The sustainability of indigenous lands in Amapá state

A sustentabilidade das terras indígenas no estado do Amapá

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ABSTRACT
We herein assess population growth in indigenous lands (ILs) Wajãpi, Uaçá, Galibi and Juminã in Amapá State-Brazil, which has influenced deforestation increase. We assumed the hypothesis of no association between demographic density and deforestation because population density in these areas is low. We used population growth, deaths, and deforestation data by considering a historical series (2002-2018). Demographic data have shown that Uaçá and Wajãpi ILs recorded the highest population growth. The highest demographic density was observed for Galibi ILs and the lowest one for Wajãpi ILs. The highest deforestation was observed for Uaçá ILs and the lowest one for Juminã ILs. Therefore, indigenous lands in Amapá State have an essential role in forest conservation.

Keywords: Indigenous populations. Population growth. Population density.

RESUMO
Avaliamos se o crescimento populacional nas terras indígenas (TIs) Wajãpi, Uaçá, Galibi e Juminã do estado do Amapá/Brasil influenciou o aumento do desmatamento. Nossa hipótese é que não há relação entre densidade demográfica e desmatamento, pois a densidade populacional nessas áreas é baixa. Utilizamos o crescimento populacional, o número de óbitos e os dados de desmatamento

levando em conta uma série histórica (2002-2018). Dados demográficos mostraram que as TIs Uaçá e Wajãpi registraram o maior crescimento populacional. A maior densidade demográfica foi observada na TI Galibi e a mais baixa na TI Wajãpi. O maior desmatamento ocorreu na TI Uaçá e o menor ocorreu na TI Juminã. As estimativas de desmatamento até 2028 confirmaram que a TI Uaçá terá baixo desmatamento. Portanto, as terras indígenas no estado do Amapá têm relevante papel para a conservação da floresta.

Palavras-chave: *Populações indígenas. Crescimento populacional. Densidade demográfica.*

1 INTRODUCTION

The uncontrolled anthropic interference in the environment has led to vast and irreversible biodiversity losses worldwide (CEBALLOS *et al*., 2017). For example, estimates have shown that only 32% of forests globally are primary, and 35% were turned into agricultural land (KORMOS *et al*., 2017). Therefore, one of the main anthropic interferences in the biosphere is caused by deforestation (RUDDIMAN, 2013).

Deforestation in the Amazonian rainforest, which is the most extensive tropical forest in the world, accounts for considerable biodiversity losses (GIBSON *et al*., 2011; GROSS, 2016) because several fauna and flora species that remain non-catalogued are lost every time a forest coverage is removed, be it due to cutting or burns, for agricultural or road construction purposes. Thus, the anthropic pressure resulting from population growth and demographic density has been preceding deforestation and, consequently, the pressure over non-renewable natural resources - such a process changes the balance and dynamics of natural processes (OLIVEIRA *et al*., 2015). Demographic factors are some of the main deforestation causes in tropical regions (GEIST; LAMBIM, 2001). They are not significantly different from those observed in the temperate areas some centuries ago (ARRAES *et al*., 2012). Tropical deforestation has been growing since the 1970s; therefore, it has become a world concern (ARAGÃO *et al*., 2014; RUDEL, 2007).

The Brazilian Legal Amazon has been suffering from substantial occupation pressure, as well as from agricultural expansion and climate changes (LOVEJOY; NOBRE, 2018) that, altogether, reduce soil fertility, cause erosion, change local and global water regimes and increase greenhouse gas emissions (FEARNSIDE, 2005; LAURANCE *et al*., 2004; NOBRE *et al*., 1991). Consequently, this process threatens biodiversity conservation (MALHI *et al*., 2008). Furthermore, climatic changes caused by uncontrolled deforestation can increase temperatures and become an irreversible hazard to the planet (ARAGÃO *et al*., 2018; FEARNSIDE, 2006; HEGERL *et al*., 2006).

There was a significant drop in the deforestation rates between 2004 and 2012 in the herein assessed region due to the public policies adopted; however, from May 2013 onwards, deforestation returned to considerable growth levels. In 2016, approximately 8,000 km^2 (19%) of the forest was destroyed, and in 2018 this number was close to 800,000 km^2. Pará state stood out for the highest deforestation rate in the Northern Region (34% of the total), based on the increase in deforestation rates in the Legal Amazon (PRODES, 2018).

The reasons presented to justify the decline in deforestation in Brazil between 2004 (it reached 27.7 thousand km^2) and 2012 (it dropped to 4.4 thousand km^2) were: the public policies adopted at that time, the actions taken by civil society and the economic policies adopted by the Brazilian Government (ARAGÃO *et al*., 2018), such as the implementation of the Action Plan for the Prevention and Control of Deforestation in the Amazon (APPCDAm), back in 2004, as well as the creation and maintenance of protected areas (PAs).

This scenario has changed in the last few years, and deforestation started growing again, mainly after the approval of the new Forest Code (law 12.651, 2012) (ASSUNÇÃO *et al*., 2012), which provides flexible rules in comparison to the law enacted in 1965. This change represented a challenge for the national government (KROGER, 2017).

Brazil faces balancing agricultural production growth and environmental protection sites (GIL *et al.*, 2015). The ability to meet the food, fuel and energy markets' demands for the decades to come has been a reason of concern in the country since it must take into account the need for such an agriculture and livestock production expansion without threatening environmental protection sites since Brazil is one of the largest world producers of these commodities (NEPSTAD *et al.*, 2009).

The creation of PAs was one of the most effective policies to ensure biodiversity conservation worldwide (STOLTON; DUDLEY, 2010; WATSON *et al.*, 2014); it became an essential strategy to reduce deforestation. As a result, their surface in the Brazilian Amazon has doubled between 2000 and 2009. Back in 2019, it reached 2,000,000 km^2, which forced the deforestation rates down (PEREIRA *et al.*, 2019).

