Latin American and Caribbean Forests in the 2020s:

Trends, Challenges, and Opportunities

Edited by Allen Blackman

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Foreword

Latin America and the Caribbean has been termed "the Biodiversity Superpower." That is in large part because of its tropical rainforests, among many other kinds of forests. But forests represent more than biodiversity. They provide vital ecosystem services (for example, mangroves serve as nurseries of fisheries), and they are the basis for important economic activities, from Brazil nut harvesting to forestry per se. The purpose of this monograph is to highlight the many facets of the region's forests and to promote an integrated and sustainable approach to the ways they are used, maintained, and protected.

A critical issue is the Amazon hydrological cycle, which has been well studied by Brazilian and other scientists. Through transpiration, the trees and leaves of this vast forest furnish moisture to every country in South America except Chile, including the rainforests in the southern and eastern Amazon Basin. Without that moisture, the region will convert to savannah, with enormous loss of biodiversity and adverse effects on the agriculturalists and the indigenous peoples who depend on the forest.

The forests of Latin America and the Caribbean also contain an immense amount of carbon. If released to the atmosphere, that carbon would render global climate change even more of a disaster than it already is. The biology of the planet will be seriously stressed at more than 1.5 degrees C of global warming: essentially, ecosystems will disassemble and the world will become biologically unmanageable.

The sensible course is to strictly curb further deforestation, offset any additional deforestation with reforestation, conserve the most intact forest ecosystems, manage the remainder in sustainable ways, and move proactively into reforestation of previously deforested areas.

In the end, managing forests for their carbon is like valuing a computer chip for its silicon. We must value the forests for their biodiversity, and manage those that are being used economically for forestry in low-impact ways from which they can recover.

This monograph brings together authorities with long experience studying Latin American and Caribbean forests to illuminate various aspects. Daniel Nepstad and colleagues present real-world examples of how to conserve and restore forests. Carlos Nobre and coauthors explain these forests' links to the global carbon cycle and the all-important hydrological cycle. Brent Sohngen examines forest management and trade in forest products. Finally, Simone Bauch describes the range of forest projects at the Inter-American Development Bank.

This monograph appears at a critical time in Latin America and Caribbean, when the Bank's leadership is working hard to show the way to sustainability. These efforts should be a model for the rest of the world as well.

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Executive Summary

Allen Blackman

Forests are among Latin America and the Caribbean's (LAC's) crown jewels. The region boasts roughly a third of the world's forests, half of its tropical forests, and a quarter of its mangroves (Blackman et al. 2014). This rich natural capital provides vital ecosystem services. At the global level, LAC forests remove vast quantities of carbon dioxide from the atmosphere (1.2 ± 0.4 Pg C per year), store almost half of the aboveground carbon in the tropics, circulate moisture at a continental scale, provide habitat for roughly half of the world's terrestrial species, and host seven of the world's 25 biodiversity hotspots (UNEP 2010; Gibbs et al. 2007; Werth and Avissar 2003; Meyers et al. 2000). At the local level, LAC forests regulate surface and groundwater quality, moderate temperature, and provide valuable economic and cultural goods and services, including 8 percent of the world's industrial wood products (Baker and Spracklen 2019; Anderson-Teixeira et al. 2012).

However, LAC's forests are confronting at least three serious challenges. The first is continuing rapid clearing and degradation. LAC deforestation rates have slowed somewhat over the past 15 years but are still alarmingly high. Between 2015 and 2020, South America lost almost 3 million hectares of forest per year, the second-highest total for any of the world's regions (FAO 2020). Of the 10 countries with the highest average annual net loss of forest area during the same period, 3 were in LAC: Brazil (1.5 million hectares per year), Paraguay (0.3 million), and Bolivia (0.4 million) (FAO 2020). Forest degradation is also an urgent problem. An estimated 240 million hectares of tropical forest in LAC is in a critical state of degradation (Armenteras et al. 2016).

Second, forest loss and degradation in LAC exacerbate climate change, which in turn has adverse effects on forests. LAC countries contribute almost a quarter of global greenhouse gas emissions from land-use change, mostly generated when forest is converted to cropland and pasture (IPCC 2019; WRI 2017). Climate change entails increases in both temperature and rainfall variability that alter forest functioning, plant growth, and tree mortality (Cusack et al. 2016; Scheffers et al. 2016). Barring significant intervention, many researchers believe, climate change, along with continued regional deforestation and fire, will trigger a self-reinforcing downward spiral that results in the loss of up to 60 percent of the Amazon Basin's forest by 2050 (Lovejoy and Nobre 2018).

Finally, the economic outlook for LAC's managed forests is mixed. Although LAC's share of the global timber market has increased significantly in the past 50 years, that growth has not benefited most of the region's countries—it has been almost exclusively due to expanded production of plantation forests in Brazil, Chile, and Uruguay (Sohngen 2020). In addition, LAC's managed forests face increasing competition from Asia, declining global demand, lagging sustainability certification, and persistent illegal logging (Sohngen 2020).

The good news is that at least some facets of the current political climate favor meaningful policy action. Forest conservation and restoration have attracted unprecedented attention in recent years in large part because of emerging consensus that averting the worst effects of climate change will require step changes in forest conservation and restoration (Griscom et al. 2017; Seymour and Busch 2016). For example, since 2011, 61 countries have signed on to the Bonn Challenge of bringing 150 million hectares of degraded and deforested landscapes into restoration by 2020 and 350 million hectares by 2030 (NYDF Assessment Partners 2019). In 2014, the 190 signatories of the 2014 New York Declaration on Forests, which include governments, companies, and nongovernmental organizations, pledged to help cut tropical deforestation by 50 percent by 2020 and 100 percent by 2030 (Verdone and Seidl 2017). The Inter-American Development Bank Group (IDBG) has invested US $1.5 billion in forest and forest-related projects since 2006 (Bauch 2020). And unilateral and bilateral action is encouraging. For example, Norway alone has committed more than half a billion dollars to address forest carbon issues (Hermansen 2015).

How can these financial and political resources best be used to promote conservation, restoration, and efficient management of LAC's forests in the 2020s? This monograph aims to help answer that question. It presents four expert assessments that tackle different facets of the issues.

In Chapter 1, Dan Nepstad and coauthors distill lessons from case studies of the application of three major approaches to forest conservation and restoration in four countries: Brazil, Costa Rica, Ecuador, and Peru. The three approaches are (1) *domestic* policies and programs led by national and subnational governments, including fiscal policies, land-use regulations, energy and transportation infrastructure, and import-export policies; (2) *market transformation* policies and programs, such as Forest Stewardship Council certification for sustainable forest management, the Brazilian Soy Moratorium, and the above-mentioned New York Declaration on Forests, that encourage consumers and traders to shift away from commodities produced in ways that cause deforestation or are otherwise unsustainable; and (3) *results-based* payment policies and programs, such as payments for ecological services and reducing emissions from deforestation and degradation (REDD) initiatives, that compensate governments and landholders for the ecosystem services provided by tropical forests. The authors offer the following observations:

- Domestic policies and programs can be quite effective but are hampered not only by the limited ability and willingness of governments to undertake meaningful sustained action but also by strong pushback from land managers, a dynamic that has played out in Brazil over the past decade. As a result, these types of policies can have short-term benefits but are unsustainable over the long term unless accompanied by positive incentives for land managers and other stakeholders.

- As for market transformation policies, unfortunately, certification programs rarely offer price premia or other financial incentives sufficient to engage the "dirty" producers whose participation is needed to spur large-scale change—they mainly attract producers that already meet the standards. Boycotts and moratoria can be effective in the short term but, like domestic policies and programs, may alienate farm sectors, triggering a backlash against efforts to slow deforestation.
- Results-based payment policies and programs can be cost-effective in promoting conservation and restoration when contracts are developed directly with subnational governments and when the benefits to land managers are clear. However, these interventions have so far been limited by the relatively small scale of financing available to tropical forest governments.
- Finally, strong synergistic links between forest conservation and economic development—as in the case of Costa Rica and the tourism industry—generate political will for regulation that facilitates conservation.

In Chapter 2, Carlos Nobre and coauthors examine the two-way links between forests and climate change. They summarize what we know about the effects of climate change on forests and human migration in LAC, and the effects of forest loss and degradation on global and regional climate change. In addition, they present case studies of some of these links for Brazil and Costa Rica. The authors report these findings:

- LAC regions have warmed an average of 1 degree C since 1900, and for many LAC regions the dry season has become longer and weather extremes more frequent. Climate projections for 2100 indicate an intensification of these changes, partially due to forest loss.
- Even leaving aside the effects of global climate change, deforestation is altering the regional climate. Deforestation alone could warm eastern Amazonia by more than 3 degrees C, decrease July-to-November precipitation by as much as 40 percent, and delay the onset of the rainy season by 0.12 to 0.17 day for each 1 percent increase in deforestation.
- Human-induced global and regional phenomena have triggered shifts in the dynamics and biodiversity of forests, reducing their resilience and productivity and culminating in large-scale diebacks. The combined effects of global climate change, regional deforestation, and increased forest fire are expected to cause up to 60 percent of the Amazon rainforest to disappear by 2050.
- As a result of climate change, some 17 million people in LAC may be forced to migrate over the next 30 years.
- LAC countries are responsible for roughly a quarter of the global emissions attributed to land-use change. Cutting these emissions will be critical to global efforts to avoid the worst effects of climate change.
- The climate challenges for LAC in the next decades will demand mixed climate policies based on forest restoration and protection, new technologies for sustainable agriculture, green infrastructure for risk reduction, and better communication between scientists and stakeholders.

In Chapter 3, Brent Sohngen explores LAC forest management, including LAC trends in international trade in timber and bioenergy, sustainable forest management, nontimber forest products, illegal logging, property rights, and climate change as it affects managed forests. In addition, Dr. Sohngen summarizes an original analysis of future timber supply potential using the Global Timber Model (Sohngen et al. 1999). His findings:

- Growth in LAC's wood products sector has exceeded the world's average since the 1960s, and the region now contributes 13 percent of the world's production. However, virtually all of this growth has been due to expansion in three countries, Brazil, Chile, and Uruguay, which have invested in fast-growing plantations.
- LAC plantations face competitive pressure because of declining world markets for paper products. It is therefore important for LAC to explore opportunities for new markets, new products, and enhanced productivity. Countries other than Brazil, Chile, and Uruguay, particularly those in Central America, have opportunities to expand timber production in both natural forests and plantations.
- LAC currently lags other regions in the area of forestland certified as sustainably managed by the Forest Stewardship Council and other organizations. Brazil and Guyana, however, have required reduced-impact logging and lower harvesting rates on their timber concessions, so elements of sustainable forest management are nonetheless being implemented in many LAC forests.
- Community forest management has promise for LAC. Although its effects on livelihoods is uncertain, evidence suggests it likely cuts deforestation in many locations and may provide opportunities to expand production of nontimber forest products.
- Illegal logging has slowed in recent years in many LAC countries. Efforts to regularize property rights via community forest management or timber concessions likely will help reduce illegal logging in the long run.
- Current estimates suggest that productivity gains in managed forests due to climate change may outweigh the losses due to dieback, leading to higher overall timber output. However, these results do not hold for every location. The eastern Amazon forest, for instance, appears particularly vulnerable to drought and possibly more forest fires because of climate change.
- Global Timber Model projections suggest that LAC forest product output will increase from 2020 through 2040–2050. However, pulpwood output is sensitive to assumptions about future policies and market conditions. This sensitivity illustrates why it is important to evaluate investments in improving plantation productivity.

Finally, in Chapter 4, Simone Bauch presents an analysis of the IDBG's experience with forest projects over the past 13 years. Having reviewed IDBG documents on all 99 forest projects approved by the bank during this period and interviewed 23 current and former bank staff, Dr. Bauch presents a brief recent history of IDBG forest projects, an overview of the major determinants of project development, and an analysis of trends in forest projects, including their number, funding, objectives, themes, and locations. Her findings can be summarized as follows:

- Starting in the 1980s, IDBG forest projects were managed alongside rural development projects, often in order to compensate for potential environmental damage from dams, roads, and other infrastructure. Starting in the 1990s, however, forest projects focused increasingly on forest conservation, restoration, and disaster prevention.
- Since 2006, the IDBG has invested almost US $1.5 billion in LAC forest projects aimed at conserving, restoring, or sustainably managing natural forest resources, as well as promoting forest plantations and agroforestry.
- The primary determinant of the types of projects funded has been country priorities.
- Both the number of IDBG forest projects and their funding have increased significantly since 2006, mostly because of the increased availability of climate finance, which accounted for 14 percent of all forest funding approved by the IDBG in the study period.
- The focus of the investments in forests has not changed significantly over time, with sustainable forest management, governance, and conservation being the lead project objectives.
- Carbon, biodiversity, and livelihoods have been the most common topics or themes used to justify forest projects.

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Innovations in Approaches to Forest Conservation and Recovery

Dan Nepstad, Juan Ardila, Tathiana Bezerra, Olivia David, Claudia Stickler, Rafael Vargas, and Matt Warren

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Innovations in Approaches to Forest Conservation and Recovery

Never before has so much funding or attention been devoted to tropical forests. Norway alone is investing approximately US $500 million to unlock the potential of tropical forests as part of a global solution to climate change. Approximately 190 entities, including governments, companies, and nongovernmental organizations, signed the New York Declaration on Forests in 2014, committing to help reduce tropical deforestation 50 percent by 2020 and completely by 2030. At the 2019 Climate Summit in New York City, a third of the events focused on nature-based solutions to climate change, all of which involve forests.

The reason for this elevated interest in tropical forests is the urgency of addressing climate change. Slowing the loss and speeding the recovery of tropical forests could account for a fourth or more of the emissions reductions that will be needed in 2030 to avoid catastrophic climate change (Griscom et al. 2017; Stickler et al. 2018).

Progress has been slow, however. The two years with the highest tree cover loss since 2000 are 2016 and 2017 (Figure 1; WRI 2019). In Latin America and the Caribbean (LAC), this trend is even more troublesome, with a higher recent uptick in deforestation. Exceptions to this trend include the nearly 80 percent decline in deforestation rates in the Brazilian Amazon region from 2004 to 2012, described below. But in general, it appears that a course correction is needed.

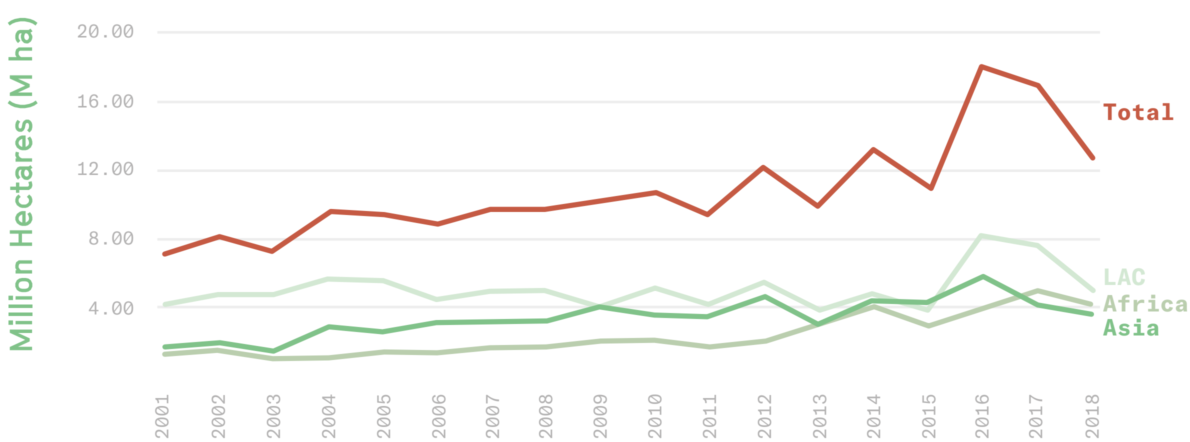


Figure 1. Forest Loss, 2001–2018

Tree cover loss for tropical countries of Latin America and the Caribbean (LAC), Africa, Asia, and all of the tropics (total), derived from Global Forest Watch using a canopy cover threshold of 30 percent. *Source:* WRI (2019).

Any course correction in strategies to slow the loss and speed the recovery of tropical forests should build on what is working and strive to fix what is not. This chapter distills some of the lessons from application of three major approaches and regional experiments to slow deforestation in LAC. We present case studies of some leading efforts to address the forest challenge, undertaken by Brazil, Costa Rica, Ecuador and Peru.

Our main findings are as follows. Command-and-control strategies have demonstrated massive short-term effects on deforestation, as we describe for the Amazon region of Brazil, but appear to be unsustainable over the long term in the absence of significant positive incentives for maintaining and expanding forests. Catching and prosecuting lawbreakers across a vast tropical forest landscape is expensive and can be maintained only with a high level of political commitment—something now flagging in Brazil.

Approaches based on positive incentives for conserving forests, such as Costa Rica's forest program and the Socio Bosque program of Ecuador, have delivered more sustainable gains in forest conservation, although the long-term source of domestic funding for these initiatives is uncertain. In Peru, a multistakeholder coalition for forest-friendly development in the Amazon region holds great promise.

The growing polarization between the farm sector and environmental groups in Brazil provides an important cautionary note. It has pushed important allies—forest-conserving farmers—away from the forest agenda. This polarization was aggravated by the opportunities missed by the Soy Moratorium and other market-exclusion mechanisms to recognize and reward farmers who are in compliance with the Forest Code. The code requires that at least 80 percent of Amazon farms be maintained under natural forest cover.

Results-based payments for jurisdictional programs appear to achieve large benefits for a fairly small amount of money when the contracts are developed directly with subnational governments and the benefits to a range of land-holding stakeholders are clear. There are only two such contracts that have these characteristics, both in Brazil.

Finally, when forest conservation is clearly and positively linked to economic development—as is the case in Costa Rica via the tourism industry—it is possible to maintain strong political will for the budget allocations and regulatory frameworks that are necessary to slow the loss and speed the recovery of tropical forests. In most LAC countries, however, this basic condition has not been met.

Causes of Deforestation

Despite several decades of public policies, environmental advocacy campaigns, and international strategizing and financing, the basic driver of forest clearing in Latin America and elsewhere in the tropics has not changed: the market value of forested land is less than that of cleared land. These land values are in sharp contrast to the value of the forest to the global economy. Using the US Environmental Protection Agency's estimate for the social cost of carbon—about $100 per ton of carbon dioxide (CO2) emitted (IWGSCC 2010)—the value of a hectare of moist tropical forest in Latin America in avoided damages to the global economy, assuming 150 tons of biomass carbon per hectare, is approximately $55,000. That is roughly 50 times greater than the market value of a hectare of cleared land in the Brazilian Amazon, which is roughly 10 times higher than the market value of a hectare of forested land (Figure 2).

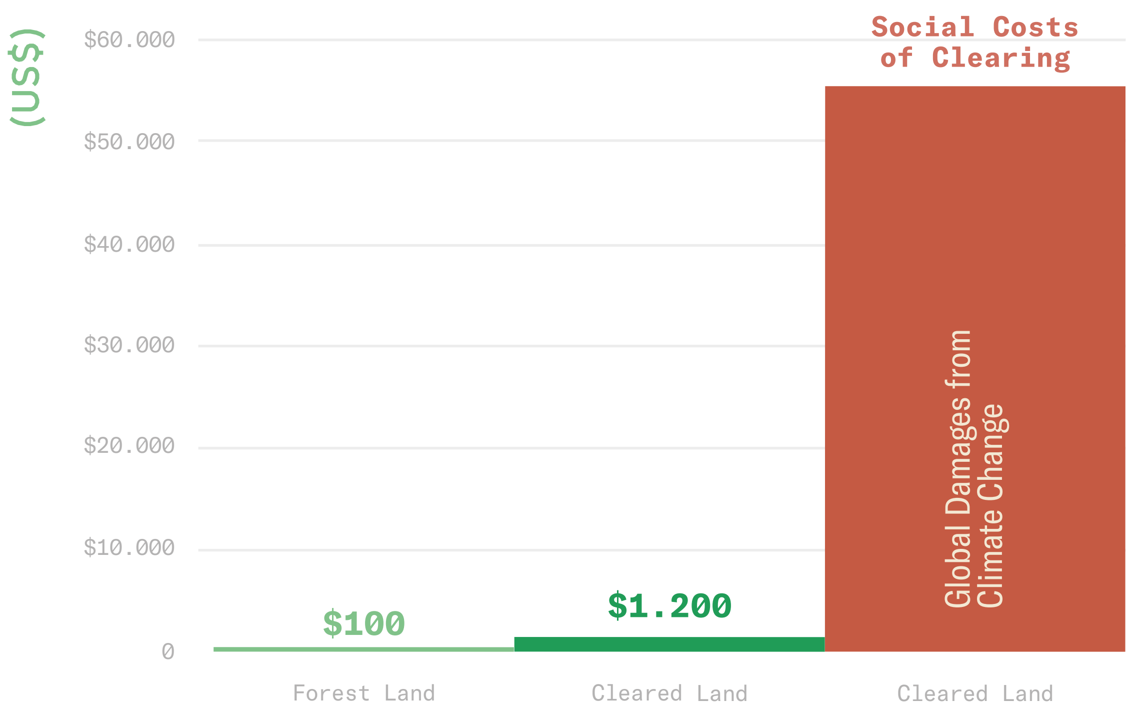


Figure 2. Land Value per Hectare in Amazon Basin (US$)

Typical price of land in the land market of the Brazilian Amazon (left two columns) and the value of a hectare of forest for the global economy associated with avoided damages associated with climate change. Each ton of carbon dioxide is estimated to cause approximately US $100 in damages to the global economy (EPA 2010). The biomass of a hectare of Amazon forest is approximately 150 tons of carbon, which becomes 550 tons of carbon dioxide when it is oxidized.

Perhaps the single most important determinant of the location and scale of forest conversion is transportation infrastructure (Soares-Filho et al. 2006; Nepstad et al. 2001). ... In the Brazilian Amazon region today, more than 75 percent of forest clearing has taken place within 50 kilometers of an all-weather highway (Soares-Filho et al. 2006).

The drivers of deforestation can be divided into primary and secondary categories (Geist and Lambin 2002). Primary drivers are directly involved with the clearing of forests and include cattle pasture expansion, land speculation, forest conversion for subsistence and semisubsistence production of manioc, beans, rice, bananas and other staple crops, forest conversion for soybean production, oil palm plantations, and other commodities, and forest clearing for wildcat mining (De Sy et al. 2015).

It is often said that cattle pasture is the main primary driver of forest conversion in the LAC region,[1] but land-use activity on a tract of cleared land should be distinguished from the motivation for establishing that land-use activity. In the Brazilian Amazon, for example, land grabbers (*grileiros*) often clear forest and establish cattle pasture to demonstrate "productive use" of the land, enhancing the likelihood that they will eventually be granted ownership.

Secondary drivers are the actions and investments that make primary drivers feasible: investments in transportation infrastructure, rural electrification, agrarian reform that provides forestland to landless farmers, subsidies for agricultural expansion in forest regions, and others. Perhaps the single most important determinant of the location and scale of forest conversion is transportation infrastructure (Soares-Filho et al. 2006; Nepstad et al. 2001). At the time of European colonization, farming was largely restricted to the margins of rivers and streams that could be navigated by canoe. Occupation of forested regions expanded most rapidly where larger vessels could navigate. As roads were cut across the interfluvial forests, colonization and forest expansion followed. In the Brazilian Amazon region today, more than 75 percent of forest clearing has taken place within 50 kilometers of an all-weather highway (Soares-Filho et al. 2006).

[1] https://globalforestatlas.yale.edu/amazon/land-use/cattle-ranching.

Three Approaches to Forest Conservation

Of the great diversity of strategies and approaches to tropical forest conservation, we examine the approaches that fall into three general categories: domestic policies and programs, market transformation, and results-based payments.

