AMAZON IN FLAMES:
DEFORESTATION, FIRE AND RANCHING ON PUBLIC LANDS

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Introduction

Public lands, which include indigenous lands (ILs), conservation units (CUs) and undesignated public land, occupy about 276 million hectares in the Amazon biome (figure 1; table 1) - if it were a European country, it would only be smaller in territory than Russia.

These areas are constantly under pressure from invasions and illegal activities, which generate deforestation and fire (Alencar et al., 2021). **In 2019 and 2020, about 44%, of annual forest clearing in the Amazon occurred on public lands.**

Considered a Brazilian patrimony, the forests that cover these public lands are, by principle, under the domain of the Federal Government and the States. They are therefore entrusted with the responsibility of protection.

However, the environmental reality on the ground is different. The current absence of actions to control and combat environmental crimes in the Amazon results in the occupation and illegal appropriation - squatting - of this patrimony, with the advance of deforestation and burning in the region

Summary

- 44% of annual deforestation in the Amazon in 2019 and 2020 occurred on public lands;

- 67% of the deforestation registered on public lands in 2019 and 2020 occurred in undesignated public forests (UPF);

- Between 1997 and 2020, 87% of deforestation on public lands occurred on the so-called unassigned public lands; 52% of this deforestation occurred in the last ten years;

- Indigenous lands and conservation units are the least deforested public lands;

- Of the areas deforested in undesignated public forests, about 75% became pastureland and remained so after ten years of conversion;

- On average, 22% of the area deforested in undesignated public land is abandoned, presenting some degree of vegetation regeneration after five years.

(Azevedo-Ramos et al., 2018, 2020; Alencar et al., 2020). To a certain extent, the advance of illegal occupation is the consequence of sequential changes in environmental and land environmental and land legislation that aim at future regularization of lands, among them many invaded and illegally occupied.
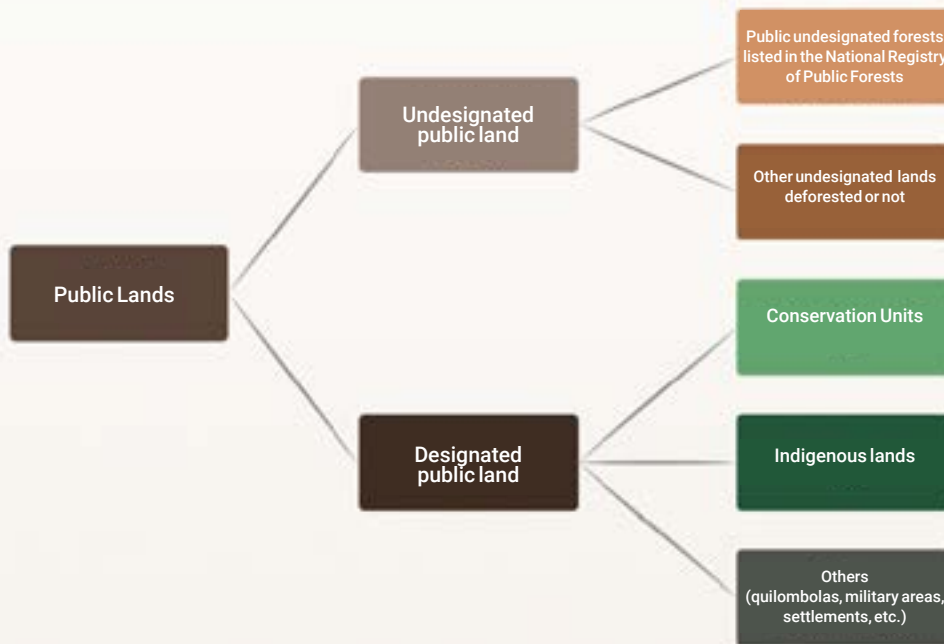

Figure 1. Categorization of public lands in the Amazon, between undesignated and designated public land. *Source: IPAM.*

Pastures, compared to other land uses, appear to be the main tool for the occupation of public lands in the Amazon, especially in regions at the frontier of deforestation (Tyukavina et al., 2017). However, little was known about the extent to which pastures have been used for illegal occupation of these lands, or how much of these pastures remain active and perennial.

In this technical note, we assess the evolution of the trajectory of illegal conversion of forests on public lands to other land uses between 1997 and 2020, with an emphasis on public lands not yet designated (figure 2), in order to answer some of these questions.

