Public Policies for the Protection of the Amazon Forest

What Works and How to Improve

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About Amazon 2030

The Amazon 2030 project is a Brazilian research initiative with the purpose of developing an action plan for the Brazilian Amazon. Our objective is to achieve conditions for a higher standard of economical and human development in the region, and to achieve a sustainable use of natural resources by 2030.

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Keywords

Forest Protection; Forest Conservation; Deforestation; Forest Degradation; Secondary Vegetation; Public Policies

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List of Acronyms

ABIOVE	Brazilian Association of Vegetable Oil Industries
ANEC	National Association of Grain Exporters
APP	Permanent Preservation Areas
CAR	Rural Environmental Registry
CGU	Office of the Comptroller General
DETER	System for Real-Time Detection of Deforestation
EMBRAPA	Brazilian Agricultural Research Corporation
ESG	Environmental, Social and Governance
FUNAI	National Indigenous Foundation
GHG	Greenhouse Gas
IBAMA	Brazilian Institute for the Environment and Natural Resources
INPE	National Institute for Space Research
LCA	Law of Environmental Crimes
MMA	Ministry of the Environment
MPF	Federal Prosecutor's Office
NDC	Nationally Determined Contribution
PAM	Municipal Crop Production
PEAA	The Amazon Now Plan for the State of Pará
GDP	Gross Domestic Product
PLANAVEG	National Plan for the Recovery of Native Vegetation
PMV	Green Municipalities Program
PNAP	National Strategic Plan for Protected Areas
PPCDAM	Action Plan for the Prevention and Control of Deforestation in the Legal Amazon
PRODES	Program for Satellite Monitoring of the Brazilian Amazon Rainforest
PRONAF	National Plan for Family Farming
PES	Payments for Environmental Services
REDD+	Reduction of emissions from deforestation and forest degradation, as well as the sustainable management of forests and the conservation and enhancement of forest carbon stocks
SICAR	National Rural Environmental Registry System
TAC	Conduct Adjustment Terms
UNFCCC	United Nations Framework Convention on Climate Change

Executive Summary

Public policy plays a fundamental role in protecting the native vegetation of the Amazon Forest. It guides the actions of the several different players needed for forest conservation, bringing together evidence-based approaches that are grounded in the use of state of the art technology and in the application of robust technical knowledge. **Brazil is fully capable of developing and implementing a public policy agenda for Amazon protection that is innovative, strategic, and effective — it has done this before.**

Over the past two decades, while the country gained broad experience in the use of policy instruments to protect its native vegetation, academia produced a robust body of empirical evidence on these instruments' effectiveness and impact. This report consolidates the main findings of the academic literature that rigorously evaluates policies aimed at combating deforestation in the Brazilian Amazon. Additionally, it draws on empirical evidence to propose ways of strengthening Brazil's policy agenda for protecting the Amazon Forest whilst promoting the region's sustainable development. The report thereby aims to contribute to the design and implementation of an effective policy framework for Amazon conservation.

What Works to Protect the Amazon Forest?

Public policy efforts to combat deforestation significantly contributed to the Brazilian Amazon deforestation slowdown, when the rate of forest clearing fell by more than 80%, decreasing from 27,800 square kilometers in 2004 to 4,600 square kilometers in 2012 (INPE 2021a). The strengthening of environmental command and control was pivotal to this. In a context in which the bulk of deforestation was illegal, the pioneering use of near-real-time remote monitoring technology to detect forest loss and target environmental control operations greatly increased law enforcement's capacity to apply binding and costly penalties to offenders. Monitoring and law enforcement inhibited illegal practices and curbed deforestation at scale. The evidence suggests that the reduction in forest clearings did not jeopardize local agricultural production. It also indicates that the policy was cost-effective and that it contributed to the expansion and permanence of secondary vegetation in the Amazon.

In addition to enhanced monitoring and law enforcement, public policy innovations introduced targeted action in critical areas and conditioned the concession of subsidized rural credit upon proof of compliance with environmental and land tenure regulations. Both helped reduce forest loss in the Amazon. Brazil also started using territorial protection as a barrier to the advance of deforestation. Protected areas and indigenous lands in regions under high forest clearing

pressure effectively shielded forests, but it is unclear if they significantly contributed to the reduction in the aggregate level of deforestation

These different policy efforts were carried out within the scope of a federal plan to combat deforestation in the Amazon, which has been highlighted in the academic literature as a central element for planning and coordinating strategic actions. Although there is still room to deepen understanding about the impacts of these multiple policies, there is a consensus that they were effective in reducing deforestation in the Brazilian Amazon. However, they were not the only forest protection measures implemented in Brazil within the last two decades. Several other policy efforts were enacted during this period, but the available empirical evidence on their causal effects is still limited. Examples include payment for environmental services mechanisms, supply chain agreements for zero deforestation, and subnational initiatives. Although this report addresses these efforts in less detail, this should not be interpreted as an indication that they are not relevant for the protection of the Amazon Forest. Rather, this is an acknowledgment of the weak empirical evidence currently associated with them, and a suggestion of relevant topics for future research.

The academic literature delivers a clear message: public policies are an effective way of protecting native vegetation in the Amazon. Brazil must use this knowledge to ensure the continuity of what has already proved effective, fill in the gaps in its understanding of forest conservation policy impacts, and seek innovative solutions for the challenges that remain.

Strengthening Amazon Forest Protection

After a strong reduction between 2004 and 2012, deforestation in the Amazon Forest started trending upwards and, as of 2019, has shown signs of acceleration (INPE 2021a, 2021b). Conservation policies enacted over the past two decades were effective in containing forest clearings, but these policies are no longer enough. In addition to improving its efforts to fight deforestation, Brazil must incorporate new dimensions of forest protection to its policy agenda for Amazon conservation. This report proposes three critical courses of action for strengthening Amazon protection:

Deforestation It is imperative that Brazil eliminate the impunity currently associated with illegal forest clearings. To that effect, it is critical to uphold environmental governance that supports effective environmental sanctioning procedures and penalties, both of which are central to law enforcement's capacity to inhibit illegal practices. Strategic efforts to combat deforestation should also target priority areas.

Forest Degradation The country must deepen its understanding of forest degradation. How does it contribute to a process of forest loss in the Amazon? How does it relate to economic activity? How does it respond to public policy? Brazil can draw on this understanding to adopt a

strategic approach to fight forest degradation in the Amazon and thereby enhance the impact of conservation efforts in the region.

Secondary Vegetation Brazil must urgently monitor secondary vegetation in the Amazon. Although tropical forest regrowth covers vast areas, it remains invisible to forest monitoring systems. The country has the technology and technical expertise needed to develop the systematic monitoring of its secondary vegetation, but this requires support from public policy. Monitoring forest regrowth in the Amazon is vital both for its protection and for advancing the understanding about this phenomenon. This is key to incorporating secondary vegetation into a strategy for large-scale restoration of degraded ecosystems.

Amazon Forest Protection Requires Solid Support from Public Policy

Brazil has a unique opportunity to align the interests of diverse government entities, productive sectors, and civil society around a single effort. As it takes steps to better conserve its native vegetation, the country protects this precious environmental asset, along with all forms of life that depend on it directly or indirectly — but that's not all. It also boosts production capacity and gains a competitive edge in global markets, while combating illegal activity and moving towards a position of global leadership on climate action.

Protecting the Amazon demands solid political leadership and an unwavering commitment to an evidence-based public policy agenda. In this context, the government is responsible for planning, supporting, and coordinating strategic activities across different spheres of action, thematic areas, and segments of society. The country knows what must be done and is fully capable of doing it. Brazil must treat the protection of its Amazon Forest with the necessary urgency.

Introduction

With over 800,000 square kilometers of deforested native vegetation, Brazil has already lost a fifth of the original extent of its Amazon Forest (INPE 2021a). Protecting this vegetation is a formidable challenge, accentuated by the vast forest and its rich diversity, as well as the complex legal framework governing land use in Brazil. But it is a challenge worth facing.

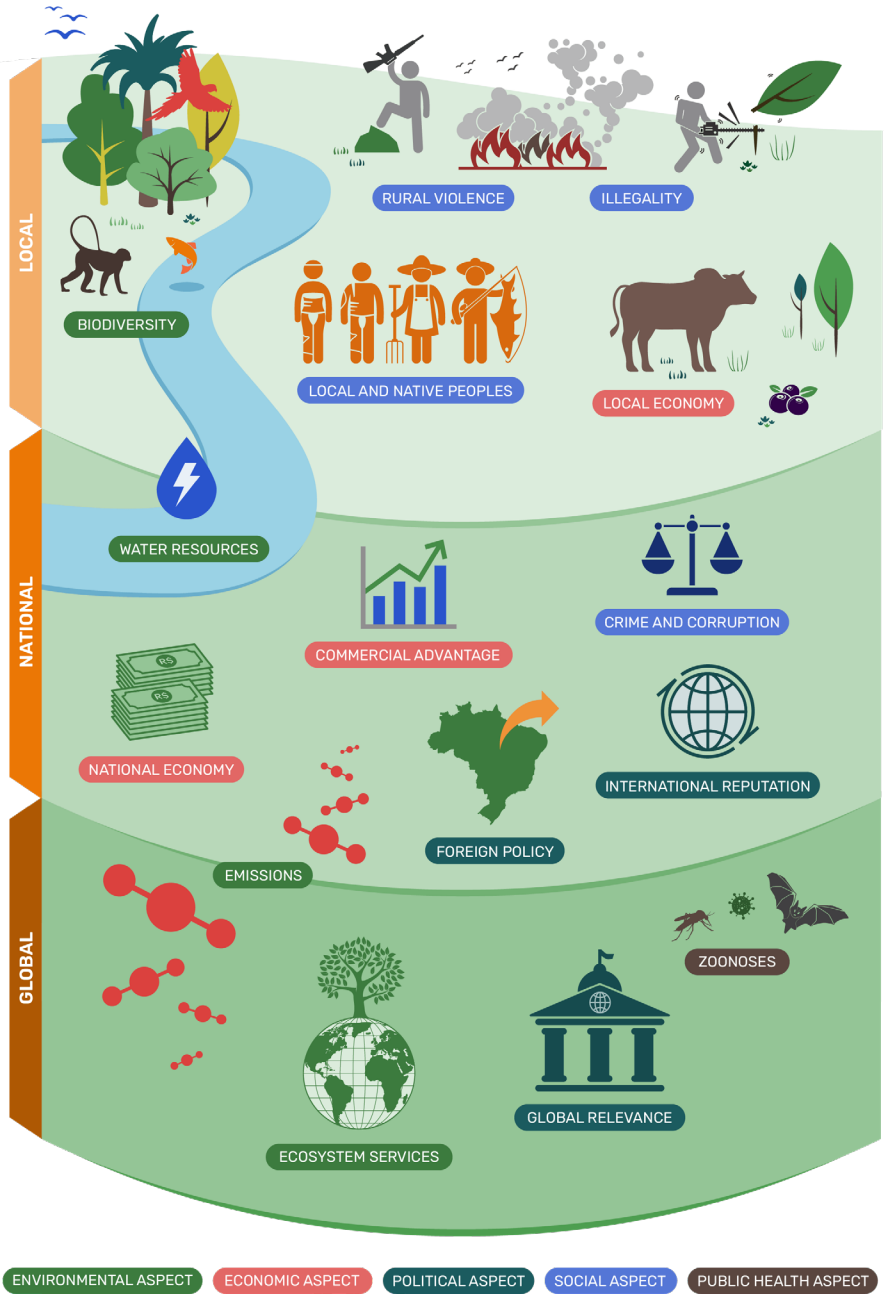
Public policy plays a fundamental role in this. Protecting native Amazon vegetation demands coordinated public policy actions across thematic areas and government spheres. Such actions must be based on empirical evidence and grounded both in the strategic use of state of the art technology and in the application of robust technical knowledge. Brazil is fully capable of implementing an effective strategy for protecting the Amazon Forest — it has done this before.

This report aims to contribute to the design and implementation of this strategy. It is organized as follows: section "Why Protect the Amazon Forest?" provides an overview of the various benefits of forest conservation, highlighting how this action has repercussions at the local, national, and international levels; section "What Works to Protect the Amazon Forest" summarizes empirical knowledge about the effectiveness of public policies for forest conservation, consolidating key results from the academic literature that evaluates policies aimed at combating Amazon deforestation; section "Strengthening Amazon Forest Protection" discusses ways to improve and strengthen the forest conservation and sustainable development agenda for the Brazilian Amazon.

Why Protect the Amazon Forest?

Given the multiple ecosystem services provided by the Amazon Forest, protecting its native vegetation provides a range of potential benefits at local, national, and international levels. This section presents some of the main benefits of protecting the Amazon Forest, addressing environmental, economic, political, social, and health aspects. Figure 1 summarizes the discussion.

Figure 1. Benefits of Protecting the Amazon Forest



Source: CPI/PUC-Rio, 2021

Local Benefits

Preserving the Amazon's native vegetation is a necessary condition for conserving its biodiversity and ensuring the balance of its forest ecosystems. Native peoples and local populations — indigenous communities, [1] *quilombolas,* river communities, and family farmers,

[1] According to the latest Brazilian Demographic Census, there are more than 380,000 indigenous peoples living in the Legal Amazon, almost half of the country's indigenous population (IBGE 2012). The Amazon Forest is also home to the largest number of isolated indigenous groups on the planet (Ricardo and Gongora 2019).

among others — depend on this balance to live, produce, and prosper. Protecting this vast natural and cultural heritage is equivalent to protecting these people's livelihood. It is thus an essential environmental and social responsibility for Brazil.

