FOREST DEGRADATION IN THE BRAZILIAN AMAZON

PUBLIC POLICY MUST TARGET PHENOMENON RELATED TO DEFORESTATION

CLIMATE POLICY INITIATIVE

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Over the past decades, Brazil has garnered significant experience in using policy to protect tropical forests. Most notably, the country designed and implemented several effective efforts to combat clear-cut deforestation in the Brazilian Amazon.[1] This was prompted by the urgent need to curb the loss of tropical forest in the country, which ranked amongst the highest in the world in the early 2000s.[2] Deforestation, however, is not the only kind of environmental damage affecting the Brazilian Amazon. Forest degradation, a phenomenon characterized by the gradual loss of vegetation, is emerging as an increasingly relevant threat to the region.[3,4] **Though degradation may seem less destructive than deforestation, combating degradation must be a priority for Brazil's conservation policy agenda.** After all, halting forest loss at an earlier stage enhances the ability to conserve native vegetation in the long run.

Today, in part because degradation remains a relatively unknown phenomenon, it is rarely prioritized in policy action aimed at protecting native vegetation. **A better understanding of degradation in the Amazon, and particularly of its empirical relationship with clear-cut deforestation, is a key input in the decision-making process for allocating scarce resources to public policy implementation.** With it, Brazil could target its efforts more efficiently and provide a more timely response to degradation.

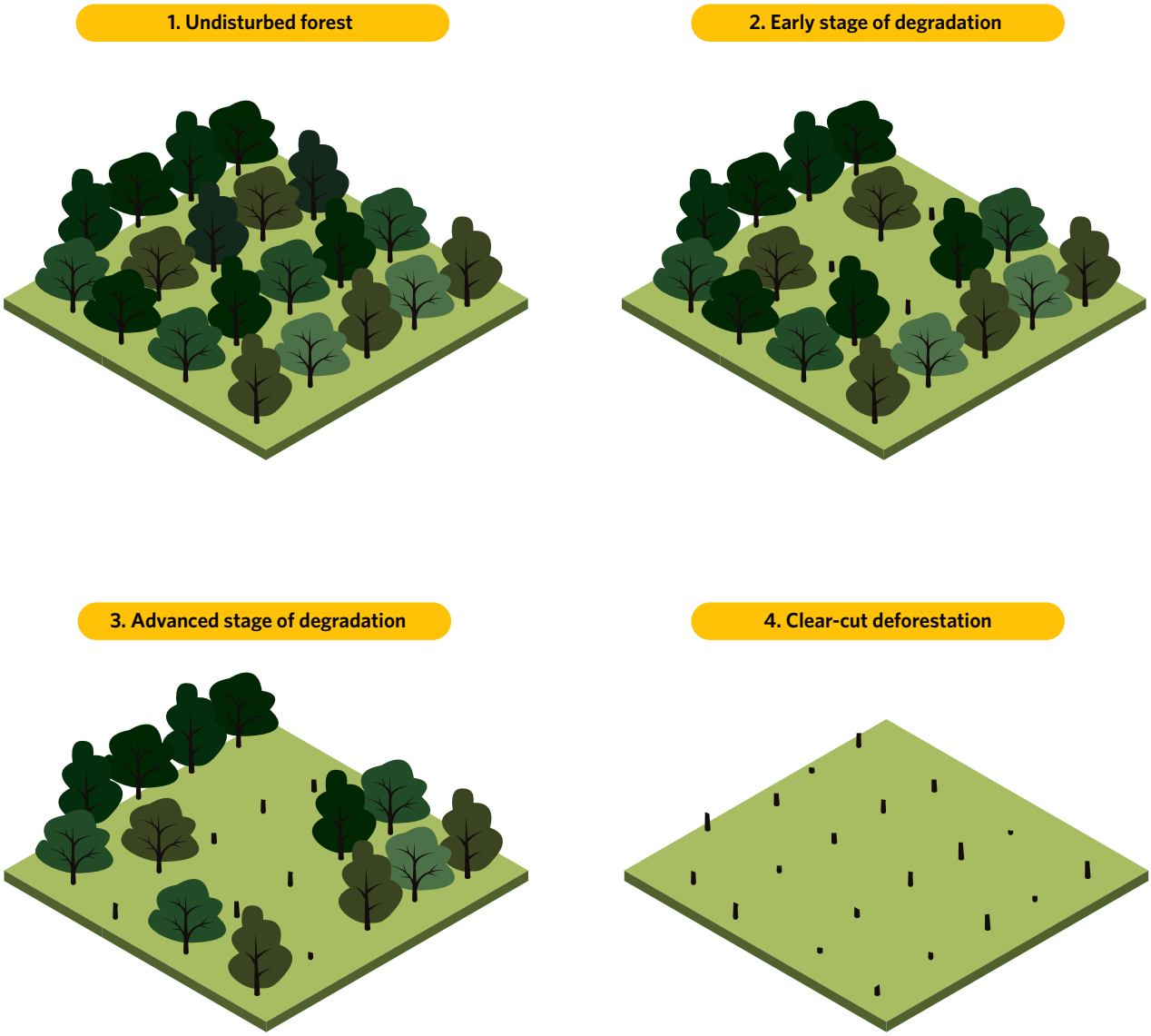
To enhance understanding of this phenomenon, researchers from Climate Policy Initiative/ Pontifical Catholic University (CPI/PUC-Rio) empirically characterized the dynamics of degradation and its relationship with clear-cut deforestation in the Brazilian Amazon. This Insight provides a brief introduction to the topic of tropical degradation, a summary of key results, and directions for future research and policy. **The analysis reinforces the recent relevance of degradation in the Brazilian Amazon, and finds that there is a close relationship between degradation and deforestation. Results indicate that this relationship varies significantly across land tenure categories, stressing the need for tailoring conservation policy to address different tenure-based governance structures.**