Indigenous lands (ILs) are among the PAs, mainly contributing to reducing deforestation. However, the inhibiting effect exerted by ILs on Amazonian deforestation can also be observed if one considers the deforested area in the region. Up to 2014, almost 20% of the forest area in the Brazilian Amazon was deforested, but it was lower than 2% in ILs, a fact that proves their reduction effect on deforestation (CRISOSTOMO *et al.*, 2015).

Indigenous peoples have been the guardians of the most extensive tropical forest on the planet for thousands of years (RICKETTS *et al.*, 2010; WALKER *et al.*, 2020). They have occupied the Amazon based on environmental management practices and strategies (WATLING *et al.*, 2017), such as the domestication of plants and animals (LEVIS *et al.*, 2017) and soil changes through controlled fire (SCHMIDT *et al.*, 2014). Such practices led to improvements in the local landscape and better heterogeneity between forest species, mainly among the rare ones. They also avoided the accumulation of combustible material (leaves, branches and the trunks of dead trees) that could cause a natural wildfire. As a result, these peoples have been making significant contributions to the Amazonian biodiversity from the pre-Colombian era to present times (FRANCO-MORAES *et al.*, 2019; POSEY, 1985).

These people also set relationships with the environment beyond the simple extraction of resources (RAMOS, 1995). Indians protect biodiversity, the right to land and subsistence by valuing their traditional ways of life (MARETTI *et al.*, 2014). Therefore, they have played a fundamental role in biodiversity formation in South America. Several plant species, such as Brazil-nut, cocoa and cassava, and many animal species, have emerged as a product from such an interaction; they formed forest management based on traditional modes. This process accounted for the biological conservation and diversity of ecosystems (BATISTA *et al.*, 2020). Land use practices are different depending on the traditional knowledge of these peoples, which is combined with their traditional ways of life and the modern perspective about sustainable land use (STEVENS *et al.*, 2014; TAULI-CORPUZ *et al.*, 2018).

Based on estimates, these people encompass 1.7 million individuals who are distributed into 375 indigenous groups living in 3,344 indigenous territories countrywide and the biogeographic limits of the Amazon. These ILs, in Brazil cover 721 sites and occupy 13.8% of the national territory (1,174,263 km^2) (ISA, 2019). Most of them are in the Legal Amazon, which holds 115.3 million hectares (Mha) distributed into 414 traditionally occupied ILs (FANY *et al.*, 2015). Thus, ILs represent approximately 23% of the Amazonian Territory; they are in well-conserved forests within a mosaic of PAs covering the Amazonian territory (COSTA, 2019).

Amapá state, Northern Brazil, stands out for its biodiversity; it holds a diversified combination of ecosystems (MUSTIN *et al.*, 2017). Furthermore, it is the most protected state in Brazil, given its historical isolation and several PAs in it (PERES *et al*., 2014). The federal and state governments were quite active in defining the PAs and the indigenous lands that covered 72% of the state (CUNHA *et al*., 2019). As a result, Amapá counts on 19 PAs, 12 of them are managed by the Federal government; 5 by the State government and 2 are managed by local governments (BRITO, 2008) – the state also holds 5 indigenous lands, namely: Wajãpi, Uaçá, Galibi, Juminã and Tumucumaque Mountains National Park.

ILs in Amapá state account for 9,635 individuals spread into indigenous villages; they also conserve more than 11,256.71 km^2 of forests. These peoples are ethnically different and have different costumes, garments, economic models and agriculture; however, they are similar in the struggle for their rights and sustainability concerns. Furthermore, these people got together to protect their territory, and all ILs were demarked back in the 1970s and approved in the 1990s (GALLOIS; GRUPIONI, 2003). Accordingly, the present study aimed to test the hypothesis that the indigenous population has grown but that it did not lead to deforestation increase in their lands since the sustainability of these sites is ensured by how these peoples manage them.

2 MATERIALS AND METHODS

2.1 STUDY SITE

The study was carried out in four ILs in Amapá state (Figure 1), Northern Brazil. The following ethnicities live in them: Wajãpi, Uaçá, Galibi and Juminã.

Wajãpi IL (Figure 1a) is located in Pedra Branca do Amapari and Laranjal do Jari counties, Midwestern Amapá state. It holds approximately 1,500 people within a demarked area of about 607,000 ha (APINA; AWATAC; IEPÉ, 2017). Wajãpi IL borders with Pas in Tumucumaque Mountains National Park, Iratapuru River Sustainable Development Reserve, Amapá State Forest, Beija-Flor Brilho de Fogo Extractivist Reserve and Perimetral Norte settlement Project at BR-210 (MORENO *et al*., 2018).

Uaçá, Galibi and Juminã Ils are located in Northern Amapá state (Figure 1b); they are known as the “Low Oiapoque Indigenous Peoples” (SANTOS; SANTOS, 2017). The population in these three Ils accounts for 8,109 individuals: 7,659 in Uaçá, 164 in Galibi and 286 in Juminã – divided into more than 50 indigenous villages (DSEI, 2019). These Ils are demarked within a huge continuous area covering 518,654 ha: Uaçá – 470,164 ha, Galibi – 6,889 ha and Juminã – 41,601 ha (SANTOS; SANTOS, 2017); they are crossed to the West by BR-156. Juminã and Galibi Ils border with the French Guiana to the North of Amapá state. Uaçá IL borders with Cabo Orange National Park to its West (TASSINARI, 2003; VIDAL, 2013).

