).

### Changes in forested landscapes due to agricultural and forestry activities

The first set of papers (Ortega et al. 2011; Puddu et al. 2011; Ruskule et al. 2012) analysed changes in forested landscapes due to wildfires and different agriculture legacies in Europe. The first paper (Puddu et al. 2011) based its studies in one of the most important biodiversity hotspots of the Mediterranean basin (Sardinia Island), where the landscape has been managed and transformed by humans for at least two millennia. The traditional agroforestry practices decreased over time due to socio-economic reasons, with negative consequences for the mosaic of traditional agricultural areas and semi-natural habitats, as well as for their conservation. However, the paper highlights that the challenges for biodiversity conservation should be focused together with the agricultural policies towards the preservation and improvement of traditional open areas.

The second paper (Ruskule et al. 2012) described agriculture abandonment and the subsequent natural afforestation ongoing in the Latvian rural landscape. This study examines spatial characteristics of afforestation in relation to environmental factors, such as soil properties, size and configuration of fields, previous land use, and the random nature of plant colonization by seeds. The results showed that the spatial patterns of natural afforestation of abandoned agriculture fields can be very diverse and do not necessarily follow the classical secondary succession model. The paper also discussed the ecological, economic, and social consequences of the afforestation process in Latvia.

The third paper (Ortega et al. 2011) described the impact of wildfire regimes on the forest-agriculture interfaces in Spanish rural landscapes. The most vulnerable landscapes to wildfires were those with high road density, a high diversity of uses, and with forest-agriculture mixtures. Ignition frequency was lower in those landscapes where crops and woodlands coexisted as in the dehesas. This paper also proposes tools to forecast the mutual interactions between land-use

pattern changes and wildfire regimes in the Mediterranean agroforestry mosaics.

### **Landscape changes due to recent intensification of agriculture**

The second set of papers (Baran-Zglobicka and Zglobicki 2011; Höbinger et al. 2011) analysed the impact on agroforestry landscapes due to changes in the intensification of agriculture in two contrasted regions: Europe and Central America. The first paper (Baran-Zglobicka and Zglobicki 2011) analysed the impact of Poland's accession to the EU on the traditional agriculture practices, which were characterised by small, family-owned holdings. These changes produced losses of forested areas and increased risk of soil erosion. This paper proposes solutions that preserve the existing land use mosaic (traditional agroforestry) in areas threatened by erosion; these practices should be implemented also within the current system of agricultural uses.

The second paper (Höbinger et al. 2011) described the impact of changing cultivation systems, based on oil palm plantations, over the structural and functional aspects of a tropical agroforestry system in Costa Rica. The heterogeneous rural sections clearly differed from the homogeneous native forests. This paper uses various landscape ecology tools to compare different scenarios from intensive agriculture to a greater conservation strategy. According to the scenario with double the area covered by oil palm plantations, non-forest native species lost large parts of their habitat, while forest species mainly lost corridors.

### **The impact of agroforestry on natural forest ecosystems**

The third set of papers (Delgado and Canters 2011; Gonçalves et al. 2011; Soler Esteban et al. 2011) analysed the impact of different agroforestry proposals on biodiversity and ecosystem integrity among three countries (Philippines, Portugal, and Argentina). The first paper (Gonçalves et al. 2011) described the influence of highly managed agro-silvo-pastoral systems in Portugal on non-flying mammal diversity. Results showed higher richness in silvopastoral systems than in pure forestry or in pure intensive agriculture, and increases in landscape heterogeneity

and riparian corridors were shown to be most beneficial to mammal species richness.

The second paper (Soler Esteban et al. 2011) analysed plant–animal interactions at the landscape level when land use is diversified in Patagonian forests, including large native herbivores, livestock, and timber harvesting. Competition for available resources among the herbivores resulted in an alternation of feeding sites, which varied throughout the year. Management plans in southern Patagonia (livestock, silvo-pastoral uses, and timber harvesting) do not consider the direct or indirect consequences on herbivores interactions. Thus, this paper discusses different management proposals and their potential benefits.

The third paper (Delgado and Canters 2011) analysed the impacts of agroforestry versus traditional mono-cropping systems on the spatial patterns of soil erosion risk in the Philippines, after considering the influences of rainfall, soil erodibility, vegetation cover, and landscape structure. Models proposed in the paper formulate site-specific agroforestry recommendations for future landscape amelioration plans, and discussed their impacts on various proposals of future land use.