1 For a summary of conservation policy assessments, see: Gandour, Clarissa. *Why Is Protecting the Amazon Important?* Climate Policy Initiative, 2019. bit.ly/3v0ow7N.
2 Hansen, Matthew C. et al. "Humid tropical forest clearing from 2000 to 2005 quantified by using multitemporal and multiresolution remotely sensed data". *Proceedings of the National Academy of Sciences* 105, No. 27 (2008): 9439–9444.
3 Rappaport, Danielle I. et al. "Quantifying long-term changes in carbon stocks and forest structure from Amazon forest degradation". *Environmental Research Letters* 13, No. 6 (2018): 065013.
4 Matricardi, Eraldo A. T. et al. "Long-term forest degradation surpasses deforestation in the Brazilian Amazon". *Science* 369, No. 6509 (2020): 1378-1382.

WHAT IS FOREST DEGRADATION?

This project defines forest degradation as the **partial loss of forest biomass**. Figure 1 provides a simplified view of this process. Starting with an undisturbed forest, degradation undermines the integrity of forest cover via the gradual loss of vegetation over time. Although a degraded forest still retains primary vegetation, it does not have the same forest structure, resilience, and functions as an undisturbed forest.[5] As degradation progresses, the loss of forest biomass approaches that of clear-cut deforestation, in which there is complete (or near complete) removal of all vegetation cover.

Figure 1. Forest Degradation and Clear-cut Deforestation



Source: *CPI/PUC-Rio, 2021*

5 Longo, Marcos et al. "Aboveground biomass variability across intact and degraded forests in the Brazilian Amazon". *Global Biogeochemical Cycles* 30, No. 11 (2016): 1639-1660.

The process depicted in Figure 1, in which an undisturbed forest undergoes several stages of degradation culminating in clear-cut deforestation, is just one of the possible paths for a degraded area. Degradation can occur more or less gradually over time, depending on the type of activity causing it. Moreover, degradation does not necessarily lead to clear-cut deforestation – a degraded area can be intentionally maintained with only a partial remnant of primary vegetation, or it might experience regeneration and contain a mixture of primary remnants and secondary vegetation.

