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Assessing the effectiveness of a land zoning policy in the Dry Chaco. The Case of Santiago del Estero, Argentina

Gonzalo Hernán Camba Sans[a,b,*], Sebastián Aguiar[a,c], María Vallejos[a,b], José María Paruelo[a,b]

[a] Laboratorio de Análisis Regional y Teledetección, Facultad de Agronomía- Universidad de Buenos Aires- IFEVA- CONICET, Av. San Martín 4453, C1417DSE, Buenos Aires, Argentina

[b] Universidad de Buenos Aires, Facultad de Agronomía, Departamento de Métodos Cuantitativos y Sistemas de Información, Av. San Martín 4453, C1417DSE, Buenos Aires, Argentina

[c] Universidad de Buenos Aires, Facultad de Agronomía, Cátedra de Ecología, IFEVA- CONICET, Av. San Martín 4453, C1417DSE, Buenos Aires, Argentina

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ABSTRACT

Land use zoning has been proposed as an instrument to steer sustainable land use and reduce deforestation. Its effectiveness is a growing concern among researchers and decision makers. Nowadays, the dry forests of the Argentine Chaco are a global hotspot of deforestation, where a zoning policy has been established through the enactment of a National Forest Law. The law imposed on the provinces the obligation to define land use zones in their native forests. Ten years after the enforcement of the National Forest Law, we assessed the effectiveness of the zoning policy of Santiago del Estero, one of Argentina's provinces with higher deforestation rates. For this, we combined the provincial forest zoning with the extent of forest cover and a plot level land transformation geodatabase. The deforested area halved during the five-year period after the enactment of the law, decreasing from 910 10^3 ha in 2003–2008 (i.e. before the law) to 450 10^3 ha in 2009–2014. Most of this forest cover loss (257 10^3 ha) occurred in areas classified under categories where deforestation was forbidden. After the enactment of the Law, annual deforestation rates decreased mostly in areas that allowed deforestation, slightly decreased in areas where deforestation was forbidden and increased in areas where a certain level of deforestation was allowed, although above that level. Despite the reductions in deforestation rates, our results suggest that the zoning policy in Santiago del Estero was not effective enough, since deforestation occurred in forbidden areas and generally surpassed the level of deforestation permitted. Alternative coercive mechanisms (e.g. more severe penalties for offenders) and greater efforts to detect illegal clearings are needed to enhance the effectiveness of the Forest Law.

1. Introduction

Eradicating extreme hunger and poverty, and achieving environmental sustainability (e.g. reducing biodiversity loss) are some of the Sustainable Development Goals (United Nations, 2015). Under the current scenario of rapid human population increase and changing diets, some researchers argue that food production must increase around 70–100% by 2050 (Godfray et al., 2010) which could imply that agricultural areas should double (Kastner et al., 2012). Land use change is an important dimension of global environmental change since it has significant impacts on other dimensions such as biodiversity loss (Newbold et al., 2015) and climate change (Houghton et al., 2012). In the 1980s and 1990s, agriculture globally expanded into tropical forests, which became the primary source of new agricultural land (Gibbs et al., 2010). More recently, the expansion partially shifted to subtropical dry forests, such as the Cerrado and Chaco forests of South America (Graesser et al., 2015; Janišová et al., 2016). In this context, one of the most important challenges is to design and implement an efficient allocation of land uses in order to ensure nature conservation and food production (Rudel and Meyfroidt, 2014).

A wide range of instruments have been developed to steer sustainable land use and to reduce deforestation. They range from command and control strategies such as land use zoning and protected areas expansion, to market based instruments such as Environmental Services Payments (Wunder et al., 2008) and product certification (Lambin et al., 2014). Land use zoning consists of delimiting areas for different land uses, for example, by implementing restrictions to natural ecosystem conversion (Lambin et al., 2014). Generally, land use zoning

* Corresponding author at: Laboratorio de Análisis Regional y Teledetección, Facultad de Agronomía- Universidad de Buenos Aires- IFEVA- CONICET, Av. San Martín 4453, C1417DSE, Buenos Aires, Argentina.