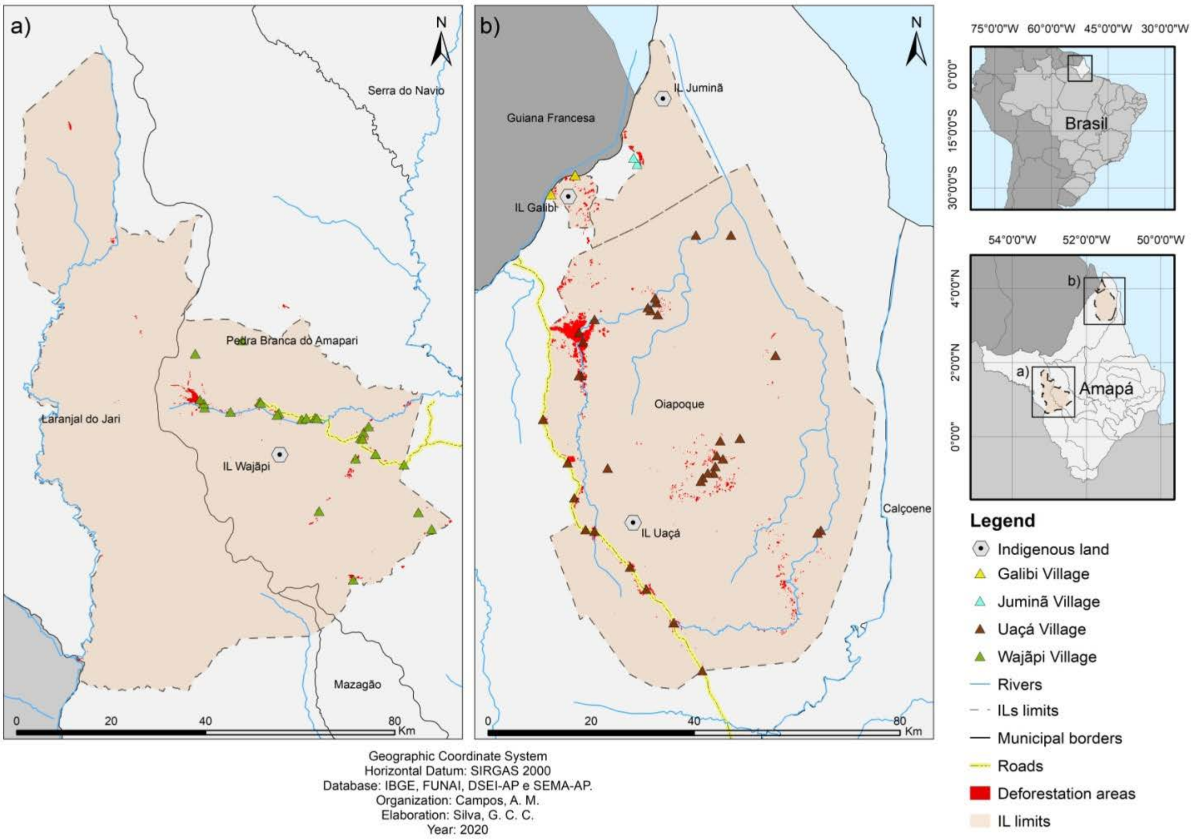

Figure 1 | Ils in Amapá state: a) Wajãpi and b) Ils Oiapoque, Uaçá, Galibi and Juminã.

Source: Authors.

2.2 DATA COLLECTION

The Ethics Committee approved the research of Unifap (CAEE 10800919.0.0000.0003). It used secondary data on these Ils: population growth (made available by the Special Indigenous Sanitary District of Amapá/DSEI-AP), birth and death data, and deforestation data (made available by the Environment State Secretariat/Sema-AP). Data regard a 2002-2018 historical series.

Deforestation data were collected through remote sensing by the LANDSAT 5 satellite – data were made available by the National Institute of Spatial Research (INPE, 2013). In addition, shapes used to quantify deforestation areas were made public by Sema. However, although the quantification of Amazonian deforestation is carried out by Inpe, through the Amazonian Deforestation Estimation Project, also known as Prodes, Amapá state is not satisfactorily assessed due to its high nebulosity throughout the year (SEMA-AP, 2014) – this climatic feature made it impossible getting good-quality satellite images. Therefore, the analysis of the images was carried out in November when skies were clearer in the Northern Region.

Sema works with original image parameters, 30x30m pixels since they allow mapping smaller areas: approximately 0.1 ha. We have adopted deforestation concepts, such as that of clear-cutting, which is used by Inpe/Prodes and is featured by the total removal of the forest cover within a short period: larger than 6.25 ha of cutting in primary forest (INPE, 2013). Often, a clear-cutting is carried out to allow the planting of another culture, be it agricultural or forest crop; the so-called "conversion" (FAO, 1989; FLOR, 1985).

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2.3 STATISTICAL ANALYSIS

Population growth and Ils' deforestation data in Amapá state were organised in Microsoft Excel 2007® spreadsheets and, subsequently, assessed for data normality based on the Shapiro-Wilk method carried out in Rstudio® application Version 1.0.153. After data normality was found, Pearson's correlation coefficient ® was applied to measure the degree of relationship among variables, which was confirmed through linear regression (r^2) adopted to assess data quadratic residue. The tests were performed in the RStudio® application Version 1.0.153. Thus, the study universe was equivalent to the total of areas recording 100% data reliability degree. Deforestation shapes were analysed in Microsoft Excel 2007® and QGIS 3.10® software.

Data tabulation allowed observing the lack of deforestation data due to technical issues caused by clouds over indigenous lands throughout the year (Sema information). However, the value accumulated from one year to the other, and it is known that the deforested areas were accounted for in the previous year, but that they were not in the following one. Accordingly, the linear interpolation of the missing data was carried out only to estimate and measure demographic density. The linear interpolation method was based on superior and inferior register data. The adopted criterion to find X (empty fields) between a and b values (fields with data) was $\{x \in R \mid a < x < b\}$, by using the line formation law f(x) = ax + b (ARENALES; DAREZZO, 2008; RIBEIRO, 2014).

Equation 1 was used to find the demographic density, wherein d is density, A is the total demarked area in Km², and n is the total number of inhabitants per year.

$$d = \frac{A}{n} hab/Km^2 \qquad (1)$$

Deforestation value was calculated through the linear function adjusted by the minimum quadratic method, based on population growth and deforestation data, by following criteria in the following equations. It was done to model ILs' deforestation by 2028.

