Land Use Policy 97 (2020) 104806

Contents lists available at ScienceDirect

Land Use Policy

journal homepage: www.elsevier.com/locate/landusepol

Amazon forest on the edge of collapse in the Maranhão State, Brazil

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ARTICLE INFO

Keywords:
Zero-deforestation
Forest restoration
Forest fragmentation
Forest fires
Secondary forests
Violence
Climate change

ABSTRACT

The year 2019 in Brazil was marked by environmental setbacks, which catalyzed the increase of illegal deforestation and fire rates in the Brazilian Amazon. In the Amazon region of Maranhão state, original forest cover diminished from 25 % (24,700 km^2) in 2016 to 24 % (23,967 km^2) in 2019, and 6,038 km^2 of remaining forests were degraded by fires and/or illegal logging – processes related to high levels of violence against indigenous and rural communities. Almost half of all deforested areas in the region (36,060 km^2) are considered a global restoration hotspot, however secondary vegetation remains unprotected and 8,294 km^2 were cleared between 2014 and 2018. Due to uncontrolled deforestation and fragmentation, Maranhão has no more forest core areas (outside protected areas) with the minimum size to ensure sustainable forest management practices for timber production. New policies at the state level must promote old-growth and secondary forest conservation and restoration. However, the trends point to the opposite direction: the Ecological-Economic Zoning (ZEE) allows the reduction of forest protection and the State Forest Policy reinforces federal legislation setbacks. The Amazon region of Maranhão state has forest aptitude, and forest and agroforestry product chains would bring social and environmental benefits, making them the best opportunity for sustainable economic development in the region. Therefore, the forest must be re-planted for the benefit of people and nature.

1. Introduction

Brazilian environmental setbacks associated with the new federal government (elected at the end of 2018) are internationally recognized (Escobar, 2019; Ferrante and Fearnside, 2019). The year 2019 was marked by the weakening of deforestation enforcement and dismantling of climate change policies in Brazil, which catalyzed the increase of Amazon illegal deforestation and fire rates (Barlow et al., 2019; Azevedo et al., 2019). Also, controversial changes in the Forest Code (Federal Law nº 12,651/2012), such as the indefinite deadline extension for the Environmental Rural Registry (*Cadastro Ambiental Rural*, in Portuguese) (Law nº 13,887/2019) and the possible regularization of public lands illegally grabbed (Bill nº 2,633/2020, former Provisional Measure nº 910/2019), will likely increase deforestation and delay liabilities regularization and restoration policies.

The Amazon region of Maranhão state is also facing environmental setbacks. This region has a strategical role in the provision of ecosystem services and biodiversity conservation, including numerous endemic endangered species (Martins and Oliveira, 2011), as *Cebus kaapori* (Schwitzer et al., 2015) and *Crax fasciolata pinima* (Alteff et al., 2019). Celentano et al. (2017) advise policymakers to urgently create protection mechanisms for both old-growth and secondary-growth forests and to establish and implement a state policy of restoration. However, these recommendations had been ignored, and the region continues to be threatened by illegal deforestation and forest degradation with visible social, economic, and environmental harm to the state. Indigenous people and rural communities are the main victims of this process (HRW, 2019). Thus, this viewpoint paper draws attention to the potential environmental setbacks in the Amazon region of Maranhão and reinforces science-oriented recommendations to policymakers.

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https://doi.org/10.1016/j.landusepol.2020.104806
Received 15 January 2020; Received in revised form 14 April 2020; Accepted 27 May 2020
Available online 09 June 2020

