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Who owns Brazilian lands?

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ABSTRACT

Land tenure in many parts of Brazil remains uncertain and controversial. These problems have recently been exacerbated by changes in the legal framework regulating protected areas and the land market. A particular challenge facing attempts to improve land tenure security and governance in Brazil is the lack of a single, integrated assessment of all types of lands. Here we address this problem and present a first, integrated map of Brazilian land tenure encompassing all official data sources pertaining to both public and private lands. Of the total (8.5 million km^2) 36.1% of all lands are public (with 6.4% officially undesignated), 44.2% are private, and 16.6% are unregistered or with unknown tenure. Strikingly, overlaps among land tenure categories sum to 50% of the registered territory of Brazil. A clearer understanding of uncertainties in land tenure, and the spatial distribution of those uncertainties can help guide research and public policies focused on minimizing land conflicts and strengthening governance and territorial planning to improve economic, environmental and social outcomes from land use in Brazil.

Despite the economic importance of agriculture for the Brazilian economy, systemic problems with the countries' land tenure system present a major challenge for development. Such problems include widespread disputes and conflict over land, weak governance and highly unequal patterns of land ownership (Reydon et al., 2015; Lapola et al., 2014). Existing land tenure designations also remain highly unstable in the face of ongoing legislative changes by the federal and state governments, increasing the risk of volatility in the land market, including through land speculation and land grabbing. For example, the global phenomenon of downgrading, downsizing, and degazeting (PADDD) of protected areas increased markedly in the last five years in Brazil (Pack et al., 2016). In 2016 permission was given to sell public land within agrarian reform settlements (MP 759/2016). Under the newly elected federal government the Brazilian National Congress is currently reviewing the possibility of increasing the area of land that could be bought by foreigners.

The combination of these systemic problems and recent increases in the uncertainty and volatility of the land market has severe implications for sustainability in Brazil, including for efforts to reduce deforestation, especially in the Amazon. Indeed the recent shift in policy by the Brazilian government towards reduced public protection and a less-strictly enforced land tenure regime can help explain the upward deforestation trend observed in the Amazon since 2012 (Soares-Filho and Rajão, 2018). As such land tenure problems may severely compromise Brazil's ability to meet its nationally determined contribution (NDC) to the Paris Agreement (Rochedo et al., 2018) – including the goals of ending illegal deforestation in the Amazon and restoring 12 million ha of native vegetation until 2030.

Historical problems with Brazil´s land tenure system and the dilution of public protections by recent governments are exacerbated by the

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lack of a single, integrated assessment of all public and private lands classified with respect to different categories of use and tenure (Reydon et al., 2017). To help address this problem and contribute towards a more transparent and effective system of territorial governance for Brazil we present a first, integrated map of Brazilian land tenure encompassing all official data sources pertaining to both public and private lands.

The map presented here departs from a preliminary version used by Freitas et al. (2018a), 2017 to model land-use in Brazil and assess environmental impacts across different kinds of ownership. The new map represents a major improvement in two main ways.

First, we have increased the coverage and accuracy of information on the distribution of private lands made available through the Rural Environmental Registry (CAR in Portuguese acronym) of the Brazilian Forest Law published in 2012 (Brasil, 2012). For this analysis we used the version of the CAR dataset from December, 18th, 2018, a date close to the official deadline for landowners to register, which was the December, 31 st. The CAR is a legal instrument to support environmental regulation and the implementation of the Forest Law. It consists of a geodatabase where landowners self-declare property boundaries and land use designations into an electronic system to be validated by the State or Federal government (Azevedo et al., 2017). The CAR system has now been widely adopted by farmers and the database covers the majority of private lands in Brazil. Although the CAR is not a land tenure classification in a legal sense it provides the best available assessment of the distribution of private properties in Brazil, is invaluable for identifying gaps in land tenure.

Second, we combined the CAR data layer with 17 other official databases and allocated land into 14 categories of tenure (the list of the 18 databases and 14 categories are described by Freitas et al., 2018b). To achieve this, an objective set of rules on land-tenure hierarchies – i.e. which designation should take priority over others in the case of spatial overlaps - was elaborated in consultation with several leading scientists and land tenure experts. These rules take into account the legal underpinnings of each land-tenure category in the various datasets, differences in the quality and accuracy of the official land tenure datasets, and the likelihood of future changes in land designation (Freitas et al., 2018b).

For example, indigenous reserves are given higher priority in the hierarchy than private land under CAR because indigenous rights are established in the Brazilian Constitution. In addition, public and private lands formally registered and recognized by a public authority have higher priority than those which are not recognized as such – such that private lands certified by the agrarian reform agency (SIGEF/INCRA) are given higher priority than lands that are only registered in the self-declaratory CAR system.