The first approach to tropical forest conservation refers to the public policies and programs of national and subnational governments in tropical forest regions. Governments have the power to establish and implement fiscal policies, land-use regulations, energy and transportation infrastructure, import-export policies, and many other actions and instruments that influence the fate of forests, the ease of doing business, and the flows of finance to the land sector. They are also charged with defending the public good by exercising these responsibilities effectively. The potential of governments to influence tropical deforestation is exemplified by Brazil's Amazon strategy, launched in 2004.

The market transformation approach to tropical forest conservation is premised on the idea that if a large enough share of the market rejects commodities produced in ways that cause deforestation and are otherwise unsustainable, then a large-scale shift to sustainable production systems results. This approach has been implemented both through international sustainability standards for certifying commodities as sustainably produced, such as the Forest Stewardship Council, the Roundtable for Sustainable Palm Oil (RSPO), and the Roundtable for Responsible Soy, and through corporate and governmental commitments to zero or "zero net" deforestation commodity sourcing, such as those registered in 2014 in the New York Declaration on Forests (New York Declaration on Forests 2019). In practice, corporate zero deforestation commitments are generally implemented via certified compliance with international standards. The Brazilian Soy Moratorium, a sector-wide zero-deforestation agreement (Nepstad and Shimada 2018), reviewed below, is widely held to be one of the most successful examples of a market-based strategy for addressing deforestation.

Finally, the results-based payments approach to tropical deforestation assumes that financial compensation to governments and landholders for the ecosystem services provided by tropical forests will lead to the conservation of these ecosystems. This approach fits within the broader set of strategies that are often called payments for ecosystem services (PES; Daily 1997). The most prominent example for tropical forests is REDD+, the acronym for "reducing emissions from deforestation and forest degradation," with the plus sign referring to forest carbon enhancement (Agrawal et al. 2011). REDD+ programs and projects vary greatly in complexity and scale and include Norway's performance-based commitment to the Brazilian Amazon Fund, REDD for Early Movers programs (Germany and the United Kingdom), and the Green Climate Fund. The disbursement of funds is tied to low or declining emissions from deforestation. Large-scale "jurisdictional" REDD+ programs measure results across entire political geographies, such as states and nations, and are more strongly linked to domestic policies and programs than the REDD+ initiatives developed by carbon project developers and financed by companies and investors seeking to voluntarily offset their carbon emissions. A second major type of results-based payment schemes focuses on the role of forests in regulating water flow and quality from watersheds.

Source: Photo by Peters D. 2018. Unsplash, Consulted 2020.

Case Studies

We examine how the three approaches have been applied to the challenge of stemming tree cover loss in four LAC nations: Brazil, Costa Rica, Ecuador, and Peru (Figure 3).

Figure 3. Tree cover loss in Brazil, Costa Rica, Ecuador, and Peru, 2000–2017
Sources: (a.) PRODES, (b.) Mongabay, Hansen, (c.) SUIA, (d.) Programa Nacional de Conservación de Bosques

Brazil

Beginning in 2005, deforestation in the Amazon region of Brazil slowed dramatically (Figure 4). From a 10-year average of 19,500 square kilometers of primary forest loss from 1996 through 2005, the annual area of forest clearing declined 77 percent to less than 4,570 square kilometers in 2012 (INPE-PRODES). It has been rising steadily since then but is still well below the historical average, even with the sharp uptick that occurred in 2019 under President Bolsonaro. Seventeen percent of the Amazon forest has been cleared.This reduction in deforestation is one of the world's largest contributions to climate change.

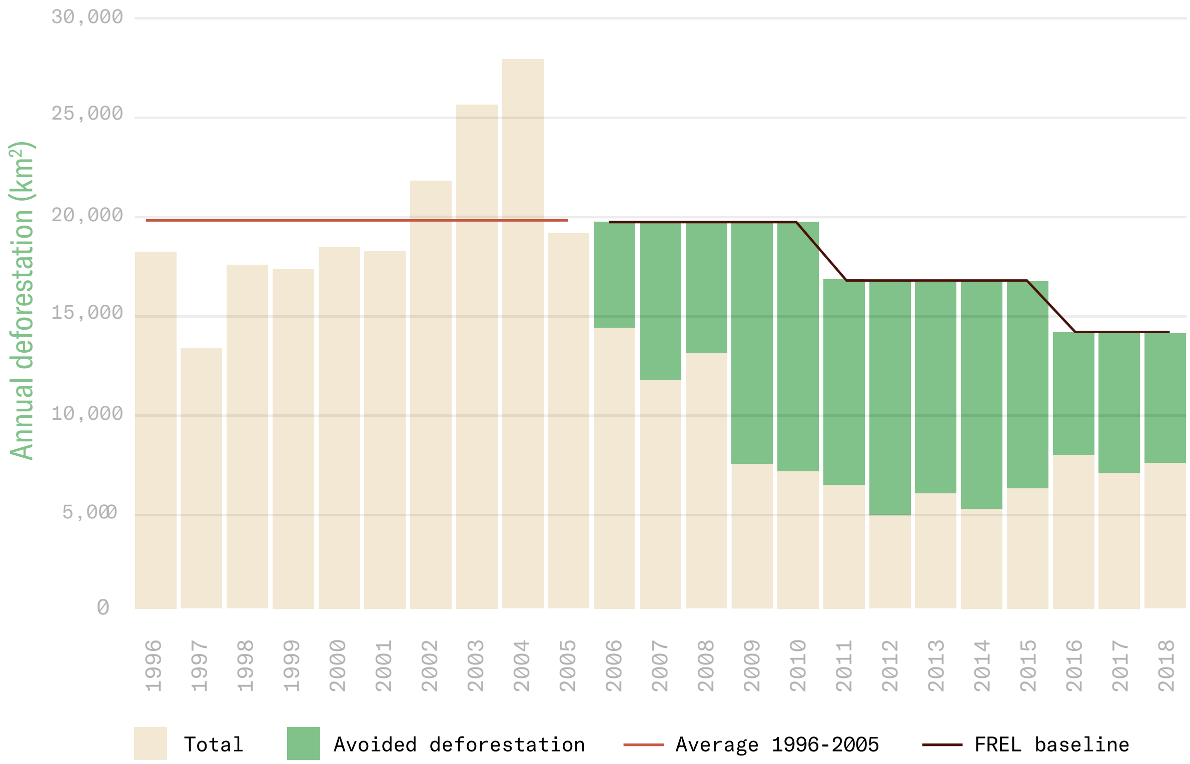


Figure 4. Deforestation in Brazilian Amazon Region, 1996-2018

Brazil's forest conservation policies slowed deforestation rates to 77 percent below the 10-year average ending in 2005, with rates climbing slowly since then. Preliminary, MODIS-based estimates of deforestation in 2019 are at approximately 12,000 km2. More than 6 billion tons of carbon dioxide emissions have been avoided in the Brazilian Amazon. FREL = UN-approved reference level against which emissions reductions are estimated. *Source:* INPE/PRODES.

Based on the forest reference level, which has been approved by the United Nations Framework Convention on Climate Change, Brazil has kept more than 6 billion tons of carbon dioxide out of the atmosphere—and in Amazon trees—through its successful efforts. Thus far, only 3 percent of these emissions reductions have been compensated through results-based payments (Nepstad 2019).

Further slowing of Amazon Basin deforestation and speeding of forest recovery and restoration are important features of Brazil's nationally determined contribution to the Paris Climate Accord, through which Brazil has committed to achieve net zero emissions from Amazonian forests by 2030.

Domestic Policies and Programs

Brazil's remarkable conservation achievement was possible in large part because of its audacious Programa de Prevenção e Controle de Desmatamento na Amazonia (Program for the Prevention and Control of Deforestation in the Amazon), orchestrated across 13 national government agencies and between national and state governments (reviewed in Nepstad et al. 2014) under President Luiz Inácio Lula da Silva. The initiative increased law enforcement efforts, including sting operations against organized crime. Through it and the Amazon Region Protected Area program, Brazil expanded the area of forest under some form of formal protection by 68 percent, including the creation of protected areas and extractive reserves, and formal recognition of indigenous territories close to the advancing deforestation frontier. More than half of the remaining forests of the Brazilian Amazon today are under some form of protection. Brazil also launched a jurisdictional strategy in 2008, through which farmers in high-deforestation *municípios* (counties) lost their access to public lines of farm credit.

Those efforts at taking control of the vast Amazon frontier were facilitated by advances in monitoring. Using data from MODIS satellites, the DETER system, O Sistema de Detecção de Desmatamento em Tempo Real (System for Detection of Deforestation in Real Time), allowed deforestation events to be spotted within days of forest clearing, increasing the effectiveness of law enforcement efforts (Assunção et al. 2013).

Another important feature of Brazil's arsenal for combating deforestation in the Amazon region was the Forest Code. Established in 1965, the Forest Code set minimum percentages of private land that must remain in a legal reserve of native vegetation. In the Amazon region, this percentage was 50 percent. After the record-high deforestation rate in 1995, President Fernando Henrique signed a temporary measure increasing this percentage to 80 percent, which was renewed each year until it was made permanent in 2000. When the government of Mato Grosso insisted that the state's "transition forest," where much of the conversion to soy has taken place, was still at 50 percent legal reserve, the federal government reversed that designation in 2005 (Stickler et al. 2013).

Finally, subnational strategies have also been prominent in Brazil's policies to address Amazon deforestation. Each state was required to develop its own program to prevent and control deforestation. All states of the Brazilian

Amazon are members of the Governors' Climate and Forests Task Force and have signed the Rio Branco Declaration, committing to reduce deforestation 80 percent by 2020 if sufficient finance is available and collaborations with companies are established (Stickler et al., in review).

The state of Acre, for example, launched the Sistema de Incentivos para Servicos Ambientais (System for Incentives for Environmental Services) law and program in 2009, which has now received its second results-based payment contract with the German government (de los Rios et al. 2018).

Mato Grosso initiated the Produce, Conserve, Include strategy in 2015, which establishes targets for slowing the loss and speeding the recovery of forests and Cerrado woodland, for increasing soybean production and the productivity of cattle operations, and for improving technical support and market access of the state's agrarian reform settlement farmers. Mato Grosso's strategy also establishes a minimum area of native cover—60 percent in both the Amazon and the Cerrado biomes, just below current coverage. A strategy for indigenous lands is also under development. If successful, Mato Grosso's policies would result in emissions reductions of 6 gigatonnes of carbon dioxide equivalent by 2030 (EII, 2015).

In Pará, the Municipios Verdes program was designed to help remove *municipios* from the federal blacklist that suspended access to farm credit. A similar Municipios Sustentaveis program was established in Mato Grosso.

Market Transformation

Brazil's Program for the Prevention and Control of Deforestation in the Amazon was reinforced by voluntary market agreements to establish deforestation cutoff dates for soybeans and beef. Products grown on land cleared after these cutoff dates would be rejected by participating companies, which included the buyers of roughly 90 percent of the soy grown in the Amazon region and a third of its beef (Nepstad and Shimada 2018; Shimada and Nepstad 2018). The Soy Moratorium and the Cattle Agreement were responses to "name and shame" campaigns led by Greenpeace (Nepstad and Shimada 2018). The Cattle Agreement featured a strong role of the Ministerio Publico, the public prosecuting ministry of Brazil, that had taken actions against some of the major beef-processing companies, such as JBS, because of their purchase of cattle from farms that were in violation of the Forest Code or had encroached on protected areas or indigenous territories (Shimada and Nepstad 2018).

Results-Based Payments

The above measures created restrictions on deforestation; a few important actions were also taken to reward reductions in deforestation. The Brazilian Amazon Fund was created in 2008 as a pay-for-performance mechanism. So far it has received approximately US $1.3 billion and disbursed more than half of that amount to state governments in the Amazon region and NGOs. As long as Amazon deforestation continues to decline or does not increase, money is released to the fund from its chief contributors, Norway and Germany. In 2010, a similar agreement was established between the German development bank, KfW, and Acre through the REDD for Early Movers program, with a second contract signed in 2017. Mato Grosso also made a results-based payment agreement with Germany and the United Kingdom in 2017. In 2019, a new contract for a $96 million results-based payment contract between Brazil and the Green Climate Fund was finalized.

Discussion

The Brazilian Amazon experience shows that in general, a largely command-and-control approach to deforestation, apparently reinforced by market exclusion of beef and soy associated with deforestation, worked for several years. Its effectiveness diminished, however, in part because of a lack of positive incentives—a shortage of carrots. The polarization that has occurred between environmental groups and the farm sector in Brazil is a cautionary tale about the limits of market exclusion strategies and the potential of the zero-deforestation movement to trigger backlashes that undermine important public policies.

Observations about four aspects of Brazil's forest conservation efforts explain why some strategies failed and other succeeded.

1. The Forest Code meets the Soy Moratorium

Have market exclusion strategies helped turn conservation-minded farmers into enemies? The polarization is best understood in the context of the Forest Code and its interactions with supply chain interventions. Brazil's farm sector organized a campaign to revise the Forest Code in 2010 that was motivated, at least partially, by Brazil's increased law enforcement. Years of inadequate enforcement and slow or no implementation of "flexibility" measures, such as the legal reserve trading scheme among farmers, had made compliance with the code, which itself was changing, extremely difficult (Stickler et al. 2013). Many environmental groups said that compliance was low because farmers broke the law. From the perspective of farmers, noncompliance was high because the responsible agencies never implemented it properly. Farmers felt demonized.[2]

The Forest Code was changed, but the most important restrictions on forest clearing—including the legal reserve percentages in each biome and most of the areas of permanent preservation—remained intact. Significantly, Article 41 was included in the New Forest Code, providing a legal framework for developing mechanisms for delivering benefits to compliant farmers. This article has yet to be implemented. Amnesty was given to all landholders who had cleared forest illegally prior to June 2008. Although much criticized by environmental groups because of this amnesty, the New Forest Code, approved by the Brazilian Parliament in 2012, was accepted by farmers and their organizations. They hoped and assumed that it was the new definition of success in addressing the forest issue, and that it would facilitate their access to global markets. They pointed out, accurately, that Brazil required more native forest on private farms than any other nation.

Farmers' support was evident during negotiations over Mato Grosso's Produce, Conserve, Include strategy in 2015. Representatives of Aprosoja, the powerful soy farmers' organization, supported the target of zero illegal deforestation by 2020.[3] They also supported a mechanism that would compensate farmers for forgoing their legal right to clear forests on their land in excess of the New Forest Code's legal reserve requirement—unchanged from the previous requirements. They stated, however, that participation in such a mechanism should be voluntary.

During these and many other meetings, farm leaders described their opposition to the Soy Moratorium, which did not recognize legal compliance with the New Forest Code. According to the terms of the Soy Moratorium, farmers with forest in excess of the legal reserve requirement on their farms were expected to forgo the legal right to clear this forest. Aprosoja decided not to fight the Soy Moratorium, given that the number of soy farms that had forest in excess of the legal requirement was quite small.

When the Cerrado Manifesto (Belmaker 2018) was launched, signaling a new global effort to conserve the Cerrado woodland savanna of Brazil, farmers grew deeply concerned. Although the soy sector of the Amazon region produced only a 10th of the nation's crop and very few farmers there retained forest that could be legally cleared, the Cerrado accounted for 60 percent of the national crop, with large areas of Cerrado vegetation on farms that could be legally cleared. The farm sector was preparing for battle. And one champion of their cause was gaining support in the presidential campaign—Jair Bolsonaro.

[2] D. Nepstad, interviews with 15 farmers.
[3] D. Nepstad, interviews with Aprosoja leaders.

Bolsonaro campaigned on an agenda of, among other things, removing restrictions on farmers and businesses more generally. He won more than 50 percent of the vote and appears to have won a particularly high level of support from soy farmers (Figure 5).

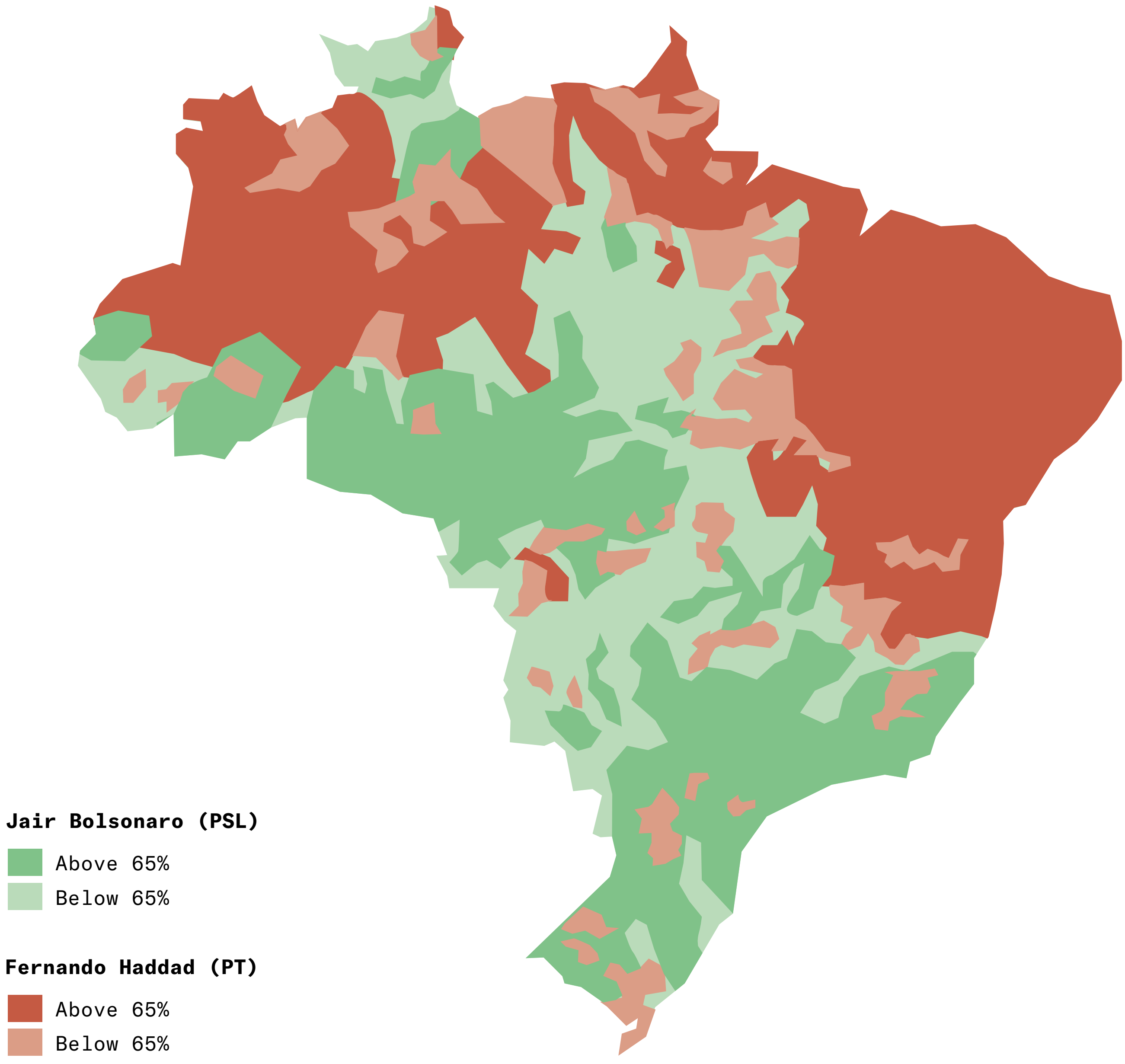


Figure 5a. Brazil's electoral map 2018

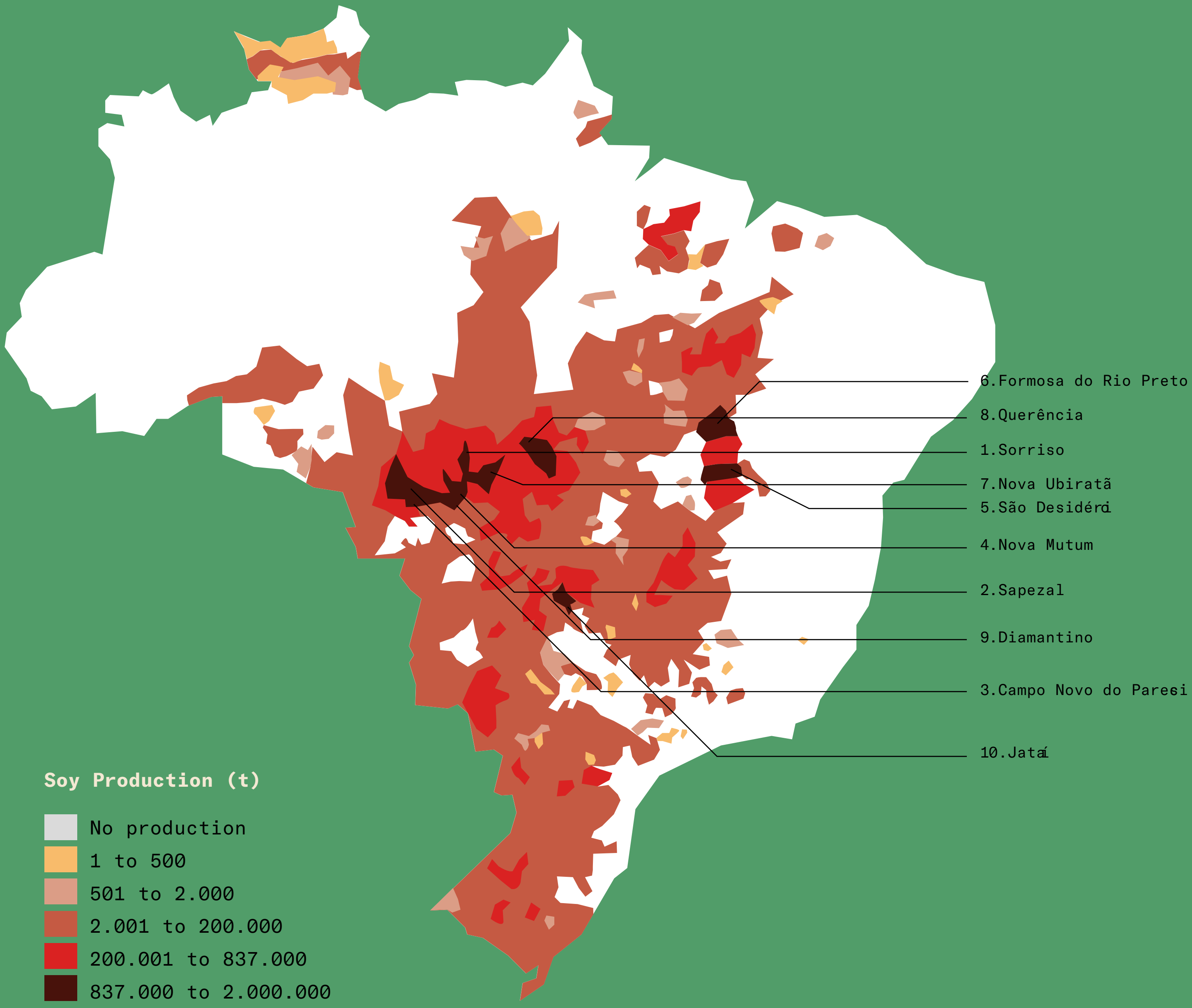


Figure 5b. Soy Farmers' Support for Bolsonaro

Municípios (counties) that voted at least 65 percent in favor of presidential candidate Jair Bolonaro (dark green, Figure 5a) generally coincide with municípios that have significant soybean production (dark red, Figure 5b)

Sources: https://infograficos.oglobo.globo.com/brasil/mapa-eleicao-2018-presidente-2-turno.html (Figure 5a)
https://twitter.com/ibgecomunica/status/779305992857260038/photo/1 (Figure 5b)

2. Law enforcement and farm credit suspension

Many of the measures put in place by Brazil to slow deforestation are either difficult to maintain over the long term or diffuse in their implementation—that is, the connection between the intervention and the desired behavioral change (less forest clearing) is not direct enough.