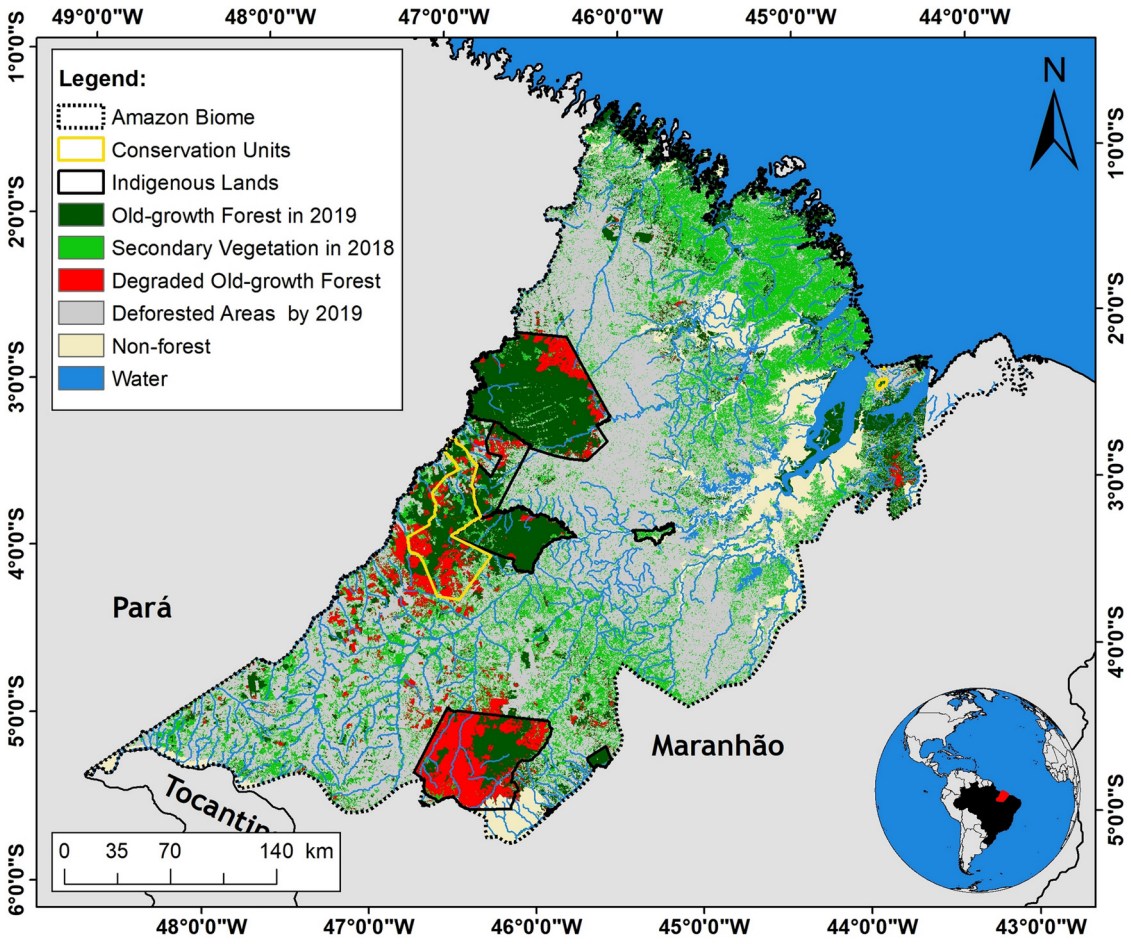

Fig. 1. Present forest cover and forest degradation in the Amazon region of Maranhão (INPE, 2019a, b and c).

2. The state of the Amazon Forest in Maranhão

Between 2017 and 2019, 733 km^2 of old-growth forests were clear-cut in the Amazon region of Maranhão state (INPE, 2019a), diminishing original forest cover from 25% (24,700 km^2) in 2016 (Celentano et al., 2017) to 24 % (23,967 km^2, Fig. 1) in 2019. In 2019, at least 25% (6,038 km^2) of the remaining forests were degraded by forest fires and/or illegal logging that occurred between 2007 and 2019 (INPE, 2019a,b,c). In the legally protected areas, forest degradation represented 37 % of Conservation Units forest remnants (1,924 km^2) and 31% of Indigenous Lands forest remnants (10,944 km^2, Supplementary Tables 1 and 2). Besides, in the Amazon, during extreme drought years, forests become more susceptible to fires, due to low rainfall rates and high temperatures induced by sea-surface anomalous warming (Aragão et al., 2018; Silva Junior et al., 2019), thus contributing to atmospheric carbon emissions, either by immediate burning of biomass (Anderson et al., 2015) or in the long-term by increased tree mortality (Silva et al., 2018).

