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# Rapidly escalating threats to the biodiversity and ethnocultural capital of Brazilian Indigenous Lands

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ABSTRACT

Indigenous land rights have been increasingly recognized in several countries, but powerful economic and political lobbies have conspired to produce major legislative alterations to severely weaken the protection status of indigenous territories, threatening their rich ethnocultural capital and biological diversity. Here, we provide a comprehensive quantitative assessment of the demography of indigenous populations and the conservation performance of all 587 physically demarcated Indigenous Lands (ILs) in Brazil. Our results show that human population density (HPD) is higher inside than outside 50 % of ILs, dispelling the often repeated argument that there is "too much land for too few Indians". Moreover, a strong positive relationship between IL size and indigenous population size is corroborated by larger resident populations within the largest territories, even they are sparsely settled. Over half of all ILs retain 90 % of natural vegetation and harbour 54 % of all indigenous populations living inside ILs. HPD within ILs was strongly negatively related to their proportion of natural vegetation cover. These results show the critical importance of legally protecting sufficiently large indigenous territories. Any alteration in the protection status and/or opening up ILs to economic exploitation such as mining, forestry and large-scale agriculture will affect the long-term ethnocultural integrity and the environmental viability of these territories. ILs remain critical if Brazil is to accomplish its international commitments to both protect tropical biodiversity and mitigate climate change.

## 1. Introduction

Many post-contact conflicts between modern westernized societies and aborigine peoples are yet to be resolved, particularly those involving contested lands in former colonies. Access to land is central for economic development and poverty reduction, but also critical in securing a wide range of fundamental human rights, including food, water, ethnocultural identity and baseline health conditions (Wickeri and Kalhan, 2010). For most indigenous peoples, the socio-cultural baggage associated with their ancestral lands is inextricably linked to their identity. Therefore, land rights has been enshrined in the Indigenous and Tribal Peoples Convention No. 169 of the International Labour Organization (ILO), and later reasserted by the 2007 United Nations Declaration on the Rights of Indigenous Peoples.

Although the plight of indigenous peoples can count on internationally consolidated policy support, they typically remain disenfranchised at the margins of national societies and farther than ever from tangible recognition of their ancestral land rights (Rudel and Hernandez, 2017). Land expropriation — often under coercion, violence, widespread contagious diseases and contemporary marginalization — has been the main driver of the dismal health conditions of many indigenous peoples worldwide compared to neighbouring non-indigenous societies (Stephens et al., 2006; Valeggia and Snodgrass, 2015). Prolonged land struggles, poverty, and inadequate access to health care are aggravated by recurrent epidemic outbreaks, drug addiction, alcoholism, financial over-dependence and otherwise degrading socio-cultural conditions (Gracey and King, 2009; King et al., 2009). Chronic detrimental exposure to the values and material culture of dominant modern societies leads, directly or indirectly, to unprecedented declines in native languages (Krauss, 1992; Walsh, 2005; Pretty et al., 2009), and widespread environmental degradation and biodiversity loss within indigenous territories (Gadgil et al., 1993; Sutherland, 2003).

Different strategies have been adopted by nation-states to recognize the land rights of indigenous peoples (Plant and Hvalkof, 2001; Ortega, 2004). Designated or recognized lands used by indigenous peoples correspond to almost one third of the global-scale land surface, overlapping over 40 % of all protected areas worldwide (Garnett et al.,

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2018). There is mounting evidence suggesting that land rights recognition contributes to reducing tropical forest conversion into agriculture (Ceddia et al., 2015), carbon emissions from land-use change and biodiversity loss induced by forest wildfires (Adeney et al., 2009; Nelson and Chomitz, 2011).

In Brazil, veiled discrimination and marginalization persisted until the early 20th century when the Indian Protection Service (*Serviço de Proteção ao Índio* – SPI) and expeditions led by Marechal Cândido Rondon began to contact indigenous peoples and encourage their lawful integration into Brazilian society. Since the 1934 Constitution and subsequent laws, indigenous peoples were assigned exclusive usufruct rights to their land. In 1967, the SPI was replaced by FUNAI (*Fundação Nacional do Índio*), and a set of regulatory demarcation rules known as the Indian Statute (*Estatuto do Índio* - Law No. 6001/1973) were sanctioned in 1973. The 1988 Brazilian Constitution finally secured a critical legislative milestone in recognising indigenous peoples land rights. It explicitly enshrined territorial claims by indigenous peoples living within the entire Brazilian national territory, stating that native Amerindians are the legitimate original landholders, whose land rights should prevail over any other competing land claim (Stocks, 2005). These territories are legally referred to as Indigenous Lands – ILs (*Terras Indígenas*). Although there is clear official recognition of land rights for indigenous peoples, they withhold no legal property ownership (whether private or communal) over their own lands within Brazilian ILs given that these are still defined as public lands. On the other hand, even with constitutional reassurances, indigenous land rights recognition has been repeatedly contentious both institutionally and politically (Carvalho, 2000) and is threatened by new legislation enacted by the current Brazilian Congress.

Unprecedented escalation of hostile policies has recently conspired to weaken the protection status of ILs with the proposition of major legislative alterations led by an ultra-conservative presidential administration and its party, and powerful economic and political lobbies (Le Tourneau, 2015, 2019). Combined with persistent economic and political crises, disputes over frontier lands threaten the stability of all environmental policy and practice in Brazil (Magnusson et al., 2018). Many protected areas have been downsized or downgraded in status to pave the way to mining concessions and major infrastructure projects, including roads and hydroelectric dams (Ferreira et al., 2014; Marques and Peres, 2015). A recent presidential decree (MP-910/2019) will empower squatters to lay legal claims of up to 1400 ha in undesignated public forest lands whose occupation occurred prior to December of 2018, clearly encouraging new encroachment and further deforestation. This presidential decree is even more acquiescent than the Federal Law 13465/2017 which extended a set of flexible requirements to lay legal claims to public lands over the entire Brazilian territory (Crouzeilles et al., 2017). Other legislative changes proposed by Brazilian Congress are even more alarming. If sanctioned, a constitutional amendment (PL 3729/2004) will dismantle environmental licensing procedures, rendering all impact assessments related to any development enterprise a mere rubber-stamping formality (Fearnside, 2016). Another proposed law currently under discussion (PL-3751/2015) can ensure the annulment of any protected area for which land tenure conflicts have not been resolved within the previous five years (Silveira et al., 2018). There are also proposals to slacken non-indigenous land use restrictions, which so far had deterred cropland leasing (PEC 343/2017 and PEC 187/2016) and mining operations inside ILs (PL-1610/1996). Physical demarcation of ILs has also been weakened, as often professed by the federal administration, severely reducing the autonomy of FUNAI (Ministry of Justice Order #68). All anthropological studies commissioned by FUNAI, the critical starting point to set aside any new IL, must now be currently authorized by an external council subjected to political interference. Another legislative proposal aims to withdraw the presidential prerogative of legally decreeing physically demarcated ILs (the last legislative step in consolidating an IL), transferring this task to the currently hostile Brazilian Congress (PL-490/2007). Several demarcation projects of new ILs have been suspended or discontinued by the federal government due to the so called “1988 deadline”, a judicial interpretation still lacking Supreme Court confirmation that only endorses indigenous territorial rights if they had been inhabiting their land claims when the current constitution was declared (September 1988). This interpretation, however, deliberately ignores the plight of many indigenous groups who had been evicted from their territories before this “deadline”.