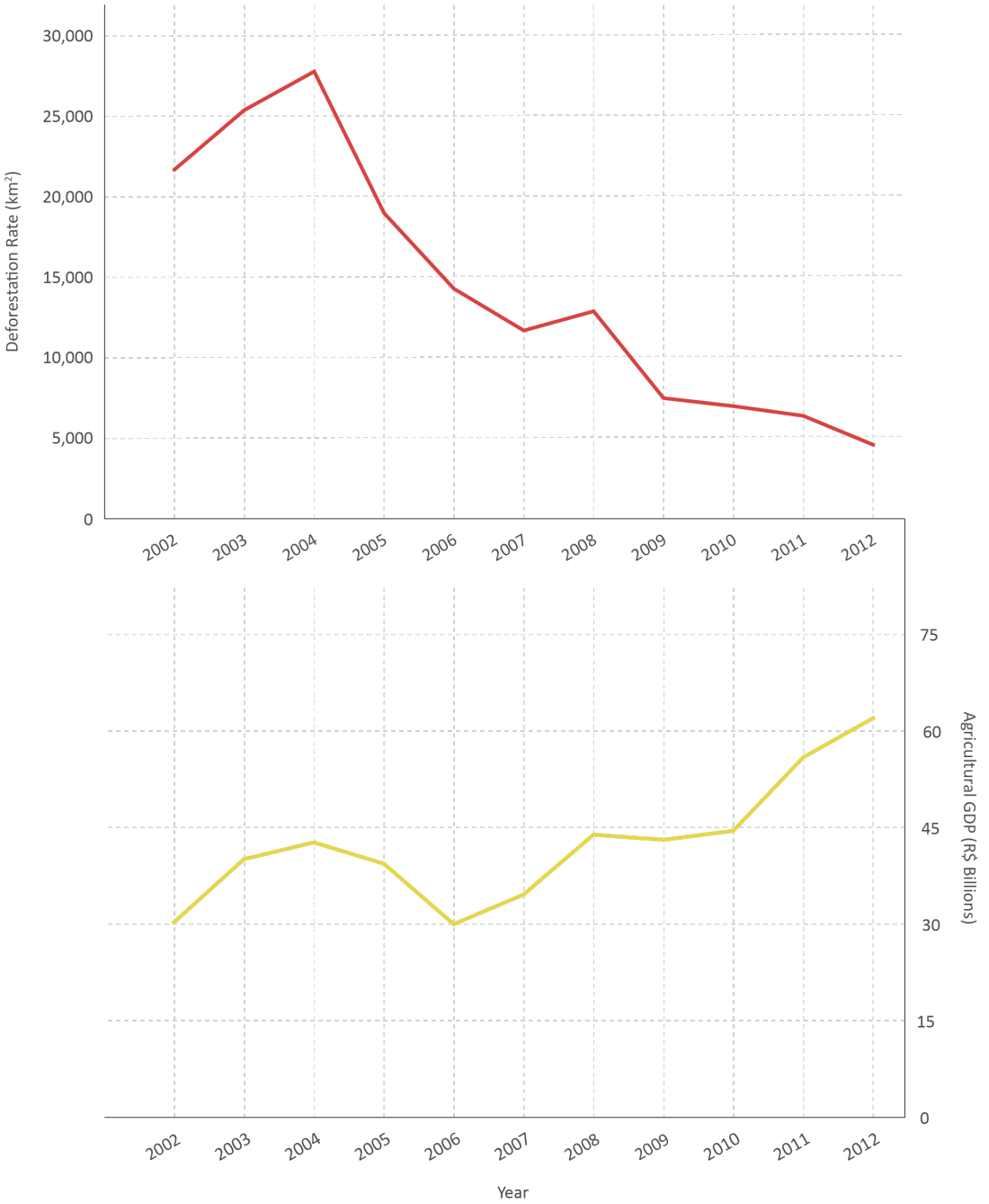
Combating forest loss in the Amazon also contributes to fighting illegality in the region. That's because, most of the deforestation that takes place in the forest is illegal. Studies show that less than 5% of the area deforested since 2008 had been duly authorized (Azevedo et al. 2021; Valdionas et al. 2021). This scale of illegality limits the Amazon region's capacity to participate in formal markets, implying huge costs for production and social well-being. The clearing of native vegetation in the Amazon is also directly linked to violence in rural areas and to illegal practices that are deeply rooted in the region's land use and occupation dynamics (Alston, Libecap, and Müller 2000; Brown, Brown, and Brown 2016; Chimelli and Soares 2017).[2] Insecure property rights in the region fuels these conflicts and creates an environment that is ripe for land grabbing and the deforestation that often follows. In the past decade, 25% to 30% of deforestation occurred in undesignated public lands, constituting unauthorized occupation of public territory and the illegal clearing of native vegetation (Azevedo-Ramos and Moutinho 2018).

Deforestation in the Amazon Forest is associated not only with illegal activities, but also to largely unproductive ones. The expansion of the area for agricultural production — especially pasture for cattle — is usually identified as one of the main drivers of deforestation in the Brazilian Amazon (Barona et al. 2010; Tyukavina et al. 2017). Mapping land use after deforestation indicates that pastures occupy nearly two-thirds of the area that has been historically deforested in the Amazon (INPE and Embrapa 2016). There is evidence, however, that the expansion of these pastures occurred as a form of illegal land grabbing, rather than for production purposes, which is consistent with the region's very low cattle productivity (Lima Filho and Bragança, forthcoming). Thus, advancing deforestation cannot be justified as being necessary for the expansion of food production in the region. This is corroborated by findings that policies that helped reduce forest loss did not affect local agricultural production (Assunção and Rocha 2019; Assunção, Gandour, and Rocha 2019; Koch et al. 2019). Indeed, between 2004 and 2012, when Brazil's rate of deforestation fell by over 80%, the real gross domestic product (GDP) of the agricultural sector for the Legal Amazon[3] increased by more than 50% (Figure 2).

[2] From 2011 to 2020, more than 5,000 conflicts over land were recorded in the Legal Amazon, half of the national total for the same period of time (CPT 2021). A survey carried out by Human Rights Watch reveals that the victims of rural violence were typically acting to prevent illegal deforestation and are often members of indigenous communities or other peoples who reside in the forest (HRW 2019). It also highlights that those responsible for the violence are rarely investigated and penalized for their actions.

[3] The Legal Amazon is a geopolitical division of Brazilian territory comprising the entire states of Acre, Amazonas, Amapá, Mato Grosso, Pará, Rondônia, Roraima, Tocantins, and part of the state of Maranhão. It contains virtually the entire Amazon biome, but also includes part of the Cerrado and Pantanal biomes.

Figure 2. Deforestation Rate and Agricultural GDP, 2000-2012



Note: GDP refers to gross value added at current prices for the agricultural sector in all Legal Amazon municipalities. GDP values are corrected for inflation and presented in terms of year 2018 Brazilian currency (R$).

Source: CPI/PUC-Rio with data from PRODES/INPE and Municipal Gross Domestic Product/IBGE, 2021

The association between deforestation and unproductive activities is reinforced by the remarkable extent of secondary vegetation (that which grows in areas that have already been deforested) in the Amazon Forest — in 2014, almost a quarter of the area that had been historically deforested contained secondary vegetation (INPE and Embrapa 2016).[4] Although the more than 170,000 square kilometers of secondary forest in the Amazon may sound like good news, it actually reveals an inefficient and wasteful land use pattern (Assunção and Gandour 2017). After all, these areas were essentially deforested and later abandoned, rather than put to productive use. Considering the vast amounts of available deforested and degraded lands in the Amazon, increasing the value of agricultural production in the region does not require further clearings, but productivity gains in already open areas (Garcia et al. 2017; Assunção and Bragança 2019; Stabile et al. 2020). This is not merely a theoretical possibility, but a strategic opportunity that has already been recognized by the private sector (Schreiber 2019). Implementation matters, however. Lima Filho, Bragança, and Assunção (2021) estimate that the dissemination of practices already used in the Legal Amazon's most productive municipalities would increase the value of cattle production in the region by 18 to 29%. Greater productivity gains require introducing new business models that contemplate the dissemination of techniques and technologies that have not yet been used at a scale in the region, as well as fighting the use of low productivity cattle ranching as part of the land grabbing process.

The Amazon's production potential is not restricted to the agricultural sector. Recent studies point to increased prospects for advances in bioeconomy, arguing that the Amazon's biodiversity could offer key materials for global cosmetics, biomedicine and food markets (Nobre and Nobre 2019). This could have a significant economic impact in the region. Coslovsky (2021) estimates that Amazon businesses that already export forest-compatible products (those obtained from non-timber forest extraction, agroforestry systems, fruit and vegetable sector, fishing, and fish farming) could have had annual revenues almost eight times higher, totaling annual sales of US$ 2.3 billion, by increasing their share of the global market for these products. Environmental conservation therefore offers an opportunity for Brazil to move towards a model of sustainable development for the Amazon region.

National Benefits

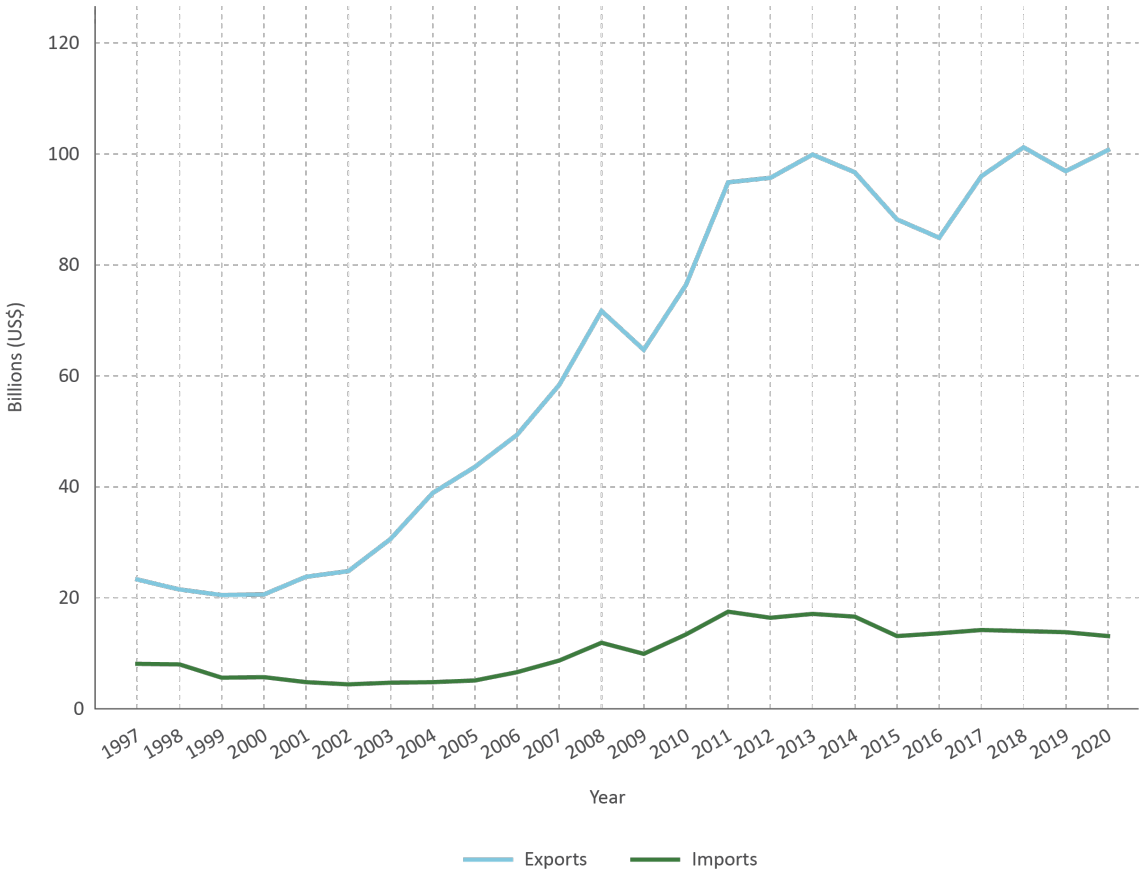
Forest protection is a strategic topic for Brazil, and one that cuts across many sectors and areas of government. Indeed, the ecosystem services the forest provides extend far beyond the geographical borders of the Amazon. Protecting native tropical vegetation is key to preserving biophysical factors that are essential for human well-being, as well as for the production of food and energy in other regions of Brazil. Specifically, the Amazon plays a fundamental role in regulating the water cycle and thereby influencing rainfall patterns and protecting against extreme weather events throughout the country (Nobre, Sellers and Shukla 1991; Spracklen,

[4] Data from the TerraClass Amazon Project, Brazil's official data source for land use in deforested areas in the Brazilian Amazon. The last year for which data are available in this project is 2014.

Arnold and Taylor 2012; Nobre 2014). Brazil will pay a high price for losing the forest's capacity to do so. Simulations suggest that changes to the climate caused by increased Amazon deforestation could lead to significant losses in production, even when the forest was cleared as a means of expanding agricultural production (Oliveira et al. 2013; Lawrence and Vandecar 2015; Leite-Filho et al. 2021).

Furthermore, environmental outcomes — particularly those related to the protection of the Amazon Forest — are a vital tool for promoting Brazil's position in global markets and building its international reputation. Brazilian agribusiness is largely dependent on these markets, as evidenced by the increased role exports have played in its trade balance since the beginning of the 2000s (Figure 3). Consumers, businesses, and investors in these markets have increasingly valued adherence to environmental regulations and fulfillment of environmental commitments throughout production chains. In 2020, ESG (environmental, social, and governance) guidelines were a prominent topic of debate at the World Economic Forum, and managers of funds holding more than US$ 4 trillion in assets expressed concern over signs that the Brazilian government was committed to protecting the Amazon Forest (Pinto and Cagliari 2020). Today, environmentally responsible production is a means of increasing the competitiveness of Brazilian products in international markets.

Figure 3. Brazilian Agribusiness Trade Balance, 1997-2020



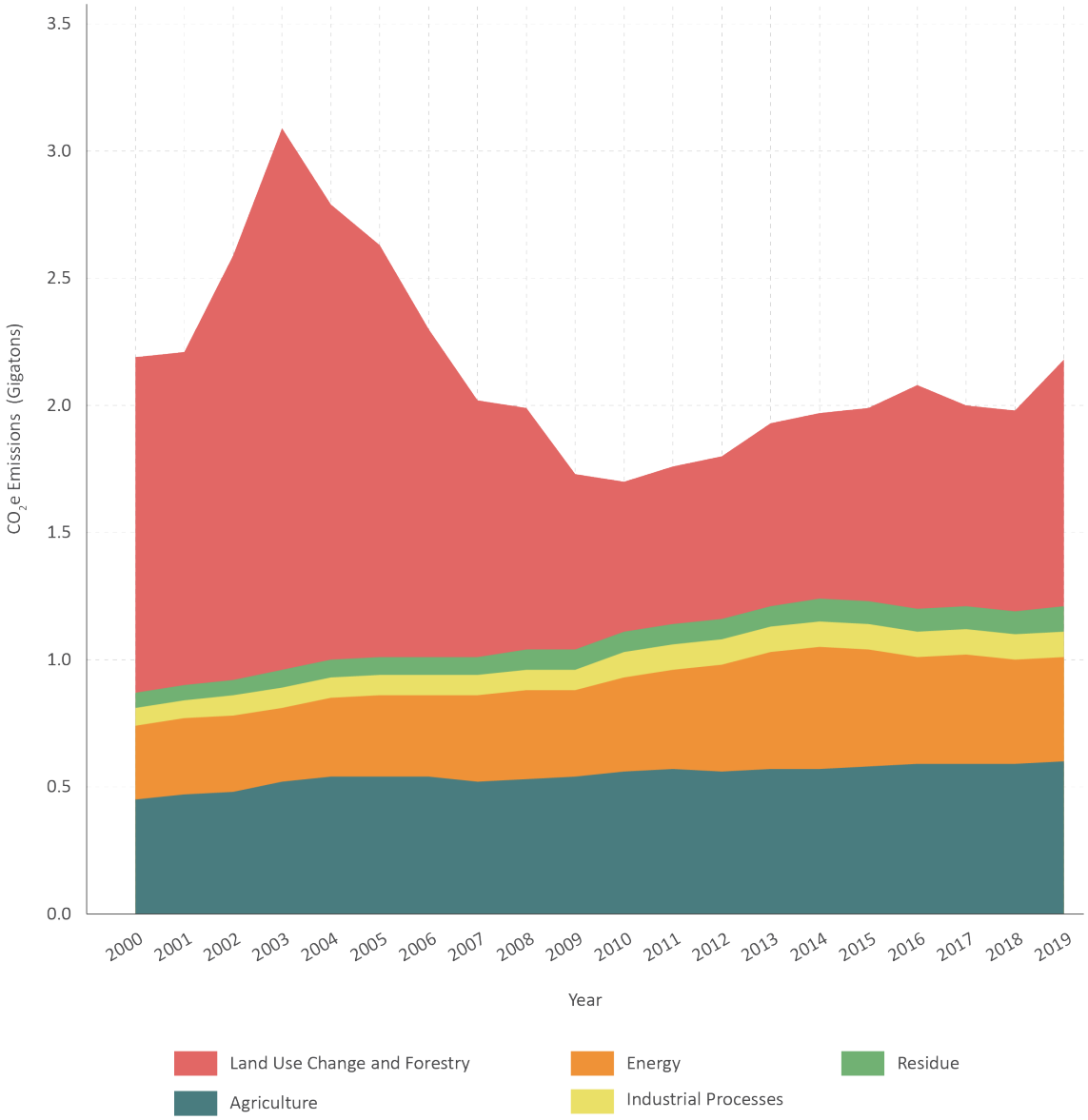
Source: CPI/PUC-Rio with data from AgroStat/MAPA, 2021

Combating deforestation in the Amazon also contributes to a broader effort of combatting illegality at the national level. Although forest clearings themselves happen far from the country's major financial centers, there are a large number of people throughout the country and large volumes of financial resources involved. Considering that clearing tropical forest is expensive, those who fund it are often located hundreds of kilometers away from the Amazon region. Public data on environmental fines issued by IBAMA for damage to vegetation from 1995 to 2019 reveal that large companies, politicians, foreigners, bankers, and others whose primary activity was not based in the forest accounted for the heaviest penalties (Castilho and Fuhrmann 2020). In addition, the Amazon Forest hosts several criminal networks involved in far-reaching illegal practices such as illegal mining, illegal trade in wild animals and plants, and arms and drug trafficking (Souza and Senra 2017; Charity and Ferreira 2020; Abdenur et al. 2020; Risso et al. 2021). There is still a need to deepen the understanding of how these practices interact with each other and with forest destruction, but the available evidence suggests that illegal deforestation is part of a sophisticated network of corruption that extends far beyond the borders of the Amazon. To fight it is thus equivalent to fighting crime at both national and international levels.