It is important to note that of all forest's remnants, only 35 % correspond to core areas (8,302 km^2), while 45 % correspond to forest edges (10,882 km^2) with less than one-kilometer width (Broadbent et al., 2008; Laurance et al., 2018), and 20 % to forest patches (4,783 km^2). This deforestation-induced fragmentation exposes the forest to strong edge effects (Fig. 2), increasing tree mortality (Laurance et al., 1997), susceptibility to fires (Silva Junior et al., 2018), and decay of tree-community composition and diversity (Laurance et al., 2006).

The Amazon forests of Maranhão state is a clear example that climate mitigation and biodiversity conservation strategies should not be focused only on reducing deforestation. Here, we show that in addition to a low level of forest cover, the remnants were negatively impacted by anthropogenic disturbances, such as selective logging, forest fires, and habitat fragmentation, causing additional carbon stock and biodiversity losses (Barlow et al., 2016; Berenguer et al., 2014).

Very recently, this part of the Amazon region has been considered as a global hotspot for tropical forest restoration (Supplementary Fig. 1), where 36,060 km^2 (almost half of all deforested areas) have high restoration potential (Brancalion et al., 2019). Secondary succession is essential for combating climate change (Poorter et al., 2016), reversing biodiversity loss (Lennox et al., 2018), and is the most effective strategy to promote and scale-up restoration (Crouzeilles et al., 2017). However, in the opposite direction, 8,294 km^2 (2,073 km^2 year^{-1}) of secondary vegetation were cleared between 2014 and 2018 (Almeida et al., 2016; MapBiomas, 2020). In 2018, 33 % of the deforested area was covered with secondary vegetation (25,119 km^2, Fig. 3), but it is at risk since the State does not have a policy to protect or regulate its conversion. Unfortunately, Maranhão state does not have a forest restoration policy and, therefore, is among the most backward states of Brazil in implementing the Forest Code (Chiavari and Lopes, 2019).

3. Illegality and violence

Historically, the deforestation process did not result in any local gains of wealth and the Amazon region of Maranhão state is among the poorest regions of the country. Deforestation and degradation of the last forest remnants in the region are direct results of the illegal logging activity, especially inside protected areas (Paiva et al., 2019). At least 16 federal enforcement operations took place in recent years to control illegal logging (Celentano et al., 2018); however, they were not enough