Method

In this note, for convenience, we separate public lands (figure 1) between those existing in (1) public lands[2] already designated by the federal and state governments, but which still remain under public domain (indigenous lands, ILs, and conservation units, CUs), and (2) undesignated public lands, the so-called unsettled lands[3] (figure 2).

1. Law 11.284/2006

- Article 4 "Art. 4 The management of public forests for sustainable production includes:

I - the creation of national, state and municipal forests, under the terms of art. 17 of Law nº 9.985, of July 18, 2000, and their direct management;

II - the allocation of public forests to local communities, under the terms of art. 6 of this Law

III - the forest concession, including natural or planted forests and the management units of the protected areas referred to in item I of the caption of this article."

The non-assigned lands were further divided into undesignated public forests (UPF), listed in the National Registry of Public Forests[4] managed by the Brazilian Forest Service (BFS), and other undesignated lands (OUL).

The latter category arises from the premise that part of the public land with forests is not yet listed in the BFS's National Registry of Public Forests.
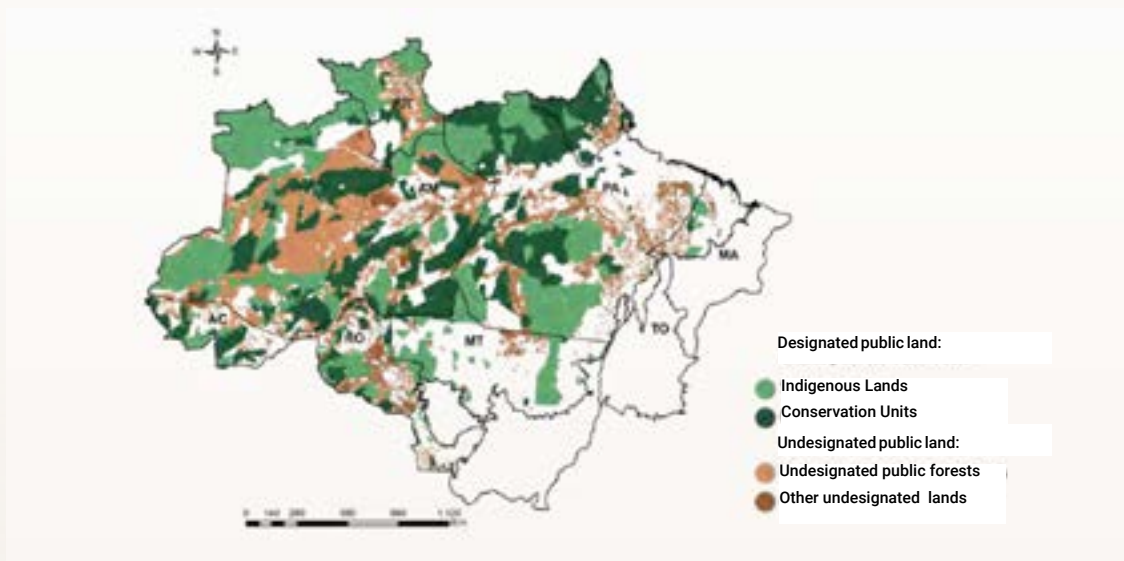

Designated public land:

- Indigenous Lands
- Conservation Units

Undesignated public land:

- Undesignated public forests
- Other undesignated lands

Figure 2. Public lands located in the Amazon biome and their classifications. *Source: IPAM, from data from Funai, ICMBio, Incra, and SFB.*

In this study we did not consider rural settlements due to their destination for rural use, even though they are under the responsibility of the public authorities. We also did not consider the environmental protection areas (EPAs), because despite being categorized as conservation units, their deforestation dynamics is closer to that of rural properties.

The land bases we used for the analyses were: (1) indigenous lands: National Indian Foundation (Funai); (2) conservation units: Chico Mendes Institute for Biodiversity Conservation (ICM-Bio); and (3) undesignated public land: National Institute of Colonization and Agrarian Reform (Incra) and BFS.

The eventual overlaps of these landholding categories with others already earmarked, such as settlements and quilombola areas, were excluded from the analyses. It is important to note that there is often spatial overlap between landholding categories in these data bases, which may imply, once the overlapping by the governments is solved, that the data presented in this note are overestimated or underestimated.

