Land Use Policy 47 (2015) 1–11

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Weakening the Brazilian legislation for forest conservation has severe impacts for ecosystem services in the Atlantic Southern Forest

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ARTICLE INFO

Article history:
Received 12 May 2014
Received in revised form 23 February 2015
Accepted 14 March 2015

Keywords:
Atlantic forest
Ecosystem services
Modeling
Environmental policies

ABSTRACT

The Atlantic Forest is a global hotspot of biodiversity that may be on the verge of ecological collapse. Current changes in forest legislation have increased the debate concerning policy impacts on land-use and the consequences for biodiversity conservation and ecosystem services provision. This paper evaluates the impact of three environmental policy options (National Forest Act from 1965-NFA65, Business as Usual-BAU, National Forest Act from 2012-NFA12) on land-use patterns and ecosystem services in the southern Atlantic Forest. InVEST (the Integrated Valuation of Environmental Services and Tradeoffs tool) was used to model ecosystem services. Synergies and tradeoffs between commodities, erosion regulation, carbon storage and habitat for biodiversity were assessed with the Spearman Correlation Test. The NFA65 produced the largest gains for forest ecosystem services, while BAU favored commodities expansion. The NFA12 approaches the baseline, contributing less to the provision of ecosystem services and biodiversity conservation.

Introduction

The rapid degradation of forest ecosystems compromises the long term provision of ecosystem services (MEA, 2005). Agriculture is a major threat to Brazil's forests but also a major driver of economic growth, which takes precedence over environmental protection and ecosystem services in national policies (Martinelli and Filoso, 2009; Martinelli et al., 2010a; Tollefson, 2010; Sparovek et al., 2011). Conservation of the Atlantic Forest – the most threatened ecosystem in Brazil – is regulated by the National Forest Act (NFA), originally promulgated in 1965, and the Atlantic Forest Law (Brasil, 2006). However, poor enforcement of both policies has resulted in the continued loss of Atlantic Forest remnants (INPE and SOS Mata Atlântica, 2011), threatening the ecosystem's resilience (Lees and Peres, 2008; Galetti et al., 2010; Metzger et al., 2010).

The Atlantic Forest Law regulates the conservation of the Atlantic Forest biome, while the NFA regulates conservation of natural ecosystems across all Brazilian states, in public and private properties. Unfortunately, in 2012 the National Congress voted to weaken the NFA from 1965 (NFA65). The debate under the NFA65 reform resulted in an intense mobilization by civil society and the Brazilian scientific community. Different sectors worked on technical reports emphasizing the negative implications of the NFA65 change when faced with the demands from the agribusiness sector (Instituto Socioambiental, 2012; Via Campesina Brasil, 2011; ABEMA, 2012; ANA, 2012). There was also an effort by the Brazilian scientific community to warn of the impacts that the NFA65 change could have on the natural ecosystems resilience and provision of ecosystem services (Develey and Pongiluppi, 2010; Galetti et al., 2010; Metzger et al., 2010; Nazareno et al., 2011; SBPC, 2011; Sparovek et al., 2011; Ferreira et al., 2012); however, it had a low impact on the policy makers (Ferreira et al., 2012).

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http://dx.doi.org/10.1016/j.landusepol.2015.03.011
0264-8377/

The final version of the reformed NFA approved by the Congress was subjected to veto and modifications by President Rousseff in May 2012 (Brasil, 2012a,b), though it still resulted in fewer obstacles to increased agricultural expansion into forests and other natural ecosystems. The impacts of policy changes have been modeled extensively for the Amazon (Nepstad et al., 2008; Soares-Filho et al., 2006), but recently studies simulating the impacts of policy changes on the Atlantic Forest have increased in number (Teixeira et al., 2009; Ditt et al., 2010; Garcia et al., 2013).

While there was a weakening of the NFA65, Brazilian policy makers have also been developing incentive-based policies to reward landowners for the ecosystem services generated by forest conservation, complementing legal mandates affecting land-use in the Atlantic Forest. One approach directed towards landowners is payments for ecosystem services (PES). Approximately 80 such programs targeting the Atlantic Forest reward forest restoration and biodiversity conservation (Guedes and Seehusen, 2011; Pagiola et al., 2012). One of the main challenges for incentive based policies is to understand the tradeoffs expected at local, regional and global scales between ecosystem services and financial returns across different ecosystems under different policy scenarios (Goldstein et al., 2012).