Line formation law f(x) = ax + b generated from tabulated and interpolated data; wherein the **a** value is found through equation 2a, and the **b** value is calculated through equation 2b:

$$a = \frac{(n.\sum xy) - (\sum x.\sum y)}{(n.\sum x^2) - (\sum x)^2} \qquad (2a)$$

$$b = \frac{(\sum x.\sum xy) - (\sum y.\sum x^2)}{(\sum x)^2 - (n.\sum x^2)} \qquad (2b)$$

The linear regression analysis of variables 'population growth' and 'deforestation' was not carried out due to the lack of deforestation data of ILs' Galibi and Juminã, at some periods. The missing data were not interpolated for greater reliability purposes. Instead, the analysis of the variables was applied to Uaçá and Wajãpi ILs, which presented lesser missing data.

3 RESULTS

3.1 DEMOGRAPHY

The indigenous population in Amapá state increased by more than 50% from 2002 to 2018, considering the number of deaths within the same period. Uaçá IL doubled its population by more than 4,000 inhabitants (56%), despite the high annual average of 15 deaths. Juminã IL recorded population growth of 40% and a mean annual average of 1 death. Galibi IL showed the lowest population growth (23%) due to its mean annual average of 2 deaths. In contrast, Wajãpi IL recorded a population growth of 57% - it was also the second IL recording the highest average of annual deaths (6/year, on average) (Figure 2).

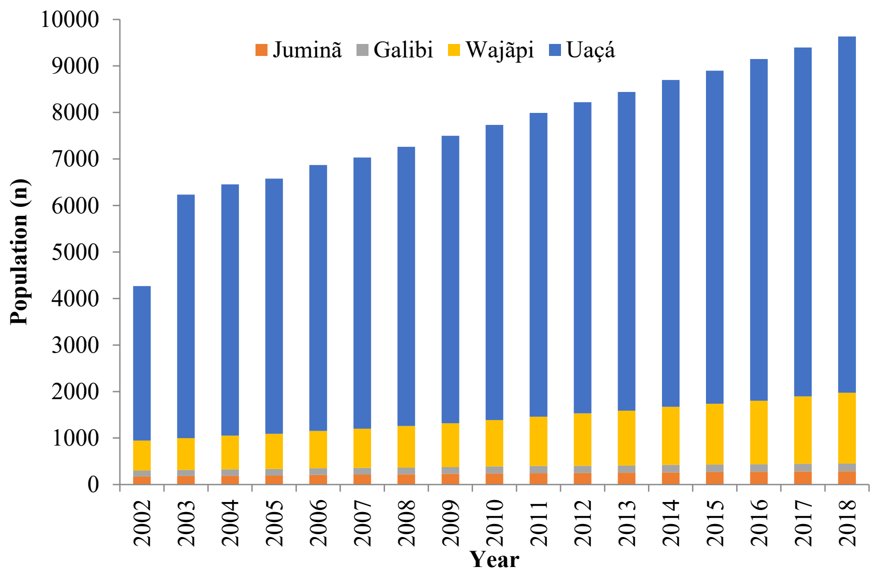

Figure 2 | Annual comparison of population growth in ILs in Amapá state.

Source: Authors.

Demographic density (Table 1) in the ILs was low. The highest mean demographic density was 2.1 inhab/km2, which was recorded for Galibi, IL. This village was followed by Uaçá (1.51 inhab/km2), Juminã (0.56 inhab/km2) and Wajãpi (0.17 inhab/km2). Wajãpi IL recorded the lowest demographic density in 2002 (0.11 inhab/km2) and the highest in 2018 (0.25 inhab/km2). The highest density was recorded for Galibi IL (2.38 inhab/km2) in 2018. Considering data from the 2010 IBGE census, demographic density in Oiapoque County was 0.91 inhab/km2, in Laranjal do Jari County, it was 1.29 inhab/km2, and in Pedra Branca do Amapari, it was 1.29 inhab/km2. Thus, in this same year, Galibi IL presented data higher than that recorded for Oiapoque density. In contrast, Wajãpi IL showed data lower than the density recorded for the Laranjal do Jari and Pedra Branca do Amapari counties.

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Table 1 | Comparison of annual demographic density of ILs in Amapá state.

	(inhab/Km²)			
Year	*Juminã*	*Galibi*	*Wajãpi*	*Uaçá*
2002	0.42	1.83	0.11	0.71
2003	0.44	1.92	0.11	1.11
2004	0.46	1.97	0.12	1.15
2005	0.47	2.02	0.13	1.17
2006	0.50	2.06	0.13	1.22
2007	0.52	2.08	0.14	1.24
2008	0.53	2.12	0.15	1.28
2009	0.55	2.13	0.16	1.31
2010	0.58	2.18	0.16	1.35
2011	0.59	2.24	0.18	1.39
2012	0.60	2.25	0.19	1.42
2013	0.61	2.28	0.19	1.46
2014	0.63	2.34	0.21	1.49
2015	0.65	2.34	0.22	1.52
2016	0.66	2.37	0.22	1.56
2017	0.68	2.40	0.24	1.60
2018	0.69	2.38	0.25	1.63

Data on blue were interpolated.

Source: Authors.

3.2 DEFORESTATION

Deforestation accumulated up to 2002 in Wajãpi IL reached 482 ha (Figure 3a). Uaçá IL presented the highest accumulated deforestation (2,793 ha), which was followed by Galibi IL (351 ha), and by Juminã IL, which recorded the lowest accumulated deforestation (120 ha) (Figure 3b).