To define the dynamics of deforestation on public lands, whether designated (CU and IL) or not (UPF and OUL, figure 1), historical data from Prodes Amazônia were used for the period from 1997 to 2020 (INPE, 2021).

2. According to Law 6.766/1979, a plot is defined as all land that has not yet been legally parceled out and registered in the land registry. It ceases, therefore, to be a "plot" when it is parceled out.

3. "Unoccupied lands are public lands that have not been allocated by the public authorities and that have never been part of the private individual's patrimony, even if they are irregularly under his possession" (see more at https://www.oeco.org.br/dicionario-ambiental/27510-o-que-sao-terras-de-volutas/**.**

4. See https://www.florestal.gov.br/cadastro-nacional.

The analysis was also done considering specific time clippings (2006-2010, 2011-2015 and 2016-2020), which relate to articles found in federal laws 11.952/2009 and 13.465/2017 (Brazil, 2009; 2017) and federal decrees 9.309/2018 and 10.165/2019, which change the recognition dates for land title regularization and may impact the regularization process and incentive to irregular occupation of public lands (appendix 1).

Finally, to identify the trajectories of land use in deforested areas within public lands, we used data from MapBiomas Collection 6 (2021), which allows tracking the dynamics of land use change annually from 1985 to 2020. The overall accuracy of MapBiomas for the Amazon biome is 97%. These data were reclassified and regrouped into three classes: (1) primary or secondary forest/ regeneration; (2) cattle ranching; and (3) other uses.

Once these three databases (land, deforestation and land use and occupation) were organized, we combined them in order to quantify and analyze the evolution and extent of deforestation from 1997 to 2020, in the following land categories: CU, IL, UPF and OUL. Additionally, in the case of UPF and OUL, this evolution was also analyzed in the time intervals mentioned above: 2006-2010, 2011-2015 and 2016-2020.

Particularly for the last two periods cited, we examined the dynamics of land use and occupation based on MapBiomas Collection 6 between 2010 and 2020 (final years of the first and last periods of analysis). Thus, it was possible to evaluate the trajectory of post-deforestation land use in those public lands.

Finally, we used the tenure declarations, until 2020, registered in the Rural Environmental Cadastre (REC) that are overlapped with public lands and their different analyzed categories. We assume that registration of tenure in the REC over public land indicates clear evidence of squatting, and may result in illegal deforestation.

Results

About 44% of the annual deforestation in the last two years (2019 and 2020) in the Amazon biome occurred on public lands. Between 1997 and 2020, a total of 21 million hectares of forests were destroyed or 8% of the 276.5 million hectares of existing public forests of the Legal Amazon. This is an area larger than the state of Paraná. **The greenhouse gas emissions associated with this destruction amount to 10.2 gigatonnes of CO_2[5] in the analyzed period, corresponding to five years of Brazil's national greenhouse gas emissions** (SEEG, 2020).

Earmarked versus undesignated land

Of the 21 million hectares deforested between 1997 and 2020 on public lands, the smallest proportion occurred on earmarked land – 6% in the case of indigenous lands and 7% in the case of protected areas[6] (figure 3). This shows that the Indigenous Lands and the Conservation Units are the most preserved land categories in the Amazon. Even though they hold a large proportion of this class in the territory, 39% of public lands (in the case of the Indigenous Lands) and 32% (in the case of the Conservation Units), only 1% and 2% of their total areas, respectively, were converted for other uses (table 1).

[5]. We consider an average carbon density of 132 tC/ha.

[6]. With the exception of the environmental protection areas (EPA), as described in the method.

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The vast majority of deforestation, or 87% of that registered on public lands up to 2020, occurred on undesignated lands. In the undesignated public forests, which occupy 20% of public lands, about 3.4 million hectares of