An example of the first situation is the suspension of access to public farm credit in high-deforestation *municípios* through the Municípios Críticos program, initiated in 2008 (Nepstad et al. 2014). Suspension of bank credit in high-deforestation areas is hard to maintain in part because banks need to make loans—it is the core of their revenue model. In a 2014 interview, Justiniano Neto, director of the Programa Municipios Verdes, said that loans were flowing once again even in *municípios* that still had high deforestation rates.

Law enforcement itself is a very expensive undertaking when the government is trying to catch infractions spread across a vast forest frontier with precarious or nonexistent infrastructure. DETER made it much easier to catch perpetrators in the act, and the Cadastro Ambiental Rural (Rural Environmental Registry) will eventually allow infractions to be associated with landholders and their tax numbers. Nevertheless, the areas in question still must be visited by well-armed teams, sometimes by helicopter.

The budget decisions that determine whether to maintain a law enforcement program in a place like the Amazon Basin are hotly contested; budget allocation to environmental law enforcement loses out during periods of economic recession or when the local benefits of declining rates of deforestation appear meager compared with the advantages.

3. Sustainability certification

The Brazilian soy farmers' response to the certification agenda (through the Roundtable for Responsible Soy, RTRS, standard), strongly influenced by the Forest Code, had the added difficulty of legal compliance. Only Brazil and Paraguay have a mandatory farm-level forest requirement (Chomitz 2007). Representatives from Aprosoja made it clear through the discussions of the RTRS principles and criteria that their participation in the standard would depend on the creation of a mechanism for covering the costs of legal compliance. In 2009, as the principles and criteria were approved at the general assembly, that mechanism had not been created, and Aprosoja left the RTRS.

One of the core challenges faced by international certification standards is that farms already using most of the sustainability practices embodied in the RTRS standard have the lowest costs to comply. The farms that are using unsustainable practices—clearing forests, causing soil erosion, ignoring legal requirements, and abusing their laborers—have very high compliance costs and tend to forgo certification. This is one reason RTRS certified less than 2 percent of global production during its first 10 years.

A second limitation of certification is the demand and associated low price premium. Demand for RTRS-certified soybeans is lower than production, and the price is usually a dollar or two above conventional soy—a premium that is meaningless to farmers. Little evidence supports the notion that sustainability certification is driven by the demand from consumers. It appears to be much more a reflection of corporate fear of being attacked by Greenpeace or other vocal environmental groups.

4. The Amazon Fund and REDD for Early Movers

The Brazilian government created the Amazon Fund as a results-based payment mechanism, managed by the Brazilian National Development Bank. The fund was not designed, however, to highlight the connection between funding and emissions from deforestation. It does not require grantees to quantify the effect of their projects on carbon emissions; even though the recipients are mostly state governments and nongovernmental organizations, it is the government of Brazil that bears the onus of demonstrating to contributors the fund's positive effect on deforestation,.

The results-based payment contracts established directly with Acre and, more recently, Mato Grosso—which, incidentally, appear to be the only subnational jurisdictions to establish such contracts throughout the tropics (Stickler et al. 2018)—may have had greater benefits. The process of developing these contracts involves dialogues with a range of public and private sectors to develop the programs that will translate the finance into emissions reductions (Fishbein et al. 2015), even though the amount of funding represents a tiny fraction of the emissions reductions that a subnational jurisdiction retains.

Costa Rica

Costa Rica is a tiny nation compared with the other three studied here (5 million hectares versus 350 million hectares for the Brazilian Amazon region), but it has an outsize importance in the field of forest conservation and development. Costa Rica's relatively early evolution from low forest cover, because of agricultural expansion, to steady forest regrowth and rising incomes made it a case that provided evidence for the forest transition hypothesis (Mather 1992).

Costa Rica's deforestation history can be divided into two major eras: pre-1980, during which the national economy relied heavily on cattle and agricultural exports, and forestland was converted to cropland and pasture; and post-1980, which saw unprecedented forest regrowth after the domestic beef industry collapsed, the development of the tourism industry, an overall transition to higher urbanization, and new forest protection legislation (Stan and Sanchez-Azofeifa 2018; Navarro and Thiel 2007; Jadin et al. 2016).

Expansion of agriculture began in the 1950s, largely driven by increases in international beef prices combined with penalties associated with uncultivated lands, and peaked in the 1960s, when pasture area nationwide expanded by more than 60 percent (Stan and Sanchez-Azofeifa 2018). Costa Rica's highest deforestation levels occurred between 1973 and 1989, with an average rate of deforestation of 31,800 hectares per year. By 1985, forest cover had reached an all-time low, at only 24 percent of the country's original forest area (Sader and Joyce 1988; but see Sanchez-Azofeifa 2015).

Forest policy began with the first forest law in 1969 and the National Forest Development Plan in 1979; however, the incentives (tax exemptions) offered through these laws excluded small and medium farmers, who were not taxpayers. These early laws were effective, however, in creating a system of protected areas. Today, 26 percent of the country is set aside in national parks and other protected areas. The laws also introduced incentives for forest conservation but still allowed forest conversion to a significant extent (Navarro and Thiel 2007; González-Maya et al. 2015).

The majority of deforestation was concentrated in Cartago, Guanacaste, and Puntarenas provinces (70 percent, collectively), with Guanacaste as the main cattle-producing region (with more than 40 percent of national production) (Stan and Sanchez-Azofeifa 2018). Guanacaste is also particularly drought-prone, in part because of historical deforestation in the region (Stan and Sanchez-Azofeifa 2018; Castro et al. 2018).

Following the pre-1980 peak, deforestation declined and eventually reached net zero by 1998 as a result of effective policies and landowners' responses. External economic factors also played a role, including the beef price collapse (Wallbott et al. 2019; Stan and Sanchez-Azofeifa 2018). In 2015, forest cover in Costa Rica was 52 percent, representing a sizable increase from the 26 percent cover in 1983 (Oviedo et al. 2015). Although forest regrowth has been substantial and continuous, recent studies in some parts of the country indicate that these regrowing forests are recleared on average within 20 years (Reid et al. 2018), that clearing of more mature forests continues (Zahawi et al. 2015), and that these dynamics have led to substantial forest and habitat fragmentation (Zahawi et al. 2015; Algeet-Abarquero et al. 2015).

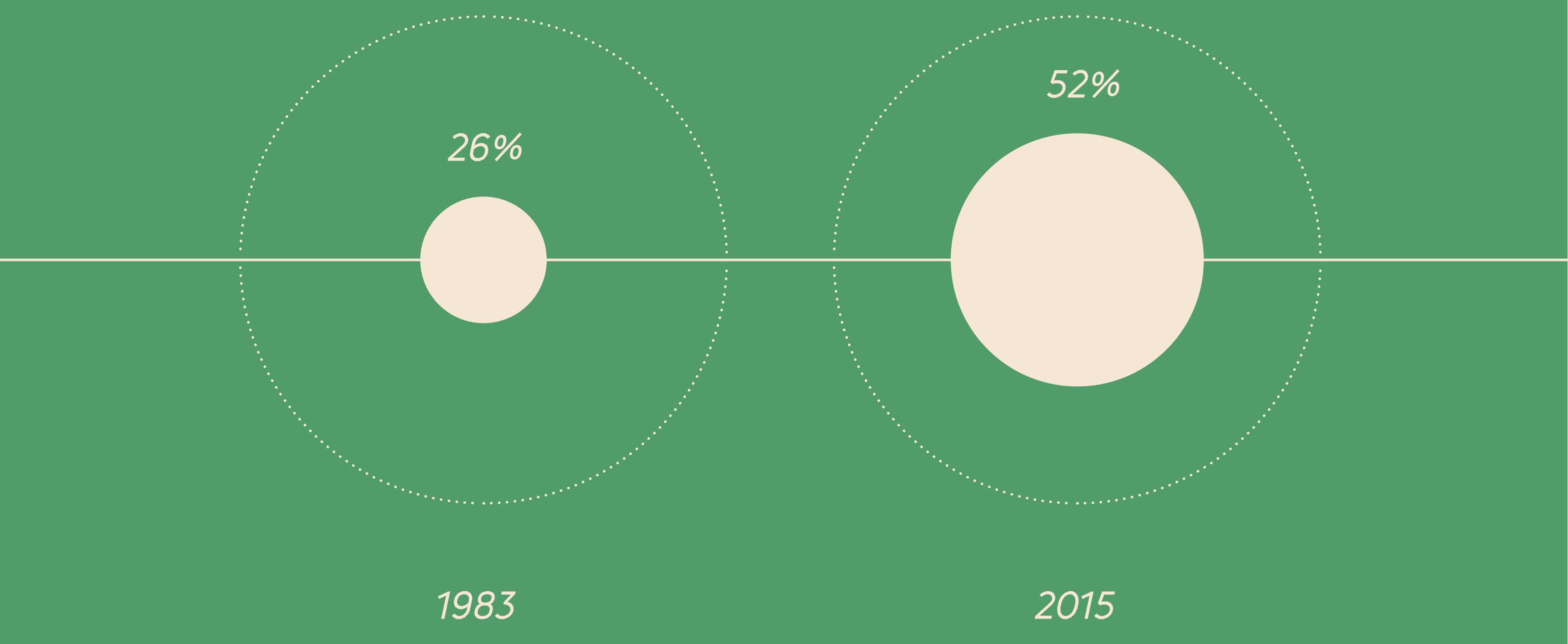
Domestic Policies and Programs

Costa Rica's most significant domestic policy implemented since deforestation peaked is the 1996 Forest Law (Law 7575), which established payments for environmental services to compensate landowners for forest conservation and banned clearing of mature forests. Deforestation subsequently declined, but the law's long-term effectiveness remains to be thoroughly assessed (Fagan et al. 2013).

Other relevant policies and programs include the National Climate Change Strategy (2008), 2021 carbon neutrality goal (2008), National Carbon Market (2011), REDD+ Strategy (2010–2014), National Development Plan (2011–2014), and National Decarbonization Plan (2018–2050) (Wallbott et al. 2019; Government of Costa Rica 2018). Costa Rica's new Política Agroambiental (Agro-Environmental Policy) could act as an overarching framework, integrating otherwise siloed processes like REDD+, agricultural policies, nationally determined contributions for the Paris Climate Accord, and other policies and programs (Wallbott et al. 2019).

In 2001, Costa Rica implemented an integrated fuel tax as part of the Law of Tax Simplification and Efficiency (Law 8114), with 66 percent of revenues distributed to the Ministry of Finance, 29 percent to the National Road Council, 3.5 percent to the National Forestry Finance Fund (FONAFIFO), 1 percent to the University of Costa Rica, and 0.1 percent to the Ministry of Agriculture (Blackman and Woodward 2010). FONAFIFO is a semi-autonomous body that manages Costa Rica's PES program (described below). Conclusive results on the effect of the tax on emissions are not available.

In 2015, forest cover in Costa Rica was 52 percent, representing a sizable increase from the 26 percent cover in 1983.



Market Transformation

The livestock industry accounts for 30 percent of Costa Rica's emissions and 35.5 percent of national land use (Martin 2017). Consequently, the sustainability of the livestock industry represents an important aspect of Costa Rica's overall environmental strategy. The National Low Carbon Livestock/Cattle Strategy targets this sector through priority themes—silvopastoral systems, improved pastures, climate change adaptation, and others. The National Commission for Forestry Certification, established by the 1996 Forest Law, sets standards and procedures for sustainable forest management and certification of natural forests and plantations based on sustainability principles, criteria, and indicators (Navarro and Thiel 2007). The National Decarbonization Plan acknowledges that its success is closely tied to agricultural systems and export industries. It aims to, among other goals, "use the most advanced technology according to standards of sustainability, competitiveness, low emissions and resilience to the effects of climate change" in agricultural industries by 2050 (Gobierno de Costa Rica 2018).

Results-Based Payments

The 1996 Forest Law provides the foundation for Costa Rica's PES system and covers four categories of environmental services:

- **mitigation of greenhouse gas emissions through emissions reduction and carbon fixation, capture, storage, or absorption;**
- **protection of water for urban, rural, or hydroelectric use;**
- **biodiversity conservation for conservation, sustainable use, scientific investigation, or genetic enhancement;**
- **protection of ecosystems or scenic natural beauty for tourism or science (Pagiola 2008).**

Landowners receive payment for providing these services through their conservation.

The program is financed by tax funding and is managed by FONAFIFO, which was set up by the law to work with private landowners and NGOs to disburse funds (Wallbott et al. 2019; Johns 2012). Its success may be attributable to behavioral aspects—landowners' efforts to comply and their understanding of the public benefit.

Discussion

Costa Rica's PES program has been lauded internationally; however, closer analyses reveal the differential effectiveness of PES across geographic areas and land-use types. Daniels et al. (2010) discuss the poorly understood role of PES at the national level, finding that PES drives different outcomes based on the starting conditions of each forest area and that PES effects may not be additional to conservation that would have occurred on PES sites without payments. Additionally, Reid et al. (2018) find that despite significant reforestation, it is unclear whether regenerated forests will persist. They question the extent to which governments can count natural regeneration as contributions toward reforestation goals, given that in Costa Rica —a supposed model of successful regeneration—the new forests may not persist more than about 20 years before being recleared.

Despite the country's small size, the Costa Rica case study provides lessons in the context of forest transitions. To evaluate national-level forest transitions and the influence of land-use policies on those transitions, subnational-level analyses are important for understanding the dynamics at play, including how land-use redistribution may influence overall regeneration processes (Jadin et al. 2016).

Subnational analyses can also help determine whether forest regeneration related to the national PES system was in fact additional (Daniels et al. 2010). Spikes in deforestation in recent years occurred primarily in northern Costa Rica, where export-oriented banana and pineapple industries are based (Fagan et al. 2013).

Ecuador

For the past decade, Ecuador has shown a strong commitment to understanding and curbing deforestation. Because of its institutions and programs, net annual deforestation in Ecuador fell from 92,742 hectares in 1990–2000 to 47,497 hectares in 2008–2014. The annual figure rose, however, to 61,112 hectares in 2014–2016. Environmental programs based on subsidies to forest-conserving landholders benefited and then suffered from the oil price boom and bust, accounting for the strong decline in deforestation up to 2014 and the less positive results in slowing deforestation after 2015.

About 25 percent of the country is home to indigenous communities (Blackman and Veit 2018) and 30 percent consists of protected areas (Government of Ecuador, Ministry of the Environment 2016).

The land-use and forestry sectors are responsible for 36 percent of the country's greenhouse gas emissions (Blackman and Veit 2018). The main driver of deforestation over the past decade has been the expansion of the agricultural frontier and extensive cattle ranching, which have contributed to forest loss in Ecuador's main ecosystems—coastal dry forest, mangroves, paramos, and tropical Amazon forest. Conservation policies are currently focused on improving agricultural practices, halting the expansion of the agricultural frontier, reforesting, and restoring agricultural production in open areas. The future of Ecuador forests is uncertain because domestic funds are limited, international funds are only beginning to flow, and recently drafted national development policies require coordinated implementation across the forestry, agriculture, and energy sectors.

Domestic Policies and Programs

Ecuador's 2008 constitution recognizes that nature in all its life forms has the right to exist, persist, and maintain and regenerate its life cycle.[4] In the years following its adoption, several environmental and agricultural programs were enacted to encourage the transition to sustainable land-use practices and the conservation of natural forests. However, many initiatives to address deforestation are still in the early stages of implementation, and their future is threatened by recent economic shocks and inadequate oversight and enforcement. Better coordination among the Ministry of Environment, Ministry of Energy, and Ministry of Agriculture, Cattle, Aquaculture, and Fisheries (henceforth, Ministry of Agriculture) is also needed.

[4] National Constitution of Ecuador, Art. 71-74, 2008; Environmental Code, Official Registry 983, April 12, 2017.

Part of the institutional and technical progress of Ecuador over the past decade is attributed to the Programa Socio Bosque, a nationwide payment-for-conservation program. The program was launched and funded by the national government during the oil price boom (2007–2014), which had signficant benefits in Ecuador (Rosa da Conceição et al. 2015). Then, as oil prices fell and the financial crisis hit Ecuador, funding for Socio Bosques declined along with other government subsidy programs. In recent years, the program has stopped adding new beneficiaries. A revenue model that provides long-term funds for Socio Bosque is urgently needed.

Socio Bosques is Ecuador's flagship program to address deforestation and alleviate poverty. Furthermore, the program was essential for the implementation of a readiness phase and for inspiring conservation policies that extended to the agricultural sector. Since its inception, the program has provided more than US $65 million in payments for the conservation of 1.6 million hectares of primary forest and native vegetation to more than 175,000 beneficiaries in private lands and indigenous communal areas (Government of Ecuador 2015a). The beneficiaries of the program commit to stopping deforestation for 20 years and in return receive a fixed yearly payment, its amount depending on the area. Recent evaluations indicate that the program has directly contributed to a 1.08–1.5 percent decline in deforestation rates after 2007 in the target areas (Cuenca et al. 2018).

Additionally, in recent years Ecuador implemented initiatives led by the Ministry of Agriculture, with some support from the Ministry of Environment, to support the transition of agricultural production systems to sustainability. These initiatives feature the Amazon Productive Transformation Agenda (Government of Ecuador 2015b) and the Forest Incentives Program (Government of Ecuador 2013) . ATPA is poised to contribute directly to forest conservation efforts in Ecuador by slowing deforestation in the Amazon provinces through diversified and environmentally sustainable agriculture. ATPA supports the conversion of degraded areas of pasture or monocultures to sustainable production systems while also raising the income of local producers. Through the ATPA program, farmers commit to protecting forest remnants on their farms and receive technical assistance and basic agricultural resources to facilitate the transformation. By June 2019, ATPA had enrolled 145,863 hectares.

Water funds are Ecuador's innovative approach to preserving the water supply of large cities and agricultural areas by protecting native forests and *paramos* andean vegetation in critical watersheds. Although reducing deforestation and mitigating climate change are not the stated intent, these funds are ideal mechanisms to implement many of the measures and actions defined in the REDD+ Action Plan. The funds have focused on roughly 900,000 forested hectares and resulted in sequestering a large volume of carbon in biomass, particularly in *paramo* soils. Of the three major water funds (FONAG, FONAPA, and FORAGUA), FONAG took the lead in 2000, seeking to conserve water resources for the 2.5 million inhabitants of Quito. The funds operate as a trust system managed by independent financial institutions. The assets are invested and distributed among land managers so that they can improve their production and conservation practices. Each fund has a steering committee, responsible for vision and planning, and a technical secretariat that oversees implementation of the committee's decisions (Kauffman 2014). These water funds have been an economically viable conservation instrument.

The Forest Incentive Program, implemented by Ministry of Agriculture, is designed to cover up to 100 percent of the costs associated with establishing commercial forest plantations for the first four years, with the goal of achieving 1 million reforested hectares on private and communal land by 2027. This program has not expanded as planned, however, because it has been underfunded by the national government in recent years.

Market Transformation

As of 2018, Ecuador had 6,800 palm oil producers (89 percent of them considered smallholders) distributed in 13 provinces of the country, with a total planted area of about 257,000 hectares. The country is the second-largest producer of palm oil in Latin America, with 540,000 tons in 2018 and a projected 480,000 tons for 2019, according to Ecuador's palm oil producers association.

Ecuador is hoping to become the first nation certified by the Roundtable on Sustainable Palm Oil as part of the certifier's pilot program for a jurisdictional approach. In 2018, Ministries of Environment and Agriculture partnered to support implementation of Ecuador's RSPO jurisdictional certification initiative, creating an interagency committee for monitoring sustainable palm oil production, known as CISPS. The committee has met multiple times to discuss the competitiveness and sustainability of palm oil in Ecuador and to advance the necessary actions to obtain certification, which will require conducting studies of conservation values, land-use change, and regulations for the environmental licensing of oil palm trees. This is an important initiative, given evidence that an increase in oil palm cultivation has stimulated new deforestation (Vijay et al. 2016 and 2018)

Results-Based Payments

Since 2008, Ecuador has been committed to the development of a national REDD+ strategy that has made the country among the first to receive international climate finance for forest conservation. During the readiness phase, Ecuador developed its REDD+ Action Plan, a forest monitoring system with observation of land-cover changes, a national reference level for deforestation activities, and a REDD+ safeguards system (Guedez and Guay 2018).

Ecuador's REDD+ Action Plan, approved in 2016, aims to reduce gross emissions from deforestation by 20 percent or more by 2025 from the 2000–2008 reference level. The plan has four strategic components: institutional policies and management for REDD+, transition to sustainable productive systems, sustainable forest management, and conservation and restoration.

The REDD+ Action Plan has catalyzed efforts to address deforestation in Ecuador. It had so far secured funding from the Green Climate Fund (US $41.2 million) and the Global Environmental Facility (US $12.5 million) for its implementation (Guedez and Guay 2018). The REDD+ Action Plan is expected to secure payments for performance; most likely the first one will come from the German REDD for Early Movers program.

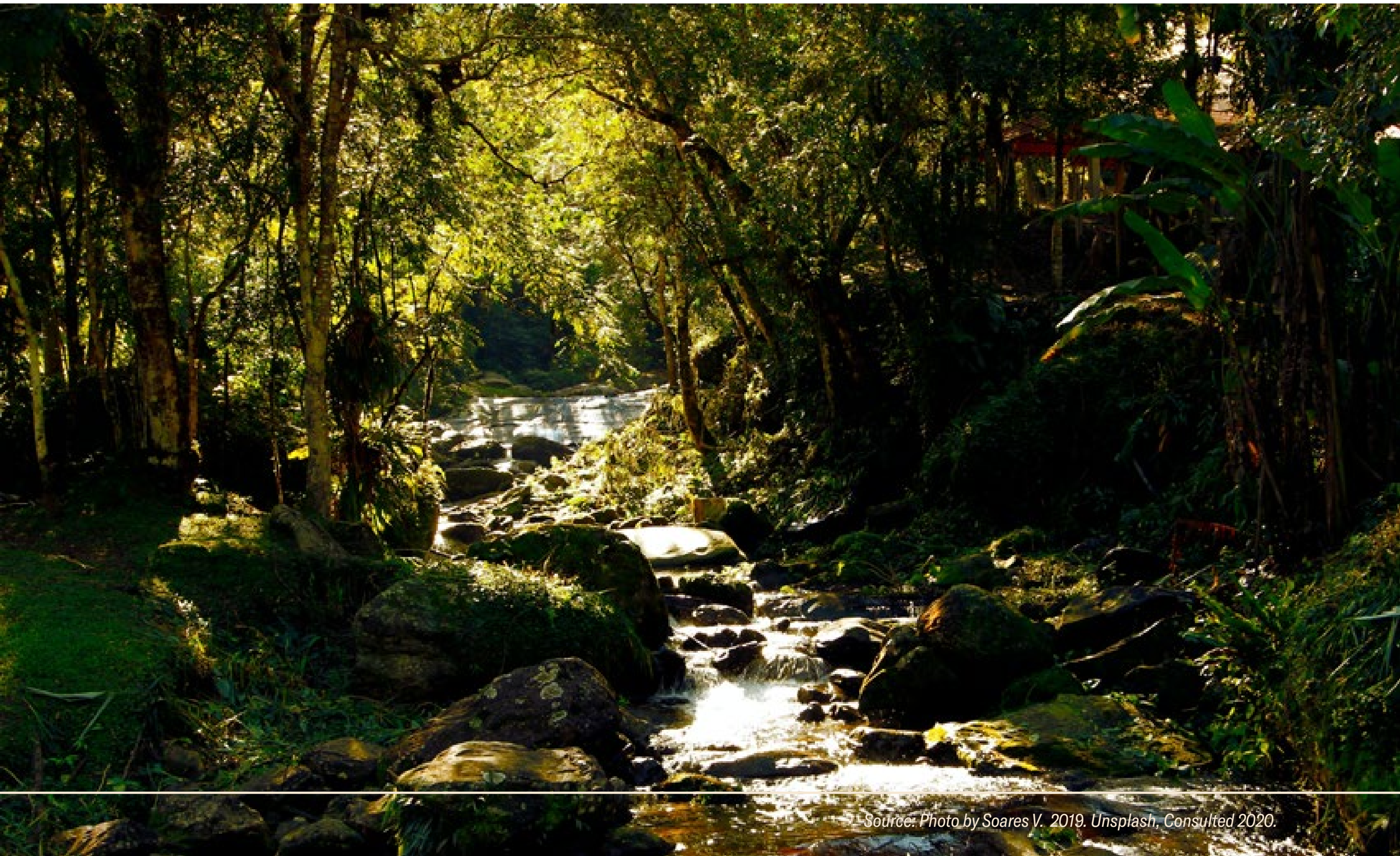
Discussion

Ecuador has a progressive constitution that recognizes the rights of nature and is undertaking innovative programs such as Socio Bosques and the RSPO jurisdictional certification pilot. It has secured substantial funding from the Global Environment Facility and the Green Climate Fund to support implementation of its REDD+ Action Plan and more recently has obtained loans from the International Monetary Fund to support its development agenda. Deforestation has decreased but still occurs, and illegal logging and forest clearance for agricultural expansion remain risks. The initiatives that have been promoted to address deforestation are troubled by management and financial challenges. To ensure long-term success and encourage sustainable production and enterprises, future initiatives could involve public-private partnerships.