This political instability encourages land conflicts and violence with relentless physical and psychological threats, including murders of indigenous leaders (Cunha et al., 2017; Lynch et al., 2018; Le Tourneau, 2019). In fact, the recent escalation in Amazonian deforestation rates detected by PRODES (INPE, 2019) reflects this tempestuous political scenario. Potential downgrading or downsizing of ILs, as repeatedly declared by the current Brazilian President, will also have disastrous consequences for over 300 ethnic groups (Begotti and Peres, 2019). These territories are critical in upholding the traditional livelihoods, cultural integrity and self-determination rights of indigenous peoples as they confront mounting threats from encroaching modern enterprises. In addition to social gains and land rights recognition, Brazilian ILs provide meaningful global scale environmental and biodiversity benefits at pitifully low costs (Sobrevila, 2008), including 25.5 % (~13.26 Gt) of Brazil’s aboveground carbon stocks (Freitas et al., 2017). ILs located within the Brazilian Amazon alone retain one quarter of the terrestrial carbon stock across the entire Amazon Basin (Walker et al., 2015) and over one fifth of all Amazonian animal and plant populations (Garnett et al., 2018). In sum, the protection status of ILs is clearly justified by the rich cultural and biological diversity that they encompass (Loh and Harmon, 2005).

Here, we provide a detailed quantitative assessment of all physically demarcated Indigenous Lands in Brazil based on both demographic and remote sensing data. Our main goal was to understand how current legislative alterations in Brazilian Congress can affect the welfare of indigenous residents within existing ILs, many of which are already confronting strong external pressures resulting in cultural assimilation and environmental degradation. We further quantify Indian population density within of each IL throughout Brazil to question the widely held criticism in Brazilian society that indigenous groups control far too much land given their often small populations (under the “*muita terra para pouco índio*” banner). As such, we also assess the human population density immediately outside ILs to examine the different demographic contexts in which they are embedded. Finally, we quantify the amount of natural vegetation cover persisting both inside and outside each IL, aiming to assess the conservation performance to date of indigenous territories across their entire range of demographic and geographic contexts.

## 2. Material and methods

### 2.1. Brazilian Indigenous Lands

There are currently 565 officially decreed ILs and an additional 114 territories under various stages of consideration (FUNAI, 2018). These are distributed throughout the Brazilian territory across all six major biomes (Fig. 1 and Appendix A). Together, they cover a combined area larger than 1,170,000 $km^2$ (three times larger than post-unification Germany), corresponding to 13.5 % of the Brazilian national territory. As of 2010, ILs safeguarded some 515,000 Indians speaking ~280 different languages (IBGE, 2010), and several uncontacted groups remain in voluntary isolation in large Amazonian ILs and immediate vicinities. Based on data from IBGE (2010), however, approximately 380,000 Indians live outside ILs, such as large numbers of Guarani, Pataxó, Kaiagang, and Terena people who live in both rural and urban settings. In terms of the overall number and aggregate area, ILs are largely concentrated within the Amazon biome accounting for ~53 % of all ILs but 98.6 % of the combined IL area within Brazil. Most large