DEGRADATION IN THE BRAZILIAN AMAZON

PRIMARY CAUSES

The practices most commonly associated with tropical degradation in Brazil are selective logging and forest fires. Selective logging entails the cutting of specific species of trees, typically selected based on the commercial value of their timber. In addition to the loss of biomass from tree extraction itself, the forest around felled trees is also compromised by the opening of access roads and storage yards and by the damage caused by trees falling on nearby vegetation. To minimize this side effect, lawful logging activities should abide by a management plan.

Fires, on the other hand, usually destroy the more fragile plants first and, after repeated burn cycles in the same location, advance to more resistant plants. Due to high humidity, tropical forests do not burn easily or right away. Upon first contact, fires consume the most fragile vegetation and compromise the resilience of the remaining plants, which become more vulnerable to subsequent fires.

The analysis by CPI/PUC-Rio uses data from DEGRAD, a system developed by Brazil's National Institute for Space Research (*Instituto Nacional de Pesquisas Espaciais* - INPE) that uses satellite imagery to compile annual maps of degraded areas across the Brazilian Amazon from 2007 to 2016. DEGRAD does not consistently categorize the type or stage of degradation, so the empirical analysis does not currently cover any such classification.

GENERAL CHARACTERISTICS

Forest degradation is a large-scale phenomenon in the Amazon, typically affecting a much greater area than clear-cut deforestation. Between 2007 and 2016, an average 11,000 km^2 of forest were degraded each year. This is twice the annual average for deforested areas in the same period. While deforestation advanced at a relatively stable pace during the sample period, **degradation varied considerably over time,** especially from 2009 to 2016. Total degraded area per year varied from a minimum of 2,700 km^2 in 2014 to a peak of 23,700 km^2 in 2016.

Spatially, **forest degradation is geographically concentrated along the Arc of Deforestation**, which historically also holds most of the Amazon's deforested areas.[6] On average, the states of Mato Grosso and Pará jointly account for 75% of degraded areas and 64% of deforested areas per year in the Amazon. Despite the phenomenon's regional concentration, **degradation exhibits a low rate of local recurrence over the years**. A given area is classified as degraded, on average, only once in the sample period.