E-mail addresses: camba@agro.uba.ar (G.H. Camba Sans), aguiarse@agro.uba.ar (S. Aguiar), vallejos@agro.uba.ar (M. Vallejos), paruelo@agro.uba.ar (J.M. Paruelo).

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processes for reducing deforestation are implemented through the enactment of regulatory laws that divide the territory into strictly protected areas and limited forest conversion areas for sustainable uses (García Collazo et al., 2013; Nolte et al., 2013). To address their goals, these policies execute enforcement processes that include sanctions (fines and embargoes) (Börner et al., 2015), or compensation mechanisms like subsidies or tax discounts for conservation or the creation of markets for sustainable forest activities (Angelsen, 2010).

The effectiveness of land use policies for reducing deforestation is a growing concern among researchers, NGOs and the civil society. The main challenge is to find evidence of which strategies are more effective in reducing deforestation and how they should be implemented to achieve their goals (Lambin et al., 2014; Nolte et al., 2017b). Recently, studies have begun to address this issue in different parts of the world. For example, forest protection laws have contributed to increase the forest area in China, India and the Republic of Korea (Liu et al., 2017). Also, several reports have shown that land use regulation laws were effective in reducing deforestation in the Brazilian Amazon (Macedo et al., 2012; Nolte et al., 2013; Nepstad et al., 2014; Börner et al., 2015). This decline was due to different instruments, principally coercive legal mechanisms (fines and embargoes) but also the creation of strictly protected areas in agricultural frontiers, and the access restriction to markets for products derived from illegal deforestation (Nepstad et al., 2014). Outside tropical forests, the effectiveness of land use regulation laws in South America is understudied.

The dry forests of Chaco are one of the global hotspots of deforestation (Hansen et al., 2013). Although several laws regulate deforestation in the South American Chaco (Ley Forestal N°1700, 1996, Ley Nacional, 2007, Argentina), their effectiveness has scarcely been assessed. In the Argentine Dry Chaco (hereafter ADC) the agricultural expansion process was driven not only by the global demand for commodities produced in the region but also by other complementary factors: an increase in rainfall, a shift in the exchange rate of the national currency (high Peso- Dollar ratio), and the adoption of technology and management practices, such as the use of GMOs and nontillage (Grau et al., 2005). Until 2012, the ADC had lost more than 10.5 million ha of natural vegetation, which represents 22% of its natural ecosystems (dry forests, scrublands and grasslands), having most of this transformation occurred in the last decade (Piquer-Rodríguez et al., 2015; Vallejos et al., 2015). The provinces of Santiago del Estero, Salta and Chaco absorbed 23, 12 and 10% of the transformed area, respectively (Vallejos et al., 2015). The replacement of natural ecosystems by annual crops and sown pastures also fragmented the remnant forests (Piquer-Rodríguez et al., 2015). The expansion occurred in areas with better soils and near towns (Gasparri et al., 2015) and also spread from already cleared areas through a contagion process (Volante et al., 2016). Based on observations in the Northern Hemisphere, some researchers suggested that the expansion of high yield industrial agriculture could spare land for nature (i.e. “Forest Transition hypothesis”, Grau et al., 2008). However, Volante and Paruelo (2015) found no evidence of “Forest Transition” in the ADC.