deforestation occurred, or 16% of the total for the period; in the other undesignated lands, which occupy only 9% of public lands, 14.8 million hectares of deforestation occurred, or 71% of the total (figure 3, table 1).
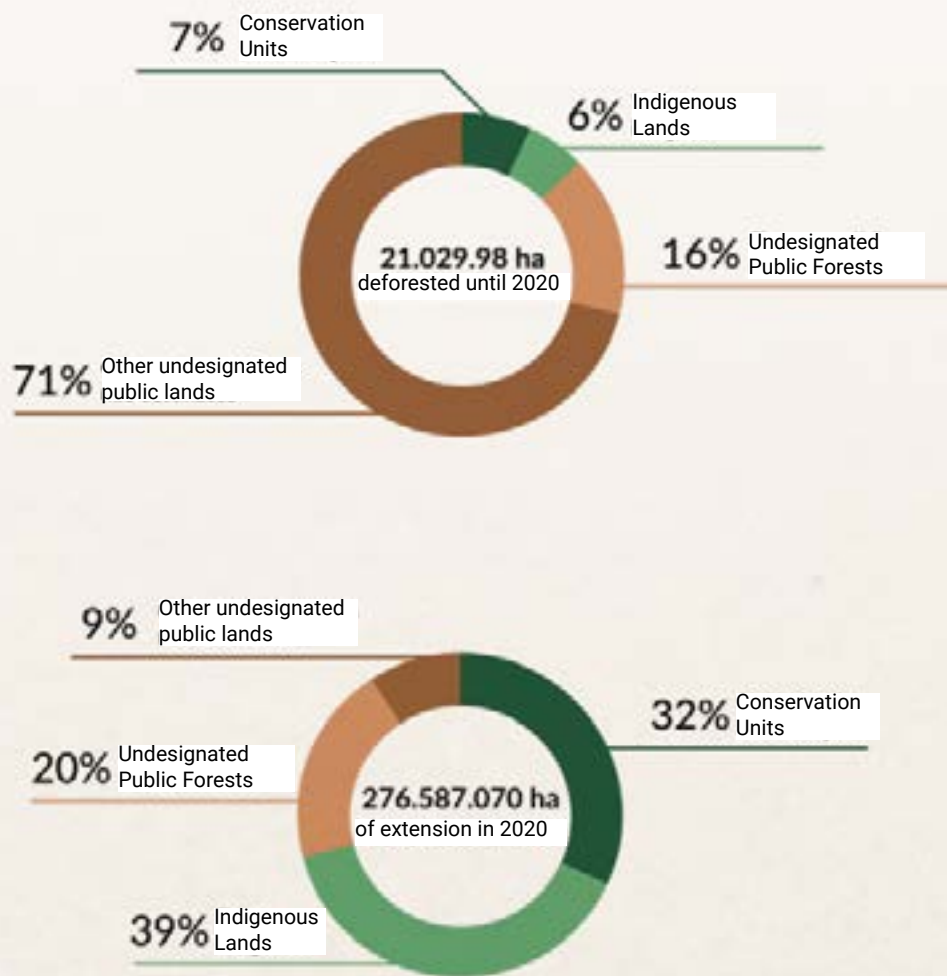
7% Conservation Units

6% Indigenous Lands

16% Undesignated Public Forests

21.029.98 ha deforested until 2020

71% Other undesignated public lands

9% Other undesignated public lands

32% Conservation Units

20% Undesignated Public Forests

276.587.070 ha of extension in 2020

39% Indigenous Lands

Figure 3. Accumulated deforestation on public lands in the Amazon up to 2020 (above) and total extension of public lands by land tenure category (below). *Source: IPAM, from data from ICMBio, Incra, Funai, and SFB.*

Table 1. Area and percentage of forest and deforestation in the main categories of public lands by 2020.. *Source: IPAM, with data from ICMBio, Incra, INPE, Funai and SFB.*

Land categories		Area until 2020	Proportion of public land	Deforestation by 2020 (ha)	Proportion of deforestation X category area	Remaining area of native vegetation (ha)
Earmarked land (protected areas)	CU*	83.152.597	32%	1.433.380	2%	83.152.597
	IT	106.480.121	38%	1.329.225	1%	100.375.713
Undesignated public land	UPF	56.500.476	20%	3.438.107	6%	49.959.935
	OUL	25.604.123	9%	14.829.277	58%	9.512.777
Total		276.587.070	100%	21.029.989	8%	255.557.081

*Except EPA, as described in the method.

