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The potential impact of economic policies on future land-use conversions in Argentina

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ABSTRACT

Agricultural expansion and intensification drive the conversion of natural areas worldwide. Scenarios are powerful tools to explore possible future changes in agricultural land use, how these may affect the environment, and how policies may influence land-use patterns. Focusing on Argentina's prime agricultural areas, the Pampas, Espinal and Chaco, we developed spatially-explicit future land-use scenarios from 2010 to 2030, considering both agricultural expansion (i.e., conversions from woodland to either grazing land or cropland) and agricultural intensification (i.e., conversions from grazing land to cropland). Our simulations were based on an econometric model of net returns, which assumes economically rational land-use actors. Using this model, we assessed the rates and spatial patterns of future land-use change under current land zoning in our study region, and contrasted this with a forecast of future land use based on land-conversion rates from 2000–2010. We systematically tested the impact of economic policies (e.g., taxes or subsidies), infrastructure improvement (e.g., road paving), and technological innovation (i.e., yield increases) on the spatial patterns of land-use conversions. Our model suggests future land-use change will mainly happen along intensification pathways, with deforestation slowing down, if land-use actors would be profit-maximizing. This general pattern did not change even for policy interventions that impacted profits from agriculture in major ways, cautioning against overestimating the leverage that economic policies provide for halting deforestation. Improving the region's road network would create a strong incentive to expand cropland further into remaining woodlands and over grazing lands. However, low agricultural profits and higher yields could curb deforestation in marginal areas to some extent. We also highlight that priority areas for conservation are particularly likely to experience high land-use pressure in the future. Given the lower-than-expected power of economic policies to alter deforestation patterns in our models, zoning, if properly enforced, appears to be a more straightforward tool for avoiding unwanted environmental impacts in the Chaco.

1. Introduction

Agricultural expansion and intensification drive the loss of natural vegetation worldwide, leading to the degradation of biodiversity and ecosystem services (Leblois et al., 2017; Maxwell et al., 2016). This is especially the case for the world's tropical and subtropical dry forests, where much of the remaining non-cultivated fertile land is found (Lambin et al., 2013; Laurance et al., 2014; Ramankutty et al., 2002). With ongoing population growth and even greater increasing consumption, the demand for agricultural products is expected to rise

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dramatically in the 21st century (Foley et al., 2011; Tilman et al., 2011). This will translate into growing pressure to intensify existing agriculture areas and to expand agriculture into natural ecosystems. Identifying policies that effectively steer agricultural land-use change and assessing their relative impact on agricultural expansion versus intensification pathways, is therefore critical (Angelsen, 2010; Meyfroidt et al., 2014).

This requires understanding the underlying causes behind agricultural land-use changes (e.g., changes in population, diets, market prices) and how they play out in given local conditions (e.g., soils, climate, accessibility, policies) (Geist and Lambin, 2002; Meyfroidt, 2015). South America harbors some of the world's key agricultural regions, where agricultural land-use change is strongly influenced by global agricultural markets (Byerlee et al., 2014; Gasparri and le Polain de Waroux, 2015). This has resulted in widespread deforestation for cattle ranching and soybean cultivation (Baumann et al., 2016a; Gasparri et al., 2013; Leblois et al., 2017). Yet, deforestation rates vary starkly from region to region, depending on the environmental characteristics and the national and subnational policy framework (Assunção et al., 2013; Macedo et al., 2012; Nolte et al., 2017). For example, whereas deforestation rates in the Amazon or the Paraguayan Atlantic Forest have decreased recently (Nepstad et al., 2014; WWF, 2006), in part due to forest protection policies (Baumann et al., 2017; Macedo et al., 2012), agricultural expansion in the neighboring Cerrado and Chaco ecoregions continues unabated (Baumann et al., 2016a; Spera et al., 2016). Likewise, agriculture in some regions, such as in the Pampas or the Atlantic Forest, has intensified from cattle ranching to soybean production (Bert et al., 2011; Viglizzo et al., 2011; WWF, 2015). In order to efficiently manage agricultural land-use change, it is therefore crucial to understand its underlying causes and how broad-scale policies, that governments or land-use planning agencies can implement, may impact future land-use patterns.

Scenario analysis is a powerful tool to explore how future land use might change in response to alternative policies (Gavier-Pizarro et al., 2014; Peterson et al., 2003; Piquer-Rodríguez et al., 2015; Polasky et al., 2011). If landowners seek to maximize profits from land, which is typically the case in agricultural frontiers, key factors influencing their decisions are those directly affecting agricultural profitability (Barbier, 2012; Bockstael, 1996; Le Polain de Waroux et al., 2018). Spatial economic models of net returns explicitly model the impact of changes in land profitability (i.e., net returns) on land-use change patterns, while accounting for regional variations in agricultural suitability (Butsic et al., 2011; Piquer-Rodríguez et al., 2018; Radeloff et al., 2012). Once parameterized, such models allow for insights into the impact of changes in underlying drivers of land-use change, to explore alternative future scenarios, and to test for the possible effects of specific policies on land-use change (Butsic et al., 2010; Lewis and Plantinga, 2007; Radeloff et al., 2012). This is a major advantage compared to models that project future land-use change based on correlations between past land-use change and its spatial determinants, while typically disregarding the mechanisms driving land-use change (Plantinga and Lewis, 2014). Yet, to our knowledge, only two models of net returns have been parameterized for agricultural regions in South America (Arima, 2016; Seo, 2009), and only one, from our own previous work, has used spatial data on agricultural costs and returns to assess profits directly (Piquer-Rodríguez et al., 2018).