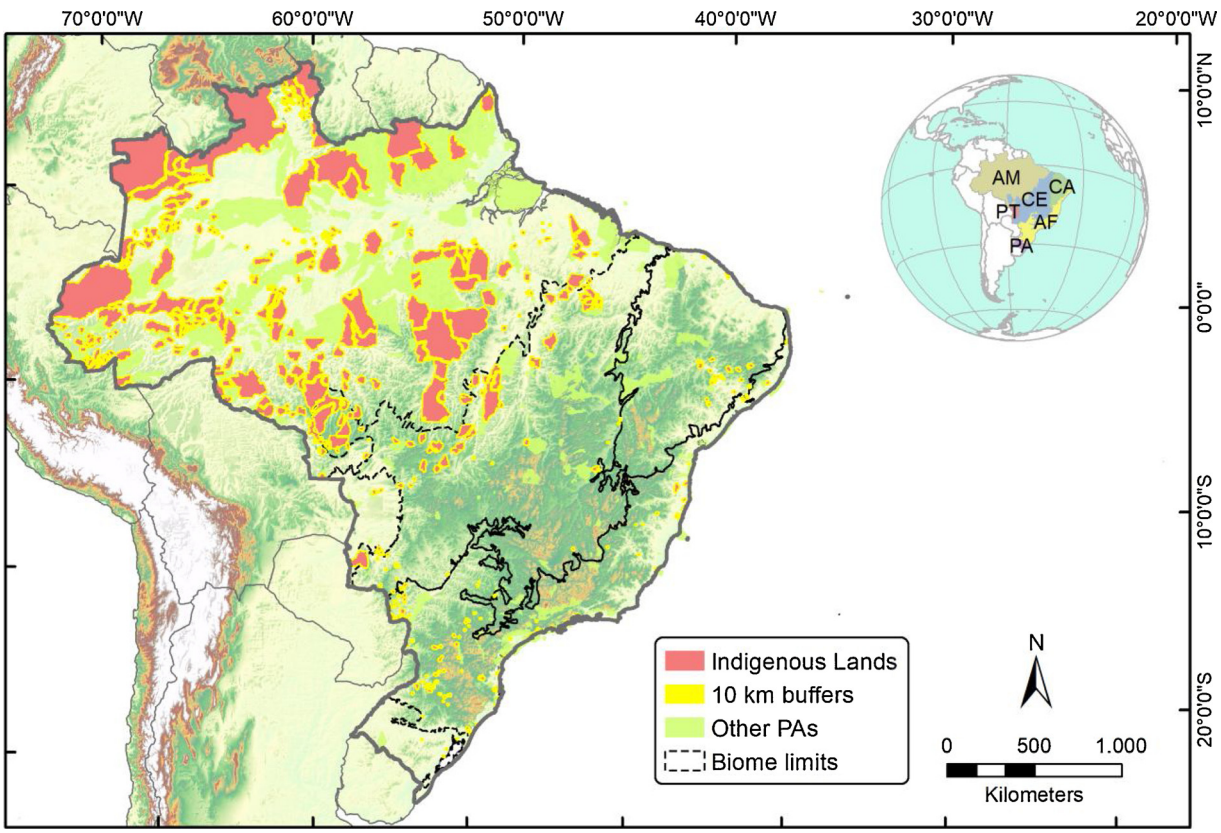


**Fig. 1.** Size and geographic distribution of all Brazilian Indigenous Lands. ILs are represented by magenta polygons, and 10-km buffer areas by yellow contours. Other protected area categories are shown in light green. Abbreviations in the small inset map of South America represent the six major Brazilian biomes. *AM*: Amazon; *AF*: Atlantic Forest; *CA*: Caatinga; *CE*: Cerrado; *PA*: Pampas, and *PT*: Pantanal.

indigenous territories are also located in the Amazon, accounting for 42 of the 46 Brazilian ILs larger than 500,000 ha (Appendix A). In contrast, the Pantanal and Pampa biomes, which largely consist of naturally open habitats, hold the smallest number of ILs.

### 2.2. Data compilation

Our datasets consist of both demographic and environmental data organized in a GIS platform. Demographic data on indigenous territories are based on the polygon map of Brazilian ILs available from FUNAI (FUNAI, 2018). We used the latest (2010) Brazil-wide national census data from IBGE (Instituto Brasileiro de Geografia e Estatística) including both the indigenous population size inhabiting each IL (IBGE, 2010) and non-indigenous populations surrounding these indigenous reserves (IBGE, 2011). Land cover maps of all six major Brazilian biomes (in decreasing size order: Amazonia, Cerrado, Atlantic Forest, Caatinga, Pantanal, and Pampa) were acquired from a Landsat-based product at 30-m resolution available from Collection 2 of MapBiomas (Mapbiomas, 2017). Due to inevitable uncertainties at present in relation to (i) the boundaries of ILs that are yet to be physically demarcated, and (ii) population size and age structure data on ethnic groups within several of these territories, we restricted our analysis to only 587 ILs.

### 2.3. GIS database

We first reprojected the map of all Indigenous Lands and all raster files describing land cover for six major Brazilian biomes into the UTM conic conformal Lambert projection for South America. Based on the IL polygon map, we generated a 10 km-buffer surrounding each territory. Buffer perimeters were, however, trimmed whenever we found overlapping areas with major rivers, dam reservoirs, and if buffer areas straddled transnational boundaries into neighbouring countries or continental coastal areas. Altogether, the 587 ILs and corresponding 10 km-buffer areas examined here amount to 1,904,731.5 $km^2$, representing nearly 20 % of the entire Brazilian national territory of ~8.5 million $km^2$ (Fig. 1).

### 2.4. Human population density

We calculated the local population density (persons $km^{-2}$) for indigenous peoples living within Brazilian ILs based on the total number of self-declared Indian residents in 2010 provided by the IBGE census for the indigenous population (5), divided by the total area of each IL. The 2010 IBGE census still provides the most complete demographic dataset available for indigenous populations (Ricardo and Ricardo, 2017). Human population density outside ILs was calculated from the main demographic census data of 2010 provided by IBGE (IBGE, 2011). In this case, population size was partitioned at the spatial scale of individual census districts (or sectors), the spatial unit used by IBGE to deploy decadal population counts. We calculated the non-indigenous population density as the sum of population sizes of all census districts weighted by their respective area ($km^2$) overlapping the 10 km-buffer area of each IL. The Amazon and Pantanal biomes had the lowest human population densities found both inside and outside ILs (Appendix B). On the other hand, the Atlantic Forest, Caatinga and Pampa biomes contained the highest population densities both inside and outside ILs, reflecting the much older history of occupation of the Brazilian territory in the aftermath of European conquest.

### 2.5. Vegetation cover analysis

In order to calculate the percentage of natural vegetation cover both inside and outside each IL, we used the Collection 2 of classified maps

available from MapBiomas for 2016 (Mapbiomas, 2017). These maps consist of raster files with 30-m spatial resolution, classified from multispectral Landsat 8 images. The data are freely available for download, including land cover maps of each of all six major Brazilian biomes. After changes in projection, we reclassified the raster files generating binary maps describing either natural vegetation cover or anthropogenic conversion of the original primary vegetation into other land use classes. Next, we pooled all six biome maps into a single mosaic for the whole of Brazil given that some ILs straddled the boundaries between neighbouring biomes (Fig. 1). The total area of natural vegetation cover within each IL was calculated using the Spatial Analyst Tool within the ArcGIS software (version 10.2). The percentage of natural vegetation cover was based on both the polygon area for each IL and its external 10-km buffer area.

### 2.6. Statistical analysis

To quantitatively assess how demographic and environmental factors may interact inside Indigenous Lands, we used generalized additive models (GAMs - Hastie and Tibshirani, 2014). GAMs are comprised of a linear predictor and a sum of non-parametric smoothing functions for each predictor variable, which are useful to detect nonlinear effects of the predictors (Hastie and Tibshirani, 2014). We fitted our first two models to explain the log-transformed indigenous population size and the area of each IL as response variables. We initially, assumed a Poisson error distribution, but due to detection of overdispersion, we used a Quasi-Poisson error. Next, we added Brazilian biomes as our covariate to examine potential changes to overall fitting, excluding the Pantanal and Pampa biomes because they contain very few ILs. For both models, we used cubic regression splines as the penalization method in the smoothing function of the IL area (Wood, 2006). For the other two models, we used a Gaussian error distribution, assuming the percentage of natural vegetation cover as our response variable. Our predictor variable was indigenous population density (log10 x + 1) inside ILs, and we added Brazilian biomes thereafter, again excluding the Pantanal and Pampa biomes because they contained only five ILs. Log-transformed human population density (HPD) inside ILs was penalized in the smoothing function using the cubic regression splines method (Wood, 2006). For all analyses, we use the R software, version 3.5 (R Core Team, 2018).