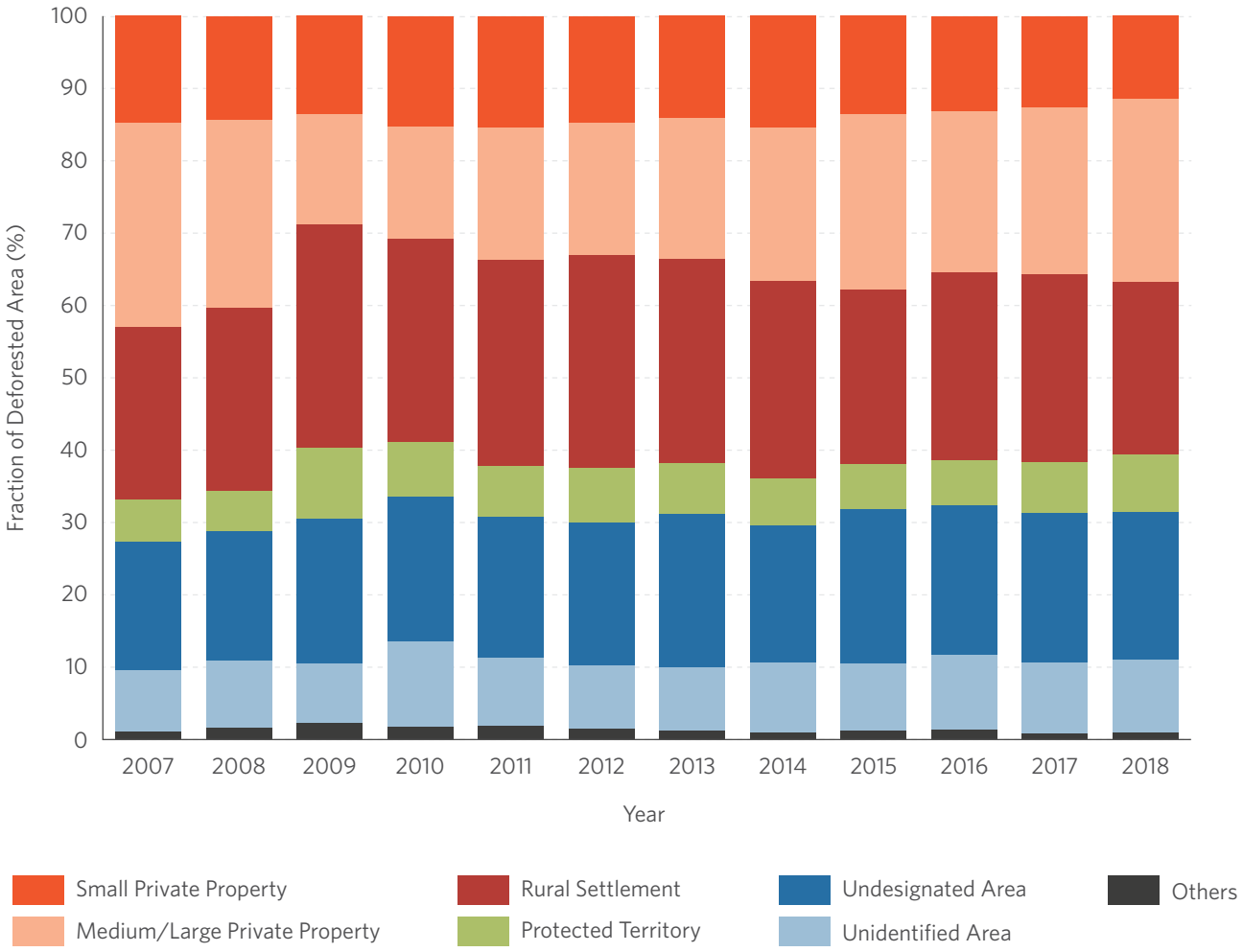
Furthermore, **there seems to be relatively little conversion from degradation to deforestation in the Amazon as a whole during the period under assessment.** On average, only 9% of degraded areas are deforested within three years, which is the average length of time between the occurrence of these two events. This, however, does not mean that a close relationship between degradation and deforestation does not exist. **Since this number is an Amazon-wide average, it may hide important differences in how stakeholders interact with the forest in specific regions.** Land tenure plays a potentially central role in this. In Brazil, tenure is a key determinant of the rules that govern local land use, including the protection and conversion of native vegetation. Tenure-based governance structure may therefore affect land use decisions and, thus, local forest conversion patterns. This calls for a better understanding of the relationship between degradation and deforestation across different land tenure categories.

DEGRADATION AND DEFORESTATION BY LAND TENURE CATEGORY

By looking at how degradation and deforestation relate in different categories of land tenure, the study aims at exploring whether governance structure influences local stakeholders' interactions with the forest. The analysis considers seven categories: small private properties, medium or large private properties, protected territories (protected areas and indigenous lands), rural settlements, undesignated public lands, unidentified lands (for which no information on tenure is available), and others (remaining categories).