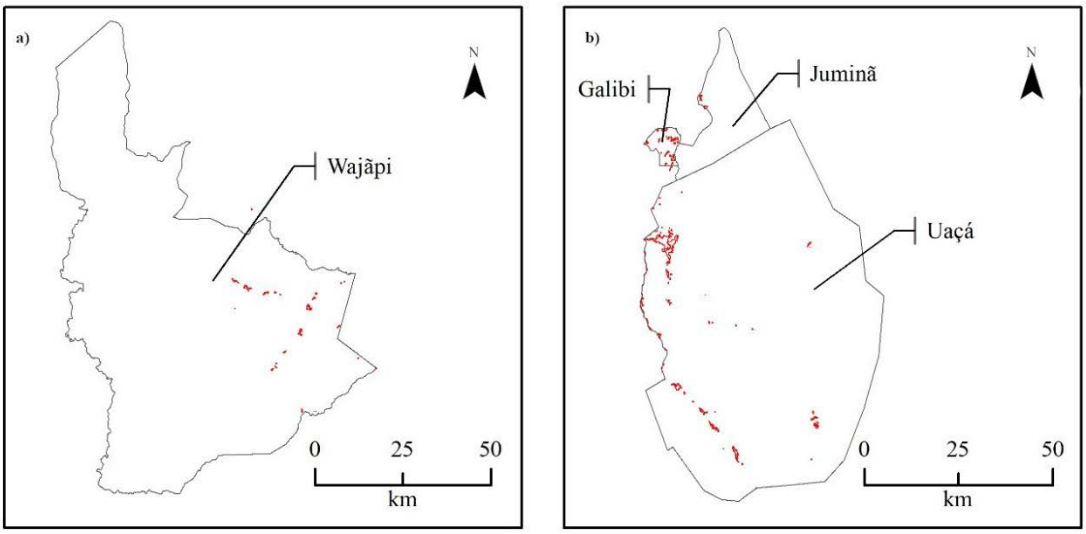

Figure 3 | Accumulated deforestation up to 2002 in ILs: a) Wajãpi IL, b) Oiapoque ILs.
Source: Authors.

Accumulated deforestation up to 2018 at Wajãpi IL (Figure 4a) reached 2,312 ha; it was 7,883 ha in Uaçá, 560 ha in Galibi and 363 ha in Juminã (Figure 4b).

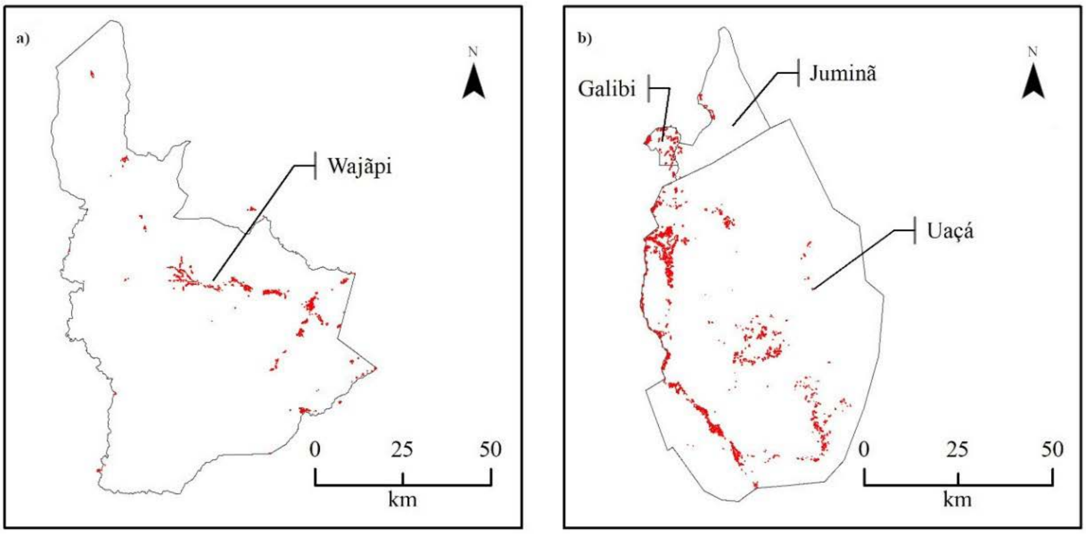

Figure 4 | Accumulated deforestation up to 2002 in ILs: a) Wajãpi IL, b) Oiapoque ILs.

Source: Authors.

In 2002, the four ILs recorded land use peaks (Figure 5). Deforestation ranged from low to high values at Wajãpi IL: 474 ha (2002), 39 ha (2005), 537 ha (2012), 154 ha (2015). Uaçá recorded high values of it: 615 ha (2008), 1,067 ha (2012), 956 ha (2018). On the other hand, the numbers recorded for Galibi IL have decreased: 104 ha (2002), 89 ha (2004), 19 ha (2014), 22 ha (2018). Finally, Juminã, despite the strong correlation among variables, presented low values for land use: 40 ha (2002), 12 ha (2006); but there was an increase by 148 ha in 2018.

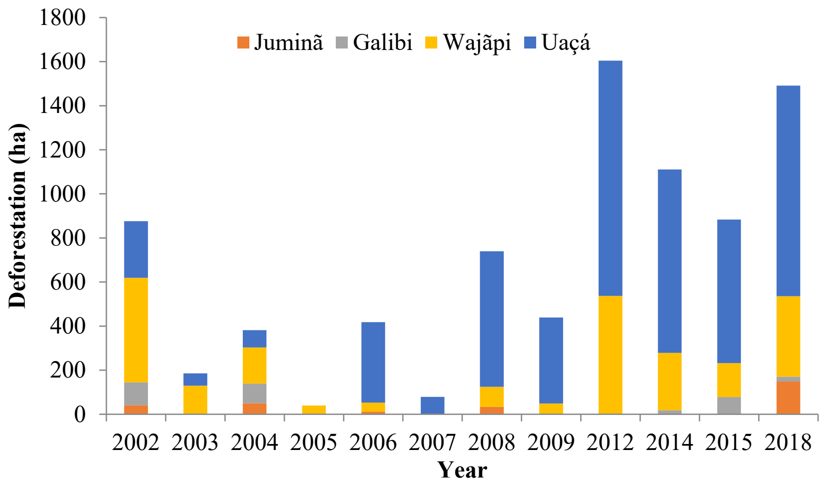

Figure 5 | Comparison of deforestation in ha of ILs in Amapá State – from 2002 to 2018.

Source: Authors.