For example, the Ecuador 2030 Productive and Sustainable initiative, promoted by the Ecuadorian Business Chamber to foster the implementation of development goals, calls for private sector engagement and could make a strong case for attracting it. Likewise, the water funds, which stand out among conservation programs because they have sustainable administrative structures and financial resources, could be ideal programs for donors seeking long-term strategies and mechanisms to expand thematically and geographically.

Currently, 25 percent of the natural area of Ecuador is covered under the Programa Socio Bosque, ATPA, and water funds. Since most programs and policies to address deforestation in Ecuador are in their early stages, it is hard to quantify their real effects on deforestation rates. Recent evaluations of Socio Bosque demonstrated that there is room for achieving greater benefits by adjusting the geographic focus and strategic prioritization of the intervention areas (Ardila et al. forthcoming). Other programs are at the point where early lessons can inform adaptation to maximize their potential. For example, further alignment and engagement of the Ministry of Agriculture and the private sector could strengthen the REDD+ Action Plan. The ministry could be more involved in revising and implementing this plan since it often targets the same lands and land managers.

Further efforts at coordination between the Ministries of Environment and Agriculture could lead to success in developing shared goals. It has been difficult to reconcile the “do not touch your forest” message of the Socio Bosque program with the “maximize production” challenge of the agriculture sector. The RSPO pilot certification is a potential space for fostering collaboration and finding common ground among the different actors.



Source: Photo by Soares V. 2019. Unsplash, Consulted 2020.

Peru

With more than 68 million hectares of Amazon rainforest in 2018, Peru is the fourth-largest tropical forest nation in the world and recognized as a globally significant hotspot of biodiversity (MINAM 2016). Natural forests cover about 72 million hectares, with 82 percent of all forest in the Amazon regions of Loreto, Ucayali, Madre de Dios, San Martín, and Amazonas (MINAM 2016).

The Amazon rainforest ecosystem is increasingly threatened by deforestation and degradation. Total forest loss in the Peruvian Amazon was 2.3 million hectares over the years 2001–2018, and increased over this period (MINAM 2019). Official deforestation data indicate a 5.2 percent increase in 2016 with respect to 2015, totaling 164,662 hectares, followed by a slight decline to 155,914 hectares in 2017 (MINAM 2019). Emissions from deforestation and land-use change accounted for 45 percent of Peru's national greenhouse gas emissions in 2014, with more than 75.3 million tons of CO2e attributed to gross deforestation (MINAM 2019b).

Deforestation in the Peruvian Amazon is driven primarily by the expansion of small- and medium-scale agriculture and cash crops such as coffee, cacao, palm oil, cassava, maize, and other fruits and vegetables. Illegal mining is also causing deforestation, most notably in the Madre de Dios region. Indirect drivers of deforestation are related to institutional challenges including incomplete land zoning, insufficient allocation of land use and landownership rights, lack of alignment among public policies, and inadequate capacity for law enforcement. Social causes of deforestation include rural migration to agricultural frontiers, weak governance, land tenure challenges, and limited access to technology and finance needed to sustain soil fertility and farm productivity (MINAM 2016).

Domestic Policies and Programs

Peru's commitment to the Paris Climate Accord (nationally determined contribution) is to reduce greenhouse gas emissions 20 percent below a business-as-usual reference level, with an additional 10 percent reduction contingent on international investment (Government of Peru 2015). As part of the strategy, the Peruvian government formally committed to net zero deforestation by 2021 and developed the National Forests and Climate Change Strategy as a roadmap to reach this goal. In addition, Peru has committed 3.2 million hectares to forest landscape restoration and conservation to support the Bonn Challenge (MINAM 2017).

Recognizing the need for increased private sector investment and multistakeholder cooperation to achieve the interrelated goals of increasing sustainable land use and forest conservation, a new program, Peru launched the Public-Private Coalition for Low-Emissions Rural Development at the 2017 ExpoAmazonica in the region of San Martin (CIAM & GCF 2017). Supported by the Amazon Interregional Council and the Governors' Climate and Forests Task Force, the coalition invites the private sector, producer organizations, and civil society organizations. The coalition's action plan has three main objectives: to guarantee forest and land-use rights without entailing new deforestation; to optimize the sustainable use of forest landscapes, recognizing high-elevation Andean forests and lowland rainforests and wetlands; and to build the enabling conditions and transformational changes required for low-emissions rural development, including technological, financial, and business model innovations. The coalition received the endorsement of more than 45 public institutions, companies, producer organizations, and civil society organizations.

Market Transformation

Peru is advancing sustainability goals in the agriculture sector across major commodities—coffee, cacao, and palm oil—through national action plans produced by trade federations and the Ministry of Agriculture and Irrigation. For coffee and cacao destined for export, trade organizations rely heavily on specialty markets focused on high-quality, sustainably produced products. Among the development projects focused on sustainable production are the Peru Cocoa Alliance, a public-private partnership supported by USAID (Peru Cocoa Alliance 2016). At the farm level, many initiatives pursue international certification through the Rainforest Alliance, Fairtrade, UTZ, or USDA Organic.

Perhaps the most significant progress in advancing sustainability goals has been made in the palm oil sector. From 2007 to 2013, oil palm accounted for 11 percent of agricultural deforestation while occupying less than 4 percent of Peru's total agricultural area (Vijay et al. 2018). Although Peruvian palm oil accounts for less than 1 percent of global production, the sector is rapidly expanding. Palm oil production increased from 140,088 tonnes in 2000 to 921,001 tonnes in 2018, and there are currently 66,171 harvested hectares (FAO 2017). Palm oil production provides about 7,200 former coca producers with a legal livelihood alternative and directly employs 37,000 rural farmers, primarily in the Amazon regions of Loreto, Huánuco, San Martin, and Ucayali (Junpalma Peru 2016).

The rapid expansion of oil palm, along with its notoriety as a major cause of deforestation in Southeast Asia, has given rise to concern within government, NGO, and civil society institution in Peru. In 2015, when the Environmental Investigation Agency and a coalition of NGOs exposed the planned deforestation of 23,000 hectares of primary forest by Grupo Palmas, Peru's largest palm oil producer and the resulting public pressure along with legal issues prevented the project from materializing (EIA 2015; Finer et al. 2017). Grupo Palmas is now implementing No Deforestation, No Peat, No Exploitation (NDPE) policies to remove deforestation from its palm oil and cacao supply chains, and it is pursuing Roundtable on Sustainable Palm Oil certification.

The RSPO certification standard provides a market mechanism to prevent deforestation of high-conservation-value and high-carbon-stock forests for oil palm plantations. The framework provides economic incentives to palm oil producers, who may command a premium for certified sustainable palm oil in international markets, often from buyers with NDPE policies. In 2015, a the Santa Clara de Uchunya indigenous community filed a complaint against the Plantations Pucallpa oil palm company for violating the RSPO code of conduct (Finer et al. 2017). While the investigation was ongoing, the company withdrew from RSPO and divested its plantations. It was later confirmed that the company had illegally cleared 5,725 hectares of primary forest. No further deforestation has been detected.

To maximize the economic potential of the growing oil palm sector while addressing deforestation and sustainability concerns, the Peruvian Palm Oil Growers Association (JUNPALMA) was formed in 2015. In 2019, the association committed to deforestation-free palm oil production by all members by 2021, in partnership with the Ministry of Agriculture and Irrigation. This commitment promised to secure Peru as a leading source of sustainable, deforestation-free palm oil in the future.

Results-Based Payments

The considerable potential for forest conservation in Peru has attracted many bilateral and multilateral cooperation agencies and international initiatives. Ongoing programs, totaling roughly US $100 million to $120 million, are supported by the Forest Carbon Partnership Facility, UN-REDD+, Forest Investment Program (Inter-American Development Bank, IADB), Global Environment Facility, Norway (phases 1 and 2 of the Joint Declaration of Intent through the UN Development Programme and the IADB; see below), Germany, USAID, and Japan.

In 2014, Peru, Germany, and Norway signed a declaration of intent on cooperation in reducing greenhouse gas emissions from deforestation and forest degradation and support for sustainable development in Peru (Joint

Declaration of Intent 2014). This REDD+ program aims to protect Peru's rainforest by reducing net deforestation to zero by 2021. The partnership requires Peru to "take immediate and decisive action to reduce its forest-related emissions toward making the forest and agriculture sector carbon neutral in 2021 and to recognize millions of hectares of indigenous peoples' land claims." Norway committed to pay for verified results up to US $300 million until 2020, and Germany committed to continue current levels of support on climate and forest issues and to consider further contributions based on the results.

In 2010, Peru's Ministry of the Environment created the Programa Nacional de Bosques para la Mitigación del Cambio Climático (National Forest Conservation Program for Climate Change Mitigation) to support the National Forests and Climate Change Strategy (MINAM 2020). The program, which aims to conserve 54 million hectares of tropical forests to avoid emissions from deforestation, has three primary objectives: to identify and map areas for forest conservation; to promote the development of forest-based sustainable production systems to generate income for impoverished local communities; and to strengthen the capacity of regional and local governments, rural communities, and indigenous peoples to conserve forests. The program has provided incentives for forest conservation by supporting alternative livelihoods—in timber and nontimber forest products, ecotourism, coffee and cacao agroforestry systems, and aquaculture—for more than 200 indigenous communities. It has also established the GEOBOSQUES platform, a satellite-based monitoring system to track deforestation in the Peruvian Amazon.

The Tambopata-Bahuaja REDD+ and Agroforestry project aims to conserve 570,000 hectares of primary forest in and around the Tambopata National Reserve and Bahuaja-Sonene National Park in Madre de Dios region (Althelia Climate Fund 2020). The US $12 million project includes a $7 million investment from Althelia Funds and an additional $2 million from the US-Peru debt swap fund, Fondos de las Américas. The project is a public–private–civil society collaboration between Peru's National Service for Natural Protected Areas, Althelia Funds, and a local nonprofit, Asociacion para la Investigacion y Desarrollo Integral. The voluntary carbon offset project follows a payment-for-performance model: more than 400 smallholder farmers living in the buffer zones around the park receive technical support and financing to establish improved agroforestry systems of high-quality cacao in exchange for ensuring that no deforestation occurs in the protected areas. A minimum quantity of certified deforestation-free, organic and Fairtrade cacao is produced every year, with a portion of the sales going to investors. This project was expected to avoid emissions of 4 million tonnes of CO2e by 2020. The carbon credits, which are verified by Verra's Verified Carbon Standard and the Community and Biodiversity Gold standard, function as collateral for the $7 million loan. A Peruvian insurance company has purchased the offsets credits generated by the project.

Discussion

A common long-term vision for a productive, sustainable Peruvian Amazon is emerging across public and private sectors, supported by national-level processes such as the National Strategy on Climate Change, National Strategy on Forests and Climate Change, and national action plans for agriculture, including coffee, cacao, and oil palm trade federations. Regional governments in the Peruvian Amazon are active in the Amazon Interregional Council and the Governors' Climate and Forests Task Force and have made broad commitments to advancing low-emissions development based on production-protection-inclusion approaches, including reducing deforestation 80 percent by 2020, with international investors as signatories of the Rio Branco Declaration (GCF 2014). Through the Public-Private Coalition for Low-Emissions Development, regional governments are committed to partnering with the private sector to reduce deforestation through sustainable economic development, yet these partnerships have been slow to develop. Of the total area deforested over the 2001–2016 period (1,974,209 hectares), 82.7 percent is in Amazon regions represented on the Amazon Interregional Council and the Governors' Climate and Forests Task Force, which underscores the need for effective interventions and strong engagement with those regions to reduce deforestation.

Many of the elements critical to rapid reduction of deforestation in the Peruvian Amazon are in place, but implementation at scale and development of sustainable systems will require further support from international donors and private investors. The regional governments of the Peruvian Amazon are developing low-emissions development strategies, finance, and action plans; they need additional help in establishing partnerships with the private sector and financial institutions for implementation.

Despite the many international donor-led programs in Peru that already focus on rural development and the forestry sector, there remain opportunities for synergies and coordination among programs at national and regional levels. Two immediate opportunities:

- **implementation of the GEOBOSQUES forest monitoring system at regional levels so that the system can systematically evaluate progress toward national and regional performance targets; and**
- **harmonization of the regional low-emissions development plans being developed by Peru's Amazonian regional governments for a basin-wide approach to forest conservation and economic development.**

The Andean Amazon Alliance of governors is committed to forest and land management goals across the region, and the Amazon Interregional Council's Manucomunidad may provide a platform for basin-wide collaboration on forest conservation initiatives and investment.

Source: Photo by Chuttersnap. 2018. Unsplash, Consulted 2020.

Conclusion

The effectiveness of the three approaches to forest conservation—domestic policies and programs, market transformation, and results-based payments—can be evaluated with the help of recent assessments by Stickler et al. (2018), Angelsen et al. (2018), and Seymour and Busch (2016). The potential effectiveness of the policy approach is very high because governments control the major levers that shape the decisions of land managers across vast territories. In practice, however, this potential is constrained by the often limited capacity of governmental institutions to carry out public policies and programs and by the will of political leaders to exercise governmental power to address tropical deforestation—often against the interests and advocacy of powerful vested interests (Brockhaus et al. 2017). Strong political will and effective public policies are best viewed as the end game for slowing the loss and speeding the recovery of tropical forests at scale, with the other two approaches best viewed as supporting strategies.

Market-based approaches arose in the early 1990s largely in response to the perceived lack of capacity and political will of many governments to address tropical deforestation. Their potential effectiveness is high because of the efficiency, reach, and independence from political processes that characterize market actors. Ironically, this same independence—the lack of a deliberate connection to public policies and programs—can also alienate the farm sectors and governments of tropical forest regions, triggering a backlash against efforts to slow deforestation. The success of market-based approaches has thus far been limited largely because the companies and producers that take on commitments and become certified tend to be those that are already performing at a high level. Market-based approaches are also constrained by the focus on individual commodities and by the lack of clear positive incentives for the producers and firm that achieve certification.

In fact, market-based strategies have been far more successful in creating risks to companies and governments that acquire commodities from, or invest in, tropical forest regions where deforestation is taking place than in defining secure pathways for companies to do business in tropical forest regions (Vogel 2005). The driving force behind the corporate adoption of sustainable sourcing commitments and policies is not consumer demand so much as fear of the reputational risk that can be incurred through the name-and-shame campaigns of advocacy NGOs, such as Greenpeace, Rainforest Action Network, and MightyEarth.[5] One of the main metrics of success adopted in recent years—zero-deforestation supply chains—can mean, in practice, that the companies and investors that are concerned

[5] Companies can face additional costs, shareholder concern, and in some cases, reduced demand for their products because of campaigns and associated publicity that link them with deforestation, labor abuses, illegality, or land conflict. These risks motivate them to change their procurement policies as part of a larger corporate strategy of risk management, with the goal of minimizing risks and associated hits on profits.

about reputational risks shift away from the forest frontier regions where deforestation is taking place, only to be replaced by companies and investors that are less vulnerable to reputation risk (Nepstad et al. 2016).

The strength of pay-for-performance systems is that they can establish a positive incentive—a payment that rewards progress. This approach is limited, however, by the small scale of the financing available to tropical forest region governments that are making progress and by the mechanisms through which it comes into tropical forest countries (Angelsen et al. 2018, Ch. 4).

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2.

Forests and Climate Change

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Forest Conservation Policies and Climate Change Mitigation

Climate change has emerged as a major concern around the world, given the evidence of intensifying extreme weather and climate events and their disastrous consequences for humans (Ahima 2020; Borchers Arriagada et al. 2020; Hulme 2020; Moser 2020). In Latin America and the Caribbean (LAC), temperature has already risen by up to 1 degree C (Li et al. 2015; Magrin et al. 2014), and projections indicate an increase of perhaps 7 degrees C for some regions by 2100, under scenarios of continued high emissions of greenhouse gases (GHGs) (Marengo et al. 2012a). Continued intensification of droughts, heat waves, and tropical cyclones is also expected (Reyer et al. 2017). These climate trends over a short period represent a great risk for LAC human livelihoods and economies because of the region's high exposure, social fragility, and lack of climate resilience and adaptation plans (IADB 2018; Magrin et al. 2014).

Forests play a crucial role in climate change mitigation and adaptation by maintaining ecosystem functions and such essential services as climate regulation, refuge for biodiversity, and provision of goods, thereby improving people's capacity to adapt to environmental changes (Bustamante et al. 2016; Delgado Assad et al. 2019; Meigs and Keeton 2018; Silvério et al. 2015). Reducing emissions from deforestation and forest degradation (REDD) is considered a relatively cheap (Soares-Filho et al. 2016; Stern 2007) and essential step toward keeping global warming below 1.5 degrees C (Hoegh-Guldberg et al. 2018).

The LAC region, especially its tropical zone, accounts for a huge part of the planet's forests—35 percent (Hansen et al. 2013). On a global scale, these tropical forests contribute to the dynamic balance of biogeochemical and hydrological cycles that are critical for sequestering and storing carbon and delivering moisture throughout the continent (Brando et al. 2008; Houghton et al. 2012). At local and regional scales, LAC forests provide climate comfort through the cooling effect (Baker and Spracklen 2019; Li et al. 2015) and higher resilience by attenuating extremes of high temperatures, droughts, and floods (Galeano et al. 2017; Martin and Watson 2016).

Despite their importance, LAC forests have witnessed rapid loss and degradation in the past five decades because of land-use changes. Agricultural expansion, logging, and mining are threatening forests' capacity to regulate climate and contribute to social, environmental, and economic resilience

(Reyer et al. 2017). Climate change in LAC might be addressed by forest conservation initiatives that integrate governance, technological, economic, social, and nature-based solutions to meet the Paris Climate Accord commitments and the Sustainable Development Goals (Binsted et al. 2018; Santos Da Silva et al. 2019).

This chapter summarizes the importance of LAC tropical forests to climate change mitigation and adaptation, the socioeconomic and ecological consequences of forest loss, and regional climate policies focused on forest management. It also presents case studies of the climate and forest policies of Brazil and Costa Rica.

Global Climate Policies for Forests

Beginning with the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, forest conservation has been an important element of global climate change mitigation. Article 4 of the document included the commitment to promote sustainable management and conservation of forests, alongside other ecosystems. However, it was only in the mid 2000s that the concept of reducing emissions from deforestation and forest degradation and enhancement of carbon stocks (REDD+) emerged as the basis for creating a mechanism to mitigate climate change at a relatively low cost (Angelsen et al. 2012; World Bank 2008). The origins of REDD+ are linked to a 2003 proposal for compensating emission reductions, devised by a group of North American and Brazilian scientists and activists (van der Hoff et al. 2015). Following the request of a group of forest countries (despite Brazil's initial resistance), the UNFCCC initiated a process in 2005 that culminated, eight years later, in approval of the Warsaw Framework for REDD+.

In parallel to the country-level bilateral and multilateral initiatives, subnational and private initiatives have also proposed REDD+ mechanisms for financing forest conservation. Inspired by the project-based approach of Kyoto's Clean Development Mechanism, international certification institutions have developed the Verified Carbon Standard and the Climate, Community and Biodiversity standard for issuing carbon credits related to forest activities. Similarly, Warsaw Framework project–based REDD+ proponents must propose a baseline and demonstrate deforestation reductions. However, these standards have drawn criticism because of high transaction costs, rights violations, arguable baselines, and risk of leakage—that is, the displacement of deforestation to a nearby area rather than its overall reduction. Similar problems can be found in UNFCCC Warsaw Framework projects, but because country-level projects are related to national policies, these initiatives tend to be seen as having a lower risk.

The approval of the Paris Climate Accord in 2015 has reinforced the importance of REDD+. Eighty-six of 160 countries have proposed targets for land use in their nationally determined contributions (UNFCCC 2020). The accord gives full recognition of REDD+ in its Article 5 as a results-based payment mechanism akin to the Warsaw Framework for REDD+. And an increasing number of countries interpret Article 6 of the accord, which regulates the creation of new market mechanisms, as including REDD+ activities, such that a country that reduces emissions beyond its nationally determined contribution could sell "internationally transferred mitigation outcomes" to enable a second country to meet its commitment (Streck et al. 2017).

All the above mechanisms deal only with the financial side of forest conservation. It is up to individual countries, subnational entities, and non governmental actors to actually implement actions that tackle deforestation drivers and deliver emission reductions. Reducing emissions by reducing deforestation and degradation is not the only policy instrument to handle the climate crisis. Conserving intact forest should be fully counted in REDD+ trades and considered an investment opportunity, especially for LAC countries with great portions of intact forest, such as Suriname, Guyana, Colombia, Peru, and Brazil. Degradation and forgone carbon removals from intact forests may increase by more than 600 percent the carbon effects from forest loss (Maxwell et al. 2019). Natural forest regeneration and active restoration of degraded and nonproductive lands are ecological solutions (Reid et al. 2018). The potential for restoration exists for almost 1 billion hectares around the world, including about 17 million hectares of unproductive and degraded lands in the Brazilian Amazon Basin, creating an opportunity to store carbon (Brancalion et al. 2019) as well as increase the socioeconomic value of the standing forest through sustainable forest management (Nobre 2019). Such initiatives have already been developed, especially in LAC's tropical and subtropical moist forest zones (Coppus et al. 2019; Romijn et al. 2019), focusing on forest restoration and regeneration and community resilience to climate change (Coppus et al. 2019). LAC has made the world's greatest progress in meeting the 2011 Bonn Challenge, an effort to restore 53 million hectares of land by 2030 (Coppus et al. 2019).

Forests in Latin America and the Caribbean

Status and Threats

Nearly 35 percent of the planet's total forest area is in LAC (Hansen et al. 2013), distributed among temperate and humid, dry, and flooded tropical types (Figure 1). It is estimated that the humid forests cover 817 million hectares (41 percent) predominantly in South America (40 percent), including the lowland forests of Central America, the Amazon Basin, Guyana, Suriname, French Guyana, the northern half of the Atlantic forest, and rain and cloud forests on the western slopes of the Andes (Eva et al. 2004). Deciduous forests, delimited by seasonality in precipitation, cover about 87 million hectares (4.3 percent) of LAC. The seasonally dry forests cover 269 million hectares in South America: 47 million hectares in the Caribbean and 22 million in Central America (Portillo-Quintero et al. 2015). Flooded forests, both inland and coastal, occupy 15 percent of South America; and temperate forests accounts for 43 million hectares (Eva et al. 2004; FAO 2015).