By merging the CAR data with other public and private land tenure data we provide the first wall-to-wall land tenure map for Brazil that combines all available official data sources on both public and private lands. The map is publicly available and is accessible for consultation and download at http://atlasagropecuario.imaflora.org/. In addition to providing much greater transparency of land ownership in Brazil the map, and accompanying estimations of the number and area of overlap between land-tenure designations provides a new level of understanding of the key gaps and inconsistencies in the spatial distribution of different land-tenure classes. These data provide the basis for new research on land tenure and patterns of irregularity and non-compliance, and by being publicly accessible they can be used by both public and private institutions and civil society to catalyze improvements in land governance across Brazil. Greater transparency in land data may also support judicial decisions about land tenure, which may result in an increase in court cases being formally judged.

Of the total Brazilian territory, we found that 36.1% is classified as public lands and 44.2% as private lands in 4,537,242 polygons of individual land units covering 682,513,148 ha (80.3%) of the country. An additional 3.1% of the country (26.3 million ha) is covered by urban and water areas. Public lands are comprised mainly of protected areas (24.2% combining conservation units with indigenous reserves) and undesignated lands (6.4%) while agrarian reform settlements occupy 4.9% of the national territory. Private lands are concentrated in large properties. By adding the properties found at CAR and SIGEF registries, 97 thousand large properties with an average size of 1876 ha cover 21.5% of the country. In comparison, indigenous reserves that provide the livelihood for 572 thousand people cover 13% of Brazil (IBGE, 2010). Strikingly, 16.6% of the entire Brazilian territory is not covered by any category and is unregistered in any official database (Table 1). The distribution and share of land tenure categories varies substantially across regions and States of the country (Supporting Tables 1–7). Protected areas are concentrated in the Northern region (95% in the Amazon biome) while private lands are concentrated in the South.

Overlaps among the 14 categories of land tenure designation sum to 354,601,858 ha of the area covered by the known lands (50%) or 41% of Brazil's territory. Because multiple land tenure designations may overlap each other in the same locality this does not mean that 354 million ha of land is under some form of overlap (see Supporting Table 8). Overlaps within public lands sum 171 million ha (48% of all

Table 1
Total and relative area and number of units of Brazilian land tenure categories.

Land tenure category	Area (ha)	% of total land area	Number	% of total number of land areas
Indigenous Reserves	112,412,239	13.2%	600	< 0.1%
Conservation Unit[a]	93,403,026	11.0%	1337	< 0.1%
Communitary Territory	1,779,373	0.2%	815	< 0.1%
Military lands	3,006,965	0.4%	104	< 0.1%
Rural Settlement	41,736,096	4.9%	7,547	0.2%
Undesignated lands[b]	54,599,607	6.4%	22,016	0.5%
Total Public Land	306,937,306	36.1%	32,419	1%
Private property from CAR[c]				
Small	83,400,520	9.8%	3,805,698	79.0%
Medium	42,077,338	4.9%	167,537	3.5%
Large	48,366,589	5.7%	34,779	0.7%
Private property from SIGEF[d]				
Small	12,700,175	1.5%	206,070	4.3%
Medium	41,551,394	4.9%	110,830	2.3%
Large	134,531,227	15.8%	62,677	1.3%
Private property from Terra Legal Program	9,830,630	1.2%	116,854	2.4%
Quilombola Territory	3,117,971	0.4%	378	< 0.1%
Total Private Land	375,575,843	44.2%	4,504,823	94%
Unregistered land	141,454,569	16.6%		
Transportation network, Urban area and Water bodies	26,310,500	3.1%	280,692	5.8%
Total Brazil	850,278,218	100.0%	4,817,934	100%

[a] We excluded APAs from the conservation unit category. APA (area of environmental protection) is a type of conservation unit of sustainable use which may occur in areas of public or private domain that allow human occupation and economic activities, including intensive agriculture, and totals 44 million ha. Its inclusion would confuse interpretation of land ownership and overlaps as it does not imply the expropriation of private land ownership and as such necessarily coincides with other land tenure categories.

[b] Public lands that have not been designated to a final use. Our findings differs from the 65.5 million ha of undesignated forest lands in the Amazon found by Azevedo-Ramos and Moutinho (2018) due to the hierarchy rules adopted, where Forests type B have a low level of priority and are classified as other categories. Forests Type B are Federal or States lands covered with forests which final designations have not been decided yet. They are under the administration of the Brazilian Forest Service (SFB).

[c] Cadastro Ambiental Rural (Rural environmental registry).

[d] Sistema de Gestão Fundiária – INCRA (Land tenure management system from INCRA).