Mean deforestation in the ILs ranged from 16.69 ha (Juminã) to 314.54 ha (Uaçá). However, within 18 years, Galibi used approximately 10% of its total territory (6,889 ha), and Wajãpi did not reach 1% (607,017 ha) of it, even if one considers the accumulated deforestation in 1999 and the interpolated data.

Although Uaçá is the second-largest IL in territorial extension (470.16 ha), it was also the first one in population growth, approximately 7,000 inhabitants, and the first one in deforestation. Uaçá used 2% of its total land up to 2018 (accumulated and interpolated deforestation).

Based on the statistical Shapiro-Wilk test, Wajãpi recorded P-value = 0.23 for variable "population" and P = 0.06 for "deforestation", both at P > 0.05; this finding proved data normality. Based on this IL, the linear regression pointed out that less than 1% of the population (r2 = 0.096) explains the observed deforestation. This result justifies the absence of other analyses and estimates for population and deforestation by 2028. Uaçá presented P = 0.44 for population and P = 0.33 for deforestation, both at P > 0.05. Uaçá data were also normal, and their linear regression showed that approximately 50% (r2 = 0.492) of variable 'population' explains the deforestation process in this IL.

In 2002, Uaçá recorded deforestation of 257 ha for a population of 3,332 people. In 2003 and 2007, there was a significant reduction in land use, even if one considers the population increase. There was deforestation peak in 2008 (625 ha) and population increase by more than 6,000 people in this same year. There was a reduction of approximately 50% in deforestation in 2009, compared to the previous year. Although there was also a reduction in the deforestation records – the population kept on growing. From 2010 on, it was possible observing deforestation data fluctuation, high peaks in 2012 (1,070 ha) and population growth by 6,689 inhabitants. After 2012, the most considerable deforestation was recorded in 2018; it corresponded to 956 ha and 7,659 inhabitants (Figure 6).

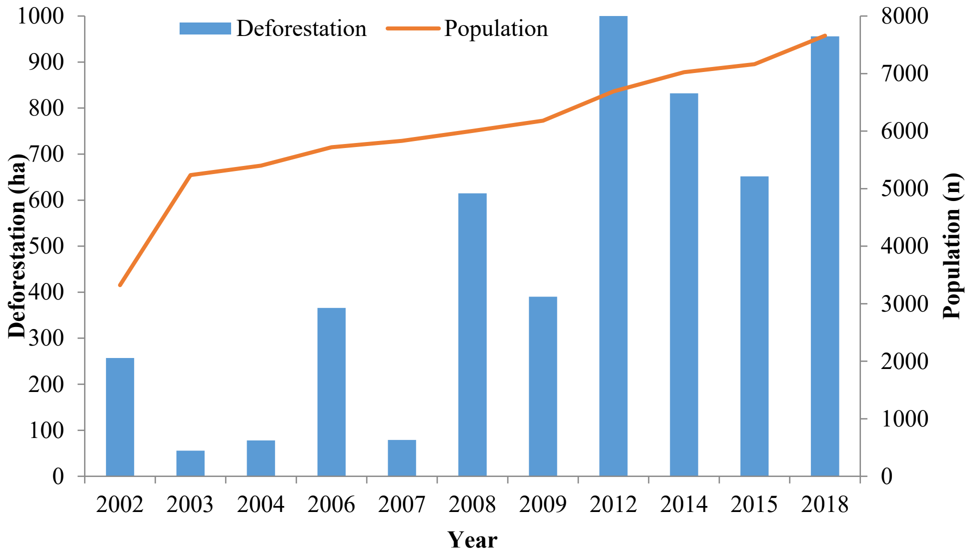

Figure 6 | Comparison between population number and annual deforestation in Uaçá IL.

Source: Elaboration of the authors.

3.3 DEFORESTATION ESTIMATES

Due to the lack of data, the modelling analysis adopted to estimate population and deforestation by 2028 (10 years) did not apply to Galibi and Juminã ILs. Furthermore, it was impossible to model Wajãpi IL because Pearson's analyses pointed towards weak association (r = 0.31) among variables, which was proven by the linear regression.

Thus, modelling was only carried out for Uaçá IL; some missing deforestation data were interpolated. According to the Pearson's test, Uaçá presented a strong correlation (0.74) between variables. The linear regression analysis confirmed it: 0.55% of the assessed variables (population growth and deforestation) explained a strong correlation between variables. Thus, the deforestation and population growth increase were continuous in this IL (Figure 7).

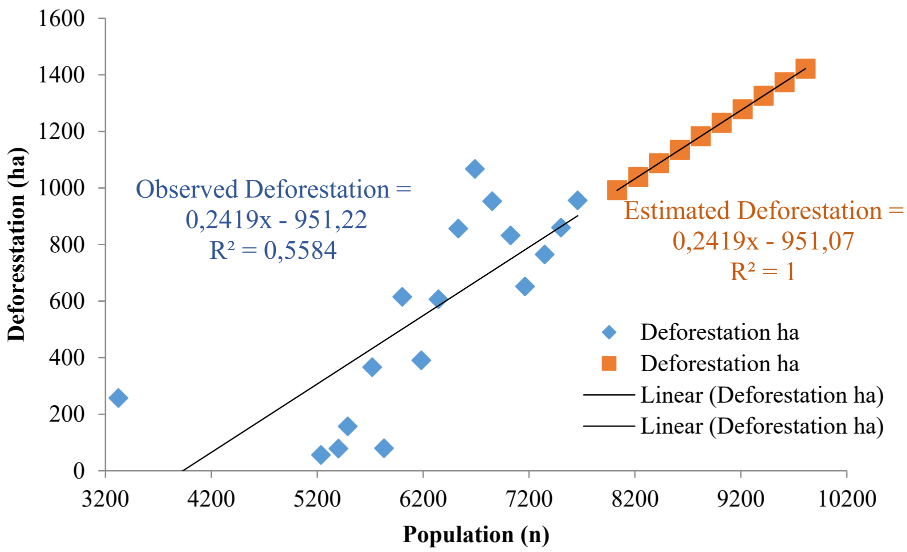

Figure 7 | Population and deforestation growth estimates up to 2028 in Uaçá IL.
Source: Elaboration of the authors.