## 3. Results

We assessed 587 physically demarcated Indigenous Lands across all major Brazilian biomes. In aggregate, these ILs retained 1,100,424 $km^2$ of relatively undisturbed natural vegetation cover, including tropical and subtropical forests, native savannahs, natural scrublands and native prairies, representing 95.6 % of the overall IL aggregate area in Brazil. In contrast, the mean percentage of natural vegetation cover within 10-km buffer areas immediately outside ILs had been reduced to 51.5 % (SD = 29.6 %). Indigenous populations living inside ILs are located primarily within the Amazon biome. According to IBGE census data on indigenous populations (IBGE, 2010), over 265,000 Indians occupy 314 Amazonian ILs, corresponding to 51.4 % of the total indigenous population settled within all Brazilian ILs.

Lawmakers and vested interests advocating wholesale legislative changes to indigenous policy in Brazil typically argue that many ILs are far too large for the small Indian populations they protect. This generalization, however, is dispelled when indigenous and non-indigenous population densities are compared inside and outside ILs (Fig. 2A). According to IBGE census data, human population density (HPD) inside 295 ILs (~50 % of the total) was higher than that in a 10-km buffer outside, and over half of these more densely settled territories ($n$ = 152) were in the Amazon, by far the most sparsely settled region of Brazil. Almost two thirds of all 210 Amazonian ILs ($n$ = 133) were surrounded by densely settled neighbourhoods, reflecting a relentlessly advancing agricultural frontier involving deforestation expansion over the last four decades. The historical occupation of the current Brazilian territory, initially by the European conquest and later by national mainstream societies occurred first across the Atlantic Forest, Caatinga and Pampa biomes, but only more recently and under greater law enforcement in the Amazon. This more recent historical occupation explain the large number of physically demarcated Amazonian ILs larger than 500,000 ha.

Within all major Brazilian biomes, overall indigenous population density was higher inside their ILs than were neighbouring non-indigenous populations immediately outside for up to the third quartile of ILs (Appendix B). Low population densities both inside and outside ILs prevailed in the Amazon and Cerrado biomes, but not in the Atlantic Forest and Caatinga biomes where indigenous population densities were much higher (Fig. 2A and Appendix B). Notably, only 35.4 % ($n$ = 208) of all 587 ILs contain population densities lower than 1 person.$km^{-2}$, including 169 Amazonian ILs. Traditional hunter-gatherer, semi-nomadic and horticulturalist societies worldwide can only subsist sustainably below this population density threshold (Tallavaara et al., 2018). Low population densities are therefore typically restricted to only the largest ILs, which also safeguard the most intact primary habitat as well as the largest and most culturally intact indigenous populations.

We found a significant positive relationship between indigenous population size and the size of the territories they occupy (GAM - $R^2_{adj}$ = 0.161, $p < 0.001$, $n$ = 465; Fig. 2B). Models containing vegetation biome as a covariate yielded similar results (GAM – $R^2_{adj}$ = 0.296, $p < 0.001$, $n$ = 460). Large indigenous populations (> 10,000) were only found in some of largest ILs (> 100,000 ha) of the Amazon. The only exception is the now severely overcrowded and relatively small Dourados Indigenous Land (3102 ha) located in the Atlantic Forest biome. Mean IL size ranged widely considering their variable demographic contexts both within and outside their boundaries. Mean size of ILs containing fewer than 1 person $km^{-2}$ was 357,280 ± 697,656 ha ($n$ = 78) where internal human population densities were higher than those outside, but much larger (804,523 ± 1,750,434 ha, $n$ = 90) when HPD outside was higher than that inside. Mean size of ILs above the 1 person $km^{-2}$ threshold was far smaller regardless of their external encroachment context ($HPD_{inside} > HPD_{outside}$, 17,341 ± 60,261 ha, $n$ = 217; $HPD_{inside} < HPD_{outside}$, 35,187 ± 87,758 ha, $n$ = 80).

Densely settled forest reserves can lead to environmental degradation and severe depletion of natural resources that are critical for local subsistence, such as game species, fisheries and non-timber forest products (Peres, 2011). Resource overexploitation, in turn, detrimentally affects indigenous peoples given that their cultural integrity and traditional livelihoods are inexorably tied to relatively undisturbed ecosystems containing sufficient amounts of natural capital (Cámara-Leret et al., 2019). We, therefore, assessed the land-cover status of all physically demarcated Brazilian ILs. Almost all ILs (~90 %) retained more native vegetation cover inside than areas immediately outside, 63 % of which ($n$ = 370) were located in either the Amazon or Cerrado biomes (Fig. 2C and Appendix C). Our results corroborate the general hypothesis that ILs are largely effective in either passively or proactively protecting natural vegetation cover. Considering all Brazilian biomes, the overall percentage of natural vegetation cover inside the vast majority of ILs was higher than that outside, particularly in the Atlantic Forest, Caatinga, Cerrado and Pampa biomes (Appendix C). Moreover, 51 % of all ILs ($n$ = 301) retained over 90 % of their original vegetation cover. Together, these territories secure a combined area 105,182,649 ha of high-quality native habitats for conservation, which represents 12.3 % of Brazil's national territory, and harbour ~54 % of all indigenous peoples living within ILs. Native vegetation cover was lower than 30 % in only 71 ILs, and these were primarily located in the Atlantic Forest biome ($n$ = 48). Mean HPD was only 4.5 ± 26.5 people $km^{-2}$ ($n$ = 258) in relatively intact ILs (i.e. > 90 % of natural vegetation cover) but was remarkably higher (235.9 ± 900.6 people