### **Conclusions**

Agricultural and forestry (new forest and agriculture management modalities) change with time following social, economic, and conservation purposes, and greatly varied along the World. Recently, intensive agricultural and forestry alternatives have produced large impacts on the biodiversity and ecosystem integrity of managed landscapes. It is critical to change policies and practices so that new management alternatives can be adopted which will substantially improve both the multiple values of forests and the social expectations for environmental benefits. Within these practices, during the last years, agroforestry become a preferred practice over intensive agriculture and forestry, and a return to traditional agricultural practices was promoted in several areas to improve local economies with greater social acceptance.

Landscape ecology has developed rapidly during the last decades due to their effective application as decision tools in a wide range of ecological conditions. The use of landscape ecology tools was described by the eight papers of the present special issue, including

changes in forested landscapes due to agricultural and forestry activities, landscape changes due to recent intensification of agriculture, and the impact of agroforestry over the natural forest ecosystems. As were evident from these papers, landscape ecology can improve the economic, environmental, and social values of agroforestry, and this knowledge should help to propose new management alternatives for agroforestry around the World. This Special Issue should be of widespread interest to landscape ecology scientists, policy makers, and forest managers worldwide. We believe that these papers will inform management at the landscape level, especially in agroforestry landscapes, offering new tools for management and conservation.

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## References

- Azevedo JC, Feliciano M, Castro J, Pinto MA (2010) Forest landscapes and global change: new frontiers in management, conservation and restoration. IUFRO LE WG. Instituto Politécnico de Bragança, Portugal, p 741
- Baran-Zgłobicka B, Zgłobicki W (2011) Mosaic landscapes of SE Poland: Should we preserve them? *Agrofor Syst*. doi:10.1007/s10457-011-9436-x
- Delgado ME, Canters F (2011) Modeling the impacts of agroforestry systems on the spatial patterns of soil erosion risk in three catchments of Claveria, the Philippines. *Agrofor Syst*. doi:10.1007/s10457-011-9442-z
- Fahrig L (2005) When is a landscape perspective important? In: Wiens J, Moss M (eds) *Issues and perspectives in landscape ecology*. Cambridge University Press, Cambridge, pp 3–10
- Gonçalves P, Alcobia S, Simões L, Santos-Reis M (2011) Effects of management options on mammal richness in a Mediterranean agro-silvo-pastoral system. *Agrofor Syst*. doi:10.1007/s10457-011-9439-7
- Höbinger T, Schindler S, Seaman BS, Wrba T, Weissenhofer A (2011) Impact of oil palm plantations on the structure of the agroforestry mosaic of La Gamba, southern Costa Rica: potential implications for biodiversity. *Agrofor Syst*. doi:10.1007/s10457-011-9425-0
- Luque S, Martínez Pastur G, Echeverría C, Pacha MJ (2010) Overview of biodiversity loss in South America: a landscape perspective for sustainable forest management and conservation in temperate forests. In: Li C, Laforteza R, Chen J (eds) *Landscape ecology and forest management: challenges and solutions in a changing globe*, Chapter 15. HEP-Springer, Berlin, pp 352–379
- Naveh Z, Lieberman AS (1994) *Landscape ecology: theory and application*. Springer, New York
- Ortega M, Saura S, González-Avila S, Gómez-Sanz V, Elena-Rosselló R (2011) Landscape vulnerability to wildfires at the forest-agriculture interface: half-century patterns in Spain assessed through the SISPARES monitoring framework. *Agrofor Syst*. doi:10.1007/s10457-011-9423-2
- Puddu G, Falcucci A, Maiorano L (2011) Forest changes over a century in Sardinia: implications for conservation in a Mediterranean hotspot. *Agrofor Syst*. doi:10.1007/s10457-011-9443-y
- Ruskule A, Nikodemus O, Kasparinska Z, Kasparinskis R, Brūmelis G (2012) Patterns of afforestation on abandoned agriculture land in Latvia. *Agrofor Syst*. doi:10.1007/s10457-012-9495-7
- Soler Esteban R, Martínez Pastur G, Lencinas MV, Borrelli L (2011) Differential forage use between large native and domestic herbivores in Southern Patagonian *Nothofagus* forests. *Agrofor Syst*. doi:10.1007/s10457-011-9430-3
- Spies TA, Reeves GH, Burnett KM, McComb WC, Johnson KN, Grant, G, Ohmann JL, Garman SL, Bettinger P (2002) Assessing the ecological consequences of forest policies in a multi-ownership province in Oregon. In: Liu J, Taylor WW (eds) *Integrating landscape ecology into natural resources management*. Cambridge University Press, Cambridge, MA, pp 179–207