Until 2005, almost all deforestation recorded on undesignated land occurred on other undesignated land. After 2006, when the Forest Law was enacted, the situation was reversed: high rates were recorded in undesignated forests: from 2006 to 2010, 73% of deforestation on undesignated land occurred on UPF. This proportion increased to 85% in the period from 2015 to 2020 (figure 4). **In aggregate, from 2006 to 2020, deforestation in UPFs represented 76% of that recorded on undesignated lands** - and, only in the last two years (2019 and 2020), deforestation in UPFs accounted for 67% of the total deforestation recorded on public lands in the Amazon, whether designated or not.
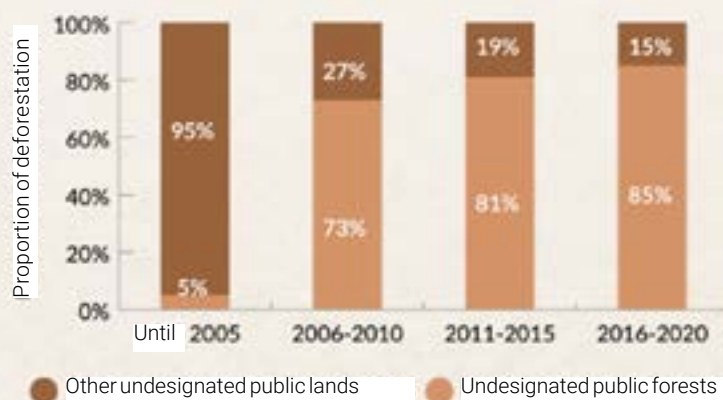

Figure 4. Proportion of deforestation of undesignated land in the Amazon, separated into undesignated public forests (UPF) and other undesignated public lands (OUPL). *Source: IPAM, from INPE and BFS data.*

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Evidence of squatting

The existence of Rural Environmental Cadastre (REC) overlapping public lands in the Amazon can be considered a strong indication of squatting (Azevedo-Ramos et al., 2020). Currently, there are 16 million ha of undesignated public forests declared as private property in the National Rural Environmental Cadastre System (Alencar et al., 2021) and 15.2 million ha in the other undesignated lands (table 2). Deforestation in areas with REC was 59% higher in the period 2016 to 2020 compared to the previous period, 2011 to 2015.

Despite REC being an instrument widely used by land grabbers to enable the possession of public land, since it is self-declaratory, it is worth remembering that it does not prove the right to land. It is an instrument for environmental and not land regularization.

Table 2. REC area in undesignated land in the Amazon. *Source: IPAM, with data from Incra and BFS.*

Land categories	Total class area (ha)	Area with REC (ha)	Proportion of the REC area
Undesignated Public Forests (UPF)	56.500.476	16.001.187	28%
Other undesignated lands (OUL)	25.604.123	15.227.037	60%
Total	82.104.599	31.228.224	38%

Land Use on Squatted Land

In addition to the alleged declaration of ownership via the REC, illegal occupation advances by trying to give a "productive" character to the illegally occupied land. Once the forest is cut down and burned, the tendency is to setup pastures.

In 2020, for example, ranching was the main land use in 75% of the deforested areas of undesignated public forests, approximately 2.6 million hectares. On the other undesignated lands, the pattern is repeated (Table 3). It is important to note that by 2020, approximately 20% of the area deforested in UPF and OUL showed some degree of regeneration of forest vegetation, according to MapBiomas Collection 6.

This pattern - most of the deforested area converted to pasture, while a smaller portion regenerates - seems to consolidate over time. In 2010, 79% of undesignated public forests (UPF) were occupied by pasture and 19% by regeneration, while in the other undesignated lands (OUL) 73% were pasture and 25%, regeneration (figure 5). Areas cleared with REC followed a similar land use and land cover dynamic as areas cleared without REC.

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Table 3. Proportion of deforestation between 2011 and 2020 and land use in 2020 on undesignated plots in the Amazon . *Source: IPAM, with data from Incra, INPE, MapBiomas 6 and SFB.*