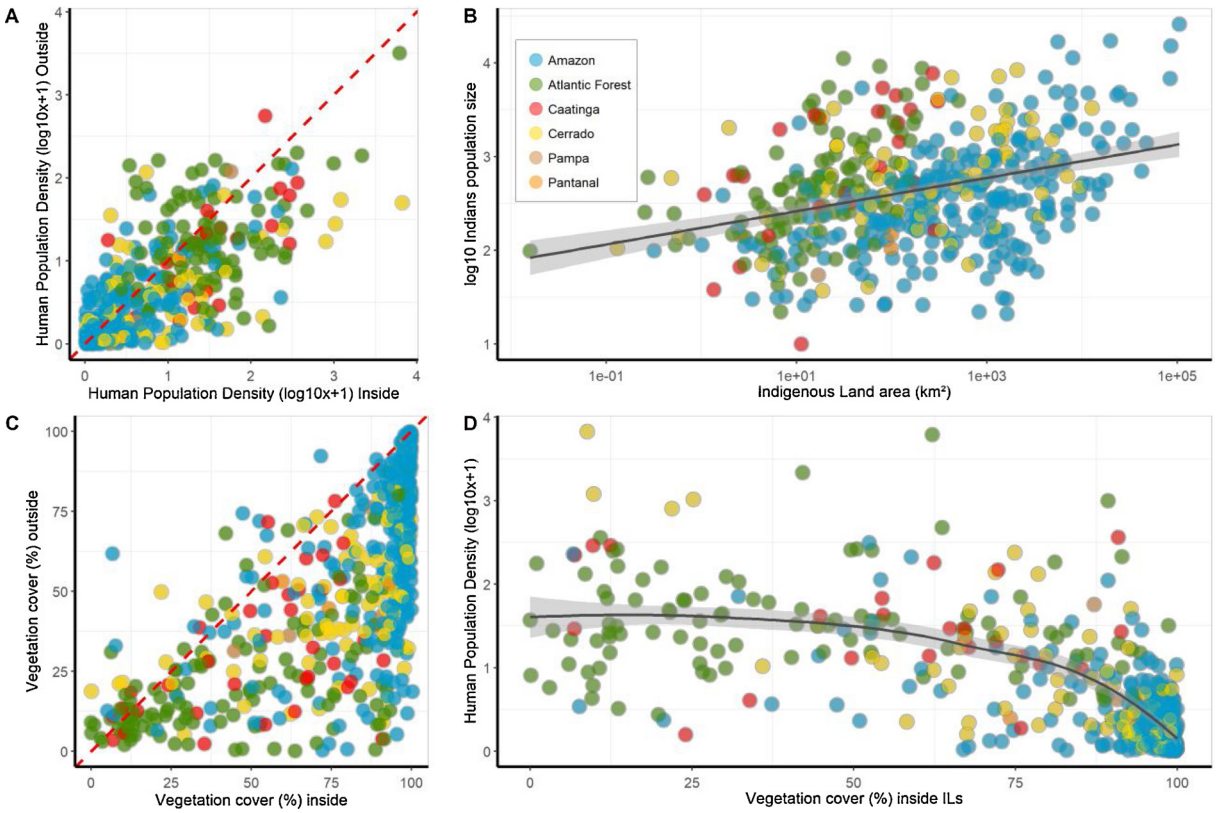


**Fig. 2.** Demographic and environmental context of Brazilian ILs. (*A*) Human population density is expressed as persons per km$^2$ either inside ILs or within a 10-km buffer area outside ILs. (*B*) Population size of indigenous peoples and total size (km$^2$) of ILs. (*C*) Percentage of natural vegetation cover retained inside and within the 10-km buffer area outside ILs. (*D*) Human population density and percentage of natural vegetation cover inside ILs. Colour-coding represents each of the six major Brazilian biomes (see legend in *B*).

km$^{-2}$, $n = 57$) in highly degraded ILs (i.e. $< 30$ % of natural vegetation cover). This clearly leads to a strong negative relationship between the amount of natural vegetation retained inside ILs and their indigenous population density (GAM $-R^2_{adj} = 0.512$, $p < 0.001$, $n = 465$; Fig. 2D), suggesting that only large, sparsely-settled ILs can continue to serve their long-term role in terms of environmental services. Adding vegetation biome and excluding only five ILs within the Pantanal and Pampa biomes yielded a slightly stronger model (GAM $-R^2_{adj} = 0.54$, $p < 0.001$, $n = 460$).

## 4. Discussion

Our results clearly show the critical importance of physically demarcating sufficiently large indigenous reserves to protect indigenous peoples against the ravages of rural enterprises induced by modern colonizing societies. This will continue to ensure both the long-term ethnocultural integrity of native Amerindians and the environmental viability of their territories, which as we argue here go hand in hand. On the other hand, ethnocultural integrity and environmental viability will become increasingly challenging without outside support in those small and increasingly overcrowded ILs, particularly in parts of the country dominated by an agricultural matrix. On the basis of differences in human population density within and outside ILs, we also show that the repeatedly made claim of "too much land for too few Indians" (Stocks, 2005), which is used as a justification against new IL demarcations, is blatantly false. Moreover, at least 280,000 people live in relatively intact territories that provide a myriad of local to global scale ecosystem services and protect high levels of biological diversity across all six major Brazilian biomes. This includes non-forest ecosystems such as savannahs, scrublands and prairies of the Cerrado, Caatinga, Pantanal and Pampa biomes whose protected area networks remains poorly developed (Overbeck et al., 2015). In contrast, large deforested areas that are only sparsely inhabited by non-indigenous people have increasingly common in the Brazilian Amazon, which contains nearly half of all ILs and the vast proportion of the total IL area (Tritsch and Le Tourneau, 2016), replicating the perverse effects of land concentration that is recurrent in other parts of Brazil (Lapola et al., 2014). Maintaining the current legal protection status and land use restrictions of ILs is therefore critical.

The last six 4-year presidential terms in Brazil have drastically reduced the total number of ILs that have either been Declared or Decreed (Fig. 3). Unfortunately, the legislative scenario under the current Bolsonaro presidential administration is even worse, and only invites more conflicts and further environmental degradation. The prospects for the current administration suggest that this political scenario is unlikely to be reversed, given that staunch pro-agribusiness parties have won most chairs in Brazilian Congress in the 2018 elections, strengthening the increasingly entrenched anti-environmentalist position of the president and his cabinet. He has repeatedly stated in the press and social media that there will not be new IL demarcations in his presidential term. Moreover, FUNAI has been severely underfunded for at least three presidential terms, thereby failing to fulfill its constitutional mission to protect and assist indigenous groups. This adverse political and institutional scenario has recently fueled attacks to FUNAI's assistance posts and caused several murders of Guajajara leaders in the state of Maranhão, and a failed ambush targeting Uru-Eu-Wau-Wau leaders in Rondônia.