Within South America, Argentina is a hotspot of agricultural land-use change, both in terms of agricultural intensification and expansion (Viglizzo et al., 2011). Widespread conversion of grazing land to cropland has occurred in the Pampas and Chaco ecoregions, mainly for the production of soybean, corn, and wheat. At the same time, agricultural expansion into the dry forests of the Chaco ecoregion, both for expanding cropland (i.e., soybean, wheat, maize, and cotton) and cattle ranching, is widespread (Baumann et al., 2016a; Gasparri et al., 2015; Grau et al., 2015; Volante et al., 2016). These trends are likely to continue in the future (Laurance et al., 2014; Ramankutty et al., 2002; Schmitz et al., 2014), which is concerning given the stark environmental trade-offs these land-use changes had in the past (Baldi et al., 2006; Baumann et al., 2016a; Macchi et al., 2013; Mastrangelo and Gavin, 2014; Torres et al., 2014).

Continued development of its agricultural sector has turned Argentina into a major global producer and exporter of soy and beef since the 1990s (Leguizamón, 2016; Urcola et al., 2015). For example, soybean production increased from hundreds of tons in the early 1970s to approximately 50 million tons in 2010 (Leguizamón, 2014). Among the total agricultural produce exported, soy and derivatives account for the highest export shares in Argentina, and the country is an important oil and biodiesel producer globally (CIARA, 2017). Export mainly comes from large and medium-sized agribusinesses (Gasparri and le Polain de Waroux, 2015; Le Polain de Waroux et al., 2018; le Polain de Waroux et al., 2016) and agricultural trade is an income source and a stabilizing factor for the Argentine economy (Meller, 1994). Due to the crucial role of the agricultural sector for Argentina's economy, governmental policy interventions at the national level (e.g., the creation or lifting of export taxes (Gasparri and Grau, 2009)) and provincial level (e.g., infrastructure improvement (e.g., Plan Belgrano, Decree 12/2015)) are frequent.

Understanding how national or provincial-level land-use policies influence spatial patterns of agricultural land-use change in Argentina is therefore important. Land-use policies could target agricultural profits directly, for example via export taxes or through subsidies, as is currently the case (e.g., *retenciones*). This affects medium to large-scale commodity producers because they are integrated in international markets and profit mainly from the production of export oriented goods and has a direct impact on deforestation rates (Gasparri et al., 2013; le Polain de Waroux et al., 2016). More indirect policy interventions include agricultural production targets or caps, such as the Strategic Food and Agricultural Plan (MAGyP, 2011) or the 'Hilton Quota' on beef exports to the European Union (Decree 906/2009 and 1231/2015). Moreover, policies can affect the agricultural sector via infrastructure development (e.g., Infrastructure Investment Plan to 2025 (Bortolín, 2015), Executive Network Framework to 2024 -E.Di.Vi.Ar or Plan Belgrano) via lowering transportation costs, thereby raising land rents (Choumert and Phélinas, 2015). This impacts agricultural producers strongly, as transportation costs are a limitation especially for small-to-medium scale producers (Le Polain de Waroux et al., 2018). As a result, land-use conversions often expands from already converted areas, where infrastructure, logistics, knowledge, labor, and technology are in place, creating typical agricultural frontiers where natural resources are not as important as agglomeration economies (Garrett et al., 2013; Gasparri et al., 2015; Piquer-Rodríguez et al., 2018; Richards, 2018; Volante et al., 2016). In contrast, however, leap-frogging land-use conversions into marginal regions does occur, often by risk-taking actors in expectation of extraordinary profits (Le Polain de Waroux et al., 2018). How policies targeting profits directly (e.g., via taxes) or indirectly (e.g., via improving infrastructure and thus lowering transportation costs) may influence rates and spatial patterns of future agricultural land-use change in Argentina, however, remains unclear.

Existing work on future agricultural land-use change in Argentina typically explores alternative narratives of potential future agricultural trends (Adamoli et al., 2011; Patrouilleau et al., 2007; Patrouilleau et al., 2012). These studies generally suggest that land ownership is increasingly concentrated in the hands of a few producers (Baumann et al., 2016b; Bert et al., 2011; Corral et al., 2008), and highlight the potential of intensification for increasing agricultural productivity (Canosa et al., 2013). Because these studies are not spatial, assessing the environmental impact of future land-use, and how particular policies would affect these impacts, is challenging. Conversely, studies that considered the spatial patterns of future land use were all based on correlative models that disregard underlying causes of agricultural conversions, such as land profits (Gasparri et al., 2015; Volante et al., 2016).