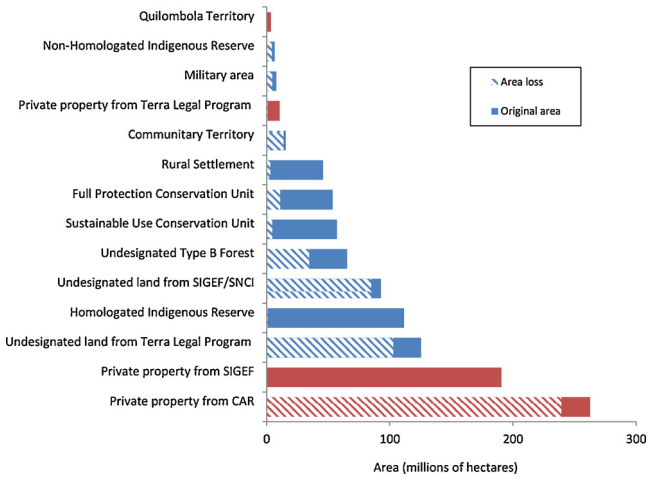

Fig. 1. Overlaps of land tenure categories.
Each bar represents the original area of each land tenure class while the hatched area of each bar represents the area of that class which overlaps with one or more other land tenure classes. Overlapping areas were classified as one type of land tenure class following our hierarchy of priority classifications. The area of overlap of each land tenure class with all other classes is given in Supporting Table 8).

overlaps), while overlaps between public and private land tenure classes sum 176 million ha (50%) and overlaps between different classes of private land sum 7 million ha (2%) (Fig. 1 and Supporting Table 8). The extent of overlap varies substantially among regions of the country with greater overlap and associated tenure uncertainty concentrated in the Northern region (Supporting Tables 9–13).

In providing the first wall-to-wall assessment of public and private land tenure for Brazil we can identify four observations that are of profound importance for territorial planning, land governance and research in the country.

First, we estimate that there is a minimum of 54.6 million ha (6% of the total known area) of public land that remain undesignated, the majority of which is in the Amazon biome. This area of undesignated land is almost as large as the state of Minas Gerais, Brazil´s fourth largest state. The fact that there is a substantial overlap between these undesignated lands and lands registered under public and private tenure highlights the widespread uncertainty that characterizes land tenure in the Amazon biome and the profound challenges this represents for forest conservation (see also Azevedo-Ramos and Moutinho, 2018). Azevedo-Ramos and Moutinho (2018) provided a less conservative estimate of the total area of undesignated land in the Brazilian Amazon at 65.5 million ha which did not account for any hierarchy of land tenure designations for overlapping lands.

Second, one sixth (16.5%) of Brazil is not classified as having any official land tenure registration posing a major challenge to efforts to improve territorial planning, increase legal compliance and reduce land conflicts, such as land grabbing and disputes for ownership between public and private actors, like the recent situation in the National Forest of Jamanxim. This public area has been illegally occupied by farmers in disputes that have resulted in deforestation and violence.

Third, the total area of overlap among at least two areas of differing land tenure comprises an area greater than that of any single land tenure category. Some overlaps between land boundaries may be due to errors in the mapping of individual public or private properties. Other overlaps may be the result of different official land registries that are not adequately updated by different State and Federal agencies. In some cases overlaps may be due to competing land claims and indicate the potential for land conflict. However, regardless of the explanation such widespread uncertainties in land tenure clearly illustrate the large extent of Brazilian land that either under legal dispute or at risk of being under legal dispute in different levels of policy and decision making, from the municipal to federal one.

Finally, our assessment illustrates the unequal distribution of land ownership with large areas concentrated in relatively few private properties. Indeed, nearly half (48%) of all private lands are concentrated in less than 100 thousand properties, representing 2% of the total.

In conclusion, this study provides the first quantitative and spatially explicit assessment of the coverage, gaps and uncertainties in the land tenure status of the entire Brazilian territory. Data is organized in the most detailed property level, but it allows integration in the various jurisdiction levels where land policy and decision occurs, from the municipal to the federal scale. Our assessment shines a spotlight on the fragile state of land tenure in the country and provides an important step towards identifying priorities for public policy. Brazil is recognized as one of the world's most biodiverse countries (Ferreira et al., 2014) and as well as one of largest food producers (Sparovek et al., 2018). The success of efforts to ensure that agricultural development in Brazil is placed on a more sustainable and socially equitable footing depends critically on efforts to tackle the profound land tenure insecurity demonstrated by this study. Further research is needed to help understand the reasons for different types and levels of land tenure insecurity and extent of land under undesignated or unregistered status in different parts of the country, and in different land tenure regimes.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.landusepol.2019.104062.

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