Physical demarcation of ILs is a basic requirement to meet both national and international legislative targets regarding indigenous peoples land rights. IL demarcations have resulted in remarkably positive demographic dividends in which many indigenous peoples who had been on the brink of post-contact extinction subsequently

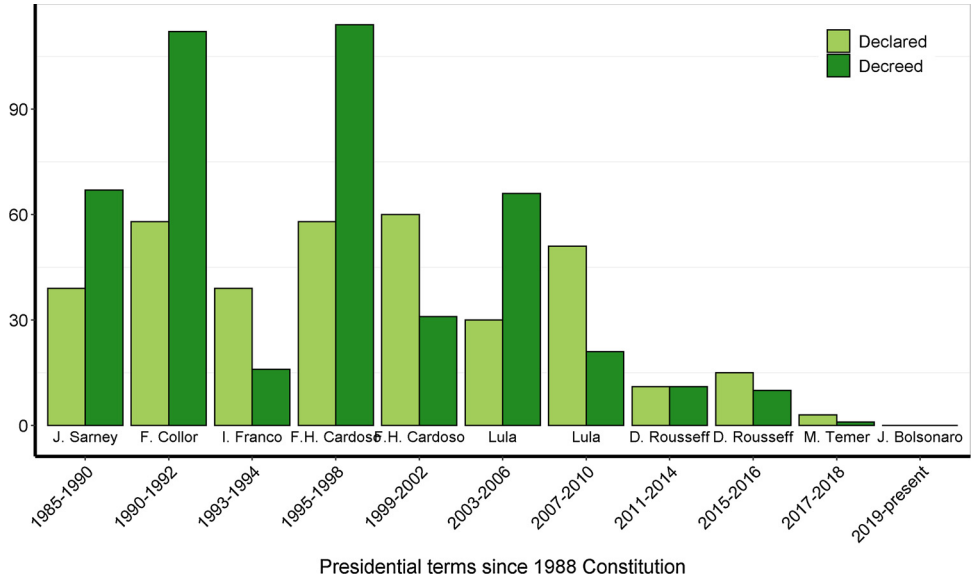


**Fig. 3.** The establishment of new ILs over a 33-year period of successive presidential administrations in Brazil. Officially declared (light green) and officially decreed (dark green) Indigenous Lands by all Brazilian presidents in office since the 1988 Constitutional Reform.
Adapted from Ricardo and Ricardo (2017) and ISA (2019a).

experienced dramatic population recoveries (Hamilton et al., 2014). However, physical demarcation of ILs alone has not been enough to protect these territories. Burgeoning environmental degradation within many ILs has been induced by deforestation frontier expansion in neighbouring areas (Nolte et al., 2013). As a result, high deforestation rates have been observed in the last few years even in sparsely populated ILs ($< 0.5$ people $km^{-2}$ – ISA, 2019b). Recurrent budget cuts and deliberate dismantling of FUNAI's administrative and operational structure have been the major obstacles for the consolidation of Brazilian ILs (Gullison and Hardner, 2018). Low territorial governance, poor management capacity and law enforcement, as well as stock depletion of high value timber species in the vicinities of ILs are the main drivers of this recent wave of deforestation. Major hydroelectric impoundments such as Belo Monte Dam on the Xingú River have also negatively impacted indigenous settlements within adjacent ILs, reducing the fisheries yields and fish diversity, undermining a significant source of animal protein (Jaichand and Sampaio, 2013; Fitzgerald et al., 2018).

Mining has been a key source of contentious land disputes detrimental to the cultural identity of indigenous peoples (Acuña, 2015). Deforestation induced by mines can be widespread outside their boundaries, and almost 10 % of all deforestation in the Brazilian Amazon between 2005 and 2015 has been attributed to mining activity (Sonter et al., 2017). Moreover, water contamination by ore tailings and the collapse of aquatic ecosystems due to mud leaks also threaten the subsistence of several indigenous peoples. This includes the Krenak and Pataxó peoples, whose traditional fishing practices have been severely affected by major toxic mud spills from iron ore tailings of the Mariana and Brumadinho dams in the state of Minas Gerais, and the Xikrin people in the state of Pará were affected by toxic waste from a nickel mine. Despite clear evidence of the environmental impacts and risks involving mining operations, the federal government and a large fraction of the National Congress are willing to open up ILs to virtually all forms of the economic exploitation. Mining has occurred within ILs, particularly in Yanomami, Cintas Larga and Munduruku territories. In the latter two cases, illegal diamond and gold miners, respectively, have worked within ILs often in partnership with some Indian residents. This complicity, which is often tempted by promises of high profits from mining, frequently results in violent incidents to the detriment of resident Indians. Current legislation foresees that mining activities inside ILs must be authorized by Congress with the explicit consent of indigenous peoples who would be directly affected. However, such licensing procedure still lacks a regulatory law.

Although there may be economic gains from mining-related income and royalty revenues, these are often concentrated in the immediate vicinities of mines (5 km), and the environmental impacts on the health of indigenous settlements result in escalating demands for expensive medical care (Von der Goltz et al., 2019). Oil and gas exploration in Peru and Ecuador has directly affected several indigenous groups by introducing infectious diseases and rampant forest degradation (Napolitano, 2007; Finer et al., 2008). Mortality and morbidity rates from diseases for native Ecuadorians are 30 % and 60 % higher, respectively, than for the non-indigenous population (Pan et al., 2010). Malaria introductions by illegal gold miners have severely affected even isolated indigenous settlements within the Yanomami Indigenous Land, along the Brazil-Venezuela border (Cabral et al., 2010). The influx of cash into indigenous settlements from extractive industries has also motivated concerns. This typically leads to deterioration in social and health conditions, increased violence, suicides and alcohol and narcotic abuse (Horowitz et al., 2018). The negative impacts of mining activities inside ILs will therefore most likely exceed any intended benefits. Reconciling appropriate legislation on both mining claims and indigenous land tenure will therefore be critical in the interest of indigenous peoples and environmental protection. In any cases, indigenous peoples should be properly informed a priori and summoned to express their worldviews in the interest of minimizing potential conflicts (Hilson, 2002).