The goal of this article is to use spatially-explicit models of land-use change and ecosystem services to improve the understanding of the tradeoffs and their mutual interactions, and based on this to discuss the implications for the policies at stake (Chan et al., 2006; Nelson et al., 2009; Goldstein et al., 2012; Su and Fu, 2013). Specifically, the spatially-explicit InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) modeling tool (Tallis et al., 2011; Sharp et al., 2014) is applied to evaluate the impact on ecosystem services caused by changes in land-use and land-cover patterns associated with three different policy options for the southern Atlantic Forest. The results inform a discussion on policy options that can balance the apparently conflicting goals of economic growth and conservation of ecosystem services and the expected impacts of the NFA65 reform on ecosystem services provision. A case study approach was adopted. The Chapecó Ecological Corridor was established in 2010 in Santa Catarina State, southern Brazil, to protect relevant biodiversity areas. As highlighted by the Chapecó Ecological Corridor Management Plan, the analysis focuses on provisioning services (i.e. commodities in the region with the greatest market potential), carbon storage, erosion regulation, as well as habitat for biodiversity (FATMA, 2009).

Methods and materials

Study site

The Atlantic Forest is mainly distributed along the Brazilian coast and is a global biodiversity hotspot. Originally it covered 1,315 million hectares, however policies favoring agricultural expansion and urbanization since colonial times have reduced forest cover by 85% from its original extent (Ribeiro et al., 2009). Actually the Southern Brazilian states together contain 34% of the forest remnants (INPE and SOS Mata Atlântica, 2014).

In spite of the high level of fragmentation, the remaining forest exhibits high diversity and endemism, including more than 20,000 species of plants, 261 of mammals, 688 of birds, 280 of amphibians and many more not yet described by science (Myers et al., 2000). Within Santa Catarina State, the Atlantic Forest covers an estimated 27% of its original distribution, and remaining forest structure is considered highly disturbed and degraded by logging, road openings, burning and extensive cattle farming (Vibrans et al., 2013). Enforcement of the laws regulating Atlantic Forest management has increased since 2006, but has failed to halt illegal deforestation (Alarcon et al., 2010; Siminski and Fantini, 2010).

Table 1
Permanent preservation areas (PPA) width according to the National Forest Act from 1965. The widths established independently to properties' size.

Rivers' width (m)	PPA's width (m)
up to 10	30
10–50	50
50–200	100
200–600	200
>600	500

The Chapecó Ecological Corridor (CEC) covers nearly 500 thousand hectares in the west of Santa Catarina state, southern Brazil (Fig. 1). The landscape is characterized by continuous remnants of Araucaria Forest and mixed Deciduous Forest in the lower areas, these two forest types have been reduced to 22% and 16%, respectively, of their original cover (Vibrans et al., 2013). At higher altitudes (1000–1350 m) native grasslands are interspersed with patches of Araucaria Forest. Agriculture and pasture account for 50% of total land-use. Corn, soya and wheat are cultivated in the plain areas, while pasture is mainly located on the steeper slopes. The region supports the highest density of pork production in Latin America. The Chapecó water-basin also provides water for nearly 800 thousand inhabitants (FATMA, 2009).

Policy options mapping

A land-use/land-cover (LULC) map based on SPOT 4 images from 2005 with 10 m resolution provided baseline data for mapping each policy option (FATMA, 2009). Three main policies were selected as follows (see electronic supplementary material Fig. S1 for a magnification of the distribution of land cover for the policy options in Fig. 2):

Policy Option 1: Enforcement of the National Forest Act of 1965. The NFA65 mandated conservation and restoration of native forest cover in ecologically sensitive Permanent Preservation Areas (PPA), which include hilltops, slopes over 45%, buffer forest along rivers and around springs (Table 1). The PPAs were mapped using ArcGis 10 and converted in the model to native ecosystems, according to the criteria established by the National Council on Environment CONAMA Resolution no. 303/2002 (CONAMA, 2002).

Although the NFA65 is forgone, its modeling represents an attempt to provide scientific basis to discuss its reinstatement. Moreover, the NFA65 is a policy closer to an ideal scenario for biodiversity conservation and ecosystem services provision (Teixeira et al., 2009; Metzger, 2010; Metzger et al., 2010; Sparovek et al., 2011) and therefore could improve comparison with the other policy options.

- Policy Option 2: Business as usual (BAU). The BAU model assumes a continuation of the negligible enforcement of existing policies and continued deforestation considering the decades following the NFA65 promulgation (Cardoso Da Silva and Tabarelli, 2000; INPE and SOS Mata Atlântica, 2003, 2009, 2011; Ribeiro et al., 2009). Specifically, it assumes that the average deforestation rate from the period 2000–2012 for the Atlantic Forest in Santa Catarina (INPE and SOS Mata Atlântica, 2011) will remain constant for 45 years (2005 to 2050). The total area to be deforested was distributed in the landscape according to the proportion of forested area in each municipality. In this sense, municipalities with larger forested areas had the largest proportion of deforestation. Forests were substituted by the main agricultural activities developed in the region: grains, pasture and pine monoculture. These three land-use types constitute important commodities within Brazil's boundaries as well as internationally as they are part of the