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Community mapping of ecosystem services in tropical rainforest of Ecuador

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ABSTRACT

Tropical forests provide a wide range of ecosystem services (ES), and their continuous supply depends on efficient and effective management against deforestation and forest degradation. In Ecuador, indigenous communities are highly dependent on the forest and therefore on forest ES. However, there is a lack of knowledge about their demands concerning ES. In order to better understand how local and indigenous people use the forest and to facilitate its management, this study completed a spatially explicit assessment of ES using participatory mapping in the Sumaco Biosphere Reserve (Napo province, Central-Northern Ecuador). The Biosphere Reserve is suitable as a case study because it is a protected area with high land-use and population pressure and therefore requires the development and monitoring of management plans.

First, semi-structured interviews were conducted with experts (n = 15) in order to identify the most important ES used by the communities in the study area. In a second step, members (n = 208) of 24 communities were asked to indicate on a 3-D map where they utilize the different ES (food, wood, water, tourism, hunting). The highlighted localities were digitized and then analyzed with statistical and GIS techniques. The results showed that the ES locations were not randomly distributed, but were most abundant four kilometers or less from roads. Spatial pattern analysis identified hotspots of ES provision, and the evaluation according to administrative units allowed us to identify five municipalities where demand for all assessed ES was high. In conclusion, the combination of participatory mapping of ES and GIS-based analysis can facilitate the identification of priority protection areas, provide guidance for developing specific forest management strategies, and also support monitoring systems to detect forest degradation.

1. Introduction

It is well known that tropical forests provide ecosystem services (ES) (Naidoo et al., 2008) which derive, directly or indirectly, from ecosystem functions (Costanza et al., 1997). According to the Millennium Ecosystem Assessment report (MA, 2003), the value of ES can be divided into use values and non-use values. The use values are subdivided into direct use values, indirect use values and option values. Whereas direct use values are more easily recognized by local people, other value types are less well understood by non-experts (e.g. Entenmann and Schmitt, 2013). Forest disturbances such as deforestation and degradation cause changes in the provision of ES (Foley et al., 2007). In this context, efficient and sustainable management of the forest to secure ES provision over time is necessary. There is evidence that rural communities depend heavily on the provision of ES (Butler and Oluoch-Kosura, 2006) which often include food, medicines, locally traded goods, and other services (Blaser et al., 2011). This dependence is rarely measured and therefore often ignored in national statistics, generating inappropriate management strategies that do not take into account the role of the environment in poverty reduction (MA, 2005). Lately, there has been growing interest in including ES concepts in landscape planning and forest management (Chan et al., 2011; de Groot et al., 2010; Nelson et al., 2009). Spatially explicit data on ES help to outline the distribution of ES and identify crucial

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areas (Alessa et al., 2008; Plieninger et al., 2013). They also assist in ascertaining the contribution of ES to human wellbeing (de Groot et al., 2010) by quantifying their supply and demand (Crossman et al., 2013; de Groot et al., 2010). Moreover, spatial data allow the identification of relationships between ES and landscape characteristics (e.g. land use/cover) (de Groot et al., 2010) as well as administrative units (Syrbe and Walz, 2012).

Spatially explicit data on ES generated by participatory mapping captures local knowledge on ES and integrates the perspectives and needs of local communities into scientific research programs and the development of management strategies (Brown, 2004; Bryan et al., 2010; Fagerholm et al., 2012; Klain and Chan, 2012; Ramirez-Gomez et al., 2015). In most cases, maps derived from participatory studies are of higher quality and are more relevant than those produced by authorities without local knowledge (Goodchild and Li, 2012).

In Ecuador, there are still about six million hectares of Amazon tropical rainforest (Pezo, 2015), which contain one of the highest levels of species richness on earth (Myers, 1990) and provide many ES to local communities (Izurieta et al., 2014). Most studies or initiatives have focused either on biophysical assessment or economic valuation of ES (e.g. Bendix et al., 2013; de Koning et al., 2011; Greiber and Schiele, 2011) and there is little information available on how the local communities perceive ES (Bendix et al., 2013; Bremer et al., 2014). Furthermore, despite a lot of expert-based information on ES in Ecuador, there is a lack of knowledge of the spatial distribution of ES from the perspective of local communities. Mapping ES in Ecuador could inform forest management in protected areas within the framework of Reducing emissions from deforestation and degradation in developing countries "plus" (REDD+) initiatives and other national forest management schemes (MAE, 2011). Additionally, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) has strongly emphasized the need to better integrate local and indigenous knowledge into biodiversity and ES studies (Díaz et al., 2015).