Global Benefits

Tropical forests are essential for maintaining life on earth. Among the many ecosystem services they provide, these forests are home to an enormous variety of animal and plant species, they help regulate water cycles, and they offer protection against extreme weather events (Nobre 2014; IPCC 2019). Furthermore, tropical forests are huge carbon sinks, with the Amazon being the largest of them (Pan et al. 2011; Brienen et al. 2015). As the integrity of the forest is essential for maintaining this stock, forest degradation and deforestation are important sources of greenhouse gas (GHG) emissions, mainly carbon dioxide. The agriculture, forestry and land use sector was responsible for an estimated one-quarter of global net anthropogenic GHG emissions between 2007 and 2016 (IPCC 2019). GHG emissions are the main determinant of the speed at which climate change happens, so they carry externalities at a global scale (Stern 2008; Nordhaus 2019). After all, a country's emissions affect not only that country, but all others across the globe. As a result, the protection of tropical forests — and, more specifically, their potential to contribute to the global effort to mitigate the adverse effects of climate change — came to occupy a prominent position on international agendas.

Figure 4. Greenhouse Gas Emissions by Sector, Brazil, 2000-2019



Note: Carbon-dioxide equivalent values refer to gross greenhouse gas emissions converted using GWP-AR5. Estimates cover all emissions sources included in Brazil's official National Greenhouse Gas Inventory.

Source: CPI/PUC-Rio with data from SEEG/Observatório do Clima, 2021

In being the country that holds the largest area of native tropical vegetation on the planet, Brazil carries great responsibility. At the beginning of the 2000s, about two-thirds of Brazilian GHG emissions originated from the land use change and forestry sector (MCTIC 2021; SEEG 2021). Emissions from the nine states that comprise the Legal Amazon accounted for more than 80% of the national total for this sector (SEEG 2021). The drop in Brazilian emissions from 2004 to 2010 was largely driven by the steep reduction in the Amazon deforestation rate during this period (Figure 4). This decline in forest loss also led to a substantial decrease in the participation

of the land use change and forestry sector, which came to represent only a third of total Brazilian emissions by the beginning of the 2010s. Since then, with the Amazon deforestation rate trending upwards again, emissions for the sector and for Brazil are also increasing. There is an urgent need to reverse this pattern, as highlighted by the fact that some regions of the Amazon are already a net source — and no longer a sink — of carbon (Gatti et al. 2021).

Accelerating climate change is not the only global threat associated with forest loss. Changes in land use, and especially the conversion of natural habitats to anthropic ecosystems, increase the risk of emerging zoonoses, infectious diseases transmitted from animals to human beings (Keesing et al. 2010; Myers et al. 2013; Gibb et al. 2020). The human, production, economic, and political costs implied by these diseases can be devastating, as evidenced by the current COVID-19 pandemic. Land use models that consider the risk of zoonotic disease outbreaks caused by the loss of natural habitats underscore the important role environmental conservation plays in preventing infectious diseases (Barbier 2021). Recent works argue that forest conservation efforts can be a cost-effective way to reduce exposure to new zoonoses (Ferreira et al. 2021; Rodríguez 2021). Climate change can also affect disease incidence by providing a more favorable environment for transmission (Colón-González et al. 2021). For example, mosquito-borne diseases, such as malaria and dengue, are at greater risk of transmission under temperature and precipitation conditions that favor vector reproduction. Forest protection therefore plays a dual role in mitigating the risk of disease at a global scale, as it reduces the chance of exposure to new pathogens caused by the loss of natural habitats and limits the increase in disease transmissibility associated with climate change.

Finally, given the close relationship between climate change and large-scale biodiversity loss, there is growing recognition among the international community that efforts to limit these two phenomena are inherently linked. Strengthening measures that simultaneously address these can maximize co-benefits (Pörtner et al. 2021). Thus, protecting tropical forests — specifically the Brazilian Amazon — is both a priority and an urgency.

What Works to Protect the Amazon Forest

Brazil knows how to combat deforestation in the Amazon. Over the past two decades, while the country accumulated rich experience using public policy to protect its native vegetation, academia produced a robust body of empirical evidence regarding policy effectiveness and impacts. Together, practical experience and academic knowledge offer paths for improving conservation policy design and execution.

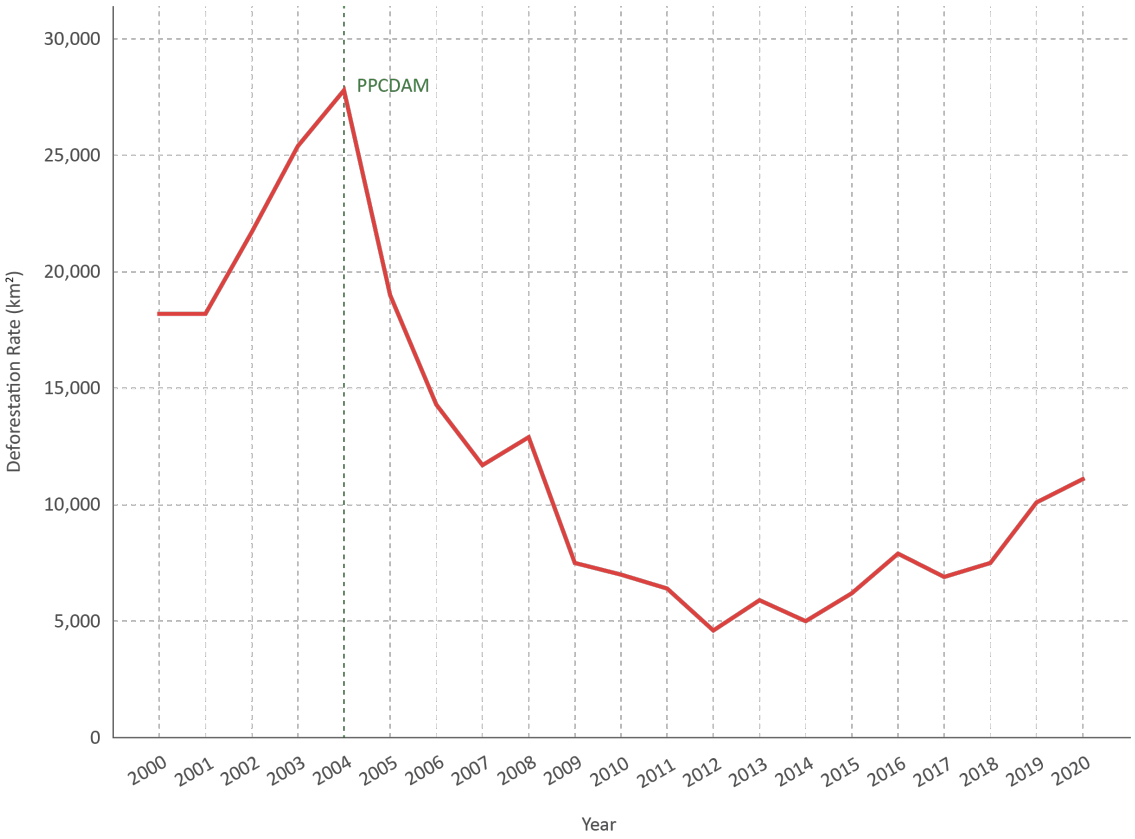
This section summarizes the main findings from an academic literature that assesses policies aimed at combating deforestation in the Brazilian Amazon. Its goal is to consolidate academic knowledge about what works to protect native Amazon vegetation. It is Brazil's responsibility to apply this knowledge to maintain what has already proven effective, fill in the gaps in its understanding of conservation policy impacts, and seek innovative solutions to the challenges that remain.

Strategic and Coordinated Action

In the early 2000s, with average annual Amazon deforestation rates exceeding 22,000 square kilometers (INPE 2021), Brazil was clearing more tropical forest than any other country in both absolute and relative terms (Hansen et al. 2008). Amid growing awareness of the role tropical forests play in the global effort to fight climate change, combatting deforestation became a priority on international policy agendas (Stern 2008). In this context of mounting pressure to control its high rates of forest loss, Brazil developed the Action Plan to Prevent and Control Deforestation in the Legal Amazon (PPCDAM). Created in 2004 by the federal Brazilian government, PPCDAM proposed a set of strategic measures to combat deforestation and promote sustainable regional development.

The action plan introduced a new approach to protecting native vegetation in the Amazon and entailed several public policy efforts over the next two decades. It broke new ground both in content, by introducing innovative policy instruments, and in form, by establishing the fight against deforestation as an interagency effort rather than a responsibility solely of the Ministry of the Environment (MMA). Originally a collaboration between 13 ministries coordinated by the Executive Office of the President of Brazil, the plan recommended actions organized around three axes: territorial and land management; environmental monitoring and law enforcement; and sustainable production. The MMA took over coordinating the PPCDAM in 2013 and added a fourth axis for action in 2016, focused on regulatory and economic instruments. The implementation of PPCDAM was divided into four phases (2004-2008; 2009-2011; 2012-2015; 2016-2020). As of 2021, the plan has not been renewed.

Figure 5. Deforestation Rate, 2000-2020



Note: The vertical line in 2004 indicates the year the Brazilian federal government enacted an action plan for combating deforestation in the Legal Amazon.

Source: CPI/PUC-Rio with data from PRODES/INPE, 2021

The first decade of PPCDAM saw the deforestation rate in the Amazon fall from 27.800 square kilometers in 2004 to 4.600 square kilometers in 2012 (Figure 5) (INPE 2021a). Empirical evidence shows that the drop in agricultural commodity prices in the middle of the decade helped slow down deforestation, but also indicates that policies introduced under PPCDAM were effective at combatting forest loss (Hargrave and Kis-Katos 2013; Assunção, Gandour and Rocha 2015). The plan played a significant part in reducing deforestation. Assunção, Gandour and Rocha (2015) estimate that if the set of policies introduced by PPCDAM had not been implemented, total deforested area in the Amazon would have more than twice greater than was observed between 2005 and 2009. After PPCDAM, Legal Amazon states developed their own action plans to strengthen forest protection at the state level, but the individual impact of the state plans has not yet been empirically assessed.

These empirical results highlight the importance of strategic and coordinated policy efforts. However, these efforts' effectiveness is closely dependent on the institutional contexts in which they are implemented. Although the set of policies adopted under PPCDAM initially helped slow down deforestation, evidence suggests that the effects were not long-lasting. The rate of forest

loss in the Brazilian Amazon started to accelerate again in 2012, amid a scenario of national economic crisis, deteriorating commitment to Brazilian environmental legislation, and changes to environmental governance (Burgess, Costa and Olken 2019).

Command and Control

Environmental command and control play a large role in protecting native vegetation in the Brazilian Amazon by regulating activities that pose a threat to vegetation and guaranteeing environmental law enforcement. Efforts include the regulation, monitoring, investigation, and punishment of environmental infractions and crimes.

Some of the main instruments of environmental command regarding the Amazon Forest are the Brazilian Federal Constitution, the Law of Environmental Crimes (LCA) and Decree 6,514/2008. Article 225 of the Federal Constitution acknowledges that everyone has the right to an ecologically balanced environment. Any activity that causes harm to the elements that make up this environment is a violation of this right and therefore a crime. The constitution also establishes a threefold environmental responsibility (criminal, administrative, and civil) and specifies that anyone engaging in conduct or activities that are harmful to the environment is subject to criminal and administrative penalties, independent of the obligation to repair the damage done. LCA regulates criminal and administrative environmental responsibilities defined in the Federal Constitution, defining environmental infractions and determining associated criminal and administrative penalties. Decree 6,514/2008 deals exclusively with administrative infractions, establishing the federal administrative procedure for investigating and punishing infractions. Among other things, the decree regulates the use of fines, embargos, and seizure and destruction of products and tools associated with environmental crimes.

For the removal of native vegetation in the Amazon to be considered a legal activity, it must comply with regulations that are specific to the land tenure category in which it occurs. It is not possible, based on currently available data, to unequivocally attest the legality of all deforested areas. But there is a consensus among academics and policymakers that most of the deforestation in the Amazon over the past two decades has been — and still is — illegal (Schmitt 2015; Azevedo-Ramos et al. 2020; Azevedo et al. 2021; Valdiones et al. 2021). Monitoring and law enforcement efforts are thus central to combating illegality and thereby reducing deforestation in the Amazon.

Empirical analyses usually focus on the impact of environmental enforcement actions. In practice, these actions occur within a broad framework of environmental command and control measures. Analytical results should therefore typically be interpreted as evidence about a set policy instruments, and not about isolated actions. Empirical evidence indicates that monitoring and law enforcement efforts effectively reduced Amazon deforestation (Hargrave and Kis-Katos 2013; Assunção, Gandour and Rocha 2019). These efforts made a significant contribution.

Assunção, Gandour and Rocha (2019) estimate that, without monitoring and law enforcement, deforested area in the Amazon would have been nearly five times larger than observed between 2007 and 2016. The authors highlight the role played by the System for the Real-Time Detection of Deforestation (DETER). They argue that DETER enhanced Brazil's capacity to enforce environmental laws by allowing authorities to detect forest loss more quickly and thereby provide a timelier response, including more binding penalties (Box 1).

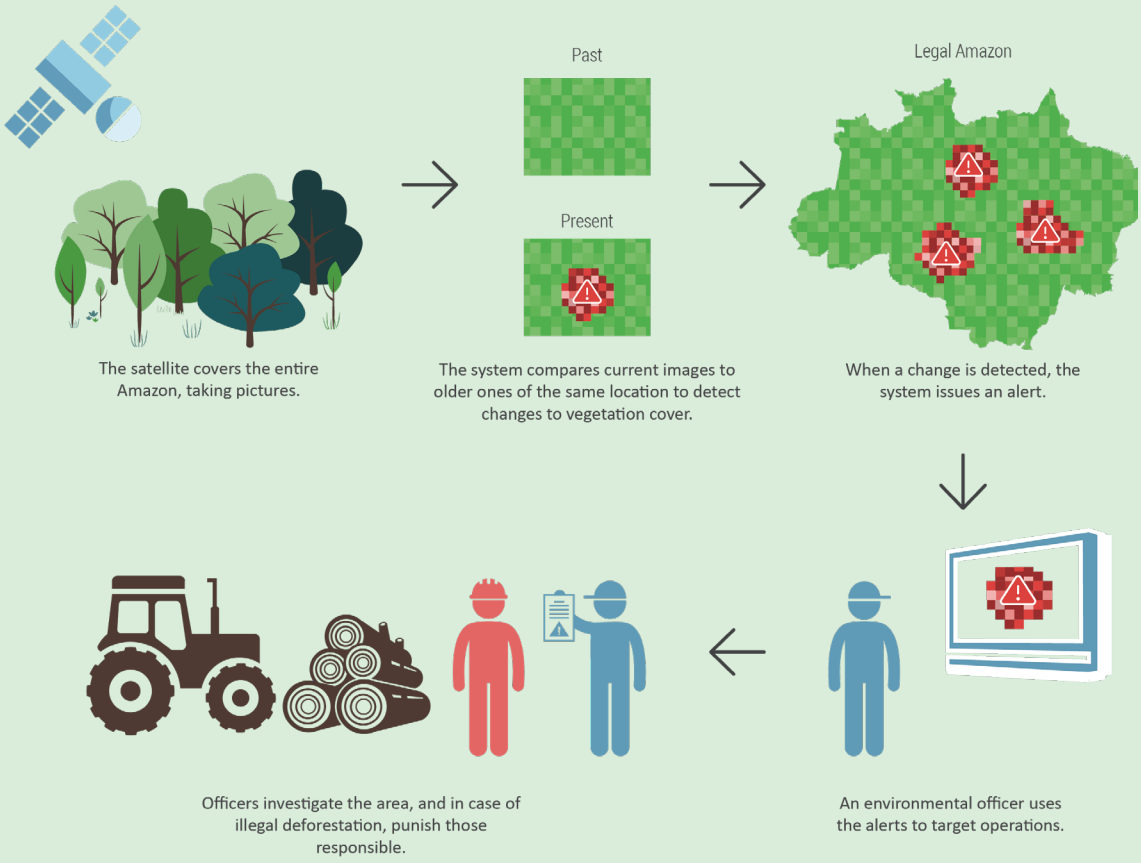
Considering the benefits of reducing deforestation, monitoring and law enforcement efforts in the Amazon were cost-effective, and do not appear to have negatively impacted regional agricultural production (Börner, Marinho and Wunder 2015; Assunção, Gandour and Rocha 2019). Additionally, recent studies that explore the indirect effects of monitoring and law enforcement efforts aimed at combating deforestation document a positive impact on the extent and the permanence of secondary vegetation in the Amazon (Assunção, Gandour and Souza-Rodrigues 2019; Oliveira Filho, 2020).[5] Since the goal of these efforts was to reduce the loss of primary vegetation, the impact on secondary forest constitutes a spillover effect of public policy.