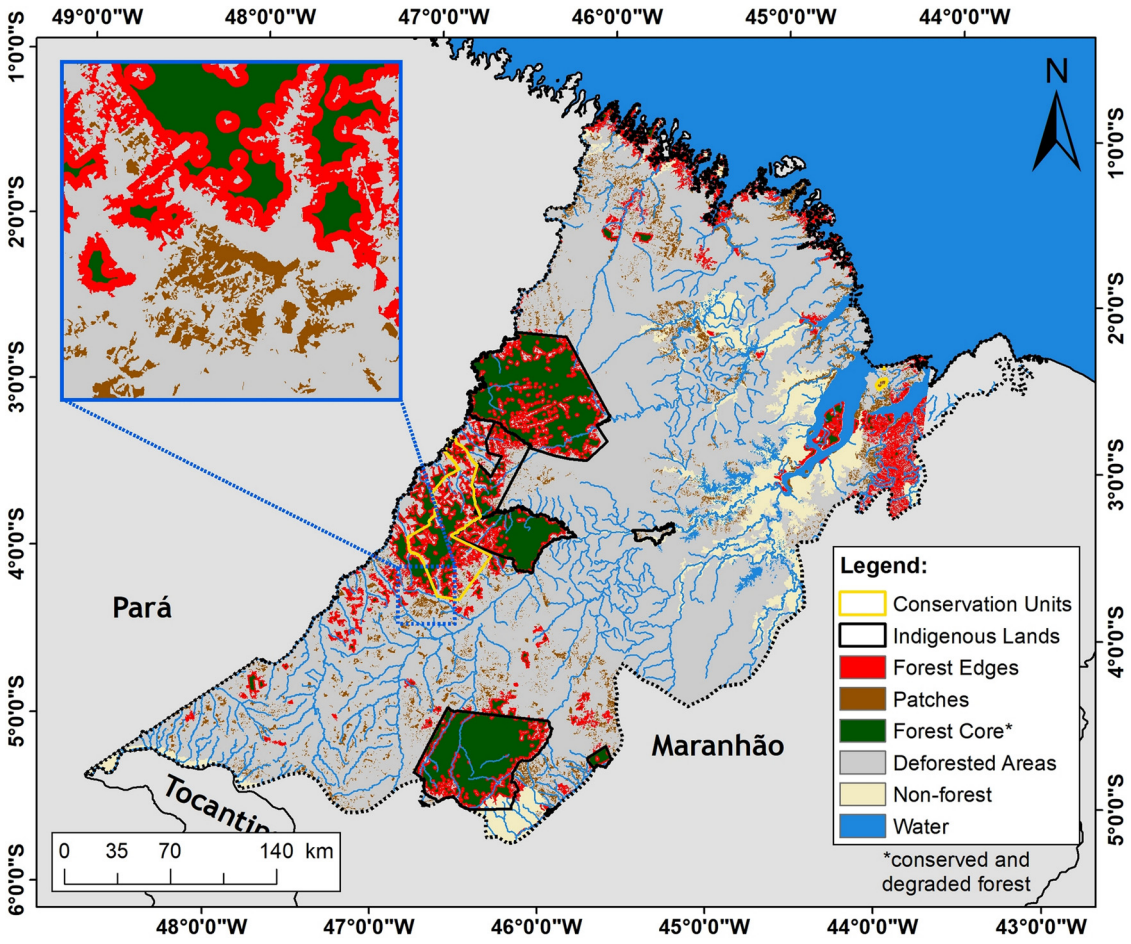

Fig. 2. Deforestation-induced forest fragmentation in 2019 for the Amazon region of Maranhão (INPE, 2019a).

to change the reality of forest destruction and violent trajectory of the region. Indigenous people got organized to defend their territories by themselves through the forest guardians (Andreoni and Andreoni, 2019; BBC, 2019; Mendes, 2019; Muñoz, 2019; Rossi and Poirier, 2019); however, this is a perilous task force. In the last 29 years, 82 indigenous people were murdered in Maranhão, including some forest guardians (CIMI and CPT, 2019).

A group formed by indigenous and non-indigenous people from governmental and non-governmental institutions has been working together since 2014 to promote the so-called "Gurupi Mosaic" (*Mosaico Gurupi*) - integrating efforts to conserve, restore and connect the last forest remnants of the Belém Endemism Area (Celentano et al., 2018). Even though this group gathers federal and state institutions together with indigenous representatives, Mosaico Gurupi is not yet officially recognized at any government level (either state or federal).

4. Avoiding setbacks at the Maranhão State level

In 2019, two critical political processes took place in Maranhão concerning the Amazon region. The Ecological-Economic Zoning of Amazonian Biome (ZEE) at 1:250,000 scale was concluded in October 2019 (Maranhão, 2019a, b), and the new State Forest Policy was rolled out (SEMA, 2019), intending to reformulate the current policy (Law nº 8.528/2006 amended by Law nº 8,598/2007). The ZEE (Bill 003/2020, Maranhão, 2020) was presented to the State Parliament of Maranhão on February 5, 2020 and approved on March 17, 2020 in a first round, and definitely on May 15 without further discussion with society. This legislation brings in its article 14 one of the major setbacks feared for the region, the reduction of Legal Reserve (LR) from 80 to 50 % where land cover is not old-growth forest. Besides an incentive to large secondary forest removal, this rewards previous illegal logging and deforestation. State Forest Policy will also be voted soon in the State Parliament, and more setbacks are expected as discussed below.