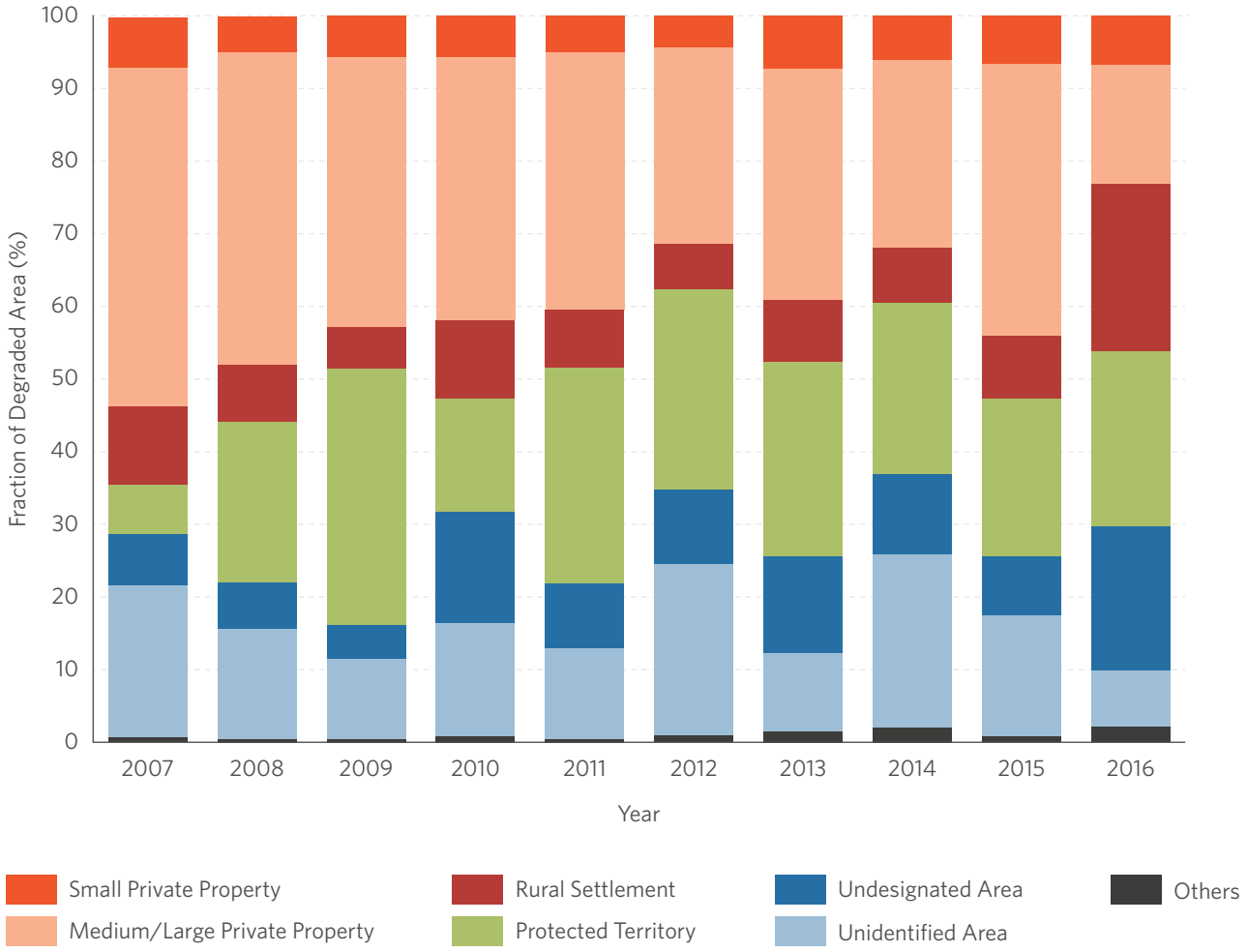
6 The Arc of Deforestation refers to a wide region of the Amazon biome that extends from western Maranhão and southern Pará towards the west, passing through Mato Grosso, Rondônia, and Acre.

Figure 2a. Deforestation, Distribution by Land Tenure Category, 2007-2018



Source: *CPI/PUC-Rio with data from PRODES/INPE, Agricultural Atlas/IMAFLORA, and National Registry of Public Forests/Brazilian Forest Service, 2021*