Box 1. Why are Remote Monitoring and Environmental Law Enforcement Essential to Protect the Amazon Forest?

Using DETER to target environmental law enforcement was one of the main innovations in Brazilian forest conservation policy over the last two decades. Developed by the National Institute for Space Research (INPE), DETER is a remote monitoring system that provides rapid assessments of changes in forest cover to support law enforcement actions aimed at combating deforestation and forest degradation. The system uses satellite imagery to scan the full extent of the Brazilian Amazon for signs of recent forest loss. By comparing images of the same location on different dates, DETER detects areas where forest cover has changed. For each of these areas, it issues an alert containing the location's geographical coordinates. These alerts flag areas that require immediate attention and help target law enforcement operations (Figure 6).

[5] Secondary vegetation is that which grows in areas that have already been deforested. In the Brazilian Amazon, secondary vegetation is predominantly an outcome of passive regeneration.

Figure 6. How Satellite Monitoring and Enforcement Work Together to Combat Deforestation



Source: CPI/PUC-Rio, 2021

DETER was developed to support environmental law enforcement authorities. During enforcement operations, offenders found engaging in illegal deforestation are punished with administrative penalties that include fines, embargos, and seizure and destruction of illegal products and equipment associated with forest clearing. These penalties impose a high financial burden on violators both directly (payment of fines, loss of products or equipment) and indirectly (restricted access to credit, legal proceedings costs). Offenders can also be held accountable in civil and criminal terms.

The implementation of DETER was a game changer. The system was the first of its kind to be used for monitoring vegetation over such a vast geographical area and in near-real-time. It not only allowed the environmental law enforcement authorities to spot illegal activity throughout the entire Amazon, but it did so with unprecedented speed — and speed was the key to boosting law enforcement's potential for impact. Prior to the activation of DETER, it was extremely difficult for to locate and reach new deforestation activity in a timely manner. By the time law enforcement reached areas where a clearing had happened, it was often too late to effectively punish offenders. Even when able to correctly identify and locate the responsible parties, which is not a trivial task in a setting

rife with fragile property rights, law enforcement could only apply truly costly penalties when catching offenders red-handed.

Consider, as an example, the seizure and destruction of equipment used for clearing. If law enforcement officers found heavy machinery, like tractors, on-site in a deforestation hot spot, they could inflict an immediate and severe financial loss on the offender by seizing and destroying it. Expensive equipment, however, was not usually left unused in deforested areas once clearing was completed, so officers could only seize and destroy when they interrupted offenders mid-clearing. DETER essentially increased the probability of such caught-in-the-act operations.

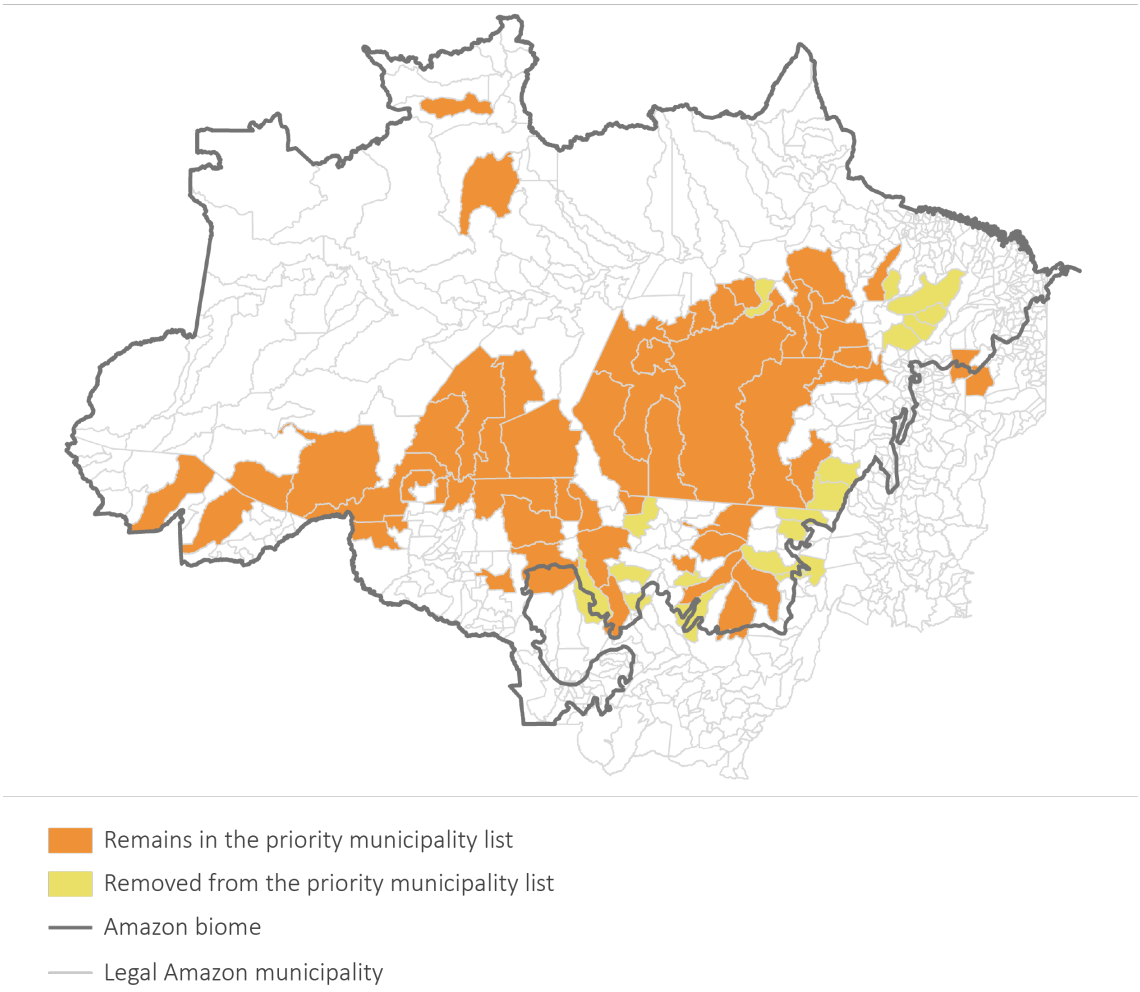
From its inauguration in mid-2004 through the end of 2017, DETER used imagery with medium spatial resolution, but high revisit rates. The detection of changes to forest cover was limited to areas greater than 25 hectares, but the entire Brazilian Amazon was scanned daily. In August 2015, INPE introduced a new version of DETER with higher spatial resolution but less frequent imagery. In this new version, each location is only visited every 4 to 5 days, but the improved resolution allows for the detection of areas as small as three hectares, as well as for the distinction across different types of forest loss.

Priority Municipalities

The Priority Municipalities policy (Decree 6,321/2007) established criteria for selecting Amazon municipalities concentrating recent forest loss and determined that these locations would be preferential targets for policy action to prevent, monitor, and control deforestation. In addition to stepping up efforts to promote the regularization of rural establishments, these municipalities would also be subject to more rigorous monitoring and law enforcement.

Since 2008, the MMA has been responsible for issuing an annual list of priority municipalities. Municipalities are added to the list based on three criteria: (i) total deforested area; (ii) total deforested area over the past three years; and (iii) an increased rate of deforestation in at least three of the past five years. To be removed from the list, a municipality must meet requirements regarding the registration and monitoring of its rural establishment, as well as maintain its deforestation rate below a cut-off established by the MMA. There are currently 52 priority municipalities and 18 former priority municipalities (Figure 7).

Figure 7. Priority Municipalities, 2021



Source: CPI/PUC-Rio with data from MMA and IBGE, 2021

The evidence indicates that this policy effectively contained deforestation in priority municipalities (Arima et al. 2014; Cisneros, Zhou and Börner 2015; Assunção and Rocha 2019; Assunção et al. 2019). Yet, there is no consensus in the literature regarding the underlying mechanisms for this effect. Some authors attribute the drop in deforestation to stricter monitoring and law enforcement (Arima et al. 2014; Assunção and Rocha 2019), while others favor economic disincentives due to sanctions imposed by commodity supply chains and the reputational risks for local politicians (Abman 2014; Cisneros, Zhou and Börner 2015).

The reduction in deforestation does not seem to have had a detrimental effect on agricultural production and was not associated with a drop in the granting of rural credit in priority municipalities (Assunção and Rocha 2019; Koch et al. 2019). Moreover, there is evidence that the policy generated a positive externality, reducing deforestation in neighboring municipalities that were not subject to targeted conservation action (Assunção et al. 2019).

Conditional Rural Credit

Rural credit is Brazil's main public policy to support agricultural production. From mid-2019 to mid-2020, more than 120,000 contracts were signed, totaling BRL 19 billion in subsidized loans within the Amazon biome, with over 80% of this amount destined to support cattle farming operations (Souza et al. 2021). To avoid having subsidized credit contribute to forest loss, the Brazilian government adopted special requirements for granting rural credit in the Amazon.

With the enactment of Resolution 3,545/2008, the Brazilian Central Bank determined that rural credit could only be granted to support agricultural activities inside the Amazon biome upon proof of compliance with environmental and property rights regulations. All credit agents — public banks, private banks, and credit cooperatives — were required to implement these conditions. Some groups, primarily small producers that were beneficiaries of the National Program to Strengthen Family Farming (PRONAF) — faced less rigorous requirements to access credit.

Empirical evidence indicates that Resolution 3,545/2008 led to a reduction in the total amount of credit granted in the Amazon biome between 2008 and 2011, mainly due to a drop in medium and large contracts (Assunção et al. 2020). This outcome is consistent with the more flexible conditions for small borrowers. The study shows, moreover, that the reduction in rural credit helped contain deforestation, and that these effects were driven by municipalities where cattle farming was the main economic activity. The authors interpret this result as evidence that, in these municipalities, rural credit had been used to support activities associated with forest loss.

Protected Territory

In Brazil, protected territories consist primarily of protected areas (such as national parks, natural monuments, and biological reserves) and indigenous lands. Protected areas aim at providing long-term conservation of high-value natural ecosystems, whereas indigenous lands aim at protecting nature as a means of preserving the livelihoods of indigenous communities and ensuring their right of access to and management of lands as part of their traditional way of life. Despite this difference, the National Strategic Plan for Protected Areas (PNAP) recognizes that indigenous lands contribute to environmental conservation and therefore regards them as protected territories.

The rules governing the clearing of native vegetation in protected territories vary according to the type of protection. Strictly protected areas only allow the indirect use of their natural resources, so forest clearing in these areas is typically prohibited; protected areas for sustainable use allow for the use of a share of their natural resources, so forest clearing may be legal if duly licensed and in accordance with the area's management plan. In indigenous lands,

the clearing of native vegetation is only legal when carried out by indigenous peoples as part of their traditional way of life.

Brazil's regulatory framework allows for harsher punishment of environmental infractions committed within protected territories. In addition to being monitored by dedicated governmental agencies, these territories are also typically under greater public scrutiny, attracting much attention from national and international medias, as well as from the civil society. Thus, environmental offenders engaging in illegal activities in protected territories face a higher expected risk of getting caught and severely punished.

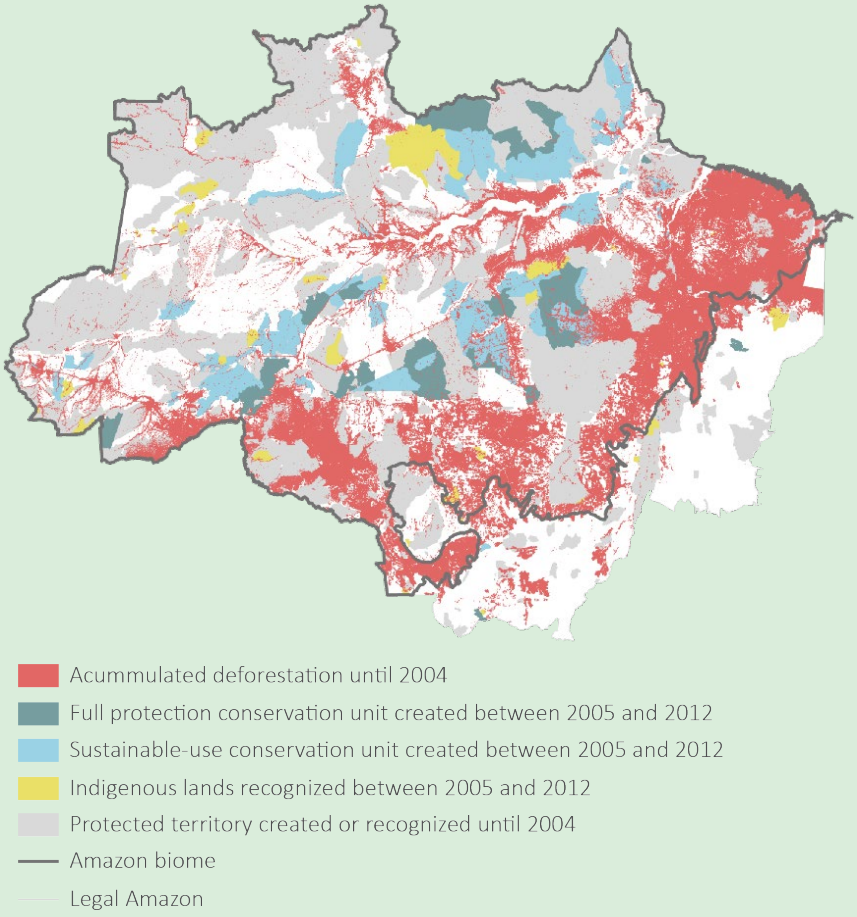
Landscape protection is one of the most widely-used environmental conservation policies in the world, and in Brazil as well — over half of the Brazilian Amazon Forest is under protection as (federal or state) protected areas or indigenous lands (MMA 2021; FUNAI 2021; ISA 2021). However, the academic literature documents mixed results regarding these areas' effectiveness in reducing Amazon deforestation. There is evidence that suggests that protected areas and indigenous lands contain deforestation within protected territories, but there is also wide variation in estimated effectiveness across regions, time periods, and types of protection (Nolte et al. 2013; Pfaff et al. 2014; Pfaff et al. 2015a, 2015b; Anderson et al. 2016; BenYishay et al. 2017; Kere et al. 2017; Assunção and Gandour 2018; Herrera, Pfaff and Robalino 2019; Baragwanath and Bayi 2020). Such a diverse set of outcomes should be interpreted in light of these areas' differing levels of exposure to deforestation threats. After all, if an area is not at imminent risk of forest loss, it will probably not have significant deforestation, whether it is protected or not. Hence, negligible and even null effects are frequently justified as referring to remote territories located far from deforestation pressures (Pfaff et al. 2015a, 2015b; Anderson et al. 2016; Herrera, Pfaff and Robalino 2019).