The conversion of natural vegetation to annual crops and pastures in the ADC had several socio-ecological consequences. This conversion has been associated with higher inter-annual variability of carbon gains (Volante et al., 2012). Also, ADC deforestation is an important source of CO_2 emissions (Gasparri et al., 2008) and energy released by fire (Verón et al., 2012). Forest replacement by croplands leads to an increase in water table levels due to the lower evapotranspiration of crops with respect to forests. The rise of groundwater levels increases the risk of soil salinization with possible impacts on agricultural production (Jobbágy et al., 2008; Amdan et al., 2013; Giménez et al., 2015). Furthermore, land use change in the ADC has been related to a loss of avian diversity (Macchi et al., 2013; Mastrangelo and Gavin, 2014), top predators such as the Jaguar (*Panthera Onca*) and Puma (*Felix concolor*) (Quiroga et al., 2014; Quiroga et al., 2016), and other smaller mammals (Periago et al., 2014). So, some researchers suggest that ADC is undergoing a process of defaunation and an empty forest syndrome (Periago et al., 2014). Social impacts include the displacement of peasants and indigenous communities through a process described as “accumulation by dispossession” (Harvey, 2003; Cáceres, 2015). This process consists of the appropriation of land, generally by private actors, for commodity production in regions where local communities have precarious land tenure (Cáceres, 2015). In the ADC, this is intimately related to the land grabbing phenomena where the appropriation of land is driven by foreign actors such as multinational companies (Costantino, 2016; Goldfarb and van der Haar, 2016). These changes in land access and tenure generally lead to an increase in social conflicts in rural areas (Aguiar et al., 2016).

The magnitude of the transformation in the ADC raised concerns within the scientific community, NGOs, national and local governments and civil society, who jointly promoted efforts to regulate deforestation (Seghezzo et al., 2011). The efforts of these social actors ultimately led to the enactment of the National Forest Law (N°26.331) (hereafter Forest Law) in November 2007. The aim of this law was to promote forest conservation and to regulate agricultural expansion through a land use zoning plan. The main requirement of the Forest Law was that each province must develop a forest zoning map based on specific criteria. The native forests should be classified according to their conservation value into three categories (hereafter conservation categories): Category I encompasses forests with high conservation value where any kind of transformation is forbidden; Category II includes forests with intermediate conservation value where transformation is not allowed but certain sustainable activities are permitted, such as tourism, harvest of non-timber products, scientific research and cattle ranching; Category III corresponds to forests with low conservation value where total transformation is allowed with a previous environmental impact assessment. To promote compliance, the Forest Law includes monetary compensation to land owners of forest areas located in categories I and II, and the application of fines for those who have performed deforestation in these categories (Ley Nacional N° 26.331, 2007).

The forest zoning criteria outlined to allocate the conservation categories in the Forest Law was interpreted differently among the provinces of the ADC (García Collazo et al., 2013). Generally, the economic dimension associated to the agricultural aptitude of the land had more influence in the forest zoning than in the ecological importance of the forests (Piquer-Rodríguez et al., 2015; Nolte et al., 2017a). In consequence, stricter conservation categories (Categories I and II) were allocated mainly to areas with little deforestation pressure due to their marginal value for agriculture (Nolte et al., 2017a). Also, inconsistencies in the interpretation of the sustainable criteria led to the assignment of different conservation categories to forests that had quite similar characteristics, for example, those located on both sides of some provincial limits (García Collazo et al., 2013). Finally, the provinces of the ADC ruled mechanisms that changed the restrictions to deforestation outlined in the Forest Law. For example, in Santiago del Estero and Chaco, some level of deforestation was allowed in areas of Category II (García Collazo et al., 2013).

The effectiveness of the Forest Law has been recently assessed in the ADC for the provinces of Salta, Chaco and Santiago del Estero (Nolte et al., 2017a). Nolte et al. (2017a) suggest that the Forest Law was effective in reducing deforestation since: (1) a widespread decline in forest cover loss was observed and (2) during the implementation period of the Forest Law, deforestation rates were higher in properties belonging to Category III (deforestation allowed) in Salta and Chaco, although this did not happen in Santiago del Estero. However, there are other drivers influencing deforestation rates besides the control imposed by the conservation policies, such as the dynamics of the global markets of agro-industrial production and the commerce system (Killeen, 2007). In this sense, the recent reduction in deforestation in the ADC is likely to be partially explained by the global economic crisis that began in 2008 (Graesser et al., 2015). Thus, an assessment of the