The population will increase by approximately 1,800 inhabitants by 2028, and it is more than the increase recorded in 2018; deforestation will reach 1,421.97 ha, by the same year. There will be a difference of almost 466.09 ha within 10 years. There was exponential growth both in population and deforestation. Uaçá IL population will use 4.6% of the total of its 470 ha, by 2028, despite the wide use of land for production focused on subsistence and the local cassava flour supply.

4 DISCUSSION

4.1 DEMOGRAPHY

It was possible observing continuous population growth in Wajãpi IL based on the association among demographic data, population growth, number of deaths and demographic density. However, the Wajãpi people were once seen as more numerous; a drop in the number of inhabitants took place during a malaria outbreak caused by contact with non-indigenous individuals (APINA; AWATAC; IEPÉ, 2017).

Demographic density in this IL did not reach 1 inhab/km², even if one considers the years accounting for the highest deforestation rates. This finding is explained by the size of its territory (607,000 ha) and its population of approximately 1,500 inhabitants. Wajãpi IL recorded the mean birth of 52 people/year and low land use since it only used 0.63% of its territory – the rest was conserved.

Accordingly, one can observe the importance of keeping big PAs, where indigenous peoples play the role of conserving ecosystems for future generations (GARNETT *et al.*, 2018) and preserving their culture and traditional knowledge.

The association between variables "population growth" and "deforestation" in Wajãpi IL was weak. It did not influence land use; in other words, the deforestation trend concerning the population heads towards stability. This is because wajãpi people live in isolation, surrounded by PAs; they have traditional customs. The reduced soil use for agriculture, crop opening, and house construction in this IL are linked to these people's traditions.

Crop use-time and its management are other relevant factors for land use reduction. Wajãpi people have used the same crop for approximately 20 years. After its use, they leave the land to rest and open a new crop by the old one. They allow a line of primary forest between crops to speed up natural recovery (APINA; AWATAC; IEPÉ, 2017). It is essential to highlight those secondary forests play a crucial role in conserving biodiversity and providing ecosystem services, such as carbon fixation (POORTER *et al*., 2016).

Indigenous peoples' crops in Amapá state are family farms. Thus, they demand specific sizes (approximately 1 to 3 ha, depending on the interest and need of each family and resource availability). According to Silveira (2015), the choice for crop-size limits is related to nature's elements such as rivers, waterfalls, hunt and fruit collection availability, seeds and materials for craftsmanship and house constructions.

The indigenous peoples, for a long now, acknowledge the importance of conserving and properly managing their land, not just because they provide their material needs, but because they reinforce or redefine their traditional commitment to the land (GARNETT *et al*., 2018).

Among all ILs, Uaçá was the one that has grown the most, despite its high annual average of deaths compared to the other ILs. Based on information by DSEI-AP, parasitic diseases account for the most significant number of fatalities in Amapá's ILs.

Although Uaçá had presented the highest deforestation and population growth rates, its demographic density did not reach 2 inhab/km^2. Land use up to 2018 was low, even after using land for agriculture. Thus, the strong dependence on natural resources, its organisational structure relation, and its management systems – developed through generations – are its vital conservation elements associated with its areas (DIEGUES *et al*., 2000).

There was a strong association between variables "population growth", and "deforestation" in Uaçá IL and this finding has statistically proven the trend of growth between them. These people extensively use their land because they grow cassava (at a large scale) to be traded in Oiapoque County and for subsistence. However, despite the cultivation for local trading, deforestation was low compared to other ILs in the Northern Region, such as in Puyanawa IL, in Alto Juruá (AC), which has 16 flour houses for local supply. The Puyanawa people are known as great flour producers: approximately 500 tons/year, and for their land use applied to other cultivars of fruits that are part of their diet, such as *açaí* (FOWLER, 2020).

Even when the indigenous culture faces changes due to the adoption of non-indigenous market society values, these peoples keep their sustainable cultivation practices. Changes in cultivation in tropical forests often concern cleaning practices to the plantation of food and non-wooden products (used to house constructions and in craftsmanship, which is other income sources). The exhaustion of soil nutrients or infestation with agricultural pests are the reason to let the land rest so that the forest can recover and start to grow again (BECKERMAN, 1987).

Galibi IL recorded the lowest population growth among Oiapoque's ILs. The trend in this IL pointed towards population stability, despite its low mean annual mortality rate. The mean annual rate of births from 2002 to 2018 was 1.3 people. The death cases were recorded for children younger than 1 year and people over 50 years old – there are several elderlies in the age group close to 100 years (DSEI, 2019). These data have confirmed that population growth in Galibi IL has decreased, reducing land use. Galibi IL recorded the highest demographic density (close to 3 inhab/km^2). It is necessary to consider that, despite its high density, it has the smallest territory (6,889 ha), but it did not influence deforestation.

Juminã IL recorded low population growth and low mean annual deaths. Therefore, its demographic density and deforestation rates are low, except in the years when it was possible to observe higher population growth and deforestation. This IL produces cassava flour and has potato, sweet potato and green vegetable crops, and fruit trees for subsistence, but they do not occupy large land extensions. Thus, population growth did not have a negative influence on deforestation increase.

The demographic density of indigenous peoples in Amapá state is lower than that recorded for other ILs countrywide. For example, the demographic density of indigenous peoples at Dourado Indigenous Reservation (MS) was the highest among indigenous peoples in Brazil up to 2013 (300 inhab/km^2) (BARBOSA *et al*., 2016). However, most ILs in Brazil accounts for low demographic density, such as the case of Rio Xingu Terra do Meio Extractivitst Reserve (PA), with its 0.81 inhab/km^2, which houses riverside populations and indigenous peoples (Arara Kuruaya, Parakanã, Xikrin and Xipaya) (ISA, 2020). In 2008, demographic density at Raposa Serra do Sol IL (RR) was 1.1 inhab/km^2 and an approximate population of 19 thousand inhabitants (Macuxi, Wapichana, Taurepang, Patamona and Ingarikó peoples) within 1,747,464 hectares (USP, 2020).