Starting in 2004, the citing strategy for protected territories in the Amazon began to more explicitly consider the possibility that these areas could serve as barriers to advancing deforestation. This contributed to a large expansion of protected territory in regions known to be under great deforestation pressure (Box 2). Assunção and Gandour (2018) explore this citing strategy to test the impact of territorial protection in high-risk areas. Results indicate that protected areas and indigenous lands effectively curbed deforestation, preventing it from advancing into protected territory. However, estimates suggest that territorial protection did not reduce the aggregate level of deforestation in the Amazon. The authors interpret this as evidence that protected territories serve as shields, effectively protecting forests within their borders, but, in turn, diverting deforestation to unprotected areas. This, they argue, is an indirect effect of protecting territories.

Box 2: Protected Territories as Barriers to Advancing Deforestation

In 2004, although a significant share of the Amazon Forest was already under protection, some of this protection was located far from deforestation activity. Through the early 2010s, there was a significant expansion of protected territories in the Amazon, mainly due to the creation of more than 500,000 square kilometers of federal and state protected areas (Figure 8).

Figure 8. Protected Territory



Source: CPI/PUC-Rio with data from SNUC/MMA, FUNAI and ISA, 2021

The growth in protection coverage was notable, but it was the new citing strategy that brought true novelty to protection policy during this period. Protection came to be granted not only based on biological and ecological factors, but also considering current and future deforestation risks — protected territories in high-risk zones now had the explicit purpose of serving as a shield. New territories were henceforth allocated such that they created a barrier to advancing deforestation.

Evidence on the indirect effects of territorial protection is still relatively limited, but the academic literature reveals a growing interest in the topic (Fuller et al. 2019). For the Brazilian Amazon, results suggest that, as with the direct effect, indirect effects vary both in magnitude and direction across locations and types of protection (Herrera 2015; Herrera, Pfaff and Robalino 2019). This highlights the importance of considering, for public policy planning purposes, how governance structures can influence the impacts of territorial protection. Furthermore, little is known about the mechanisms behind these indirect effects. Herrera (2015) moves in this direction by exploring migration patterns and expansion of transport infrastructure as possible mechanisms for an estimated outcome of reduced deforestation in the immediate surroundings of protected territories. The author argues that the existence of a protected territory seems to affect the dynamics of regional development, and thereby influence deforestation close to these territories.

Overall, the evidence corroborates the use of territorial protection as an instrument for both protecting critical areas and containing advancing deforestation. However, it also reinforces the need to integrate territorial protection strategies and complementary conservation policies to curb deforestation throughout the entire Amazon Forest. This requires a deeper understanding of the possible indirect effects of territorial protection and its mechanisms.

Other Efforts: Opportunities for Research

The academic literature offers a robust set of rigorous evaluations of the policies aimed at combating Amazon deforestation discussed so far. Although there is still room to deepen knowledge about the impacts of these policies, there is a consensus that they were effective in reducing deforestation in the Brazilian Amazon. They were not, however, the only forest protection measures enacted over the last two decades. Several other public policy efforts were developed and executed during this period, at the federal and subnational levels. While such efforts may have contributed to reducing deforestation and protecting the forest, the available empirical evidence about them is currently limited.

The remainder of this section covers a subset of these efforts that have already been subjected to some form of impact evaluation. It is worth highlighting, however, that the academic literature does not yet provide robust evidence on these efforts' contribution to the dynamics of deforestation in the Brazilian Amazon. The section does not cover forest protection efforts that have not yet been subjected to empirical assessments, such as criminal law enforcement, the Protect the Amazon (*Amazônia Protege*) project of the Federal Prosecutor's Office (MPF), and various subnational initiatives. This should not be interpreted as an indication that such efforts are not relevant to the protection of the Amazon Forest, but as a suggestion of timely opportunities for future research.

Payments for Ecosystem Services

Payment for ecosystem services (PES) mechanisms seek to promote the conservation of native vegetation by financially compensating those who protect it. Payments can be made at national (countries), subnational (states, projects), or individual (communities, families, individuals) levels, and are typically conditioned upon proof of environmental outcomes. Because this mechanism entails voluntary conservation, PES is considered an important ally in promoting forest protection beyond what is required by law. However, PES mechanisms currently in place for the Brazilian Amazon are not restricted to compensating reductions in the legal removal of native vegetation.

Developed under the United Nations Framework Convention on Climate Change (UNFCCC), REDD+ is one of the most prominent incentive and payment mechanisms for ecosystem services at the national level. Originally focused on reducing emissions from deforestation and forest degradation (REDD), the concept has also come to encompass efforts relating to the conservation of forest carbon stocks, sustainable forest management, and increasing forest carbon stocks (REDD+). This mechanism financially compensates developing countries that preserve their forests and thereby reduce GHG emissions from deforestation and forest degradation.

Although considered to be quite promising, there is still little evidence regarding the impact of PES policies and programs in the context of the Brazilian Amazon. Simonet et al. (2018) estimate that the pilot for the Sustainable Settlements Project in the Amazon, aimed at promoting sustainable practices in family farming, led to a reduction in deforestation and associated emissions. However, the project entailed a mix of interventions, including PES and technical assistance to participants. Cisneros et al. (2019) explore the environmental impacts of *Bolsa Floresta*, a PES program focused on protected areas for sustainable use in the state of Amazonas. Results suggest that effects on deforestation were negligible, likely due to mistargeting of the program, which was implemented in protected areas under low risk of deforestation. On the other hand, Anderson et al. (2021) evaluate the *Bolsa Verde*, a federal program that provides cash transfers to families in extreme poverty, in which payments are conditional on regional forest cover results. Their study indicates that *Bolsa Verde* was associated with a reduction in deforestation, especially in the poorest areas. However, this reduction did not occur inside the properties of the program beneficiaries, but at the regional level. The authors argue that this might be explained by increased law enforcement presence in the regions, and suggest that the program generated incentives for beneficiaries to monitor and report deforestation near their homes.

One of the main challenges in assessing PES impacts is being able to identify additionality in changes to forest loss — did payments really help protect the forest or would deforestation

have fallen even without the financial incentive?[6,7] West et al. (2020) address this issue in an assessment of 12 voluntary REDD+ projects implemented in the Brazilian Amazon between 2008 and 2017. Results indicate that payments did not significantly contribute to the reduction in deforestation or emissions. In addition, the evidence suggests that project baselines, typically established from historical deforestation patterns, overestimate forest loss. In this case, reductions in forest clearings during the term of the project would not be related to the financial incentive, but to other factors that contained deforestation. The authors point out, however, that a series of practical difficulties related to the design and implementation of PES projects may have compromised the effectiveness of the financial incentive mechanism.

Zero-Deforestation Commitments

Commitments to eliminate deforestation along supply chains traditionally associated with forest loss occupy a prominent position in the ongoing debate about the protection of native Amazon vegetation. Despite not being public policy instruments per se, some of these commitments are officially endorsed by government entities. This is the case of the Soy Moratorium, a voluntary zero-deforestation agreement for soy production in the Amazon biome. It was agreed upon by the private sector — the Brazilian Association of Vegetable Oil Industries (ABIOVE), the National Association of Grain Exporters (ANEC), and associated companies — and the civil society, and endorsed by the MMA. The moratorium was first signed in 2006 and was renewed indefinitely in 2016. It formalizes the commitment by ABIOVE and ANEC to not market, acquire, or finance soy from Amazon biomes areas that were deforested after July 2008, as well as from areas under administrative embargo due to deforestation or listed under the Ministry of Labor's list for the use of slave-like labor.

The literature documents a sharp drop in the expansion of soy farming in forest areas following the adoption of the Soy Moratorium, suggesting that the terms of the agreement were generally respected (Rudorff et al. 2011; Macedo et al. 2012; Gibbs et al. 2015; Gollnow et al. 2018). In addition, Heilmayr et al. (2020) find that the moratorium helped contain deforestation in areas suitable for soy production, but highlight that its effectiveness fundamentally depends on monitoring forest loss and implementing complementary policy efforts to register rural establishments.

[6] For potential beneficiaries who are already intended to protect native vegetation, there is a low cost of joining the program, as they will not need to change their behavior to receive payments. In this case, the resources allocated to these individuals do not actually reduce deforestation, and the impact of PES is zero. Jack and Jayachandran (2019) discuss how the determinants of the decision to enroll in PES programs can affect the environmental benefit (additionality) and cost-effectiveness of these programs. Although they do not address programs in the Amazon, the general discussion also applies to the Brazilian context.

[7] Jayachandran et al. (2017) estimate a causal effect that points towards additionality in a PES mechanism for forest protection in Uganda. Considering the differences in context and programs, the results cannot be extended to the case of the Brazilian Amazon. They indicate, however, that additionality can be tested within an adequate empirical framework.

There is no robust causal evidence linking the Soy Moratorium to the observed reduction in the aggregate levels of deforestation in the Amazon. This should be interpreted in light of the fact that, when the moratorium was agreed on, less than 5% of the area that had been historically deforested in the Amazon was used as cropland, including for soy production (INPE and EMBRAPA 2016). The moratorium's impact on land use conversion dynamics could still be relevant for regional patterns of deforestation[8] and when accounting for the commitment's indirect effects, including interactions with pasture expansion dynamics in the Amazon and leakage to biomes to which the moratorium's restrictions do not apply (Gollnow et al. 2018; Moffette and Gibbs, forthcoming).

The livestock sector has also demonstrated interest in signing a zero-deforestation commitment for the Amazon. In 2009, after being the target of lawsuits from the MPF and the Brazilian Institute for the Environment and Natural Resources (IBAMA) and suffering market pressure, meatpackers operating in the state of Pará signed Conduct Adjustment Terms (TAC) with the MPF and a public commitment to Greenpeace.[9] In the agreement, the meatpackers commit to only buying cattle from farms in which there was no deforestation after 2009, that are not listed in the Ministry of Labor's list for the use of slave-like labor, that were registered in the Rural Environmental Registry (CAR), and that are not located inside protected territories. In subsequent years, meatpackers in other states signed similar commitments.

Evidence on the impacts of these agreements is quite limited. Although at first TACs may have contributed to further the registration of properties in CAR and curbed deforestation within registered properties, they do not appear to have had a significant effect on aggregate forest loss over time (Gibbs et al. 2016; Alix-Garcia et al. 2017). Significant difficulties regarding the effective implementation of TACs and the monitoring of compliance with their terms are usually pointed out as likely explanations for the documented lack of significant impacts of TACs on Amazon deforestation (Gibbs et al. 2016; Imazon 2017; Klingler, Richards and Ossner 2018; Gibbs et al. forthcoming).

Subnational Initiative: Green Municipalities Program

Decentralized initiatives for forest protection and management have been gaining ground in the public policy sphere for forest protection in developing countries, but the available evidence on their effectiveness is usually qualitative or derived from case studies (Blackman and Bluffstone 2021). Indeed, few studies use rigorous empirical methods to obtain estimates of causal impact and thus robust implications for public policy.

[8] The impact of the moratorium may be particularly relevant for regional patterns of deforestation in Mato Grosso, a state that concentrates more than 85% of the soy planted area in the Amazon biome (IBGE 2019).
[9] The TAC is a legal commitment. By signing it, the meatpackers authorize the MPF to impose penalties without the need for judicial intervention if the terms of the agreement are broken.

Several subnational initiatives to protect the Brazilian Amazon Forest fit into this scenario. One of the few exceptions is the Green Municipalities Program (PMV) in the state of Pará. Created in 2011 in response to the federal government's Priority Municipalities policy, the program aimed to reduce forest loss, promote a sustainable rural economy, and improve local governance. Although it is still a limited literature, some studies empirically assess the program's impact. Sills et al. (2015) focus on the case of Paragominas, the first municipality to implement the measures that would eventually make up the PMV and also the first to leave the list of priority municipalities.[10] The evidence suggests that the program contributed to both reduce deforestation in Paragominas and keep it at low levels for three years, even when comparing with other municipalities in the priority list. However, the difference between Paragominas and these other municipalities is only significant for one year of the sample, which suggests that the program may have had only a limited effect beyond that of being a priority municipality. The assessment of the state-level impacts of PMV conducted by Sills et al. (2020) reinforces this interpretation. The results indicate that the program did not significantly contribute to municipalities reducing deforestation beyond what they did in response to inclusion in the priority list.

Forest Code

The Forest Code is Brazil's main public policy for protecting native vegetation within private lands. By defining rules for land use, it imposes on landowners the obligation to preserve part of the native vegetation within their lands. Given its complexity, the Forest Code requires detailed treatment. Chiavari and Lopes (2015a, 2015b) address its key points: the instruments for the conservation of native vegetation, the complexity of consolidated areas and their rules for conservation, and the processes for environmental regularization.

The Forest Code's main instruments for the protection of native vegetation are the Permanent Preservation Areas (APP) and the Legal Reserve. APPs are areas considered critical for the protection of essential environmental services, such as water supply, biodiversity conservation, and geological protection. The vegetation in these areas must be preserved, and no economic exploitation of forest resources within the APP is allowed. The Forest Code determines several categories of APP, including the banks of water bodies, hills and slopes with an inclination of more than 45° and areas around springs, and establishes specific protection rules for each category. The Legal Reserve is an area within the rural establishment that must remain covered with native vegetation. It aims at conserving biodiversity and protecting remnants of native vegetation throughout the country. The Forest Code establishes the size of the Legal Reserve as a share of the establishment's total area and determines shares according to geographic location and associated type of native vegetation. Legal Reserves are generally much larger in

[10] Paragominas was one of the 36 municipalities in the federal government's first list of priority municipalities, in 2008. It was also the first municipality to leave the list of priority municipalities, in 2010.

rural establishments within the Amazon biome (80% as forest areas) than in other regions of Brazil (20% to 35%).

The body of empirical evidence on the effectiveness of the Forest Code for protecting native vegetation is still very limited. Sant'Anna and Costa (2021) assess how a particular feature of the code affected deforestation in the Amazon. Despite determining that clearings within APP or Legal Reserve must be restored, the 2012 version of the Forest Code established more flexible rules and parameters for complying with vegetation conservation requirements in areas that were illegally deforested before July 22, 2008 (consolidated rural areas). The authors argue that, by giving amnesty to those who violated the environmental law in the past, the new code encouraged opportunistic behavior of non-compliance with current law. Results point to a harmful impact of the Forest Code revision on the loss of vegetation within rural establishments in the Amazon. However, this increase in deforestation should not be interpreted as an effect of the Forest Code's instruments for protecting vegetation, but of the changes in the legal framework associated with them.

Strengthening Amazon Forest Protection

The previous section sends a clear message: public policy works to protect the Amazon. Empirical evidence shows that the main policies to combat deforestation adopted since 2004 played a key role in reducing the rate of tropical forest loss. But these policies are no longer enough. In addition to improving its efforts to fight deforestation, Brazil must incorporate new dimensions of forest protection to its policy agenda for Amazon conservation. This report discusses concrete pathways to strengthen the protection of the Amazon, and proposes three courses of action:

Deforestation It is imperative that Brazil eliminate the impunity currently associated with illegal forest clearings. To that effect, it is critical to uphold environmental governance that supports effective environmental sanctioning procedures and penalties, both of which are central to law enforcement's capacity to inhibit illegal practices. Strategic efforts to combat deforestation should also target priority areas.

Forest Degradation The country must deepen its understanding of forest degradation. How does it contribute to a process of forest loss in the Amazon? How does it relate to economic activity? How does it respond to public policy? Brazil can draw on this understanding to adopt a strategic approach to fight forest degradation in the Amazon and thereby enhance the impact of conservation efforts in the region.

