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Restoring forest landscapes for nature conservation and human well-being: advanced spatial decision support tools

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Abstract

Forest management involves dealing with conflicts between the protection of nature and the use of natural resources. Bad management practices have led to significant forest degradation worldwide. It is estimated that globally about 13 million hectares of forest are lost every year, leading to a massive loss of biodiversity and other forest-related ecosystem services, such as soil stabilisation and watershed protection. This is particularly dangerous in poor regions, where livelihoods are strongly based on locally available natural resources. In 2000, IUCN and WWF have introduced a new restoration approach called Forest Landscape Restoration (FLR) that aims to regain ecological integrity and enhance human well-being in deforested or degraded forest landscapes. FLR goes well beyond planting trees: it is about re-designing the landscape mosaic in a way that both nature and people are benefited. To this purpose, different actions should be taken at different locations across the landscape. From a planning perspective, this calls for proper methods and tools that help identifying where to act and what to do. The present research aimed to contribute to this problem by developing and testing spatial decision tools to support the design of landscape mosaics. More specifically, the study had three main objectives.

The first objective was the identification of criteria and indicators (C&I) for the prioritisation of forest restoration interventions. Knowing which areas are ecologically more suitable to host a restoration intervention is a prerequisite of any FLR-based plan. There can be areas where restoration is more urgent, areas where it is more likely to succeed and areas where it is expected to bring the highest ecological benefits. Unfortunately, a widely accepted framework for the prioritisation of forest restoration areas is lacking. This problem was addressed by conducting an expert survey to define a set of readily applicable C&I. This was based on a two round Delphi involving 37 people, aimed at defining the key criteria and a broad set of indicators,

and a final face-to-face meeting with a smaller group of experts, aimed at refining the list of indicators and making them operational. Finally, 8 criteria and 22 indicators were obtained, whose main advantage is their spatial character, which makes them suitable for spatial analysis and mapping.
The second objective was the development of a GIS-based multicriteria methodology to identify reforestation priorities, to design a number of landscape-scale reforestation options and to assess them according to their socio-ecological performance. The prioritisation was based on two main non-compensatory factors: the need for biodiversity conservation and the ecological feasibility of reforestation. Suitability maps were generated for both factors through spatial multicriteria analysis and threshold pairs used to extract priority areas. The minimum suitability levels and the total area to be reforested were used as input parameters to generate a finite number of resulting reforestation options. These were assessed for their ability to conserve biodiversity and improve living conditions of local communities by introducing additional ecological and socioeconomic indicators. The methodology was tested in an area of Chiapas (Mexico), where forest degradation is significant and poverty widespread. The tool proved to be effective in shaping compact reforestation areas and easy to use. Nevertheless, it does not allow the user to a priori define targets on both conservation and livelihood standards. Also, the forest-poverty link was little explored and the issue of access to forest resources totally neglected.
This leads to the third objective of the thesis: the definition of a spatial optimization model to re-design the landscape mosaic through reforestation in a way that nature protection is enhanced, the provision of ecosystem services is ensured and livelihoods are sustained. Either one of two possible uses was assigned to forest: protection, if forest is primarily devoted to biodiversity conservation, and harvest, if forest is available for the collection of timber. The model, which is an Integer Programming-based one, identifies land to be reforested and assigns this to the two uses such that all environmental classes over the landscape are adequately covered by protected forest, each village has a sufficient amount of harvestable forest at short distance and a given amount of erosion-prone land is reforested. The model also accounts for opportunity costs, by limiting the amount of economically strategic lands (e.g. agriculture) to be converted to forest. The model is the first of its kind to account for local people’s livelihoods by ensuring the accessibility to natural resources. The application to a case study in central Chiapas (Mexico) showed that increasing the demand for the provision of an ecosystem service does not significantly affect the ecological benefits up to a given threshold. Although some assumptions had to be made, the model provided a demonstration that the principles of the FLR can be put in practice and ad hoc planning tools can be designed to support decision-makers in their activity. Most of all, the model provided a solution to the problem of conserving

biodiversity in poor regions where maintaining the access to local natural resources is vital to people.

Redesigning forest landscapes for nature conservation and livelihood improvement is a difficult task. But one of dramatic importance as well. This study provided tools that can be of practical help to decision-makers and planners willing to undertake the challenge. Nevertheless, the problem is complex and intrinsically affected by uncertainty: further research effort is needed to test indicators, include the time dimension into the model and involve stakeholders in the decision process.