The ZEE comprises technical studies (Catunda and Dias, 2019a), zoning (Catunda and Dias, 2019b), prognosis and scenarios (Catunda and Dias, 2019c). Even though, ZEE technical studies identified conservation and restorations needs as well as the high vulnerability of soils to erosion, the zoning and specific indications for decision making (chapter 4 of Catunda and Dias, 2019b) do not propose any practical interventions to avoid degradation processes. Instead, agriculture, cattle ranching, and plant extractivism are the main indicated land-use for the 17 identified zones of the Amazon region. Forest conservation and restoration (of pasture and degraded areas) are indicated in only zones 3 and 2, respectively.

The ZEE prognosis and scenario do not fully recognize the forest aptitude of the Amazon region of Maranhão. During public audiences it became evident that one of its primary goals, driven by the lobbying groups, is to reduce Legal Reserve (LR) in the region. According to the Forest Code, ZEE at 1:250,000 scale is a requirement to States reduces LR from 80 to 50 %. This reduction is possible outside areas prioritized for biodiversity and hydrological conservation. Interestingly, between 2007 and 2018, there was a reduction of 61% in the areas considered a priority for biodiversity conservation in the Amazon region of the State (Supplementary Fig. 2; MMA, 2019). The LR plays a crucial role in ecosystem services provision (biodiversity, climate, water, pollination, biological control, etc.), which increases the sustainability of regional agrosystems, in addition to other important environmental, social and economic functions (Metzger et al., 2019).