Secondary Vegetation Brazil must urgently monitor secondary vegetation in the Amazon. Although tropical forest regrowth covers vast areas, it remains invisible to forest monitoring systems. The country has the technology and technical expertise needed to develop the systematic monitoring of its secondary vegetation, but this requires support from public policy. Monitoring forest regrowth in the Amazon is vital both for its protection and for advancing the understanding about this phenomenon. This is key to incorporating secondary vegetation into a strategy for large-scale restoration of degraded ecosystems.

Deforestation

After a sharp decline from 2004 to 2012, the Amazon deforestation rate began to trend upwards, and has shown signs of acceleration since 2019 (INPE 2021a, 2021b). This has been attributed to a combination of the depleted potential for impact of current policies for forest protection and the weakening of the country's institutional context for conservation (Burgess, Costa and Olken 2019; Rajão et al. 2021; Vale et al. 2021). Reversing the upward trend in deforestation requires a solid political commitment to maintaining an institutional environment

that supports the protection of native vegetation in the Amazon. Moreover, Brazil must strengthen measures that have already proven effective in curbing forest loss, paying particular attention to environmental command and control, while drawing on the available empirical evidence to update its strategy for combating deforestation and take more targeted action in critical areas.

Strengthening Environmental Governance

Since the overwhelming majority of deforestation in the Amazon is illegal, guaranteeing law enforcement is at the heart of an effective forest protection strategy (Schmitt 2015; Azevedo et al. 2021; Valdiones et al. 2021). Illegality thrives in permissive environments, so the mere hint of tolerance about crime can lead to a wave of illegal activity. When this materializes in the form of impunity, illegality quickly escalates. Reducing deforestation in the Amazon therefore requires a solid commitment to the law.

Brazil is headed in the opposite direction. Trends in the administrative penalties applied by IBAMA in the Amazon during the period of accelerating deforestation illustrate this.[11] Starting in 2015, there was a substantial drop in the number of fines associated with damage to vegetation, accompanied by relative stability in the fined area (Figure 9, Panel A). It is worth underscoring that, although deforested area saw a 50% increase in 2019 as compared to the previous year (INPE 2021a), both the number of fines and total fined area decreased in that same year. A similar pattern is seen in environmental embargos, with falling numbers of embargos and embargoed areas, particularly over the past two years (Figure 9, Panel B). Although a simple comparison of trends cannot be used to establish a causal relationship between increasing deforestation and decreasing law enforcement outcomes, the contrast suggests a weakening of environmental control efforts over the past decade in the Amazon.

[11] The Brazilian Federal Constitution establishes that offenders can be simultaneously held accountable for environmental damage in administrative, civil, and criminal spheres. This section focuses on the administrative sphere for two reasons. First, because the available empirical evidence, both descriptive and causal, largely refer to administrative processes. Second, because these processes have seen recent legislative changes with enormous potential to limit their effectiveness.

Figure 9. Administrative Penalties for Flora-Related Infractions, 2012-2020

Panel A

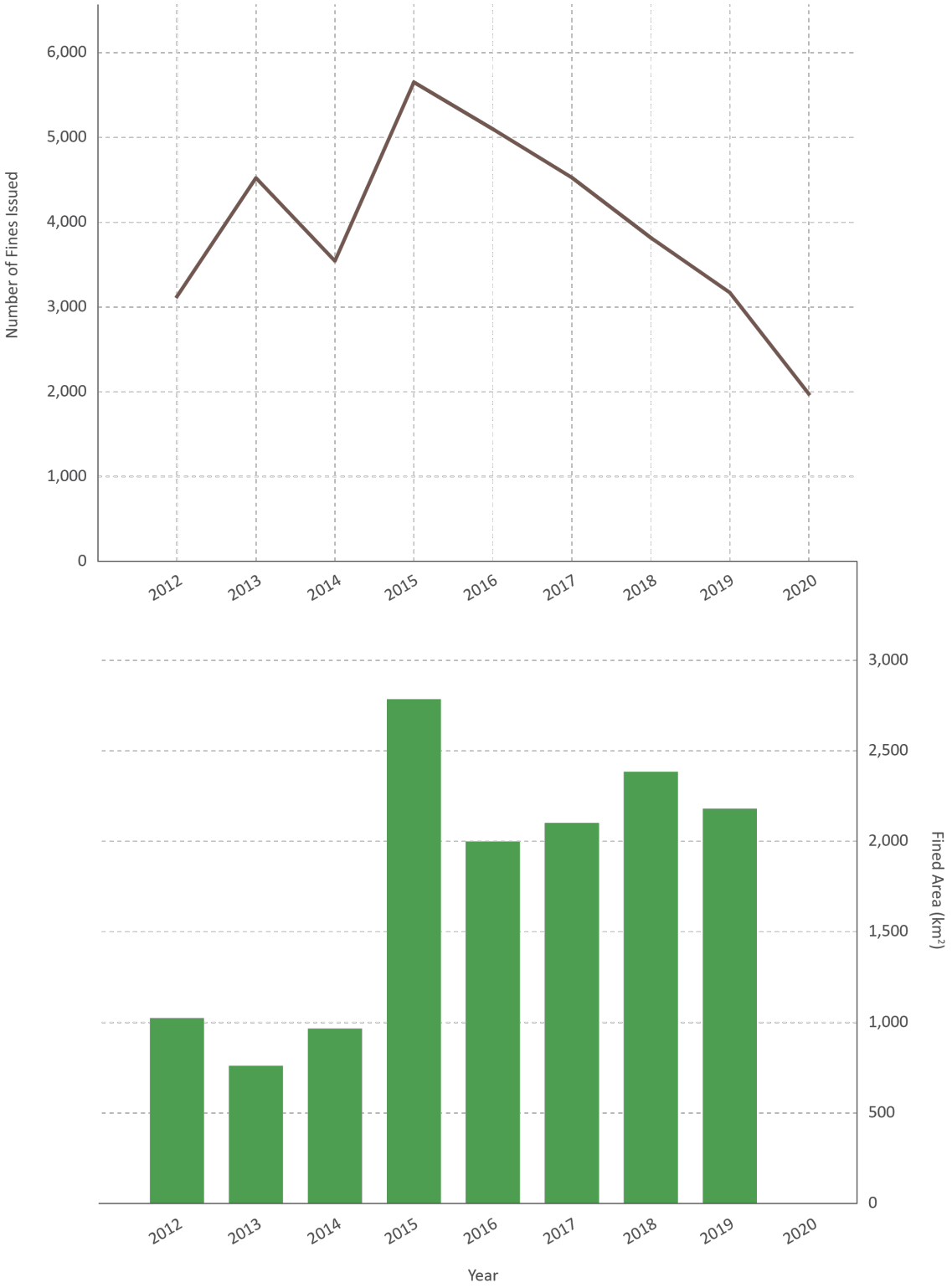
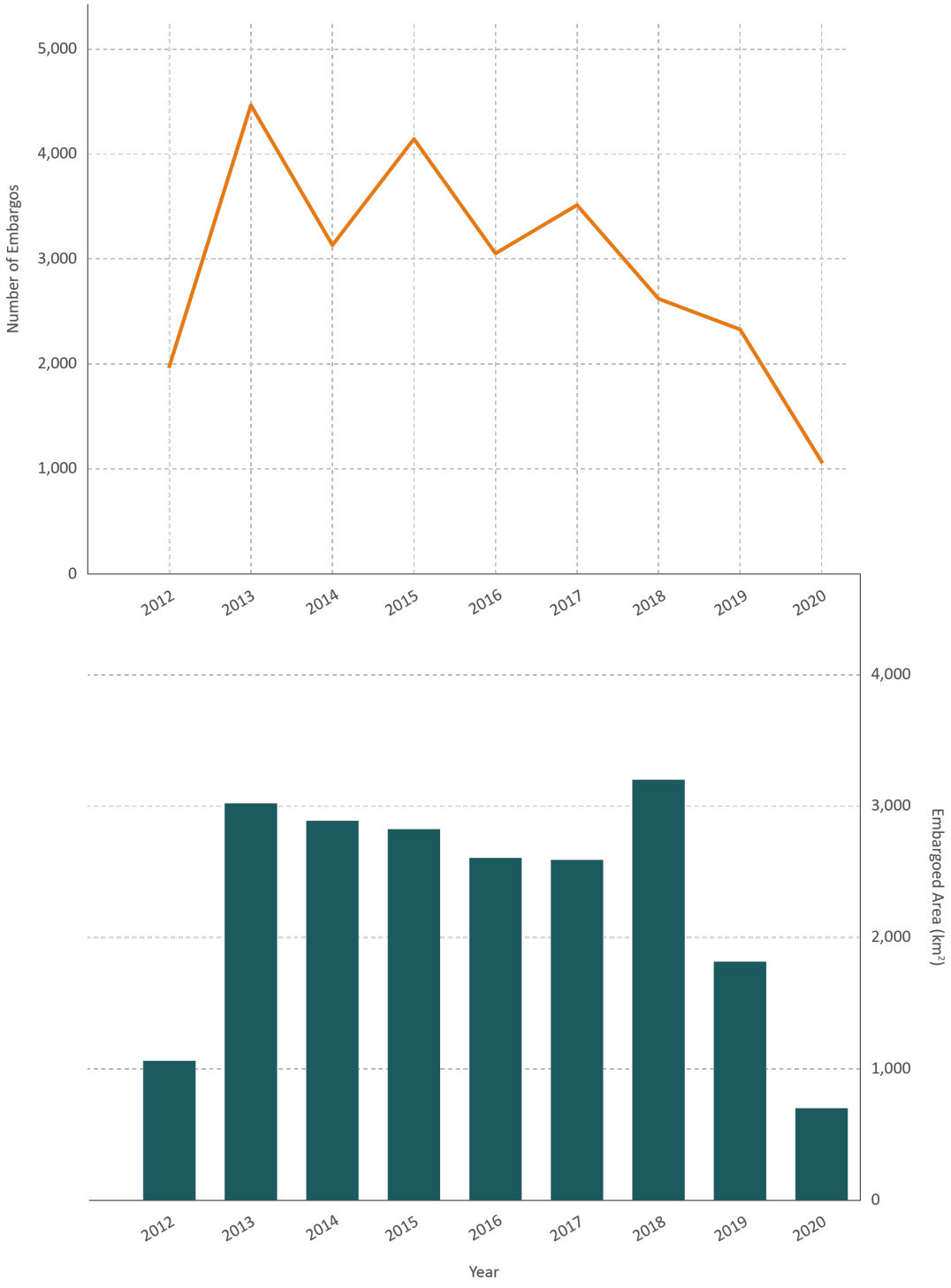


Figure 9 continues on the next page…

Panel B



Note: The figure covers only administrative penalties issued by IBAMA due to damage caused to flora in municipalities located partly or entirely within the Amazon biome. To enable comparison with deforestation trajectories, penalty data are presented in terms of PRODES years (aggregated from August 1 of a given year through July 31 of the following year). Raw data for fines and embargoed areas are incomplete and may therefore underestimate real areas. There is no available data for fined area referring to the 2020 PRODES year.

Source: CPI/PUC-Rio with data from IBAMA, 2021

This interpretation is backed by studies geared toward evaluating governance and institutional arrangements for environmental control, particularly regarding how these influence the effectiveness of the federal administrative sanctioning process. The Office of the Comptroller General (CGU) analyzed environmental law enforcement activities carried out by IBAMA since 2013 and found a series of structural and procedural flaws that have undermined the effectiveness of the sanctioning process (CGU 2017, 2019, 2020). Since 2019, this scenario has worsened with a move toward what has been considered an intentional dismantling of conservation policies carried out by the current administration, especially with respect to environmental control measures. Various elements have contributed to this dismantling, including directives to law enforcement personnel to refrain from using penalties specified in environmental legislation, the unlawful (according to an audit by the Federal Court of Auditors) appointments to management positions within IBAMA, and substantial budget cuts to environmental control institutions (Borges 2020; Werneck et al 2021; Menegassi 2021; Rajão et al. 2021; Vale et al. 2021; West and Fearnside 2021).

Furthermore, IBAMA's sanctioning process has been weakened by recent changes that made it more subject to political control and increased legal uncertainty regarding environmental accountability (Lopes and Chiavari 2021). A less effective sanctioning process perpetuates impunity and fosters a climate of tolerance toward illegal activity — the exact opposite of what is needed to combat deforestation.

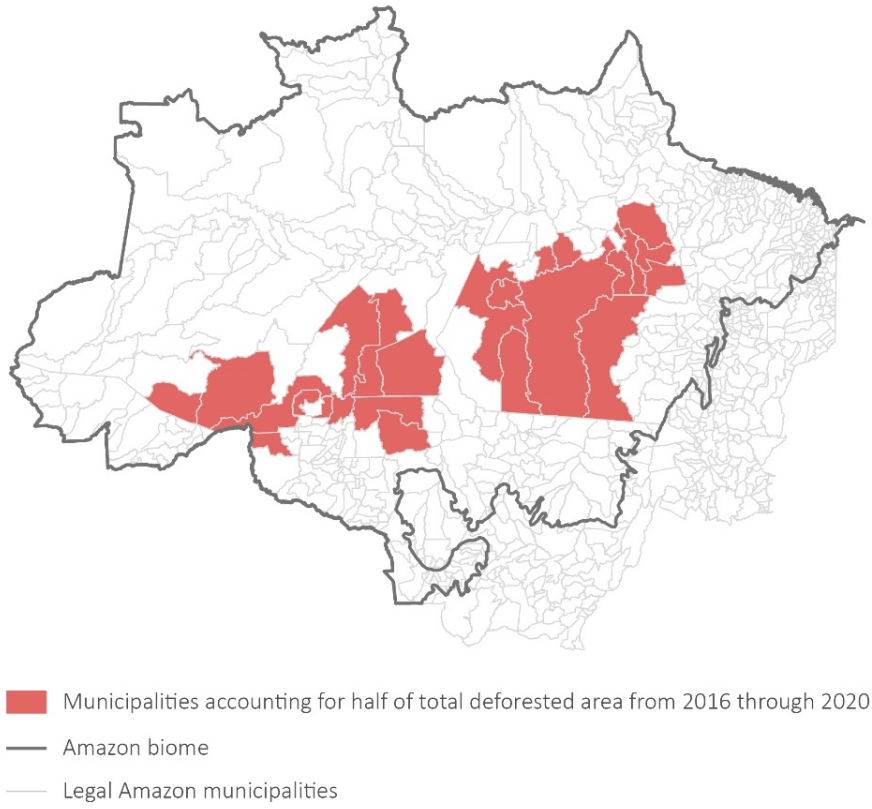
Strategic Evidence-based Action

While Brazil's goal is to combat deforestation throughout the Amazon, it must select priorities for immediate action. Deforestation patterns offer clear candidates for targeting. Only 24 municipalities account for half of total Amazon deforestation between 2016 and 2020 (Figure 10). These areas should be the focus of priority action to combat deforestation.[12] Forest loss also appears to be concentrated by land tenure category. For the Amazon as a whole, on average, a third of annual deforestation occurs in medium and large private properties, a quarter in agrarian reform settlements, and a fifth in undesignated public lands or unidentified lands (Figure 11).[13] This pattern highlights the importance of designing conservation actions to meet specific needs and governance contexts for each land tenure category.

[12] The previous section discusses evidence that attest to Brazil's successful experience with targeted action in critical areas. The Priority Municipalities policy is still formally in effect, and the list of priority municipalities was last updated at the beginning of 2021.

[13] Due to specificities of the original land tenure data, the fraction of deforestation that occurs in undesignated public lands or unidentified lands may be underestimated and that which occurs in private properties may be overestimated. This is because the spatial data used in the calculation regard all establishments registered under CAR as private properties, even if they are located within undesignated public lands or unidentified lands.