4.2 DEFORESTATION

All ILs had deforestation peaks from 2002 to 2018, but population growth did not influence it. Nevertheless, there were moments when it was possible observing high deforestation in all ILs. It is worth highlighting that ILs close to the roads can face deforestation threats. There is a strong association between deforested sites and the influence of roads within the deforestation process (NEVES *et al*., 2021).

Thus, Uaçá IL recorded a higher deforestation rate than the other ILs, and it can be justified by its intense land use for cassava crops, for flour production and trading in the local market.

The environmental strategy to form secondary forest adopted by the Wajãpi people is also adopted by the Kayapó people (Xingu River, Brazil). Forest spots between agricultural cultures are called “apetês”; they ensure the formation of secondary forests and work as barriers at times of war, as parapets and defence lines for indigenous villages; at times of peace, they are used as a place for resting, for spending the warmest times of the day (POSEY, 1985).

Secondary succession regards the replacement of organisms by another type of organisms from an environment that has been disturbed by hurricanes, drought events, landslides – due to strong wind –, cutting agricultural practice, burns or intensive agriculture (ERICKSON; BALÉE, 2006). The influence of human management also changes the Amazonian Biodiversity.

The Amazonian Biodiversity was influenced by human management, for example, when it comes to differences in the relative abundance of species between the ancestral and old forests, which are not related to soil conditions, but to previous human management (FRANCO-MORAES *et al*., 2019). The indigenous peoples in Amapá state manage their land by targeting their future and the future of the forest. The traditional knowledge of these peoples covers management practices that limit low-intensity environmental disturbances to ensure ecosystems’ stability and resilience (BEGOSSI *et al*., 2000). Thus, it was proven that old indigenous populations had a hybrid lifestyle, including fishing, hunting, extracting, picking up fruits and forest management. This process allowed their non-full (only partial) dependence on agriculture (ROWLEY-CONWY; LAYTON, 2011). These populations managed the forest and opened the room to create agroforest systems by enriching them with valuable species and suppressing the undesired ones (ERICKSON; BALÉE, 2006).

As time went by, it was possible observing that the trend of indigenous peoples to protect their forests against deforestation got lost, as these groups started to adopt non-indigenous costs – it also increased their demographic density (TERBORGH; VAN SHAIK, 2002). Nepstad *et al*. (2006) tested this hypothesis and assessed the "response from deforestation inhibition by indigenous reservations since their first contact with non-indigenous groups and from demographic density". Their study was carried out based on the analysis of satellite images; they concluded that the tested comparisons did not lead to any significant association between variables. Thus, they have confirmed that indigenous reservations inhibit deforestation, their land use relationship with the forest disturbances is weak, but it is relatively high in inhabited and invaded areas.

4.3 DEFORESTATION ESTIMATES

A research about deforestation estimate for Amapá state by 2030 has shown that although the state shows an isolated geographic profile in comparison to the rest of the country – a fact that contributes to the high native vegetation cover preservation degree –, deforestation has been growing in the last decades (LESS *et al.*, 2018).

Unlike the results recorded by Less *et al*. (2018), estimates about the increase in deforestation and population growth in Uaçá IL were low if one considers the 10-year projection by 2028. The estimated modelling to 2028 recorded a low population growth increase and approximately 50% more deforestation than that accumulated until 2018. However, if one considers the size of the land and how it is used, these processes will not negatively influence forest coverage. According to Fearnside *et al*. (2009), deforestation inside ILs is not considered since land use there has low impact and focuses on subsistence.

The social organisation model is based on low population density and high mobility in the territory as a whole, such as the case of indigenous peoples, in addition to management practices based on traditional knowledge and the conscious use of natural resources (fishing, hunting, wooden and non-wooden products), can ensure the maintenance of traditional peoples, as well as biodiversity and forest conservations (BEGOSSI *et al*., 2000; SMITH; WISHNIE, 2000).

Based on the results, it is possible to state that territory size is essential in ensuring forest conservation and biodiversity because it can influence PA's effectiveness in stopping deforestation. The smallest PAs present higher deforestation than those holding large blocks of forests, more than 10,000 km^2. Even so, the smaller areas that are more subjected to anthropic pressure manage to contain deforestation. The internal percentage of deforestation is lower than that outside its external limits (location close to 10 km) (VITEL; FEARNSIDE; GRAÇA, 2009).

5 CONCLUSION

We have confirmed the hypothesis that there is no association between demographic density in ILs and deforestation in Amapá state since density in these areas is relatively low. Their sustainability is ensured by the way Indians use the land, mainly for subsistence cultures. Indigenous peoples conserve their land and are concerned with sustainability; they use land based on traditional knowledge. Such knowledge on preserving and protecting the land and fighting for their rights is passed on through generations.

Deforestation in Amapá's ILs was low, and this finding has shown that these areas have a high potential for forest conservation. The herein used variables presented a solid correlation to each other in all ILs, except for Wajãpi, which showed a weak correlation to them; Galibi IL recorded a robust negative correlation to them. This IL deserves closer attention from the scientific community and several governmental spheres since its population is decreasing. We believe that this is not a common factor among indigenous peoples.

The size of the territory is an essential factor for life, culture, and traditional knowledge conservation and the guarantee of forest conservation and biodiversity maintenance. Therefore, understanding the increase in deforestation rates and population growth in ILs is essential to predict the measures indigenous community leaders and the State government can take to ensure forest conservation and life maintenance among traditional peoples.

Based on the current research, assessing and evaluating the causes of low population growth in the Galibi and Juminã ILs are variables to be considered because, without these people, lands can be at risk of invasion by miners; and illegal timber exploration hunting and fishing. Furthermore, it is vital to reinforce public policies focused on healthcare and education, specific to indigenous peoples. Finally, it is worth highlighting the urgent need of paying attention to Uaçá IL, which recorded high mean annual death rates because of public health issues.

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