LAC forests host around 50 percent of the world's terrestrial species (UNEP 2010) and seven of the world's 25 hotspots of biodiversity (Myers et al. 2000). The number of plant species per country varies from 4,000 (Chile) to 30,000 (tropical Andes), of which 17 to 50 percent are endemics (Mittermeier et al. 2004).

LAC has 23 percent of the global protected lands (IUCN 2016), with 11 percent of its forestland included in some IUCN protection categories (Blankespoor et al. 2014; UNEP-WCMC 2019). The highest percentage of protected area is in Brazil (56 percent of the territory) (UNEP-WCMC 2019), especially in the Amazon region, where 43 percent of the area is under some protected status (Soares-Filho et al. 2010). Protected areas, added to indigenous territories, have 58 percent of the total carbon stock in the Amazon Basin and account for a large proportion of carbon sequestration in the region (Soares-Filho et al. 2010; Walker et al. 2019). The carbon sequestration and storage services provided by these forests have been threatened by changes in legislation that allow exploitation of natural

Figure 1. Distribution of Forests in Latin America and Caribbean

Sources: World Ecophysiography Map; Sayre et al. (2014)


N
Observed Climate Trends
Warming
+ Warm days
- Cold nights
+ Heat waves
- Precipitation
+ Precipitation
Longer Dry Spell
+ Heavy precipitation
Sea level rise
Swampy or often Flooded Vegetation
Mostly Needleleaf / Evergreen forest
Mostly Deciduos Forest

resources, and by the downgrading, downsizing, or degazettement of protected areas (Kroner et al. 2019; Mascia et al. 2014). In Brazil, around 7 million hectares of protected area was downsized or downgraded between 1981 and 2012 (Bernard et al. 2014).

Despite its high proportion of protected areas, LAC has the highest deforestation rates in the world (Hansen et al. 2010). About 24 percent of the global forest loss between 2000 and 2017 occurred in LAC, totaling 120 million hectares (Hansen et al. 2013). In 2017, South America accounted for 22 percent of the global deforestation amount, Central America, 1.5 percent, and the Caribbean, 0.6 percent. Brazil lost the largest area, nearly 60 million hectares, between 2001 and 2017, followed by Argentina (6.4 million hectares) and Paraguay (5.6 million hectares). Central America lost about 12.5 percent of its total forest cover between 2001 and 2017, mainly in Guatemala (1.4 million hectares), Nicaragua (1.4 million hectares), and Honduras (1 million hectares), where the percentage of forest loss exceeds 5 percent of the national territory. In the same period, the Caribbean lost more than 10 percent of its forests, particularly in Cuba (569,000 hectares), the Dominican Republic (327,000 hectares), and Puerto Rico (79,500 hectares) (Hansen et al. 2013).

The loss of primary (old-growth) natural forests is sometimes partially compensated by recovery of forest area—the so-called forest transition. Hansen et al. (2013) recorded a loss of 230 million hectares of forest in the period 2000–2012, but also a gain of 80 million hectares. Rates of net forest loss increased in the tropics during this period (Hansen et al. 2013). However, in a municipality-scale analysis, Levy et al. (2012) showed that from 2001 to 2010, recovery of 362,430 square kilometers of forest in LAC occurred in areas with seasonally dry climates and unsuitable topography for agriculture. In a parallel analysis for the same period in Central America (El Salvador, Guatemala, Honduras, Nicaragua, Costa Rica, and Panama), Redo et al. (2012) showed that 6,825 square kilometers of forest was recovered in seasonally dry zones and in areas originally characterized by coniferous forests. Meanwhile, from 2000 to 2017, forest cover remained stable (i.e., below 1 percent of forest loss) in most regions in Peru, Ecuador, Guyana, French Guiana, Suriname, Costa Rica, Panama, Haiti, and Jamaica (Figure 2).

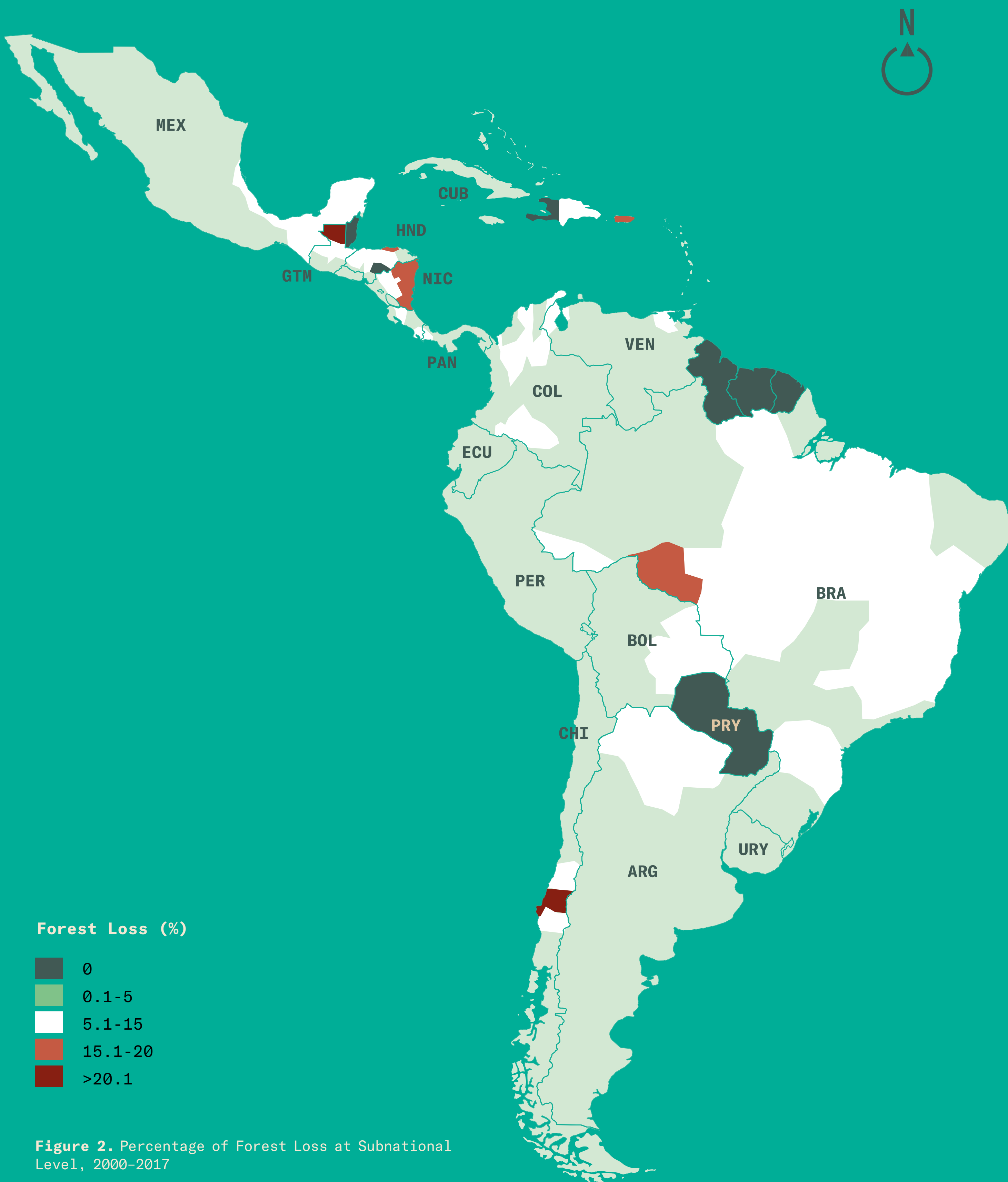


Figure 2. Percentage of Forest Loss at Subnational Level, 2000-2017

Source: Hansen et al. (2013).

Forest degradation is also a problem in LAC (Armenteras et al. 2016). Partial forest clearance brings a loss of diversity and biomass density, compromising the forest's ability to function as an ecosystem, provide environmental services, and regenerate after disturbances (Ghazoul et al. 2015; Houghton 2012; Sasaki and Putz 2009). An estimated 240 million hectares of tropical forest in LAC is in a critical state of degradation (Armenteras et al. 2016). Haiti, Belize, and Mexico have the highest degradation rates, with more than 50 percent of their forest area in a critical state. On the other hand, Costa Rica, French Guyana, Guyana, and Suriname have large percentages of conserved forests—80, 76, 70, and 50 percent, respectively (Armenteras et al. 2016; Hansen et al. 2013).

Drivers of Deforestation and Degradation

The causes of forest loss in LAC have varied over time and by regional geophysical characteristics and socioeconomic dynamics (Armenteras et al. 2017). In South America, direct conversion from forest to pasture is a historical pattern; however, the influence of commodity markets on forest depletion has intensified, contributing to the expansion of agricultural commodities (e.g., for soybeans) (Gibbs et al. 2015; le Polain de Waroux et al. 2019). Because of soy, the Santiago del Estero region in Argentina and the northwestern portion of Paraguay lost 13.6 and 17 percent of the remaining Chaco biome, respectively (Fehlenberg et al. 2017; Hansen et al. 2013). Soybean production expanded in Mato Grosso in Brazil as well, although since the 2006 Soy Moratorium in the Brazilian Amazon Basin, most of the land had already been cleared for cattle ranching (Gibbs et al. 2016). However, leakage from avoided deforestation in Brazil through this policy has affected other Brazilian biomes, especially the Cerrado, and influenced agricultural expansion in neighboring countries, such as Paraguay and Bolivia (Gasparri and de Waroux 2015; Graesser et al. 2015; Moffette and Gibbs 2018).

Other activities that drive deforestation in South America are mining and illicit crops, especially in Peru, Bolivia, and Colombia (Armenteras et al. 2009; Caballero Espejo et al. 2018; Kalamandeen et al. 2018), and the expansion of roads, railways, ports, and dams (Anderson et al. 2019; Andrade-Núñez and Aide 2020; Moran 2016). In Central America and the Caribbean, expansion of commodity production and cattle ranching are among the main drivers of forest loss (Curtis et al. 2018; FAO 2015).

Forest degradation in LAC is mainly triggered by logging and fire. Conventional logging has been very destructive in LAC, causing loss of biodiversity and increasing deforestation risk (Putz et al. 2012).

Climate Change and Its Implications

Observed Changes

Temperature

The natural climate in LAC is warm (~26 degrees C) with small seasonal and daily changes (Reboita et al. 2014; Seidel et al. 2008), but significant changes in temperature patterns have been observed in LAC since the 1900s (Figure 1). The average temperature has risen as much as 1 degree C for most of the region (Li et al. 2015; Magrin et al. 2014), with warming trends generally being stronger at lower latitudes (Feron et al. 2019) and at higher elevations (e.g., 0.5 degree C per decade at 1,000–1,500 meters above sea level, MASL, and 1.7 degrees C per decade above 5,000 MASL), in response to climate zone shifts (Aguilar-Lome et al. 2019; IPCC 2019; Morán-Tejeda et al. 2016). In Peru, a positive trend in temperature (annual average of 0.17 degree C per decade) varied in magnitude along elevation gradients, from 0.13 degree C per decade at sea level in the Pacific coastland to 0.27 degree C per decade at 4,500 MASL in the Andes (Vicente-Serrano et al. 2017). Daily temperature variability has been changing in Central America and in the west, southeast, north, and northeast of South America, with fewer cold days and more warm days (up four days per decade) and nights (up to three days per decade). Rising temperatures are associated with increased rates of sea-level rise along some coastal areas of LAC (7 millimeters per year, southeast Atlantic Coast), such as Brazil (4 millimeters per year) and Guyana (2 millimeters per year), and disturbing mangroves and other forests along coastlines (Magrin et al. 2014; UN 2018).

Intensification of climate extremes has been observed in the 21st century in LAC. Increases of monthly maximum (0.06 degree C) and minimum (0.04 degree C) temperatures were recorded between 1980 and 2013 in the northern coast of northern Brazil and in most regions of the Amazon (0.04–0.06 degree C for maximum temperatures) (Da Silva et al. 2019). Extremely warm December-January-February days of heat waves in South America have become more frequent, harming human health (e.g., by increasing risks of infectious diseases) and agriculture (e.g., by causing crop losses) (Geirinhas et al. 2018; Gusso et al. 2014; Magrin et al. 2014; Rusticucci 2012).

Rainfall

LAC shows substantial natural spatial variability in precipitation (e.g., Andes and mountains of Mesoamerica and Caribbean) because of the interaction between rainfall regimes with land surface attributes (e.g., topography, continentality) and high-level atmospheric circulation patterns. As result, LAC has a large climatic spectrum that influences biodiversity distribution and regulates ecosystem functioning (Esquivel-Muelbert et al. 2017; Magrin et al. 2014; Steidinger et al. 2019).

Interactions of global warming with regional land surface features have been causing temporally uneven and spatially divergent rainfall trends in LAC (Magrin et al. 2014; Gouveia et al. 2019). Positive trends have been recorded in central and eastern South America, as in southern Brazil, where rainfall has increased at a rate of 5.5 millimeters per year (Silva Dias et al. 2013). In Bolivia, precipitation increased 18 percent until 1984, after which drier conditions advanced (Seiler et al. 2013). Warming of the Atlantic Ocean has led to more precipitation in the western Amazon Basin (15 millimeters per year), resulting in higher river discharge (Gouveia et al. 2019).

Despite some regionally divergent trends, observations since 2000 indicate that the atmosphere over the Amazonian rainforest is drying because of global warming, biomass burning, and land-use change. The moisture produced by forest has diminished, especially in the southeastern basin, and strong drought and wildfire events have increased (including in the northwestern part of the basin) (Barkhordarian et al. 2019; Leite-Filho et al. 2019). Drier climates have been developing in the Peruvian Amazon Basin, southern Peru and Chile, southwestern Argentina, the Andes, western Central America, and northern South America (Haylock et al. 2006; Magrin et al. 2014; UNFCCC 2012). From 1980 to 2013, the northern coast of northeast Brazil saw a reduction of 4.6 millimeters per year in total precipitation during the austral winter (Da Silva et al. 2019), and from 1965 to 2009, the Peruvian Amazon Basin had a significant negative trend in total precipitation and consecutive wet days (Heidinger et al. 2018). A negative trend in precipitation was also recorded for the Caribbean islands from 1950 to 2002, with 30 percent less rainfall (Karmalkar et al. 2013; Neelin et al. 2006). By contrast, rainfall increases were registered in the Caribbean region, including the South American coast, from 1990 to 2009 (81.8 millimeters in 20 years) (Infante 2018), indicating the influence of the spatial scale on climate change observations.

The effect of gradual changes in climate may be exacerbated when they are associated with increased frequency and intensity of extreme climate events: heavy rainfall, severe droughts, floods, and variability in streamflow all increase the vulnerability of socioecological systems to natural disasters (IPCC 2019; Marengo et al. 2012b; Patricola and Wehner 2018). In the Brazilian Amazon Basin, historically intense droughts were registered in

1906, 1912, 1926, 1964, 1986, 1992, 1998, 2005, 2010, and 2015–2016 (Nobre et al. 2016). In Venezuela, the heavy rainfall recorded in 2017 by the NASA Earth Observing System Data and Information System was responsible for flooding the Orinoco and Caroni rivers.

Projections

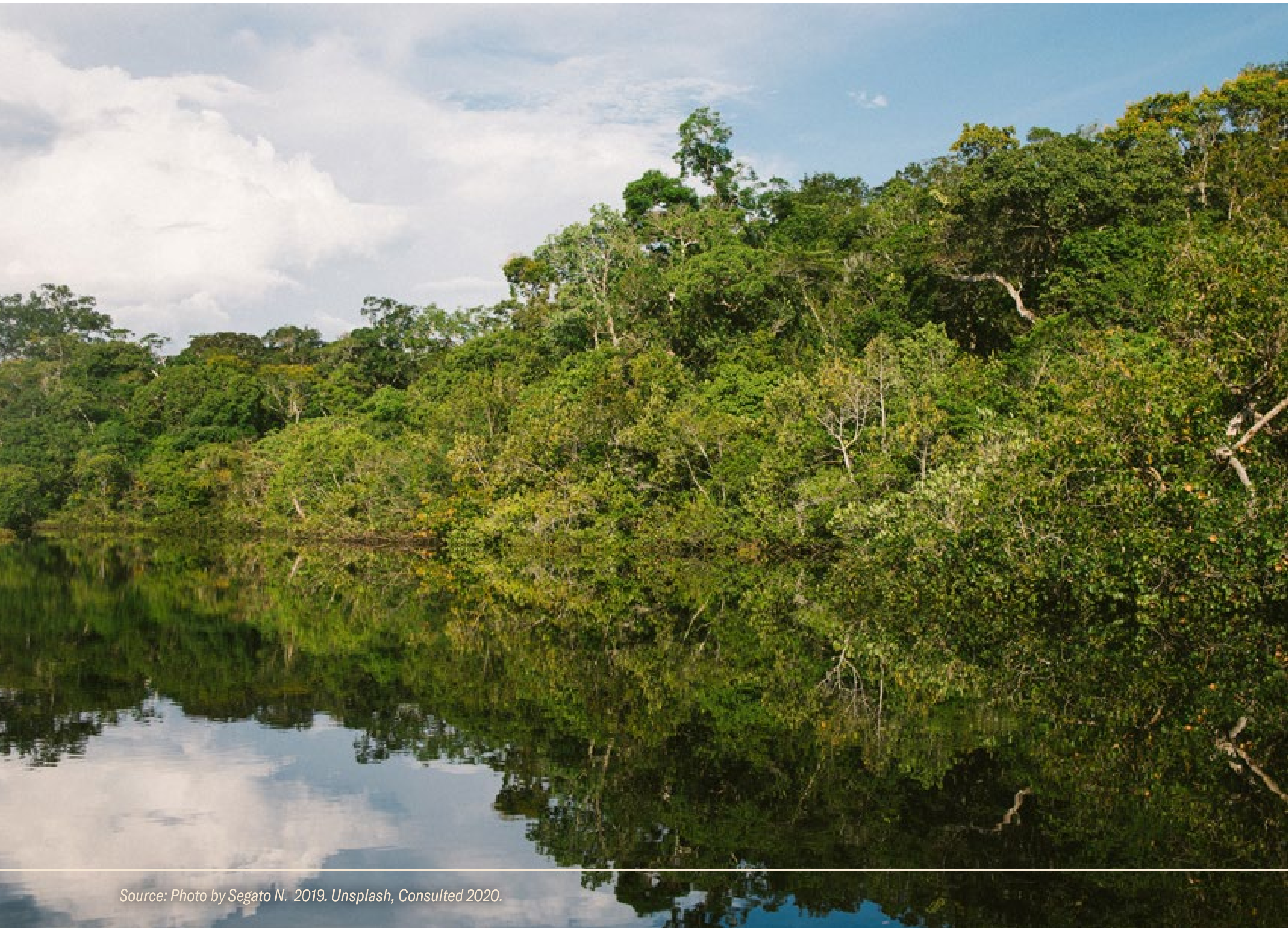
Temperature

Projected changes in temperature, precipitation, and climate extremes in different sectors of Central America, South America, and Caribbean are supported by model intercomparisons (e.g., CMIP5), with different greenhouse gas (GHG) emissions scenarios selected from Intergovernmental Panel on Climate Change (IPCC) assessment reports: AR4 for A2, A1B, and B2 scenarios (Magrin et al. 2007), and AR5 for RCP2.6, RCP4.5, RCP6.0, and RCP8.5 scenarios (Magrin et al. 2014; Romero-Lankao et al. 2014).

Projections for temperature and rainfall to 2100 follow the historical regional trends (Marengo 2007). For the most pessimistic scenarios, based on higher GHG emissions (SRES A2, RCP8.5), both Central and South America may experience an increasing mean annual warming of 2 degrees C to 5.8 and 6 degrees C, respectively (Colorado-Ruiz et al. 2018; Salazar et al. 2015). This warming is mostly in the range of the global average projections to 2100, 2.6 to 4.8 degrees C (Collins et al. 2013). Projections from regional models (HadRM3, Inland-Eta-HadGEM2-ES, EtaCPTEC) (Lyra et al. 2016; Marengo 2007) suggest a greater increase in temperature for some LAC regions. For the southern and eastern Amazon rainforest, for example, the A1B scenario projects an increase of 7 degrees C by 2100 (Marengo et al. 2012). The warming projected for the Amazon region is influenced by the decrease in latent heat flux due to forest dieback (Lyra et al. 2016). Warming projections for southern Brazil, Uruguay, Paraguay, and northern Argentina are lower than those for northern South America, about 2 to 4 degrees C by 2100. In the Chiquitano dry forest in Bolivia, after forest was converted into cropland, the modeled surface temperature increased 0.6 degree C, indicating the sensitivity of local climate to vegetation cover (Bounoua et al. 2004; Salazar et al. 2015).

Rainfall

Projected changes in rainfall vary tremendously across the LAC region (Magrin et al. 2014; Marengo 2007). In climate model downscaling, some contrasting rainfall trends are evidenced for the coming decades across South America. Rainfall reductions are expected in northern South America, eastern Amazonia (by 5 to 20 percent), central-eastern and northeastern Brazil, Andes Altiplano, southern Chile; increases are expected for southeastern South America (about 15 to 20 percent), northwestern Peru and Ecuador, and western Amazonia (Magrin et al. 2014; Marengo 2007). In Central America, in particular in Mexico, rainfall reductions of 5 to 10 percent are expected, with longer dry spells (Colorado-Ruiz et al. 2018). For the Caribbean, climate scenarios suggest a decrease in precipitation by as much as 50 percent for Haiti, the Dominican Republic, and Jamaica (Karmalkar et al. 2013).



Source: Photo by Segato N. 2019. Unsplash, Consulted 2020.

Drivers of Climate Change
Influence of Forests on GHG Emissions

Scientific observations, local perceptions, and forecasts from models indicate that gradual and extreme climate changes, in particular global warming, are mostly generated by GHG emissions related to fossil fuels, energy production, and land-use change (Reboita et al. 2014; Salazar et al. 2015). The world's emissions reached 39.4 gigatonnes of carbon dioxide equivalent ($GtCO_2$-eq) in 2014. LAC countries were responsible for 12.4 percent (3.9 Gt) of the total (Explorer 2017).

LAC tropical forests remove large amounts of carbon dioxide from the atmosphere (1.2 ± 0.4 $GtCO_2$-eq per year) (Pan et al. 2011) and store it in their plant biomass, both above ground and in roots and soil. The carbon stocks in this region account for about 49 percent of total above-ground carbon in the tropics, equivalent to around 93 to 120 GtC (Gibbs et al. 2007; Malhi et al. 2006; Saatchi et al. 2011), and 16.5 to 30 GtC below ground (FAO 2015; Guevara et al. 2018).

In LAC, the activities with potential to generate emissions include agriculture, land-use change, and forestry and energy production (Figure 3). Among the tropical LAC countries, Brazil has had the highest GHG emissions, 1,496 million tonnes of carbon dioxide equivalent ($MtCO_2e$) in 1990 and a maximum of 2,015 $MtCO_2e$ in 2005 (just after the peak of deforestation in the Amazon Basin), then declining to 1,379 $MtCO_2e$ in 2016 (Figure 4) (CAIT 2019). According to the Brazilian System of Estimation of Greenhouse Gas Emissions (SEEG, http://seeg.eco.br/#), which has slightly lower carbon emissions than the CAIT data set, the increase in emissions from 2017 (1,403 $MtCO_2e$) to 2018 (1,410 $MtCO_2e$) is attributed to an 8.5% increase in deforestation, increasing the biome's emissions by 44.5 million tons (Observatório do Clima 2019).

Countries in LAC are responsible for 24 percent of the global emissions attributed to land-use change … (Explorer 2017; IPCC 2019; Vourlitis et al. 2019). The GHG emissions associated with land-use change come mostly from biomass burning and soil carbon loss… (Armenteras et al. 2016; FAO 2017; van der Werf et al. 2009).”