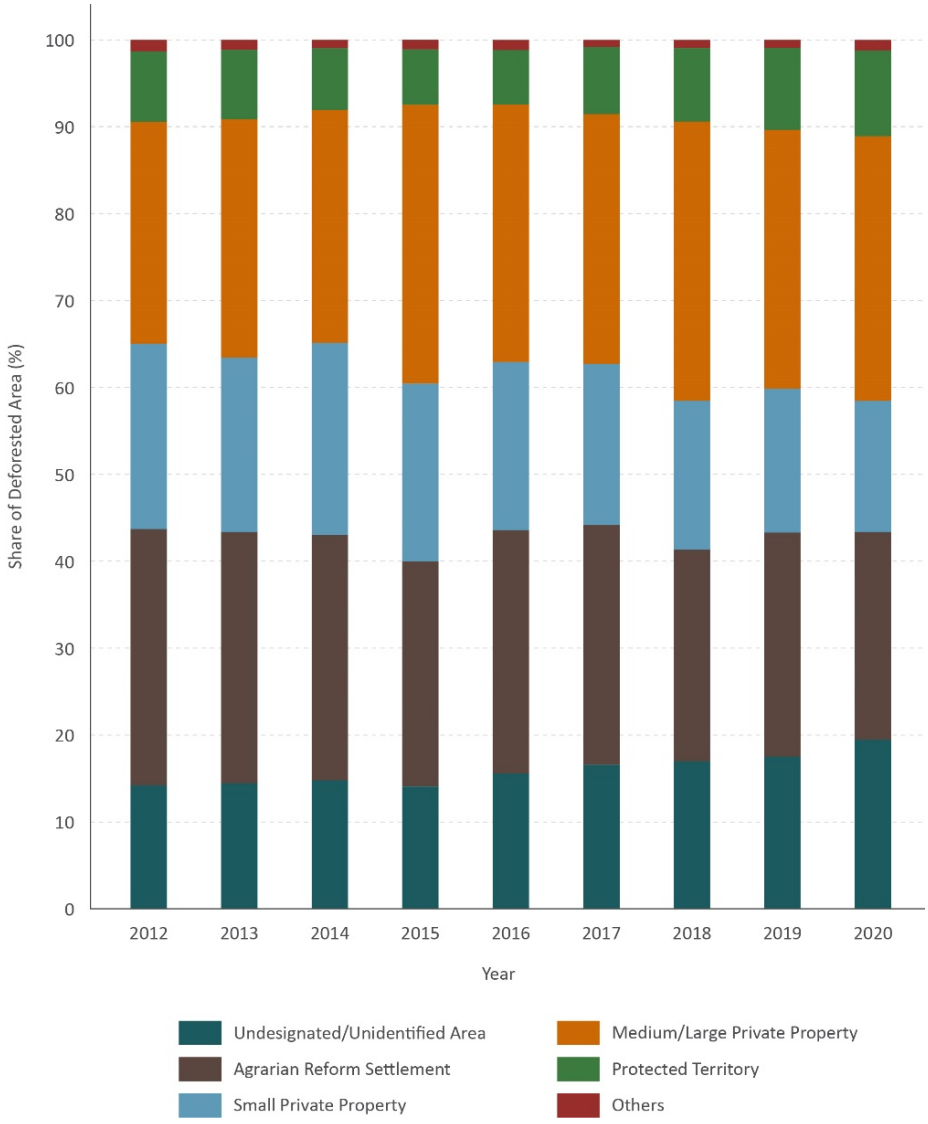
Figure 10. Spatial Concentration of Deforestation, 2016-2020



Source: CPI/PUC-Rio with data from PRODES/INPE and IBGE, 2021

Deforestation happening in undesignated public lands is particularly relevant, as it reveals the scale at which land grabbing occurs in the Amazon, a practice that is closely linked to illegal forest clearings in the region (Azevedo-Ramos and Moutinho 2018; Azevedo-Ramos et al. 2020). Alencar et al. (2021) calculate that, by the end of 2020, more than 180,000 square kilometers of public forest in the Amazon (32% of its total area) were illegally registered as private rural properties under the National Rural Environmental Registry System (SiCAR), an increase of 230% over the area registered in 2016. In 2020, nearly three-quarters of the deforestation alerts emitted by DETER in undesignated public forests were located within these properties (Alencar et al. 2021). Combating land grabbing in public lands in the Amazon should be a priority for conservation policy, not only because of its direct association with combating forest loss, but also because it helps fight crime, corruption, and violence in rural areas.

Figure 11. Distribution of Deforested Area by Land Tenure, 2012-2020

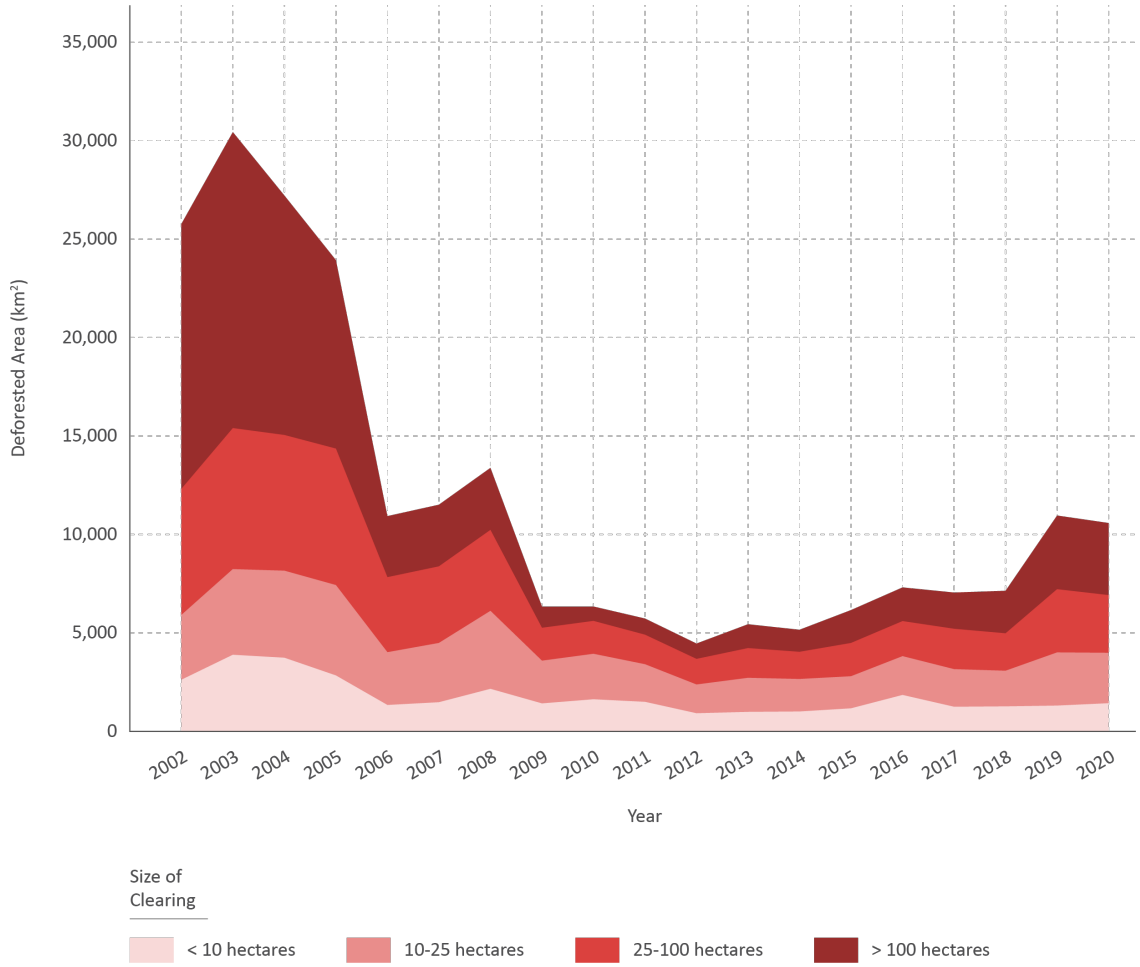


Note: The share of deforestation that occurs in undesignated or unidentified public areas may be underestimated, while that which occurs in private properties may be overestimated. This is because the land tenure data used in the distribution calculation considers that all records in the CAR system are private properties, even when located in undesignated or unidentified public areas.

Source: CPI/PUC-Rio with data from PRODES/INPE and Agricultural Atlas/Imaglora, 2021

It is also important that actions to fight deforestation be systematically enhanced to account for behavioral changes among those who engage in forest clearing activity, including as a response to conservation efforts. Changes in deforestation patterns over time serve as an example. There was a sharp drop in the share of deforestation that occurred via medium and large clearings starting in 2006 (Figure 12). There are indications that this drop can be partially attributed to a strategic response on the part of those responsible for deforestation, as they began operating at a smaller scale to evade detection by the monitoring system (Godar et al. 2014; Börner, Marinho and Wunder 2015; Assunção et al. 2017; Kalamandeen et al. 2018; Montibeller et al. 2020). This led INPE to improve its monitoring system, which, as of 2015, can detect clearings of as little as 3 hectares.

Figure 12. Deforested Area by Size of Clearing, 2002-2020



Source: CPI/PUC-Rio with data from PRODES/INPE, 2021

This example also illustrates the central role played by technological innovation in combatting deforestation. By inaugurating the use of near-real-time remote monitoring to target law enforcement actions, the adoption of DETER was a turning point in the Brazilian strategy to combat deforestation in the Amazon. The system provided a key input for more effective environmental control and, when the technology reached its limits, it was enhanced to continue supporting enforcement efforts.[14]

Today, there is plenty of room to boost the effectiveness of public policy through the strategic use of technology. The country has vast amounts of data that could be useful for environmental control, but its information systems lack transparency, integration, and systematization. Initiatives that improve access to data and enable easier crossing of relevant information (for

[14] In addition to official systems, there are civil society initiatives that also measure and monitor Amazon forest loss. Examples include the SAD system (by Imazon), Global Forest Change (a collaboration led by researchers at the University of Maryland, USA) and the MapBiomas and MapBiomas Alerta Projects (a collaboration between universities, non-governmental organizations and technology companies). These initiatives are important mechanisms for transparency and accountability of government actions.

example, deforested areas, forest loss alerts, rural establishments, permits for vegetation removal, fines, embargoed areas, and others) are essential to increase the precision, agility, transparency, and effectiveness of public action.[15,16] The MPF's Protect the Amazon is an example. The project combines satellite imagery and public data to open civil lawsuits against those responsible for illegal deforestation without the need for in-person law enforcement field visits. Targeted areas are publicly listed in an interactive map, allowing public entities, businesses, consumers, and the civil society to incorporate this information into their decisions.

Although the strategic use of technology is key to combatting deforestation, it is not enough to control forest loss. Technology offers essential inputs and tools, but Brazil must also guarantee wide institutional support to ensure the state's ability to respond. The recent reversal seen in deforestation patterns, with a sharp increase in the number of large clearings, illustrates this point (Figure 12). Large-scale deforestation is increasing despite the improvements made to monitoring technology. This has been linked to the deterioration of the institutional environment for combatting deforestation in the Amazon, and particularly to the weakening of environmental command and control efforts (Trancoso 2021). There is a pressing need to strengthen this institutional environment.

Forest Degradation

The Amazon Forest is not only at risk from deforestation. Forest degradation, or the gradual loss of vegetation, is emerging as an increasingly relevant threat to the region (Rappaport et al. 2018; Matricardi et al. 2020). Although degradation may seem less destructive than deforestation, combating degradation should be a priority for Brazilian conservation policy. After all, degradation reduces forest resilience, making it more susceptible to future damage. It also interferes with the provision of ecosystem services, causes loss of biodiversity, and lessens the forest's capacity to sequester and stock carbon (Barlow et al. 2016; Longo et al. 2016; IPCC 2019).

Yet, forest degradation is still a relatively unknown phenomenon. A better understanding of degradation in the Amazon, and particularly of its potential relationship with deforestation, is a key input in the decision-making process for allocating scarce resources to policy implementation. With it, Brazil could target its efforts more efficiently and provide a timelier response to degradation, thereby enhancing its ability to protect native Amazon vegetation.

[15] Two initiatives that have advanced on this front are INPE's TerraBrasilis and MapBiomas Alerta platform. The first gathers official data on deforestation and forest loss alerts, making them available in different formats and aggregations, and presenting them in an accessible form to the general public. The second is a forest loss alert validation and refinement system, which generates, for each alert validated with high-resolution images, an automated report containing images from before and after deforestation, associated information from other relevant spatial layers (land tenure, geographic boundaries, embargoed areas) and complete land cover and land use history (1985 to 2019) for that area.

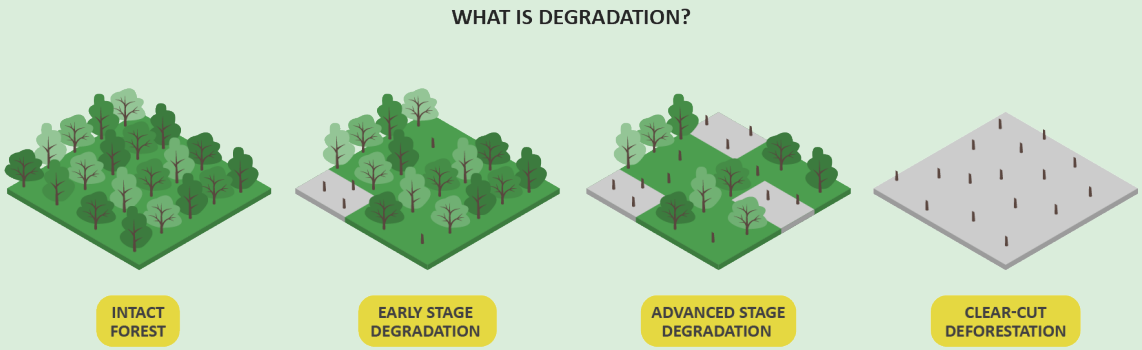
[16] Data transparency and integrated information systems are also key to increasing traceability along supply chains, a topic that has been gaining momentum in the private sector.

Box 3. What is Forest Degradation?

For the purposes of this report, forest degradation is defined as the partial loss of forest biomass. 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 (Barlow et al. 2016; Longo et al. 2016). 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.

The process through which an undisturbed forest undergoes several stages of degradation culminating in clear-cut deforestation (Figure 13), 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.

Figure 13. Process of Forest Degradation



Source: CPI/PUC-Rio, 2021

Forest Degradation Occurs At Scale in the Brazilian Amazon

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.[17] 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.

Although forest degradation can be defined and measured in a variety of ways, there is a consensus that it occurs at scale in the Brazilian Amazon (Asner et al. 2005; Rappaport et al. 2018; Matricardi et al. 2020). According to official data, between 2007 and 2016, an average of 11,000 square kilometers of forest were degraded each year — twice the annual average for deforested area during this period (INPE 2017; INPE 2021a).[18] Forest degradation is geographically concentrated in the regions that also concentrate deforestation. Between 2007 and 2016, the states of Mato Grosso and Pará jointly accounted for an average of 75% of degraded areas and 64% of deforested areas each year in the Amazon.

Degradation as a Leading Indicator for Deforestation

If degradation is an earlier part of the process that eventually leads to clear-cut deforestation, then combating degradation could also help reduce deforestation. The empirical relationship between degradation and deforestation needs to be better understood, but there are some indications that these phenomena are associated across space and time. Gandour et al. (2021) show that it is relatively common to find deforestation near previously degraded areas in the Amazon. In light of this, they argue that degradation could be seen as a leading indicator for regional forest loss, signaling the imminent risk of deforestation in the area.