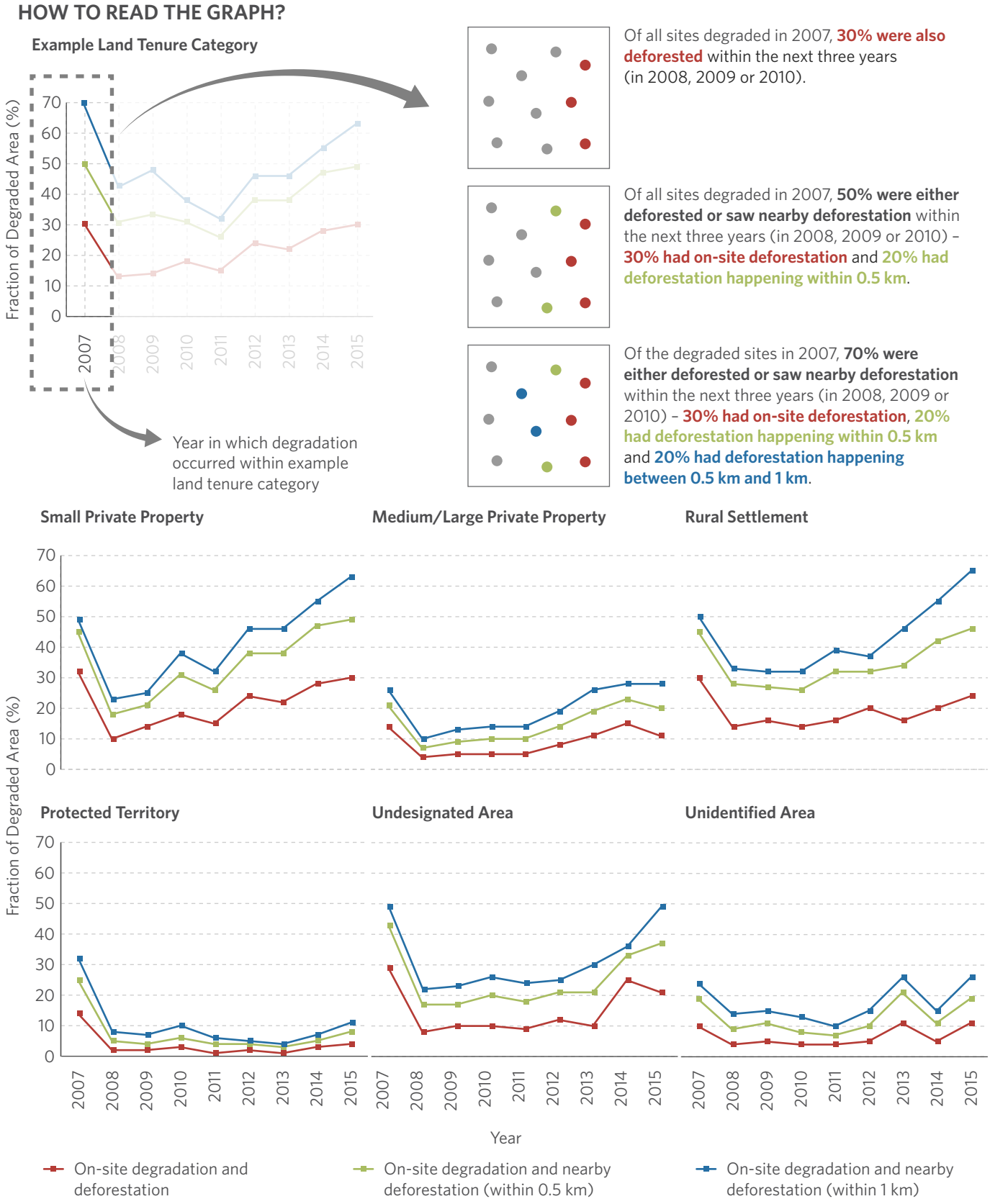
Figure 2b. Degradation, Distribution by Land Tenure Category, 2007-2016



Source: *CPI/PUC-Rio with data from DEGRAD/INPE, Agricultural Atlas/IMAFLORA, and National Registry of Public Forests/Brazilian Forest Service, 2021*

Figure 2 shows the annual distribution of deforestation and degradation across categories. For deforestation, the distribution remains quite stable over time, with similar shares of forest loss occurring every year in private properties (mainly medium or large), rural settlements and undesignated public lands. Degradation, on the other hand, varies significantly across categories and years. A large share of degradation occurs in medium or large private properties and, to a lesser extent, in unidentified lands. The lower participation of small private properties and rural settlements, as well as the greater participation of protected territories contrast with the pattern seen for deforestation.