A whole suite of proposed legislative changes favouring legal permission for commercial agricultural use within ILs by non-indigenous people also raises serious concerns. Over the last two decades, mechanized agriculture such as soybean and maize become widespread within ILs. According to estimates by FUNAI, 3.1 million hectares of IL land are being leased to mechanized farming and cattle ranching by non-indigenous people, and these operations have been directly managed by Indians residents in at least 22 ILs throughout Brazil (Borges, 2018). This is targeted to demarcated ILs where natural vegetation has been completely or partially converted into agriculture decades ago. Consequently, these ILs have already become increasingly isolated within a dominant agricultural matrix. Overall local scarcity of agricultural land, high land prices, improvements in road infrastructure,

and access to urban and industrial facilities all militate to render undeveloped lands within existing ILs highly desirable to farmers, thereby further fuelling political lobbies to weaken the legal protection of ILs. Leasing IL acreage to non-indigenous enterprises is therefore at best questionable, if not objectionable on various legal grounds. Firstly, the Brazilian Constitution prohibits any land use within ILs by non-indigenous stakeholders. Secondly, use of public lands by private interests without any form of compensation is at least ethically unfair considering the reality of millions of landless Brazilians. On the other hand, some indigenous groups have shown interest in developing commercial croplands and livestock operations within their ILs. For this reason, federal prosecutors, FUNAI, the Brazilian Environmental Protection Institute (IBAMA) and four ethnic groups (Haliti, Nambikwara, Manoki, and Paresi) of the of Mato Grosso have signed a Mutual Adjustment Agreement (Portuguese acronym, TAC) under the following terms: i) total exclusion of non-indigenous peoples from agricultural activities, except for technical support; ii) respect for the collective consensus in terms of land use within indigenous territories; iii) banning the expansion of commercial cropland areas and the use of genetically modified cultivars; and iv) full distribution of crop yields across all group members, including those not engaged in commercial agriculture. FUNAI is responsible for overseeing the terms of agreement and provide further assistance in terms of access to financial and technical support.

Given this context, the currently severe underfunding and understaffing of FUNAI, leading to widespread failure to perform its key role, it is at least concerning. The Indigenous aspiration to become integrated into market economy may be legitimate, provided local decisions are not influenced by external stakeholders. The potentially widespread environmental degradation due to conversion of natural vegetation into pastures and cropland will almost certainly increase economic dependence and trigger an irreversible negative spiral that may lead to disintegration of indigenous traditional livelihoods and their cultural identity. Again, there should be suitable preliminary and regular consultations with potentially affected indigenous peoples, including safeguards for their veto decisions. In any case, growing demand for agricultural lands and food production over the next decades can be supplied by management practices that enhance crop yields and livestock production in millions of hectares of anthropogenic pastures in the Amazon and Cerrado biomes outside ILs (Martinelli et al., 2010; Strassburg et al., 2014).

The current discontinuity of executive decrees creating new ILs has been disastrous for several indigenous groups. In the state of Mato Grosso do Sul, the Guarani-Kaiowás and Guarani-Nandeva who had been evicted from their lands in the 1940s, currently live in humiliating conditions under extreme poverty, awaiting the unlikely demarcation of their land claims. Consequently, they have succumbed to far greater suicide rates than the national average, affecting mainly adolescents and young adults (Coloma et al., 2006; Orellana et al., 2016). This high prevalence of suicides in indigenous youth, particularly aged 15–24 years old, is often related to misrecognition of their collective land rights, and poor education and health care (Pollock et al., 2018). These abysmal conditions are leading to cultural disintegration and undermining the traditional livelihoods of all indigenous peoples who still lack territorial demarcation. Clearly, land disputes are the primary motivation for the non-recognition of indigenous peoples' land rights in Brazil, and this plight extends to several unique ethnic groups across the country. Moreover, ongoing institutional neglect and ethnic-biased persecution can often be characterized as cultural genocide (Kingston, 2015). In this context, the Supreme Court interpretation of the "1988 deadline" is both ethically and legally questionable, and we strongly recommend this should not to be confirmed.

Considering all current threats, the long-term demographic and cultural survival of many indigenous peoples in Brazil remain at best uncertain even within previously demarcated ILs, and virtually unattainable outside them. In most respects, repeated contact and social interactions with Brazilian hegemonic society have brought many more problems than solutions. The lure of market integration, has resulted in atrocious health conditions, including stunting and malnourishment in indigenous children, obesity and escalating incidence of chronic diseases (e.g. hypertension and diabetes) in adults (Coimbra et al., 2013; Horta et al., 2013). Even in highly developed countries, socioeconomic disparities between non-indigenous and indigenous peoples still persist, with the latter characterized by poor health care, high unemployment rates, low average schooling and short life expectancy (Cooke et al., 2007). Outside ILs, hegemonic Brazilian society still maintains a strong stereotyped view about Indians as a broad ethnic group, even those who have become fully integrated into urban life but still retained a collective indigenous identity (Maher and Cavalcanti, 2019). Yet native Amerindians should hold the prerogative of settling in urban areas, if they wish to do so, but while maintaining their indigenous identities. We further argue that the independent subsistence and sustainable use of officially recognized ILs by their indigenous residents remain more critical than ever in upholding their collective identity and traditional livelihoods.

The enormous negative impacts of hegemonic societies —induced by timber extraction, mining and agricultural development—, are also associated with language extinction risk worldwide (Amano et al., 2014). Loss of long-accumulated traditional knowledge on a wealth of tropical biodiversity, including the use of therapeutic and food plants, is coupled with language decline, thereby reducing the adaptation capacity of indigenous societies (Cámara-Leret et al., 2019). The largest documented losses in traditional knowledge are associated with indigenous groups who are most exposed to adverse socio-economic conditions (Reyes-García et al., 2005; Saynes-Vásquez et al., 2013). Given the interdependence between ethnocultural identity and territorial rights, cultural decline will likely lead to increasing environmental degradation. Therefore, ILs remain the most effective legal and institutional instrument to protect indigenous peoples as legitimate guardians of natural ecosystems and a wealth of ethnocultural diversity. Although the long-term outcomes are still uncertain, commercial agriculture and livestock within ILs must be managed in light of the self-determination of indigenous peoples, connecting traditional knowledge with modern forms of sustainable agriculture.