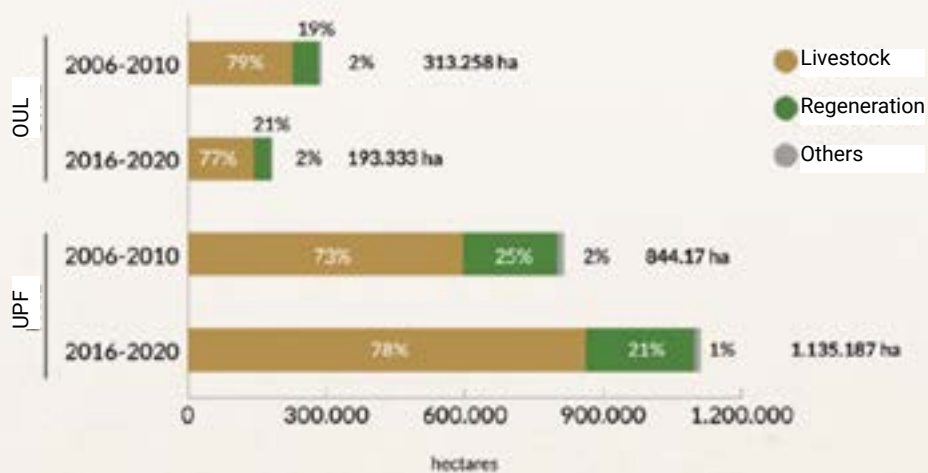| Land categories	Deforested area by 2020 (ha)	% of deforestation 2011-2020	Land Use in 2020		
			Ranching	Regeneration	Other Uses
Undesignated Public Forests (UPF)	3.438.107	52%	75%	24%	1%
Other undesignated lands (OUL)	14.829.277	2%	74%	20%	6%

Figure 5. Evolution of the use of deforested areas of undesignated land in the Amazon per studied period. *Source: IPAM, based on data from Incra, Inpe, MapBiomas 6 and BFS.*

Even after ten years, the area deforested in UPF not only continued to be occupied by pasture, but the proportion increased by five percent in the comparison between 2006-2010 and 2016-2020. In other words, **there was economic investment for permanence and conversion of new areas for ranching in that period.**

Discussion and recommendations

Our findings indicate that **more than half of the deforestation (52%) in the unlogged public forests occurred in the last decade and deforestation there has been increasing**, confirming that, to a good extent, squatting advances unchecked in the region (Alencar et al., 2021; Azevedo-Ramos et al., 2018, 2020).

Approximately 28% of UPF areas have RECs (Table 2), which is completely illegal according to the Public Forest Law (Brazil, 2006). In other words, this may be a harbinger of an outbreak of illegal deforestation in these undesignated forests in coming years, as REC has preceded deforestation (IPAM, unpublished).

Once cleared, the forests on unallocated land give way predominantly to pastureland (figure 3). The ox is used as a kind of "janitor" of the land that has been illegally appropriated and is used as a means of "possession". Historically, this has been the practice of squatting in the Amazon (Lima Filho et al., 2021). The focus is not on the production of calves or meat, but on the "legitimization" of land occupation for subsequent land title regularization. To this end, the REC becomes an additional instrument to demonstrate that supposedly land ownership is legitimate, thus increasing the chances of negotiation in the real estate speculation market (Reydon et al., 2020).

It should be remembered that this conversion of public forests into pastures is almost always fraught with uncertain land rights, violence, and corruption (Alston et al., 2000;

Fetzer and Marden, 2017). Furthermore, the use of cattle ranching as a means to legitimize public land ownership presents a potentially harmful damage to the reputation of the producer who follows environmental and land legislation, and puts the reputation of the sector at risk, both inside and outside of Brazil.

In this sense, the end of illegal logging in the Amazon is closely linked to discouraging new invasions. For this, it is necessary to quickly destine public forests as determined by the Public Forest Management Law of 2006. The data reinforce the importance of protecting these territories, even if both categories suffer intense pressure from invaders. This is a proven efficient way to pacify land use and occupation, and in conjunction with command and control actions can curb the levels of illegal deforestation in the region (Stabile et al., 2020; Nepstad et al., 2014). In the same direction, it is essential that slaughterhouses are seriously engaged in the monitoring and traceability of their supply chains, whether direct or indirect (Rajao et al., 2020) (appendix 2).

Our results also reveal that about 20% of the invaded and deforested areas on undesignated plots were abandoned after occupation and logging, because they showed some degree of regeneration (Table 3). Although this regeneration is welcome from the point of view of biodiversity and climate, it indicates the proportion of environmental and economic waste that this dynamic represents: rich and dense forests are cut down and then abandoned. There is an accumulation of ecological and economic costs, in addition to the cost of converting native vegetation

to pasture (Garcia et al., 2017), which compromises biodiversity (Solar et al., 2015) and numerous ecosystem services (Strand et al., 2018; Strassburg et al, 2014). It should also be remembered that this secondary vegetation is unlikely to return to its original conditions and is more susceptible to further degradation, for example, by fire (Alencar et al., 2020).