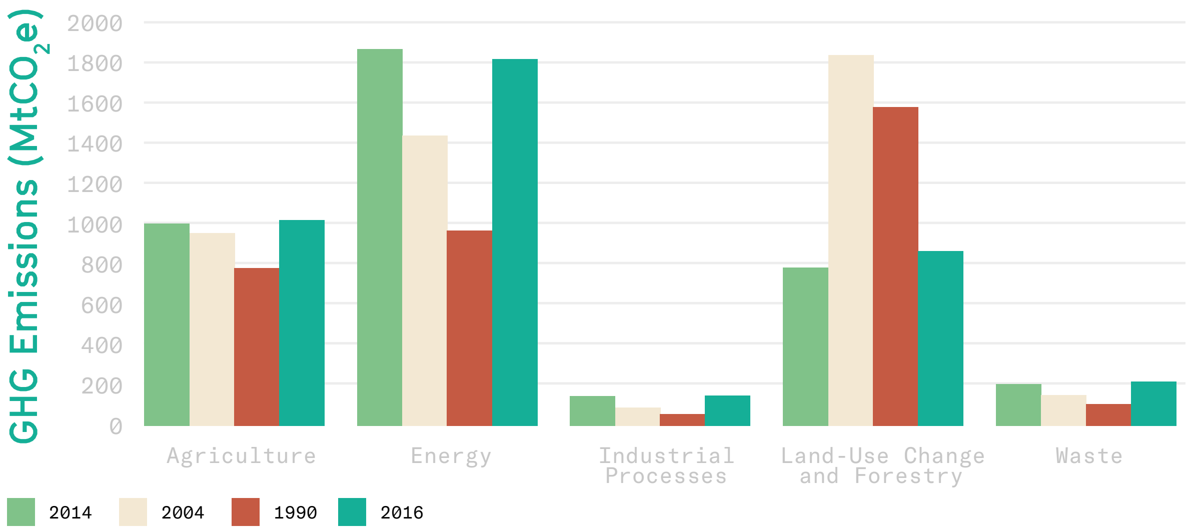


Figure 3. LAC Emissions, by Sector ($MtCO_2e$), 2014, 2004, 1990 and 2016

Source: Climate Watch, based on raw data (CAIT - Climate Analysis Indicators Tool, 2019).

Countries in LAC are responsible for 24 percent of the global emissions attributed to land-use change and 22 percent of total emissions from 2007 to 2016 (Explorer 2017; IPCC 2019; Vourlitis et al. 2019). The GHG emissions associated with land-use change come mostly from biomass burning and soil carbon loss (heterotrophic respiration) during net conversion of forest to other uses, particularly agricultural cropland and livestock pasture (Armenteras et al. 2016; FAO 2017; van der Werf et al. 2009). The biomass burning may represent 11 to 70 percent of emissions from deforestation, mainly released during the austral dry season (van der Werf et al. 2009; Aragão et al. 2018). Indirectly, the increase in carbon emissions from forest areas is also related to forest fragmentation, which makes forest edges vulnerable to ignition sources and fire scatter (Aragão et al. 2018; Brando et al. 2020).

In South and Central America, an estimated average of 443.4 MtC per year was emitted because of deforestation and forest degradation between 1990 and 2000. The average amount increased to 464.8 MtC per year between 2000 and 2010 (Achard et al. 2014). The CO_2 released to the atmosphere from forest loss now exceeds the total amount sequestered (loss = 516.0 ± 69.5; gain = 191.2 ± 18.2; net 324.8 ± 73.5 MtC per year–1) (Baccini et al. 2012), converting the forest from a carbon sink to a carbon source (Gatti et al. 2014; Houghton et al. 2012; Pearson et al. 2017).

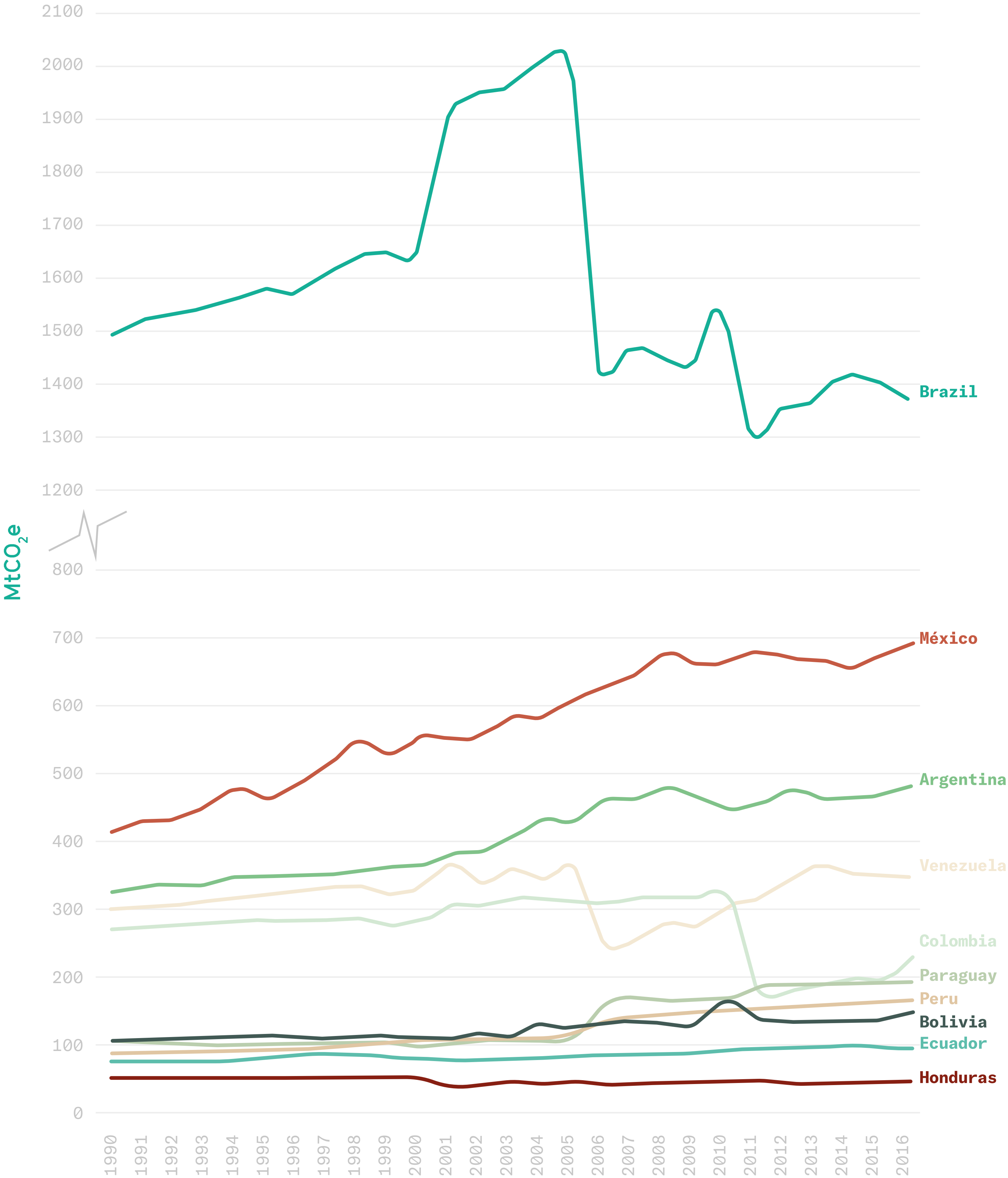


Figure 4. GHG Emissions (Including Land-Use Change and Forestry (Net emissions/removals)), by 10 Largest Emitters in LAC, 1990-2016

Source: Climate Watch, based on raw data (CAIT - Climate Analysis Indicators Tool, 2019).

Biophysical Influence of Tropical Forests

Climate trends are partially caused by interannual climate variability, generated by El Niño–Southern Oscillation, the Atlantic Multidecadal Oscillation, and the Pacific Decadal Oscillation, as well as land surface features (structure and extension of vegetation cover) (Haylock et al. 2006; Leite-Filho et al. 2019; Mestas-Nuñez and Miller 2006).

The biophysical role of tropical forests in climate regulation is related to their function in cooling the atmosphere and maintaining the regional precipitation budget and moisture production (Anderson-Teixeira et al. 2012; Casagrande et al. 2018). High rates of evapotranspiration from rainforests are fundamental for maintaining the surface energy balance, regulating global and local heating (Davidson et al. 2012; Ellison et al. 2017; Müller et al. 2012), and ensuring rain recycling in several areas of the South American continent (Coe et al. 2017; Ellison et al. 2017). Between 35% to 80% percent of rainfall in the Amazon rainforest is a product of forest water recycling (tree transpiration), buffering against interannual drought (Marengo et al., 2018; Staal et al., 2018), and keeping the dry season short (less than three months), an essential element for rainforest maintenance (Nobre et al. 2016; Nobre and Borma 2009).

Deforestation weakens the cooling effect of forests and affects cloud formation, precipitation, and climate seasonality (Ellison et al. 2017; Langenbrunner et al. 2019). Although forest loss normally increases surface albedo, meaning less absorbed solar radiation, the reduction in latent heat flux (evapotranspiration) results in higher surface temperatures (Arias et al. 2018; Sampaio et al. 2007). Some studies suggest that the atmosphere at the surface can be 2 degrees C cooler and more humid in forest areas than in deforested areas (Arias et al. 2018; Llopart et al. 2018; Pavão et al. 2017). Deforestation alone could warm eastern Amazonia by more than 3 degrees C, decrease July-to-November precipitation by as much as 40 percent, and delay the onset of the rainy season by 0.12 to 0.17 day for each 1 percent increase in deforestation (Leite-Filho et al. 2019; Nobre et al. 2016). The reduction of moisture recycling after forest removal leads to longer dry seasons in the southern Amazon Basin and reduces moisture flows to the east (Agudelo et al. 2019). That would also reduce southward moisture flows, affecting rainfall in the southern portions of the La Plata Basin (Arraut et al. 2012).

The conversion of more than 66 percent of the tropical dry forests of LAC (Portillo-Quintero and Sánchez-Azofeifa 2010) resulted in an increase in surface temperature and a decrease in precipitation (Salazar et al. 2015). Forest degradation aggravates the effects of the increasing droughts under global warming by creating microclimates drier and warmer than intact forests and increasing the risks of fire propagation (Berenguer et al. 2018; Brando et al. 2012; Silvério et al. 2019).

Effects of Climate Variability and Change

Forest Dynamics and Biodiversity

Warming and rainfall variability are affecting the functioning of LAC's tropical forest, from the genetic to the ecosystem level, causing changes in plant growth and carbon uptake, tree mortality, species extinctions and interactions, genetic diversity, and ultimately forest dieback (Cusack et al. 2016; Scheffers et al. 2016).

The effects of droughts and rising temperatures on tropical forest trees have been broadly documented (Clark et al. 2013; Fontes et al. 2018; Scheffers et al. 2017; Slot and Kitajima 2015). Reductions in rainfall, total plant growth (wood, root, and litter production, by as much as 40 percent) and gross and net primary productivity are often attributed to the decline of photosynthetic capacity (Brando et al. 2008; Costa et al. 2010; Doughty et al. 2015). Warmer temperatures can accelerate drought-induced mortality by decreasing photosynthesis of individual tropical trees and slowing tropical forest dynamics, as evidenced in the rainforests of Brazil, Bolivia, Costa Rica, and Peru (Adams et al. 2009; Aubry-Kientz et al. 2019; Doughty et al. 2015).

Tree mortality is exacerbated by positive feedbacks among deforestation, climate, and forest die-off (Allen et al. 2010; Lovejoy and Nobre 2018; McDowell et al. 2011; Nepstad et al. 2007). Broad-scale forest mortality often results from the combined effect of climate-driven warming, drying, fires, and changes in the dynamics of forest insects and pathogens (Aragão et al. 2018; Cusack et al. 2016; McDowell et al. 2008). Studies in Amazonian, Atlantic, and Costa Rican tropical rainforests show an increased tree mortality due to high temperatures and especially to seasonal and severe droughts (Chazdon et al. 2005; Condit et al. 1995; Rolim et al. 2005; Williamson et al. 2000), reducing CO_2 uptake and increasing carbon loss from woody biomass (Doughty et al. 2015; Doughty and Goulden 2008; Phillips et al. 2009). Rising CO_2 concentrations in the atmosphere may attenuate the effects of drought and warming on water-use efficiency, via accelerated carbon uptake and growth rates (Allen et al. 2010; Cusack et al. 2016; Norby et al. 2010), although this positive effect depends on the availability of soil nitrogen and phosphorus and the plants' physiological response. The influence of Amazon forests on carbon uptake in the increasingly CO_2-rich atmosphere, for instance, has decreased since the 1990s, causing biomass mortality and bringing uncertainty about the role of tropical humid forests as a carbon sink (Brienen et al. 2015).

Climate change and its feedbacks with other global change drivers have also been altering the distribution and abundance of tropical forest plant and animal species, disrupting species interactions (e.g., between pollinators and plants), and increasing the rates of species extinction to the extent that a sixth "mass extinction" is foreseen (Barlow et al. 2018b; Ceballos et al. 2015; Gomes et al. 2019). Evidence of local extinctions related to global warming is already very strong (47.1 percent from 976 species) (Wiens 2016). Recent studies show that for the global total of 8,688 species on IUCN's Red List of Threatened Species (https://www.iucnredlist.org/), climate variability and change are the dominant threats for 1,688 species (19 percent) (Maxwell et al. 2016). Warming-related species range shifts (Freeman et al. 2018; Morris 2010) may diminish plant biodiversity, in part because of temporal asynchrony among coevolved species, such as pollinators and seed dispersers (Olivares et al. 2015). Cases of rapid species declines in Brazil, Ecuador, Costa Rica, and Ecuador are increasingly ascribed to disease and anthropogenic climate changes (Stuart et al. 2004). Climate-related biodiversity loss can be particularly harmful in the Amazon region, where studies have pointed out the dependence of forest productivity on biodiversity (Liang et al. 2016), a turnover of wet-affiliated to dry-affiliated tree genera, and an increase in the abundance and biomass of lianas (woody vines), driving substantial shifts in the Amazon Basin's ecological functions (Esquivel-Muelbert et al. 2017; Nepstad et al. 2007; Phillips et al. 2009).

Projected Changes for LAC Forests

With rising temperature and CO_2 levels, models project the disappearance of roughly one-quarter of the world's existing species by 2050 (Arruda-Neto et al. 2012). In the near future, it is expected that 11 percent (with dispersal) to 34 percent (without dispersal) of species become subject to extinction under the minimum expected climate change (i.e., a mean increase in global temperature of 0.8 to 1.7 degrees C and in CO_2 of 500 ppm by volume) (Thomas et al. 2004). Under harsher climate scenarios (temperature increases of 1.8 to 2.0 degrees C and atmospheric CO_2 increases to 500 to 550 ppm by volume), 48 to 56 percent of woody plant species in Cerrado vegetation in Brazil and 8 to 26 percent of mammals in Mexico will likely become endangered by extinction (Thomas et al. 2004). Projections of the HADCM2GSa1 model for the Amazon Basin have predicted that by 2095, 43 percent of 69 angiosperm plants will become nonviable populations because of drastic changes in their potential and realized niche distribution (Miles et al. 2004). The combined effects of climate and deforestation are predicted to cause a decline of perhaps 58 percent in Amazon tree species richness by 2050; climate change alone would cause a 31 to 37 percent decline (Gomes et al. 2019).

From a regional perspective, tree mortality related to climate change and more direct anthropogenic disturbances often occur in a nonlinear manner, suggesting the existence of critical thresholds to forest resilience, beyond which catastrophic tree mortality causes a redistribution of biomes in tropical South America (Nobre et al. 2016; Salazar et al. 2007). The gradual replacement of forest by savanna-like vegetation is expected for the Amazon Basin by the middle of the century (Barker et al. 2007; Nobre et al. 2016). The risks that the Amazon rainforest reaches a tipping point toward a degraded savanna depends on the interactions of large-scale environmental drivers, such as deforestation, global warming, extreme drought events, and the associated more frequent wildfires (Nobre et al. 2016; Nobre and Borma 2009). Projections indicate that such a transition in central, southern, and eastern Amazon forests may begin when temperature increases approach 4 degrees C, as a result of reduced rainfall, longer dry seasons, and more frequent severe droughts, or as deforestation characterizes 40 percent of the total forest area in the Amazon Basin (Nobre et al. 2016; Sampaio et al. 2007). When all the principal human drivers of changes (global climate changes, regional deforestation (20%-25%), increased forest fires, and elevated CO_2 concentrations in the atmosphere) are considered, including their synergistic interactions, as much as 60 percent of the Amazon forest may disappear by 2050 (Lovejoy and Nobre, 2018b; Nobre et al., 2016).

Whereas a drying climate may reduce humid forests, other forest types in LAC may expand. Based on niche modeling under the RCP 4.5 IPCC scenario, the area of seasonal dry forests in Mexico will likely expand by about 6 percent and shift toward higher elevations by 2070, at the expense of local extinctions of habitat specialists and species replacement in local communities (a turnover for more than 40 percent of species) (Prieto-Torres et al. 2016). Dry forests of Bolivia are expected (LPJ-GUESS model) to undergo a 72 percent reduction of carbon stocks due to rainfall decrease, suggesting a higher risk for forest loss along the drier southern fringe of the Amazon Basin (Seiler et al. 2015). In Central American and Caribbean

The gradual replacement of forest by savanna-like vegetation is expected for the Amazon Basin by the middle of the century (Barker et al. 2007; Nobre et al. 2016).

tropical forests, extreme climate events such as the intensification of hurricanes, related to warmer sea surface conditions and lower stratospheric temperatures, may cause instantaneous massive tree mortality (Balaguru et al. 2018). Intensification and unpredictability of hurricanes may lead to species turnover and lower aboveground biomass in mangroves and upland forests (Lugo 2000).

Climate Change and Human Displacement

In all LAC regions, climate change and intensification of extreme climate events can affect human populations in different ways (Reyer et al. 2017). Changes in temperature, rainfall, and climate limit the land available for food production, increase the number of natural disasters, and reduce the availability of places with thermal comfort for humans and animals (Porter et al. 2014). The rise in sea level is expected to affect millions of people living in coastal areas, being particularly harmful to countries in LAC with low elevation and with more exposed and less resilient populations (Hauer et al. 2019). Populations from the most diverse regions of LAC, both in rural areas and in cities, may be forced to migrate or/and have to adopt urgent adaptation measures (Carr 2009; Rigaud et al. 2018).

Weather-related hazards, attributed to storms, floods, extreme temperatures, drought, wildfire and landslides, are major causes of human displacement in LAC. One of the greatest anthropogenic climate change consequences for Latin America for the next 30 years is the expected migration of as many as 17 million people (Rigaud et al. 2018). Drought and warming will be critical for human displacement (Abel et al. 2019; Hsiang and Sobel 2016; IPCC 2014; Renaud et al. 2007) and will especially affect vulnerable residents in arid and semiarid areas like Mexico and northeastern Brazil (Barbieri et al. 2010; Feng et al. 2010). In Mexico, 900,000 people are leaving arid and semiarid zones annually, driven by the effects that soil degradation and dry conditions have on people's health and on water and food security (Feng et al. 2010; Renaud et al. 2007).

Displacement may trigger social conflicts through discrimination, unemployment, and human insecurity (Melde et al. 2017). Migration trends in Central America show south-to-north human flows, suggesting an increase in immigration conflicts with the United States (Hanson 2010). In South America, within-country migration is both historical and projected for the next decades (Barbieri et al. 2010; Hoffman and Grigera 2013). The effects of drought on agriculture, as in El Niño years, induced migration from rural to large northeastern cities in Brazil in the 1980s and 1990s (Barbieri et al. 2010). Migrant-receiving countries may be seriously affected by the large influx of people (Feng et al. 2010; IDMC 2019). For decades, the Amazon region was one of the first migration destinations in Brazil because of the cheap land, economic opportunities, and governmental policies (Hoffman and Grigera 2013). More recently, Amazon immigrants have come from Haiti and Venezuela and occupied mainly peripheral zones (Oliveira 2016). The development of such areas in Amazonia has brought violence, and the demographic changes associated with agricultural expansion and illegal extractive practices can pressure forests (Hoffman and Grigera 2013; Lapola et al. 2014). Considering past experiences and the scarcity of policies for human relocation (Hauer et al. 2019), human displacement toward remote forest areas might increase pressure on natural resources and lands, putting forests at high risk of degradation and deforestation; traditional and indigenous peoples would also be at risk from illicit activities, land conflicts, and infectious diseases and contact-related epidemics (Fearnside 2018; Grillet et al. 2019; Hoffman and Grigera 2013).

Reducing the risks of climate-caused migration is one strategy for climate adaptation, but it depends on climate mitigation actions (reducing emissions) and better development pathways (Rigaud et al. 2018). More often, people respond to climate change by adapting and remaining in place (Kniveton 2017). Nevertheless, poverty, social inequality, lack of government subsidies, and failing infrastructure in LAC might increase the chances of migration and magnify socioenvironmental disasters (Hoffman and Grigera 2013; Renaud et al. 2007; Rigaud et al. 2018). Adaptation strategies related to conservation and management policies are needed (Heller and Zavaleta 2009; Perch-Nielsen et al. 2008), as well as agricultural policies that address the risks under climate extremes (drought and floods) and take a long-term, regional perspective for planning. These are among the major strategies for reducing the climate risks and ensuring human security (Feng et al. 2010).

One of the greatest anthropogenic climate change consequences for Latin America for the next 30 years is the expected migration of as many as 17 million people (Rigaud et al. 2018). Drought and warming will be critical for human displacement.

Case Studies

Brazil: Climate and Forest Conservation Policies

Since the signing of the UNFCCC in 1992, Brazil has actively contributed to the creation of a global climate governance regime. Because of its status as a developing country, Brazil did not have specific emissions reduction targets, yet it played a central role in developing the Clean Development Mechanism (CDM) of the Kyoto Protocol. The CDM allows developing countries (i.e., non-Annex I parties) to host projects that deliver GHG emissions reductions or removals and to issue carbon credits that Annex I countries acquire to meet their targets. One of the project modalities implemented in Brazil is forest plantations to produce biomass and replace the burning of fossil fuels.

Aware that most of its emissions come from forest clearance, Brazil has tried to implement deforestation control policies. The national Forest Code establishes conservation requirements for riparian forests and a legal reserve—a minimum percentage of native vegetation that must be kept to produce timber, conserve soils, and regulate the local climate. With the creation of the "Our Nature" program at the end of the 1980s, the Forest Code was reframed as a legal instrument to slow deforestation in the Amazon Basin. A provisional act turned into law in 2001 (MedProv 2,166-67) raised the legal reserve requirements on rural private lands in the Amazon forest from 50 to 80 percent of a property's area. Moreover, enactment of an environmental crime law (Law 9.605) in 1998 signaled the intent of improving environmental protection. Nevertheless, the institutional capacity of environmental agencies to control deforestation was still weak, with poorly qualified personnel and limited use of GPS and monitoring systems.