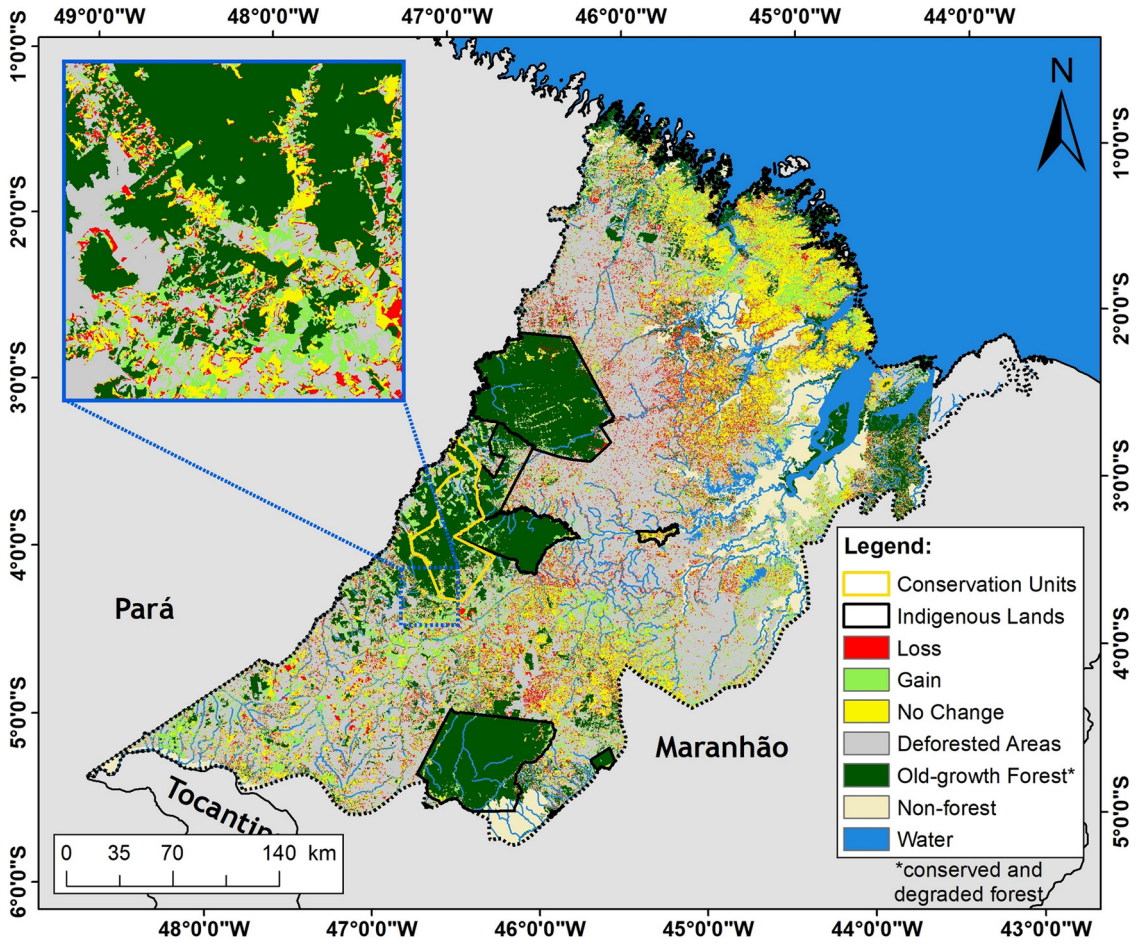

Fig. 3. Secondary forest cover (gain and loss between 2014 and 2018) in the Amazon region of Maranhão (Almeida et al., 2016; MapBiomas, 2020). Old-growth forest in 2019 (INPE, 2019a).

The reduction of LR, as well as the amnesty of deforestation (before 2008), are among the setbacks of the Forest Code update, which can be corrected by the State Forest Law (Brancalion et al., 2016), but have not yet been. Landowners who have complied with the country's environmental law are harmed, while those who illegally deforested will benefit from a proportionally more substantial area for agriculture and fewer restoration requirements. Celentano et al. (2017) recommended to maintain 80 % of the LR, and to promote a compensation system of the LR inside the state and preferentially in the same watershed. This last recommendation was included in the revised text of the State Forest Policy; however, we fear that it will be suppressed by the legislative assembly as to compensate in another Amazonian state may be cheaper than to restore. Considering that the Forest Code allows secondary succession to be counted for both RL compensation and environmental reserve quotas (CRA), we strongly recommend that the economic and ecological benefits of these mechanisms stay exclusively at the Amazon region of Maranhão.

In December 2019, the legislative assembly of Maranhão adopted, as a matter of urgency, the Bill nº 494 (December 2, Maranhão, 2019b) authorizing large wood consumers, such as the pig iron industries, to supply from deforestation. This is prohibited by federal law and the new State Forest Law which, in such cases, authorizes timber only from planting or sustainable forest management (SFM). SFM is an alternative to forest use, but unfortunately, Maranhão has no more forest core areas (outside protected areas) with the minimum extension required (27,000 ha) to ensure sustainable 30-year cycles (Santos de Lima et al., 2018). Governments, landowners and the private sector must commit to "Zero Deforestation" and forest restoration agenda in order to re-grow areas large enough to allow for SFM in the future. These commitments need to be assured through laws and policies, with clear criteria for implementation and monitoring, including incentives and tax restrictions.

Restoration and promotion of forest and agroforestry product chains (timber and non-timber) bring social and environmental benefits and is the best opportunity for economic development and sustainability in the Amazon region of Maranhão. The business-as-usual policy will drive the region to further economic breakdown leading to more poverty due to the collapse of ecosystem services. The region is proof that the past and current land-use policies are a complete failure. Moreover, Maranhão should be an example to offset the current setbacks in federal environmental policies. For that, forest must be fully protected, and degraded areas restored; indigenous peoples and other traditional and rural communities must have their rights assured. Degradation, illegality, and violence must be the only things dismissed in the region.

CRediT authorship contribution statement

Celso H.L. Silva Junior: Writing - original draft, Data curation, Methodology, Formal analysis. **Danielle Celentano:** Conceptualization, Writing - original draft, Methodology, Formal analysis. **Guillaume X. Rousseau:** Conceptualization, Writing - review & editing. **Emanoel Gomes de Moura:** Writing - review & editing. **István van Deursen Varga:** Writing - review & editing. **Carlos Martinez:** Writing - review & editing. **Marlúcia B. Martins:** Writing - review & editing.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001, the Foundation for Scientific and Technological Research and Development of Maranhão (FAPEMA), and the Maranhão State University (UEMA). We thank the scientists at the National Institute for Space Research (INPE) and the MapBiomas Project for providing the freely available datasets. We thank Starry Sprenkle-Hyppolite for language editing. We also thank the editor and reviewers whose helpful comments and suggestions helped to improve and clarify this manuscript. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.landusepol.2020.104806.

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