Finally, as demonstrated by previous studies (Soares-Filho et al., 2010; Kruid et al., 2021), the public lands already deforested present a much lower degree of deforestation and illegal occupation. For example, we found that IL and CU occupy 71% of all public lands in the Amazon (table 1), but concentrated only 13% of the total area deforested until 2020 (figure 3).

On the opposite path, undesignated public lands (UPF and OUL) cover 29% of the total area of public lands (table 1), but concentrated 87% of accumulated deforestation (figure 3) until 2020. Here again, the indication is that squatting is advancing as the new driver of forest destruction in the region. In the OULs, vegetation suppression largely occurred before 2005, but from 2006 to 2020 the proportion of deforestation occurring in UPFs ranged from 73% to 85% of the total (figure 4).

The rapid and widespread advance of squatting over public lands in the Amazon imposes a serious risk to the country's efforts to meet its emissions reduction targets (Albuquerque et al., 2019; IPCC 2021), as well as to agricultural production itself.

In large part, the rainfall regime in the Ama-

zon and beyond depends on a volume of preserved maintained forests (Leite-Filho et al., 2021) and, as presented in this note, to a good extent these are public.

Therefore, illegal occupation must be urgently combated. To this end, command and control actions allied to the end of executive[7] or legislative[8] propositions to grant amnesty to illegal occupation of public lands must be pursued. This movement creates political and institutional instability, as well as a kind of "race" for the irregular occupation of public lands, destined or not, in the expectation of a future change in legislation to their benefit, with direct impact on Brazil's environmental assets.

It is necessary to emphasize, however, that land regularization in OULs is possible in light of norms related to environmental regularization (Appendix 1) and official programs such as Terra Legal. UPFs, on the other hand, according to the 2006 Public Forest Management Law, cannot be legalized for private use.

Recommendations

• The state and **federal governments must move forward with the allocation of federal and state public forests** to conservation units, indigenous lands, production forests, among other categories provided for by Law 11.284/2006, which governs the management of public forests;

• **Promote, on the part of the Executive and Legislative branches, clear and transparent debates on legislation regarding land regularization**, enforcing Law 13,465/2017;

7. For example, Federal Decrees nos. 9,309/2018 and 10,165/2019, which proposed extending the cut-off date from 2008 to 2014 for granting land title, and other initiatives that keep the cut-off date at 2014 and make other criteria flexible, such as minimum property size, in addition to proposing to waive the survey for regularizing tenure.**6.** With the exception of the environmental protection areas (EPA), as described in the method.

8. For example, Laws 510/2020 and 2633/2021 currently under debate in the Senate.

• **Combat illegal occupations in undesignated public forests**, including in this action the RECs overlapping with them and declared in the states' cadastral database;

• **Governments and Federal and State Public Ministries must understand the challenges and develop strategies to stimulate more slaughterhouses adhesion to the Beef TAC**, especially regional slaughterhouses;

• **Slaughterhouses should map production farms using GIS and remote sensing tools to identify** which regions concentrate the greatest challenges regarding the legality of the chain, and intensify their monitoring of these regions and farms;

• **Slaughterhouses and retailers should intensify actions to monitor indirect suppliers**, giving scale and implementing actions discussed in initiatives such as Boi na Linha, GT Traceability of the Sustainable Livestock Working Group (GTPS), Working Group of Indirect Suppliers (GTFI), Green Stamp, etc., even with the intention of separating squatting from livestock production;

• **Support, on the part of the slaughterhouses plants, their suppliers in training activities** in topics such as productive improvement and environmental and land regularization, in order to promote the use and occupation of the land already open, in a sustainable and legal way;

• **Combat illegality in the meat chain, by means of the suspension/blocking, by the financial agents, of agricultural financing in undesignated public forests**, as well as stimulating the commitment, on the part of retailers, not to buy agricultural products originating from these areas.

Acknowledgments

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Annex 1 - Regulatory milestones related to land regularization on public land.