After 2003, the political context became more favorable for strengthening environmental governance in Brazil. The climate issue became more pressing as the Kyoto Protocol of the UNFCCC entered into force in 2005; negotiations to create a mechanism for REDD+ began two years later (van der Hoff et al. 2015). At the national level, during President Lula's administration (2003–2010), the Ministry of Environment was strengthened under Marina Silva. New environmental policies, programs, and institutions were emerging. Government budgets started allocating more financial resources to law enforcement agencies (Börner et al. 2015; Cunha et al. 2016; Rajão and Vurdubakis 2013), and penalties for environmental crimes became better defined (Sauer and França 2012). An example is the improved institutional robustness of the environmental protection agency (IBAMA), achieved through the hiring of technically qualified, graduate-level employees, whose share of the ministry workforce rose from 41 percent in 2005 to 52 percent in 2007 (Rochedo et al. 2018), and the acquisition of new GIS technology for monitoring and enforcing environmental laws (Rajão and Vurdubakis 2013) (Figure 5). Moreover, landowners received economic incentives to reduce deforestation through the Soy Moratorium, adopted in 2006 (INPE 2018), faced restrictions on loans from public banks for illegal deforestation (Executive Decree 6.321) in 2007, and obtained new conditional financial support from the Central Bank of Brazil (Resolution 3.545) in 2008. Finally, under Marina Silva's administration at the Ministry of Environment, protected areas increased from 57 million to 103 million hectares, and 69 indigenous territories were demarcated between 2003 and 2008, creating a barrier against expansion of the agricultural frontier (Dambrós 2019; Soares-Filho et al. 2010) (Figure 6). Although price dynamics may also have contributed to reducing deforestation in some years, policy changes were the primary factor (Assunçąo et al. 2015; Macedo et al. 2012; Soares-Filho and Rajão 2018): deforestation in the Brazilian Amazon dropped from 27,772 square kilometers in 2004 to 4,571 square kilometers in 2012 (INPE, 2020). These results gave the Brazilian government the confidence to propose stronger climate mitigation targets related to deforestation reduction in the years that followed.

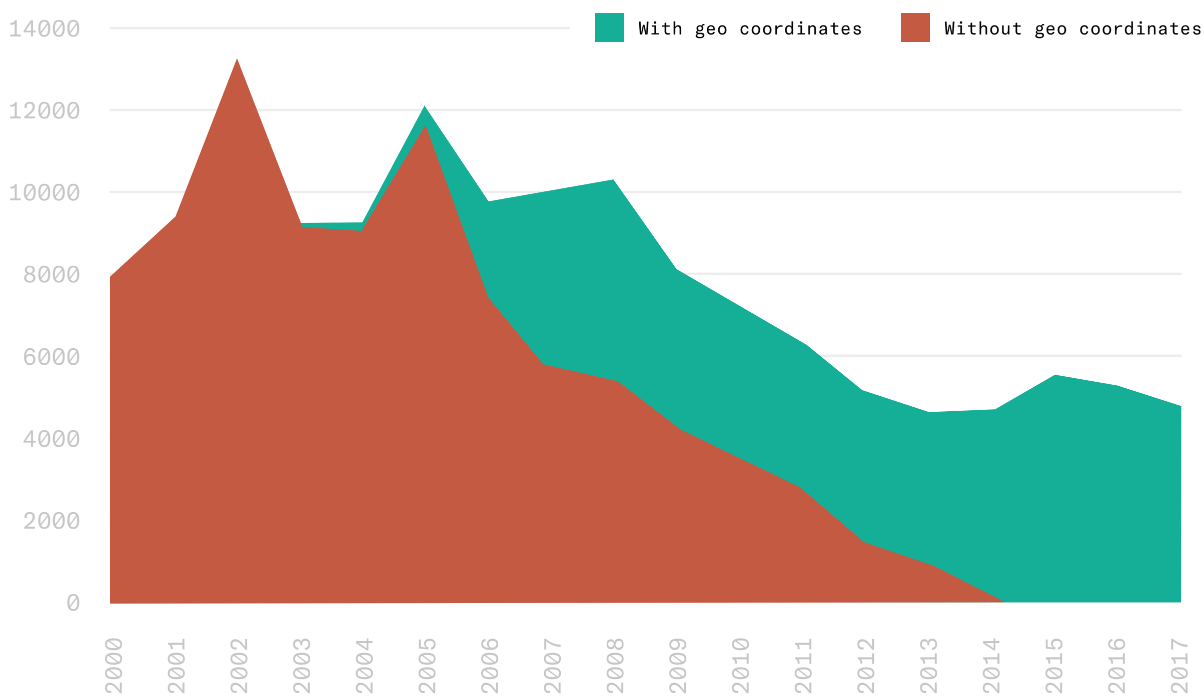


Figure 5. IBAMA Fines, 2000- 2017

IBAMA = Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazilian Institute of Environment and Renewable Natural Resources)

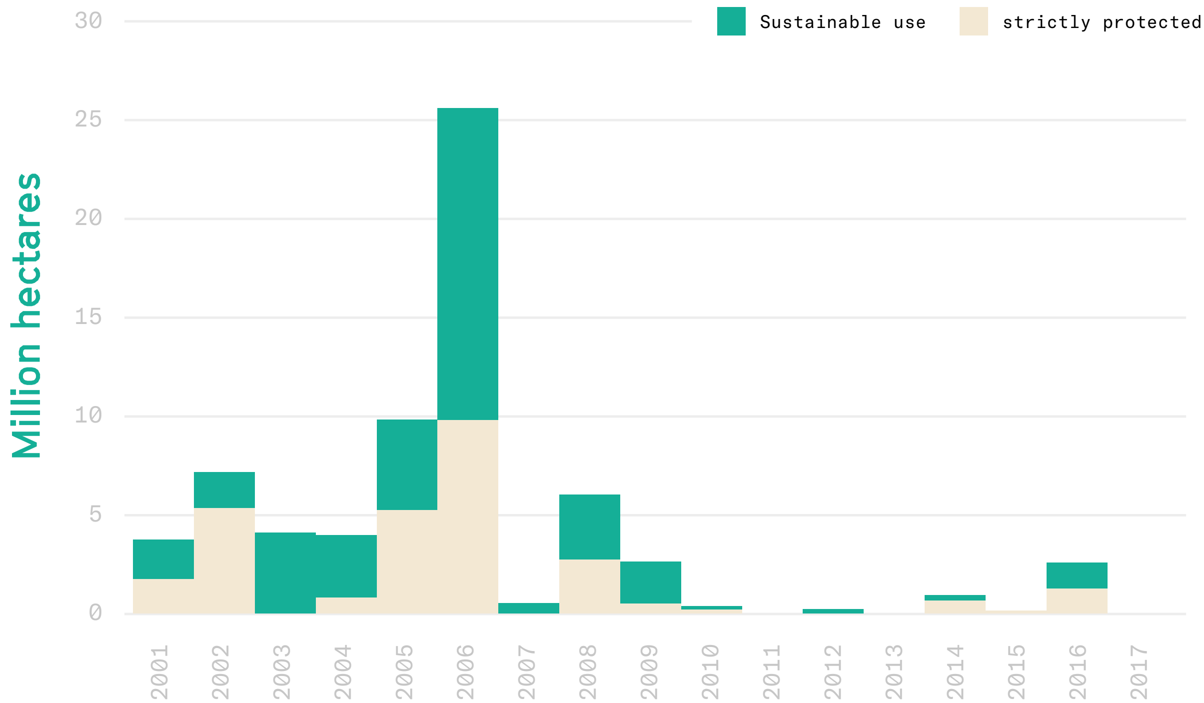


Figure 6. Creation of Protected Areas in Brazil, 2001-2017

In the late 2000s, Brazil formally framed forest conservation programs as part of the country's climate policies. During international climate negotiations in 2009, Brazil made a voluntary commitment to reduce greenhouse gas emissions by 36 to 39 percent below business-as-usual projections for 2020 (Viola and Franchini 2014). This commitment was the basis of Brazil's National Climate Change Policy, instituted by Law 12.187/2009 and regulated by Decree 7.390/2010. To achieve these reductions, the policy instituted sectoral plans, two of which are specifically aimed at reducing deforestation in the Cerrado and Amazon biomes.

In 2014, the link between climate and forest conservation policies was further consolidated in Brazil's nationally determined contribution to the climate mitigation targets of the Paris Climate Accord. To meet its commitment—to reduce GHG emissions 37 percent by 2025 (and 43 percent by 2030) in relation to 2005—Brazil has focused most of its actions on the forest sector, including restoration of 12 million hectares and a pledge to end illegal deforestation. Since 2000, secondary forest regrowth in the Amazon Basin has seen a substantial increase, of around 23 percent of deforested areas (EMBRAPA and INPE 2018). It is unclear, however, whether this is due to policy incentives or simply the abandonment of marginal areas.

Brazil has also been active in the development of REDD+ through the establishment of the Amazon Fund in 2008 and the adoption of the National REDD+ Strategy (ENREDD+) in 2015. Through REDD+ initiatives, the Brazilian government has received US $1.2 billion in donations, mostly from Norway and Germany, and the transfer of another $96 million via the Green Climate Fund.

The strengthening trend in the country's environmental governance did not last very long, however. The rural caucus in the national congress grew from 116 members before the 2010 elections to 142 in President Rousseff's first term (2011–2014). Because of its swelling numbers in Congress and the increasingly delicate position of the Workers Party (PT) following the "Mensalão" corruption scandal, the rural caucus in Congress managed to change the Forest Code in 2012. While maintaining most environmental protections for standing forests, the new law provided an amnesty that exempted 58 percent of the area of all illegally cleared forests before 2008, thus signaling that the government might provide a similar benefit in the future (Sauer and França 2012; Soares-Filho et al. 2014).

The effects of the more flexible environmental restrictions were further exacerbated by the economic and political crises during President Rousseff's administration. The persisting political and economic crises led to the impeachment of President Rousseff in May 2016 and the inauguration of President Temer (2016–2018). President Temer himself was charged for corruption and had to bargain for votes from Congress members against his impeachment, giving the rural caucus more power. Environmental bargains, for example, included proposals to lower environmental licensing requirements, suspending the ratification of indigenous lands, reducing the size of protected areas in the Amazon Basin and legalizing illegally deforested areas as large as 2,500 hectares per farm in the Amazon rainforest. Although some of these deals were later cancelled because of national and international outcry, they again sent a clear signal that the political climate was favorable to illegal deforesters.

Corruption, economic crisis, and deteriorating public security have fed people's indignation and rage toward public authorities at all levels of government. This sentiment culminated in the election of President Bolsonaro in 2018. In just the first few months of his government, it became clear that environmental concerns were low on the political agenda. Examples of the deteriorating environmental governance include the shuttering of the climate change division in the Ministry of Environment, the transfer of the Brazilian Forestry Service (responsible for implementing the Forest Code) to the Ministry of Agriculture, and the announcement of large infrastructure projects that are known to be important drivers of deforestation. It is also unclear what lies ahead for REDD+ in Brazil, since the Amazon Fund is at the center of a diplomatic crisis: the donor countries (Germany and Norway) have refused to allow the Brazilian government to alter the governance structure of the fund. Although the recent trade agreement between Mercosur and the European Union may create demand for deforestation-free supply chains, it is unclear whether that will be enough to reverse the trend in Brazil's environmental policies.

Costa Rica: Trends in Forest Cover

Forests, forest conservation, and environmental policy in Costa Rica have become tightly interdependent with climate change issues and policies for mitigation and adaptation. Climate action includes the pioneering Decarbonisation Plan, which seeks to decarbonize the country's economy by 2050 (discussed below). Costa Rica's current vulnerability to climate change, its adaptive capacity, and its potential contribution to climate change mitigation can best be understood by looking at the 20th-century dynamics of forest cover.

Deforestation rates in Costa Rica were high from 1960 to 1986 and were reputed to be among the highest in the world in the 1970s (e.g., Sader and Joyce 1988; Sanchez-Azofeifa et al. 2001; Stan and Sanchez-Azofeifa 2019). Sánchez-Azofeifa (2013) showed that during 1960–1986, forest cover declined from 60 to 41 percent, then recovered to 51 percent by 2010.

Most of the reforested area is secondary forest on abandoned agricultural land, mainly pasture, and therefore on private property. Stan and Sanchez-Azofeifa (2019) show that 56 percent of the total secondary forest regrowth has occurred in seasonally dry Pacific-slope areas, and less than 20 percent is in the wet Caribbean areas. Sequestration of carbon by secondary forests may be rapid, but long-term storage is less probable. Nevertheless, the secondary forests that have regenerated during the past 50 years may be better adapted to current and expected climatic conditions than mature forests.

Most of the remaining mature forest is in the country's 169 protected areas (PAs), sited in inaccessible regions with a low probability of conversion (Sánchez-Azofeifa 2013). Figure 7 shows the location of PAs (green) and the biological corridors that connect them. The biological corridors are located on private land, mainly agricultural, and range widely in altitude. Lowland corridors (gray) provide horizontal connectivity for movements of forest animals; corridors at higher elevations provide the altitudinal connectivity essential for adaptation to climate change.

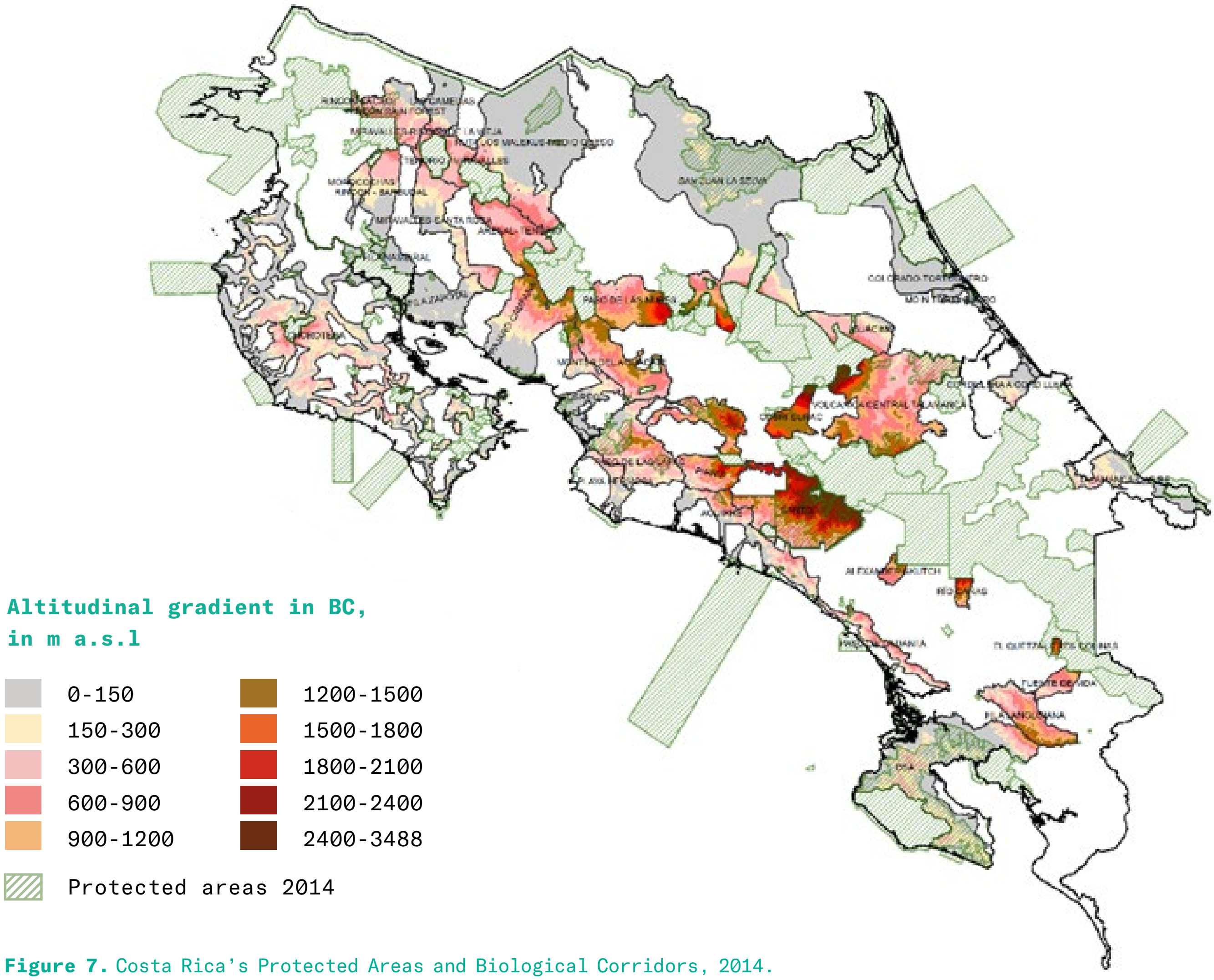


Figure 7. Costa Rica's Protected Areas and Biological Corridors, 2014. Excluding Coco's Island

BC = biological corridor

Costa Rica's potential to contribute to climate change mitigation through forest conservation and restoration is shown by the results of the recent National Forest Inventory (NFI). The forests' degree of vulnerability to climate change is less well established. Forest cover was estimated at 52 percent of the national territory, mostly (47.8 percent) in PAs (Hernández Sánchez 2017; SINAC 2015). If pasture with trees is classified as forest, forest cover would rise to 75.5 percent (Programa REDD/CCAD-GIZ - SINAC 2015). The NFI identified 24 percent of the total forest cover including pastures, and 36 percent of the forest cover excluding them, as secondary forest.

Forest Fragmentation

Forest fragmentation and conventional logging degrade forests, reducing their contribution to climate change mitigation goals and possibly reducing their resilience. Forest cover in Costa Rica is highly fragmented (Sánchez-Azofeifa et al. 2003), and the National Biological Corridors Program seeks to reduce the isolation of protected areas. Landscape connectivity, which is critical for biodiversity resilience and adaptation to climate change, has increased with the expansion of secondary forest in some areas, remained quite constant in others (Arroyo-Mora et al. 2005; Morse et al. 2009), and been compromised by agricultural intensification in some places (Shaver et al. 2015). The land area cultivated for oil palm, for example, grew from 52,600 hectares in 2008 to 77,750 hectares in 2014, with severe effects on biodiversity (Alonso-Rodríguez et al. 2017).

Much of the forest outside the country's PAs classified as mature in analyses of land-cover change has probably been logged at least once. Since 1996, the Sistema Nacional de Áreas de Conservación (SINAC) has not supported timber harvesting in natural forests, and relatively small volumes of timber are now authorized for legal harvest (Hernández Sánchez 2017). Illegal logging, often of high-value timber species such as *Dalbergia* spp., nevertheless continues. Logging is typically low intensity (e.g., Finegan and Camacho 1999), with little effect on biodiversity or carbon stocks (Finegan et al. 2001; Rincon et al. 1999).

Secondary Forest Cover

Secondary forests on abandoned agricultural lands are ecologically very different from the original forest of a site (Gei et al. 2018; Poorter et al. 2016; Rozendaal et al. 2019). They are also valued differently by landowners, the forest sector, and other actors. These differences and their implications for ecosystem service recovery in Costa Rica have been analyzed in many studies (e.g. Finegan 1992; Janzen 1988; Kalacska et al. 2004; Poorter et al. 2019).

Among numerous threats to Costa Rica's forest cover, its contribution to mitigation goals, and its resilience is the vulnerability of secondary forest to reclearing (Fagan et al. 2013; Morse et al. 2009; Reid et al. 2019; Shaver et al. 2015). Dry-season fires have become common in secondary forests of the Pacific northwest, and the degradation they cause, along with the uncertainty of successional processes and the consequences of these factors for carbon sequestration and storage, is not well-understood.

Effects of Climate Change

Costa Rica's mature and secondary forest ecosystems are being affected by gradual climate change and by climate variability and extremes. The so-called dry corridor of Central America, including northwestern Costa Rica, is especially highly exposed and vulnerable (Quesada-Hernández et al. 2019).

Current and future threats to Costa Rican forests are assessed and managed through several government initiatives that define, directly or indirectly, how forests will contribute to mitigation and their vulnerability to climate change. In the country's Red List of Ecosystems (Herrera-F et al. 2015), nine of Costa Rica's 41 natural ecosystems were considered critically threatened, three endangered, and four vulnerable. The threatened ecosystems—those vulnerable to climate change because of degradation, isolation, and area reduction—have stored carbon that is in danger of being released to the atmosphere.

SINAC (2013) has analyzed the PAs' vulnerability to climate change. *Potential impact* of climate change on forests was evaluated using MAPPS model simulations (Imbach et al. 2010), and *adaptive capacity* of people and their organizations was evaluated for local human populations living in biological corridors and in or close to PAs. SINAC (2013) found that 40 to 52 percent of the potential forest vegetation would experience significant ecological change, with a potentially very high probability of change over 47 percent of the national territory. Modeling of potential future distributions of phytogeographic units for the year 2050 (Fung et al. 2017) and a vulnerability analysis for mountain PAs (Delgado et al. 2016) complement this work. The very high diversity of ecologically sensitive tree species in Costa Rica's PAs is a major challenge for adaptation (Veintimilla et al. 2019).

Some studies have called attention to the observed effects of climate variability and change on Costa Rican forests and their component species (see "Forest Dynamics and Biodiversity," above).

A large proportion of Costa Rica´ s national territory is mountainous, and much of the mature forest conserved in PAs is mountain forest, at elevations above 300 MASL (Veintimilla et al. 2019). These forests are highly vulnerable to the effects of rising temperatures, and their carbon fluxes will change (Esquivel-Muelbert et al. 2019). Many studies suggest that tree species migrations will lag behind the changing temperatures (e.g., Bertrand et al. 2011). Recent work in rainforests on altitudinal gradients in the Andes and in Costa Rica suggests, however, that differential growth and mortality—"thermophilization"—are occurring: at any given point, species composition is indeed changing toward greater ecological importance of species best adapted to lower, warmer elevations (Feeley et al. 2013; Fadrique et al. 2018). Such changes indicate the natural resilience of these ecosystems to the temperature increases observed to date.

Government Forest Conservation Initiatives

The Costa Rican government has mainly used two policy tools to directly reduce deforestation: protected areas and payments for environmental services (PES). These policy tools have also been applied in Bolivia (Ferraro et al. 2013), Brazil (Herrera et al. 2019; Pfaff et al. 2015, 2014), Chile (Arriagada et al. 2016), Colombia (Bonilla-Mejía and Higuera-Mendieta 2019), Ecuador (Van Der Hoek 2017), Mexico (Blackman et al. 2015; Sims and Alix-Garcia 2017), and Peru (Vuohelainen et al., 2012), with mostly positive effects. In Costa Rica, high deforestation during the 1970s led to the goal of protecting 50 percent of the national territory. The expansion of PAs continued during the 1990s, and the National System of Protected Areas was established in 1994 (Biodiversity Law 7788, http://www.sinac.go.cr/EN-US/asp/Pages/default.aspx). PAs now cover 25 percent of the country and 44 percent of the forested area.

Although PAs were set aside to reduce extraction of natural resources and prevent expansion of agriculture and development (Robalino et al., 2017), most are located in remote areas with a low deforestation risk (Pfaff et al., 2009). In many cases this means PAs do not reduce deforestation rates, but they have been effective in Costa Rica (Andam et al., 2008; Pfaff et al., 2009) because areas with potentially high deforestation risk are also covered (Robalino et al. 2017).

Evaluations of the effectiveness of PAs must consider leakage, which occurs when the reductions in deforestation due to PA establishment are entirely or partially negated by increased deforestation in areas outside the PA (definition based on Aukland et al. 2003). Leakage close to PAs occurred in Costa Rica during 1986–1997 but was stemmed by the 1996 Forest Law 7575 (Robalino et al. 2015).

Payments to landowners to conserve forests have been implemented in, for example, Colombia (Zapata et al. 2015), Mexico (Costedoat et al. 2015; Sims and Alix-Garcia 2017), Ecuador (Cuenca et al. 2018), and Peru (Montoya-Zumaeta et al. 2019). Costa Rica's PES program, one of the first conservation initiatives of this kind in a developing country, aims to create an economic incentive for forest protection by private landowners. It is financed by a tax on fuel, and by 2018, it had signed 17,776 contracts covering more than 1 million hectares. Some landowners are paid to conserve forest, other to let forest regenerate on their land, and still others to actively reforest with plantations. The amounts and timing of payments depend on the management approach.

As with PAs, the benefits of the PES program depend on the deforestation risk of the land. Initially, forest conservation, regeneration, and reforestation contracts attracted many landowners with low opportunity costs and therefore low deforestation risk, generating little additionality. Around 99 percent of the land enrolled at this time would not have been deforested (Robalino and Pfaff 2013). Subsequently, the program prioritized areas on the basis of provision of environmental services, indirectly selecting land with higher deforestation risk and increasing additionality (Pfaff et al. 2008). It is statistically highly likely that the program, therefore, achieved an increase in the provision of environmental services (Robalino and Villalobos 2015). The current range of six PES contracts for forests and agroforestry systems could potentially increase the provision of environmental services and reduce the economic costs of conservation.