In this context, the overall goal of this study was to conduct a spatially explicit assessment of ES using participatory mapping in order to better understand the demand for ES from local communities and to facilitate ES management. The study was carried out in the Sumaco Biosphere Reserve (SBR) in Ecuador, which is characterized by high land-use and population pressure on the remaining tropical forest areas. The concept of a service provisioning area is used, referring to the source of ES (locations) (Syrbe and Walz, 2012). In particular, the study aimed to:

- identify the forest ES that are most important to the communities;
- examine the spatial distribution of selected ES based on participatory mapping; and
- evaluate the spatial arrangement of ES according to hotspots and administrative units using GIS techniques.

The results are expected to demonstrate that local community knowledge provides important information on ES that can be used as a basis for local authorities to develop forest management plans and land use planning. Furthermore, we will provide recommendations on how to use the tool of participatory mapping in other areas of Ecuador.

2. Study area

2.1. Geographic location

The study area is located in the Sumaco Biosphere Reserve (SBR), province of Napo in central-northern Ecuador (Fig. 1). The SBR consists of: (a) a core zone which comprises the National Park Sumaco-Napo-Galeras, (b) a buffer zone, and (c) a transition zone. It aims to improve quality of life for local people while maintaining the conservation of natural resources (Valarezo et al., 2002).

The core zone was designated for biodiversity and genetic resources protection, water production, and landscapes conservation. The activities allowed are research, environmental education and controlled ecotourism. The buffer zone includes protected forest and State Forest Estate. The objectives of this area are to reduce pressure on the core zone and to have places to develop ecological practices; the sustainable extraction of timber and non-timber forest products, agroforestry, research, environmental education and ecotourism are allowed. In the transition zone, the sustainable use of natural resources is promoted for the benefit of the reserve's inhabitants and users (e.g. small hydropower and water supply development, agro-productive activities, tourism and research are allowed) (MAE, 2010; Valarezo et al., 2002).

2.2. Land tenure in sumaco biosphere reserve

Indigenous communities gained legal ownership of the land in their ancestral territories in the Ecuadorian Constitution of 1998. The study area has 24 communities; each one has an administrative unit with an average area of 2295 ha. Seven communities have additional territory (called "rural territory", Ortiz et al., 2012) distributed across three administrative units that are shared by two or three communities; and one administrative unit corresponds to National Park Sumaco. In total, 28 administrative units are part of the study area.

The territory of the indigenous communities who live within the SBR is located in the buffer and transition zones and the communities have the legal title through regular land tenure laws. Communal and individual titles may exist in the area. Yet, further clarification of land tenure in SBR for both communal and individual titles is required (GAD-PHS, 2014; Valarezo et al., 2002). Although communities may hold titles to communal land, these lands are not necessarily used collectively. Every family has a "farm" where they harvest wood to support their households (Romero et al., 2011). Communal forest land use is organized internally within the local community (USAID, 2008). Since 2010, a community may confer at its general assembly the ability to request and receive a logging license to a community member who uses the land.

2.3. Description of population in the study area

The study area comprises the Hatun Sumaco parish[1] and the Kichwa[2] People of the Rukullakta (KPR)[3]. Each community that is part of the Hatun Sumaco and KPR is represented by a council consisting of a president, vice president, treasurer, secretary and ordinary members. Additionally, Hatun Sumaco has a parish government consisting of five members elected by popular vote, whereas KPR has a council with a similar structure at the community level, which represents the entire organization. The main economic activities in the study area are agriculture, fishing, hunting, gathering of non-timber products, and logging (Lehmann et al., 2010). Given that the livestock production model has not improved the economic situation in the area and has had very serious impacts on the ecosystem, ecotourism has recently become a strategy for economic development (Valarezo et al., 2002).

KPR has 17 Kichwa communities with 5266 inhabitants and an area of about 42,000 ha (Ortiz et al., 2012). In areas where most

[1] Parish is a political division by territory of low rank (third level).
[2] Kichwa is a Quechuan language which includes all strands of Quechua in Ecuador and Colombia.
[3] KPR is a social and private organization founded for indigenous communities.