Regulatory Instrument	Federal Law 11.952/2009	Federal Law 13.465/2017	Federal Decree 9309/2018	Federal Decree 10.165/2019
Status	Revoked	Approved	Not Approved	Not Approved
Article	Art. 5	Art. 4 and Art. 2	Art. 10 A.	Art. 10 A.
Description	"IV - prove the exercise of direct, peaceful occupation and exploitation, by himself or his predecessors, prior to of December 2004".	"Law No. 11.952, of June 25, 2009, shall come into effect with the following changes: ...IV - prove the exercise of the occupation and direct exploitation, peaceful occupation and exploitation, by himself or his predecessors, before July 22, 2008.	"Proof of the practice of effective cultivation, occupation and direct, peaceful and undisturbed exploitation, by itself or by its predecessors, prior to May 5, 2014, may be provided by means of documents, remote sensing techniques and other means of proof, by Decree no. 10,165, of 2019)."	"Proof of the practice of effective cultivation, occupation and direct, peaceful and undisturbed exploitation, by itself or by its predecessors, prior to May 5, 2014, may be provided by means of documents, remote sensing techniques and other means of evidence."

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Annex 2 - Public commitments of the livestock sector and the monitoring of direct and indirect

The Cattle Raising Conduct Adjustment Term (TAC) was established in 2009 by the Federal Public Ministry of Pará focusing on the slaughterhouses in that state, and from 2010 on in the other states of the Legal Amazon, known as the Legal Meat TAC. They commit not to buy meat from farms that (i) have an environmental embargo for illegal deforestation, (ii) do not present a deforestation polygon from Prodes after signing the TAC, (iii) do not have REC, (iv) present an overlap with ILs and CUs, (v) are on the list of labor analogous to slavery, (vi) and that do not have the Rural Environmental License (REL), in the case of Pará.

Whether through the Cattle and Beef Legal TAC, or the Zero Deforestation Public Commitment (Greenpeace, 2009), advances have been made in order to prevent the commercialization of cattle produced on lands embargoed for illegal deforestation or for other environmental, land tenure, and social requirements not met.

Slaughterhouses and retailers have created their own methodologies and protocols, but they produce individual results that in many cases cannot be cross-checked. To remedy this scenario, the three leading beef slaughter and processing industries in the Amazon biome - JBS, Marfrig and Minerva - and the three main retail companies in Brazil, Carrefour, Grupo Pão de Açúcar and Walmart, have harmonized their geomonitoring protocols to establish a single approach to monitoring livestock chain suppliers (MPF, 2020).

In addition, state governments, such as those of Pará and Amazonas, in partnership with the MPF, have implemented tools such as the Green Stamp and the Visipec, which track the chain and connect health inspection information, such as the GTA, and environmental regularization information, such as the REC.

However, actions and adherence to these public commitments by slaughterhouses have been inconsistent among Amazonian states (Moffette et al., 2018). According to the Boi na Linha project[9], there are 132 slaughterhouses industries in the Amazon biome: one hundred signed the TAC and 32 stayed out. Those that do not participate in any commitment avoid inspection and monitoring costs and increase their net profit (Barreto et al., 2017), engaging in unfair competition with those who signed the agreement.

Today, the monitoring done by slaughterhouses of their suppliers focuses only on direct suppliers, that is, those who sell to the slaughter plants, although the three largest slaughterhouses have recently made announcements about the monitoring of indirect suppliers[10,11,12]. Most of the deforestation in the supply chains occurs precisely on the properties of indirect, unmonitored suppliers.

A portion of these cattle are raised and reared on farms that do not follow the principles of the agreements cited above, including those that are irregularly within protected areas or public lands. The cattle are sold to compliant farms, which act as intermediaries before sale to slaughterhouses (Gibbs et al., 2016; Klingler et al., 2018; Skidmore et al., 2020). This "laundering" of cattle that come from invaded areas undermines the Amazon cattle ranching chain.

9. The Boi na Linha Project (www.boinalinha.org) is an articulation aimed at strengthening the social and environmental commitments in the value chain of beef in the Amazon and to boost its implementation.

10. Available at https://forbes.com.br/forbesagro/2021/04/jbs-inicia-monitora-mento-de-fornece-dor-indire-to-de-gado--com-blockchain/

11. Available at https://www.noticiasdapecuaria.com.br/noticias-agrone-gocio/noticia/geral/marfrig-lanca-ferramenta-de-monitora-mento-de-produto-res-indiretos

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