The evidence suggests, however, that the relationship between degradation and deforestation varies significantly among land tenure categories. There is little association between degradation and deforestation in protected territory (protected areas and indigenous lands), whereas small private properties and rural settlements exhibit a significant share of degradation followed by deforestation in surrounding areas, and often in the degraded area as well. Undesignated public lands appear to be nearing this pattern, too, with growing association between degradation and deforestation. Gandour et al. (2021) argue that these differences could be the result of rules governing land use in different land tenure categories, which influence the way people interact

[17] Legal timber extraction should follow a management plan to minimize the risk of degradation.
[18] Note that the same area can be identified as degraded several times over the years, but only once as deforested.

with the forest. They suggest the following interpretations for these patterns. In protected territories, where environmental offenders face more severe penalties for their actions, a potential offender might conclude that furthering the removal of vegetation is simply not worth, since deforestation carries a greater risk of detection. The high cost of clearing tropical vegetation could lead small landholders, settlers and even land-grabbers — all of whom typically have very limited access to abundant financial resources — to use degradation to remove vegetation gradually and at a lower cost. Gandour et al. (2021) emphasize the need to seek a better understanding about the mechanisms driving these associations.

Opportunities for Research and Public Policy

Forest degradation in the Brazilian Amazon is still relatively unknown. [19] Analytical knowledge of the subject must be expanded, beginning with a few key questions. Where degradation serves as a leading indicator for imminent severe environmental damage, what is the specific relationship between degradation and deforestation, and how is it affected by different governance structures? Where degradation does not lead to deforestation, what are the reasons for degrading an environmental asset and not using the land for economic purposes? Do efforts to combat deforestation influence patterns of forest degradation? If so, how does this effect vary across land tenure categories and types of degradation?

With a more robust understanding of forest degradation, Brazil will be able to optimize its conservation policy efforts, adopting more effective measures to combat the various types of forest loss affecting the Brazilian Amazon.

Secondary Vegetation

There is a pressing need for global action to reconcile mitigating the adverse effects of climate change with the pursuit of sustainable development goals. Since forest growth absorbs carbon and improves human well-being, the restoration and protection of natural ecosystems — especially tropical forests — plays a fundamental role in this. Estimates indicate that restoring 3.5 million square kilometers of degraded and deforested areas around the world could absorb 1.7 $GtCO_2$ per year and generate approximately US$170 billion in net revenue from the protection of water resources, improved agricultural productivity, and forest products (IUCN and Winrock International 2017). Ecosystem restoration is gaining momentum at a global scale, as evidenced by the emergence of multilateral initiatives such as the Bonn Challenge, the Initiative 20x20, the Nationally Determined Contributions (NDC) established under the Paris

[19] The increasing availability of data on forest degradation is an important input for advancing the understanding about the phenomenon. Some of the systems that detect degradation are: DEGRAD/INPE (series ended in 2016), DETER/INPE, DETEX/INPE. and Simex/Imazon.

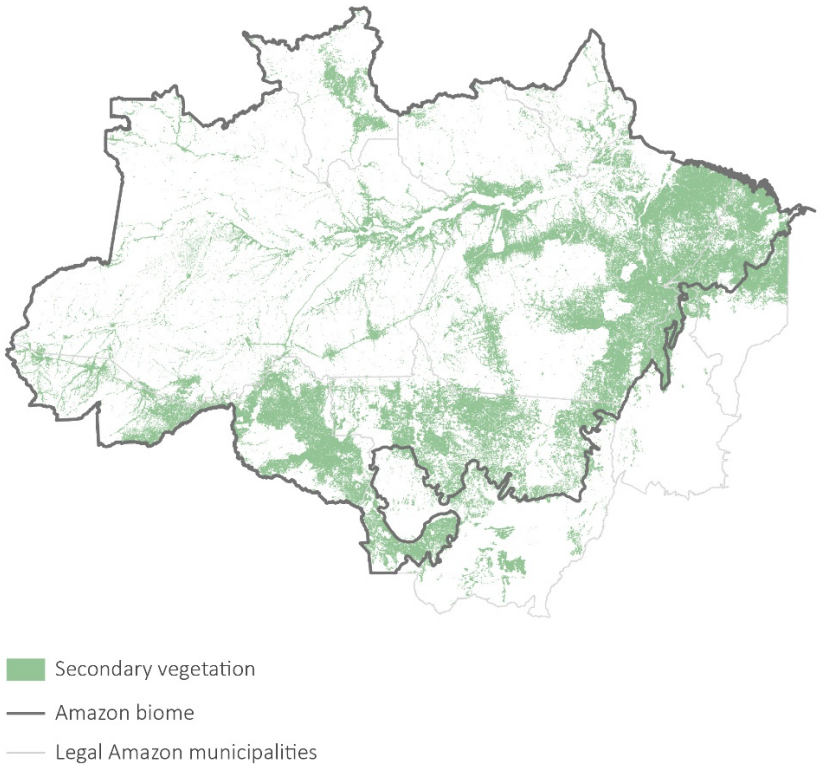
Agreement, as well as by the recent launch of the United Nations Decade on Ecosystem Restoration (2021-2030).

With vast amounts of degraded and deforested areas in tropical zones, Brazil is in a unique position to contribute to this effort. Yet, its forest conservation policies tend to focus on containing primary deforestation pressures and pay little attention to boosting and protecting secondary vegetation. At present, the country does not even systematically monitor these areas. It is critical that Brazil act to incorporate ecosystem restoration into its conservation policy agenda. By making a firm commitment to recovering degraded ecosystems and ensuring their protection, the country would make progress towards meeting its environmental goals, foster improvements to human well-being at the local and global levels, and move toward reclaiming its position as a global leader on climate action.

An Invisible Phenomenon

The Brazilian Amazon contains a large area of secondary vegetation. In 2014, the last year for which official data on land use inside Amazon deforested areas were available, there were approximately 170,000 square kilometers covered by secondary vegetation (Figure 14) (INPE and EMBRAPA, 2016). This amounted to nearly a quarter of all land historically deforested in the region. This was not just secondary vegetation that had grown long ago, but an ongoing phenomenon, since its area increased by more than 70% between 2004 and 2014.

Figure 14. Secondary Vegetation, 2014



Source: CPI/PUC-Rio with data from TerraClass/INPE and EMBRAPA, 2021

Secondary vegetation remains invisible to Brazil's official systems for monitoring Amazon forest cover. Official mapping of secondary vegetation was carried out for some years by the TerraClass Amazonia project, a collaboration between INPE and EMBRAPA, but 2014 was the last year mapped. Moreover, the loss of secondary vegetation is not covered by DETER, the key tool for targeting environmental law enforcement. Although there are non-governmental efforts that monitor secondary vegetation, this does not eliminate the need for the Brazilian government to have a system of its own to provide timely information and ensure methodological consistency across official data regarding the various types of vegetation cover in the Amazon.[20] The country cannot currently observe medium and long-term trends related to gains or losses in secondary vegetation in its largest biome. This greatly limits its ability to keep track of and demonstrate its fulfillment of international restoration goals, as well as its compliance with the restoration requirements established by Brazilian environmental legislation for rural properties. Furthermore, Brazil cannot quickly detect the loss of secondary vegetation, which prevents law enforcement from responding effectively.

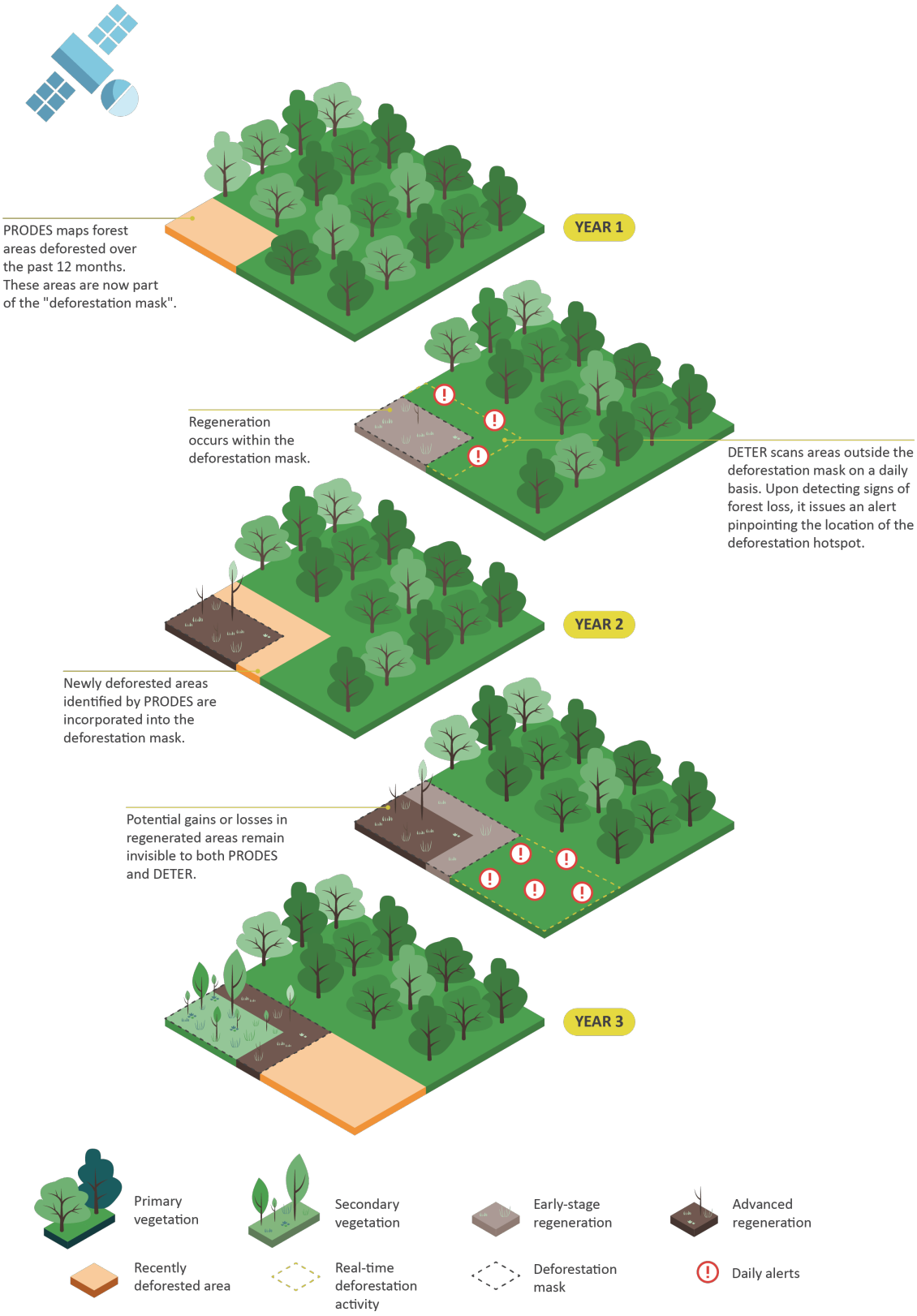
In practice, secondary vegetation is completely vulnerable. The evidence suggests that secondary deforestation in the Brazilian Amazon has grown over time, and has, by some accounts, even exceeded primary deforestation in the last decade (Nunes et al. 2020; Pinto et al. 2021). As long as secondary vegetation remains invisible to monitoring systems, Brazil will continue to lack access to the data it needs to design and execute policies for environmental conservation and sustainable development.

Box 4. Why Is Secondary Vegetation Invisible to Brazilian Satellite Monitoring Systems?

DETER serves as the basis for targeting law enforcement and environmental control efforts in the Amazon Forest. The system was designed to exclusively detect the loss of primary vegetation. This is in line with the way Brazil has measured tropical deforestation since the end of the 1980s with INPE's Program for Satellite Monitoring of the Brazilian Amazon Forest (PRODES). Whereas DETER is used to monitor the forest and emit forest loss alerts in near-real-time, PRODES makes more precise maps and measurements of the deforested area over the course of a year. Once identified as deforested by PRODES, a given area is not revisited in future years and is incorporated into what is known as the "deforestation mask". The mask thus represents accumulated deforestation over time, so DETER searches for signs of forest loss strictly outside it. By definition, however, secondary vegetation grows in areas that were previously deforested — precisely inside the mask. Considering that the mask is a blind spot for PRODES and DETER, changes to secondary vegetation cover in the Amazon remain invisible to both systems and, consequently, to Brazilian environmental authorities (Figure 15).

[20] Examples of non-governmental initiatives that provide data on areas with secondary vegetation (including restoration, regeneration, and reforestation) in Brazil are: Project MapBiomas, Plataforma FloreSer/Imazon, and the Observatory of Restoration and Reforestation by Coalizão Brasil.

Figure 15. Why is Regeneration in the Amazon Invisible to Forest Monitoring Systems?



Source: CPI/PUC-Rio, 2021

Protecting Secondary Vegetation is Strategic and Feasible

Adding the support and protection of tropical secondary vegetation to its environmental policy agenda would be a strategic and timely decision for Brazil. This would enable the country to simultaneously meet its environmental goals of reducing GHG emissions and improve human well-being at local and global levels, in addition to contributing to the recovery of degraded ecosystems and their biodiversity. Systematic, regular, and frequent monitoring of secondary vegetation is needed to catalyze tropical forest regrowth and ensure its protection. Today, the biggest obstacle to developing monitoring systems for secondary vegetation is not technological. Brazil has access to both the technology and the technical knowledge it needs to monitor secondary vegetation, but its policy framework doesn't support this endeavor. It is vital that policymakers understand that this vegetation needs to be protected, and above all that implementing the necessary systems is relatively easy.

Assunção, Almeida and Gandour (2020) provide recommendations on how to move forward with the development of remote monitoring systems for secondary vegetation: (i) establish clear criteria for classifying secondary vegetation in remote sensing imagery; (ii) develop two complementary systems to guarantee the monitoring of secondary vegetation in both the short and the medium-to-long term; (iii) use available remote sensing imagery to build the first version of the systems; and (iv) plan and maintain a thorough communication strategy with policymakers and the general public. In addition to reinforcing the need for a public system for the continuous monitoring of secondary vegetation, Pinto et al. (2021) argue that it is important to grant legal protection status to these areas, and essential to boost the economic value of secondary vegetation.

Opportunities for Research and Public Policy

Promoting and protecting forest regrowth has been largely absent from Brazilian environmental policy in recent decades (Antonaccio et al. 2018).[21] [22] While Brazil works to develop essential systems to monitor tropical secondary vegetation, the country should also incorporate the restoration of degraded ecosystems into its conservation policy agenda. This will require a deeper understanding of tropical forest regrowth and its interaction with regional occupation and land use practices. Moreover, it is important to understand how public policy can affect secondary vegetation, whether directly or indirectly, so as to catalyze forest recovery and ensure its protection.

[21] An important exception was the National Plan for the Recovery of Native Vegetation (PLANAVEG), launched in 2017 aimed at recovering at least 120,000 square kilometers of vegetation across Brazil by 2030, mainly in APPs and Legal Reserves. Although the plan formally still exists, its implementation has not progressed.

[22] Secondary vegetation started to be contemplated in a more systematic and strategic way in some subnational public policy efforts for forest conservation. An example is the Amazon Now Plan for the State of Pará (PEAA), launched in 2020. Aiming to achieve net zero emissions at the state level in 2036, Pará includes the recovery of degraded areas in its action plan, with particular attention to the potential contribution of passive regeneration to expand and consolidate areas with secondary vegetation.

Amazon Forest Protection Requires Solid Support from Public Policy

Brazil has a unique opportunity to align the interests of diverse government entities, productive sectors, and civil society around a single effort. As it takes steps to better conserve its native vegetation, the country protects this precious environmental asset, along with all forms of life that depend on it directly or indirectly — but that's not all. It also boosts production capacity and gains a competitive edge in global markets, while combating illegal activity and moving towards a position of global leadership on climate action.

Protecting the Amazon demands solid political leadership and an unwavering commitment to an evidence-based public policy agenda. In this context, the government is responsible for planning, supporting, and coordinating strategic activities across different spheres of action, thematic areas, and segments of society. The country knows what must be done and is fully capable of doing it. Brazil must treat the protection of its Amazon Forest with the necessary urgency.

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CENTRO DE EMPREENDEDORISMO DA AMAZÔNIA

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