## 5. Conclusion

Indigenous land rights embrace a set of basic assurances enshrined by both national and international policy, such as access to food, clean water, individual and collective identity and self-determination. Traditional indigenous knowledge, beyond its intrinsic importance, is crucial for the conservation of biodiversity and natural ecosystem services that are directly or indirectly protected by indigenous territories. Strengthening the *de jure* and *de facto* protection status of ILs is therefore more critical than ever if Brazil is to meet its ratified international commitments to protect native biodiversity and mitigate climate change. A large body of evidence points to the highly detrimental impacts of downgrading the current protection status of ILs, whose legislative basis has been hard-won over a long history of political struggles by both Brazilian civil society and indigenous peoples. We hope that Brazil's current and future executive administrations and National Congress will explicitly consider both indigenous welfare and the multiple irreplaceable environmental benefits flowing from ILs, rather than continue to support haphazard frontier expansion and short term revenue from highly degrading predatory land use.

## Authors contribution

R.A.B. and C.A.P. shared all tasks of data compilation, data analysis and writing the manuscript.

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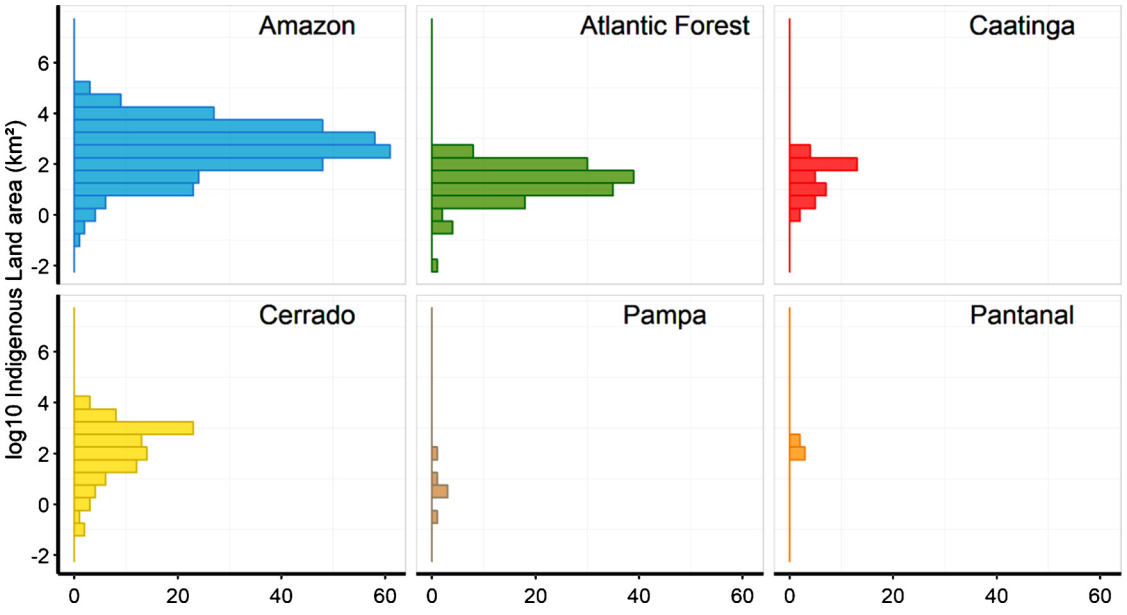
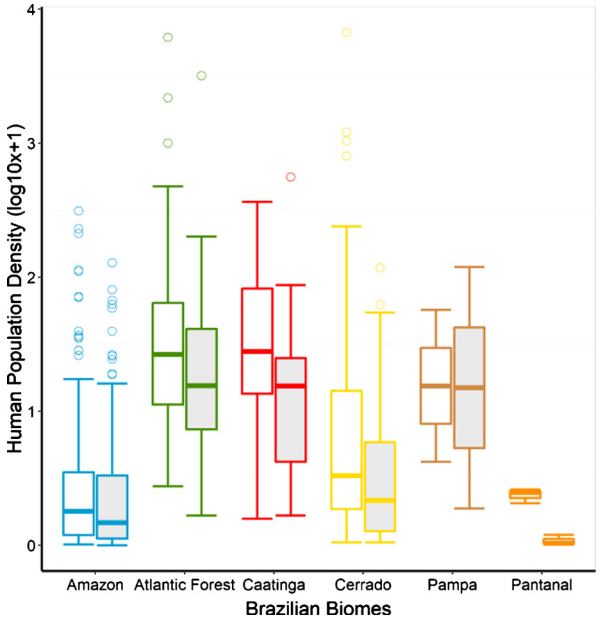
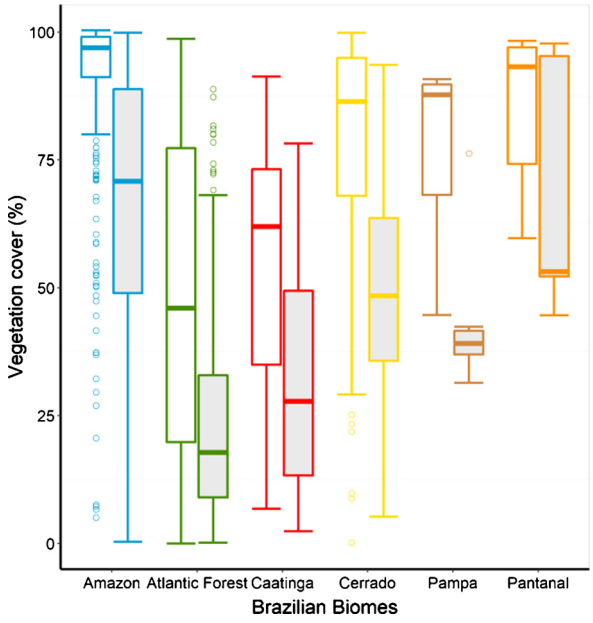
**Appendix A. Number and size distribution of Indigenous Lands (ILs) for each the six major Brazilian biomes**




**Appendix B. Human population density (persons. km$^{-2}$) both inside (white) and outside (light grey) Indigenous Lands (ILs) are grouped into the six major Brazilian biomes**



## Appendix C. Percentage of natural vegetation cover remaining either inside (white boxes) or outside (light grey boxes) Indigenous Lands grouped into the six major Brazilian biomes




## Appendix D. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.landusepol.2020.104694.

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