Figure 3. Relationship Between Degradation and Deforestation by Land Tenure Category, 2007-2015



Note: *For each land tenure category, the graph shows the share of area degraded in each year that was followed by deforestation within three years. The analysis considers deforestation happening in the same site as degradation (conversion of degradation to deforestation) and in its vicinity (deforestation near degradation).*

Source: *CPI/PUC-Rio with data from DEGRAD/INPE, PRODES/INPE, Agricultural Atlas/IMAFLORA, and National Registry of Public Forests/Brazilian Forest Service, 2021*

Does deforestation systematically follow degradation in any of the land tenures categories? Figure 3 suggests it does. Although the local conversion of degradation into deforestation remains low or moderate across all tenure categories, the data point to significant deforestation occurring near degraded areas within three years of the degradation event. In this sense, **degradation in a given site may not always be a precursor to on-site deforestation, but it may serve as an indicator that deforestation will soon occur in that region**.

As Figure 3 shows, the relationship between degradation and deforestation varies among land tenure categories. Although it is impossible to determine the reasons for these differences from the data used in the study, the analysis raises a few likely interpretations. There are three main patterns. First, the conversion of degradation into deforestation is consistently low within protected territories, even when accounting for deforestation occurring in the vicinity of degraded areas. Considering that environmental crimes committed inside protected territories are subject to harsher penalties, the low conversion rates could be explained by the fact that removing more vegetation in degraded areas, which carries a greater risk of detection by environmental law enforcement authorities, is simply not worth it.

Second, degradation appears to be followed by nearby deforestation in small private properties and rural settlements. In these categories, even local conversion from degradation to deforestation is relatively high. This pattern is likely tied to the high cost of clearing vegetation in a tropical forest. For smallholders and settlers, who typically have limited access to financing, degradation might provide a way to remove forest cover little by little and at a lower cost.

Third, medium and large private properties, undesignated public areas, and unidentified areas seem to lie somewhere in-between the two previous patterns. Local conversion of degradation into deforestation is low, but there appears to be a moderate portion of degraded areas that are followed by nearby deforestation. These categories are less homogeneous than the previous ones, so this pattern likely encompasses a variety of degradation and deforestation profiles.

Finally, the evidence suggests that the share of degradation followed by on-site or nearby deforestation grew in the final years of the sample across all land tenure categories. This may point to degradation as an increasingly relevant precursor to – and therefore an important leading indicator of – deforestation.

NEXT STEPS FOR RESEARCH AND PUBLIC POLICY

Forest degradation appears to be closely related to deforestation in the Brazilian Amazon, and, for select land tenure categories, it seems to be a precursor of deforestation. Degradation can therefore be used as an indicator of imminent environmental damage and help target conservation policy efforts. On the other hand, for cases in which degradation does not convert to deforestation, it is important to understand why the degradation of environmental assets is happening if the land is not being subsequently used for production.

In this setting, public policies must tailor approaches to address the various forest conversion practices found across different land tenure categories. Research, in turn, must support public policy design and implementation by advancing the understanding of how tenure-based

governance structures influence patterns of degradation and subsequent deforestation. This study offers a first look at how policymakers can understand degradation and use this knowledge to enhance their ability to combat forest loss in its various forms.

DATA

The analysis explores a rich and spatially explicit (raster) dataset built from a variety of publicly available sources. The key variables and their sources are: degraded areas from DEGRAD/INPE; deforested areas from PRODES/INPE; and land tenure categories from the Agricultural Atlas/ IMAFLORA and National Registry of Public Forests/Brazilian Forest Service.

METHODOLOGICAL NOTE

The analysis aims at empirically characterizing forest degradation in the Brazilian Amazon and investigating its relationship with clear-cut deforestation between 2007 and 2018. The spatial sample includes tropical forest areas in the Brazilian Amazon Biome that were degraded and/ or deforested during the sample period. A raster database was compiled at 30-meter resolution to include georeferenced data on degradation and deforestation over time, as well as on land tenure categories for the entire Amazon Biome. The study relates degradation and deforestation events happening in the same place or in close proximity, and stratifies the results by land tenure category. Due to the large number of observations in the database (almost 2 billion), random sampling was used to build the dataset for analysis (containing 2.5% to 15% of all observations in the original database).

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