The government has pledged to decarbonize its economy by 2050, a goal that includes increasing forest cover to 60 percent by 2030. It is unclear how the objectives will be achieved, but generating additionality is essential. Formal protection of new areas threatened by deforestation and increasing reforestation will be necessary, as will agroforestry systems. The transformation of cattle ranching through low-carbon technologies over 60 percent of the pasture area is vital, and the PES program must create incentives for silvopastoral systems. Greening of the metropolitan area will also be undertaken—a challenge, given the high cost of land.

The decarbonization plan is still under development and discussion. Policy discussions at the national level and potential modifications of the policy tools are expected.

Source: Photo by Concious Design. 2020. Unsplash, Consulted 2020.

Conclusion

Across the world, effort has been made in the past three decades to link forest conservation and climate mitigation policies. This report brings attention to the major role of natural forests in Latin America and the Caribbean in regulating climate through biogeochemical (carbon cycles) and biogeophysical (e.g., cooling effect, water recycling) processes, and in providing ecosystem services (e.g., provision of goods, disaster risk reduction) essential for people to adapt to environmental changes. LAC countries are responsible for around 12.4 percent (3.9 Gt) of the world's GHG emissions (~39.4 $GtCO_2$-eq). They store almost half (49 percent) of the total aboveground carbon in the tropics and remove large amounts of carbon dioxide from the atmosphere (1.2 ± 0.4 Pg C per year).

The observed and projected climate changes in LAC highlight the urgent need for immediate actions to avoid or adapt to the catastrophic scenario foreseen for the region. LAC regions have warmed an average of 1 degree C since 1900, and for many LAC regions the dry season has become longer and weather extremes more frequent. Climate projections for 2100 indicate an intensification of the observed climate change for LAC, partially due to forest loss. All these changes have triggered shifts in the dynamics and biodiversity of the forest, reducing its resilience and productivity and culminating in large-scale forest diebacks. Even considering the potential positive effects of elevated CO_2 concentration in the atmosphere, the effects of global climate change, regional deforestation, and increased forest fire present a perverse combination that is expected to cause up to 60 percent of the Amazon rainforest—the largest continuous forest of LAC—to disappear by 2050. The harms to society may be equally catastrophic, with projections that some 17 million people in LAC will be forced to migrate over the next 30 years by worsening health and water and food insecurity.

International funds (e.g., Amazon Fund) and treaties (e.g., the Paris Climate Accord) have been supporting policies and actions to tackle deforestation and emissions reductions, using results-based payments (e.g., REDD+) at national and subnational levels as a mechanism to reduce the historical and current risks of political disruption. Despite the advances that forest-based climate policies have made, the LAC region still requires governmental and nongovernmental actions, as well as economic incentives, to tackle deforestation, mining, oil and gas exploration, large-scale gray infrastructure, and the conversion of forest to pasture and cropland for agricultural commodities.

The climate challenges for LAC in the next decades will demand mixed climate policies based on forest restoration and protection, new technologies for sustainable agriculture, green infrastructure for risk reduction, and better communication between scientists and stakeholders.

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3.

Forest Management and Trade for Forest Products

Brent Sohngen

Index

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Forest Management and Trade for Forest Products

Over the past 60 years, timber production in Latin America and the Caribbean (LAC) has grown substantially as the region has become an important hub in the global timber market. This growth has come from the harvesting of tropical timber, the development of forest management in an increasing area of second- and third-growth forests, and the establishment of fast-growing exotic timber plantations established solely for timber production. Historical trend data suggest that aggregate output has continued to grow year after year, but future growth depends on many factors, including economic and social trends that influence the demand for wood products, policy shifts that alter the methods that people and industries can use to manage the land, and climate change and the policies intended to address it.

Furthermore, a strong interaction exists between forest products and environmental outcomes, particularly outcomes related to forest habitat, biodiversity, and the large carbon sink in LAC. Numerous policies have been tried in an effort to preserve or protect the region's forested habitats and carbon sink, and many of these policies have interacted with timber markets. This chapter examines several of these policy issues—sustainable forest management, illegal logging, biomass energy, carbon policy, and the role of nontimber forest products—to better understand how they might influence timber production and forest management.

The chapter begins by presenting data on major trends and their implications for forest management and trade in the region. Then the Global Timber Model (Daigneault et al. 2008; Sohngen et al. 1999; Tian et al. 2018) provides a policy analysis, assessing how shifts in the trends could affect forest management and timber production in the region. Finally, the paper recommends several lines of action.

The analysis illustrates that timber output in LAC has increased more rapidly than the global average in the past 50 years, and the increase has been most pronounced in three countries—Brazil, Chile and Uruguay—primarily because of their expansion in fast-growing timber plantations since the 1970s. Not only has the area of plantations increased, but investments have allowed the yield of plantations to increase as well. Timber price growth has moderated globally, however, putting economic pressure on these plantations. To continue growing, the IAC plantation sector must identify ways to reduce the costs of establishment and management.

One new market that could influence future prices for timber is bioenergy, given that wood-based biomass energy is considered carbon neutral. The analysis discusses some of the trends in renewable energy in LAC, and in particular in countries with substantial plantation resources. Although there is a growing market for renewable bioenergy in the European Union, the United States has provided a large share of this resource and is an important competitor for this market. However, LAC's plantation forests have opportunities to compete in this market both domestically and in Europe and Asia.

An important trend in forest management in the past 30 years has been the emergence and expansion of sustainable forest management globally. The analysis finds that although sustainable forest management has expanded substantially across the globe, accounting now for 36 percent of global timber harvests, it covers a relatively modest amount of land in LAC and accounts for a small proportion of harvesting. The costs of getting certified relative to market or financial benefits likely have limited expansion in this region, but the distribution of property rights in the region is another likely factor. The area of certified forestland is currently small, but efforts to curb climate change could encourage expansion in the future.

Considerable concern has been raised about the role of illegal logging in timber trade and deforestation. It potentially amounts to 80 percent of timber harvested in some LAC countries, but most of this timber enters markets and provides benefits to consumers. The main efficiency losses are externalities that may be exacerbated when logging occurs illegally: for example, when land is cleared for another purpose, or when species such as mahogany are illegally harvested and exported. Additional inefficiencies may occur if timber prices are lowered by illegal harvesting, thus disincentivizing legal harvesting.

Recent trends have expanded property rights on forestland throughout the region. Considerable evidence from many different studies suggests that property rights combined with community forest management can help reduce deforestation and increase forest stocks. Whether property rights and community forest management increase income is less certain, however, although some individual studies have found positive effects. Community management combined with property rights does appear to provide options for more widespread harvesting of nontimber forest products, in addition to timber.

Nontimber forest products contribute to livelihoods, lifestyles, and communities throughout Latin America and the Caribbean. The literature suggests that harvesting of nontimber forest products is sustainable, but evidence that they reduce poverty or significantly increase incomes when not linked to timber production from the same forests is lacking. Data on

Industrial wood production has increased from 3 percent of the world's total production in the 1960s to nearly 13 percent by 2017 (FAOSTAT 2019). Most of this increase occurred in three countries: Brazil, Chile, and Uruguay.

production of nontimber forests products do exist for some categories, but annual data on production, as well as inventory information, would clarify the trends, opportunities, and challenges for economic and environmental sustainability.

Climate change presents both threats and opportunities for LAC forests and foresters. One threat is potential drying in parts of the Amazon Basin, combined with an increase in natural forest fires. Economic studies that have combined dynamic global vegetation models with economic models have shown that LAC timber output will likely increase over the next 30 to 80 years as a result of climate change, with factors that enhance growth outweighing those that increase fire activity. This suggests that if the region's governments develop policies to increase forest carbon for mitigation purposes, these forests will be well suited to provide carbon services for the foreseeable future. Increased dieback potential in the eastern Amazon Basin does present some risk for carbon sequestration projections, however.

Analysis of Trends

Industrial Roundwood Markets and Prices

This section focuses on the current status of industrial wood production in Latin America and the Caribbean, and the effects of various demand and supply factors on output. Currently, the region produces around 240 million cubic meters of the world's 1,907 million cubic meters of total industrial wood product, on 880 million hectares of forestland (Table 1). These forests generate about $23 billion per year in forest rents, which amounts to 0.4 percent of the region's total gross domestic product (GDP), and around $27 per hectare of forestland. Industrial wood production has increased from 3 percent of the world's total production in the 1960s to nearly 13 percent by 2017 (FAOSTAT 2019). Most of this increase occurred in three countries: Brazil, Chile, and Uruguay.

	Output[1] (1000 m³)	Rent[2] (percentage of GDP)	Rent		Total[1] forest area (1000 ha)	Planted[1] forest area (1000 ha)
			Million $	($/ha)		
Caribbean						
Aruba	-	0.00	$0.1	$216	0.4	0.0
Bahamas	17	0.02	$1.6	$3	515.0	0.0
Barbados	6	0.01	$0.6	$102	6.3	0.0
Cuba	611	0.09	$65.1	$20	3,200.0	556.0
Dominican Republic	55	0.06	$43.9	$22	1,983.0	119.0
Haiti	239	1.24	$98.9	$1,019	97.0	32.0
Jamaica	151	0.23	$32.0	$96	335.2	6.9
Trinidad and Tobago	167	0.06	$12.6	$54	234.5	11.2
Subtotal, Caribbean	**1,246**	**0.12**	**$254.9**	**$40**	**6,371.4**	**725.2**
Central America						
Belize	41	0.43	$6.8	$5	1,366.3	2.4
Costa Rica	1,223	1.18	$568.7	$206	2,756.0	17.6
El Salvador	682	0.94	$206.8	$780	265.0	16.2
Guatemala	654	1.23	$647.3	$183	3,540.0	185.0
Honduras	493	1.62	$331.8	$72	4,592.0	0.0
Mexico	7,955	0.16	$2,062.1	$31	66,040.0	87.0
Nicaragua	118	2.01	$250.9	$81	3,114.0	48.0
Panama	267	0.10	$46.9	$10	4,617.0	80.4
Subtotal, Central America	**11,432**	**0.28**	**$4,121.3**	**$48**	**86,290.3**	**436.6**
South America						
Argentina	12,682	0.08	$376.4	$14	27,112.0	1,202.0
Bolivia	953	0.47	$130.1	$2	54,764.0	26.0
Brazil	145,102	0.62	$14,056.3	$28	493,538.0	7,736.0
Chile	45,987	0.56	$1,521.3	$86	17,735.0	3,044.0
Colombia	2,729	0.18	$678.8	$12	58,501.7	70.9
Ecuador	2,440	0.36	$316.1	$25	12,547.9	55.2
French Guiana	84	--	$0.0	$0	8,130.0	0.7
Guyana	401	7.22	$215.6	$13	16,526.0	0.0
Paraguay	4,044	1.55	$559.6	$37	15,323.0	98.0
Peru	1,076	0.19	$370.8	$5	73,973.0	1,157.0
Suriname	860	1.73	$78.5	$5	15,332.0	13.0
Uruguay	13,330	1.60	$792.7	$430	1,845.0	1,062.0
Venezuela	1,317	--	$0.0	--	46,683.0	0.0
Subtotal, South America	**231,004**	**0.50**	**$19,096.1**	**$23**	**842,010.6**	**14,464.8**
Total Latin America	**243,683**	**0.43**	**$23,472.3**	**$25**	**934,672.3**	**15,626.6**

Table 1. Recent Industrial Wood Output, Forest Rents, Total Forest Area, and Planted Forest Area, by Country

[1]Data from FAO (2015). [2]Data from World Bank (2019).

The region produces industrial wood for export and domestic markets and accounts for 13 percent of the world's total industrial wood market (FAOSTAT 2019). Harvests of nonconiferous types represent the largest share of total production (62 percent) in the region. An important competitor region for nonconiferous tropical wood is Southeast Asia (Figure 1). Total industrial wood output has grown more rapidly in LAC than in Southeast Asia since the 1960s, but the competitive advantage that LAC enjoyed from the 1970s to the early 2000s appears to have eroded in the past 15 to 20 years (Figure 1). This shift may be related to China's growing demand for resources after the country entered the World Trade Organization (WTO) in 2001 and its proximity to Southeast Asia.

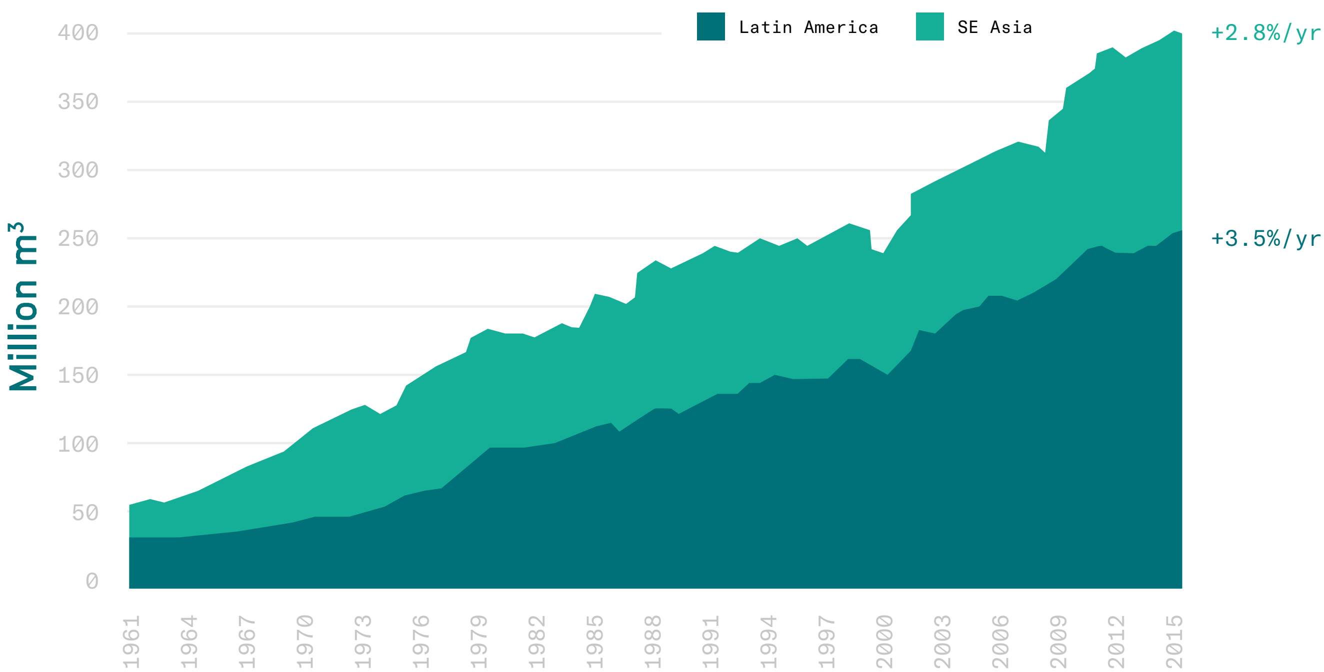

Figure 1. Industrial Wood Output in LAC and Southeast Asia, 1961-2015

Source: FAOSTAT (2019).

Brazil has experienced the largest absolute increase in industrial wood production of any country in the region over the past 50 years (Figure 2), with the strongest gains in nonconiferous timber. Industrial wood production increased 3.8 percent per year from 1960 to 2018, only slightly more slowly than Brazil's 3.9 percent per year increase in GDP over the same period (World Bank 2019). Economic growth in Brazil, the region's largest economy, has influenced growth in forest management, and it has undoubtedly had similar effects in other countries in the region.

Chile and Uruguay also experienced large increases in output and the largest proportional increases in industrial wood output (Figure 2). The increase in wood production from Chile began in the 1980s; Uruguay began to expand output significantly in the early 2000s. Whereas the expansion in output in Brazil is due to increased harvesting at both intensive (plantation) and extensive (natural forest) sites, the increased output in Chile and Uruguay is mostly related to expansion of timber plantations (Figure 3). Uruguay increased its area of planted forests from 200,000 hectares to more than a million hectares between 1990 and 2015, and Chile almost doubled its plantation area, from 1.7 million hectares to more than 3 million hectares, between 1990 and 2015.[1]

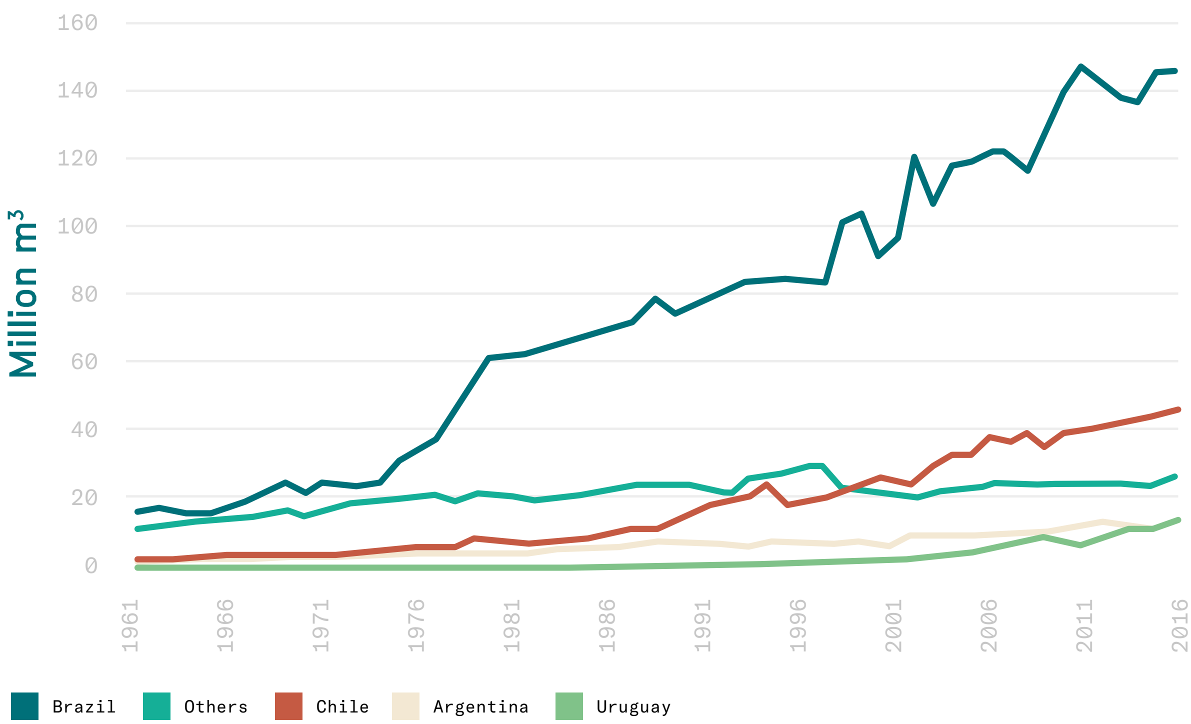

Figure 2. Industrial Wood Production in LAC, 1961-2016

Source: FAOSTAT (2019).

[1] This section focuses on the economic benefits of plantations; however, numerous concerns have been raised about plantations, including conversion of natural land, water use, and biodiversity. See Miranda et al. (2017) and Putz and Romero (2014) for a discussion of such issues. The role of plantations in capturing forest carbon has been positive over the past century (Mendelsohn and Sohngen 2019).

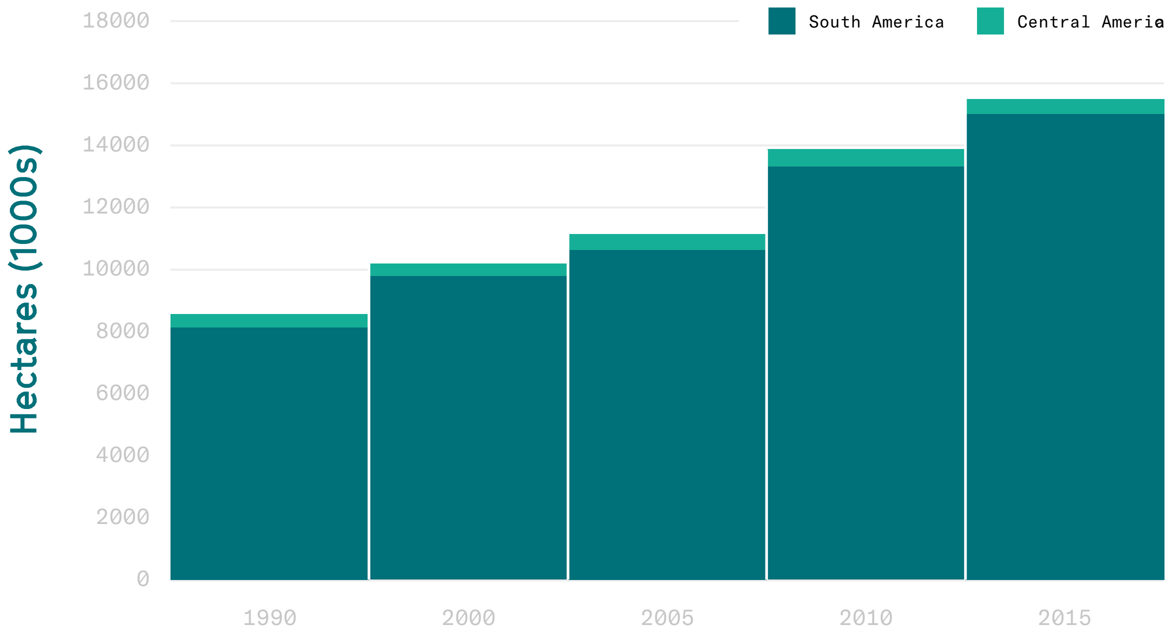

Figure 3. Area of Planted Forests in Central and South America, 1990–2015. Source: MacDicken et al. (2016).

As a result of large investments in plantations in Uruguay and Chile,[2] these countries' share of the region's total industrial wood production has increased from 1 percent and 13 percent in 1965 to 5 percent and 20 percent in 2015, respectively. At the same time, Brazil has increased industrial wood production and now accounts for nearly two thirds of all wood production in South America. Interestingly, as the area of plantations has expanded in South America, plantation area has contracted in Central America, according to MacDicken et al. (2016). Although plantation area has declined in Central America, teak plantations appear to still be profitable there (Kollert and Cherubini 2012) and may have encouraged an increase in wood products export value over the past 10 to 20 years.

One driver of the increase in plantation areas has been the long-term increase in prices for wood products. Figure 4 presents two long-term price series for US softwoods and hardwoods, both of which experienced a long period of upward price pressure.[3] US softwood prices, however, stabilized and even declined in real terms. Roundwood export prices for Latin America and the Caribbean fell in real terms from the 1960s to the early 2000s and then experienced a strong increase. Differential prices for coniferous and

[2] These investments included subsidies by governments whose goal was to create a larger wood products sector (see, e.g., Clapp 1995).

[3] US prices are used for comparison for three reasons. First, long-term data are readily available and published. Second, the United States represented a significant share of global demand for industrial wood over the time period considered. Third, even though the market for wood is global, the United States is the closest large demand center outside Latin America.

nonconiferous types have been reported by the United Nations Food and Agriculture Organization (FAO) and International Tropical Timber Organization only since 1990, and coniferous prices are shown from 1990 to 2016. They have fluctuated substantially over this time period, with no strong trend up or down.

An additional driver of the increase in plantation area has been the return to management (Cubbage et al. 2009; Sedjo 2015). Although plantations require significant upfront investments, these investments have typically paid off over time because of relatively rapid tree growth and the ability of managers to improve the value of the output. Plantations can also be co-located with processing facilities, helping to lower transportation costs. The economic value of plantations was described by Sedjo (2015) and further illustrated in Cubbage et al. (2010). Sohngen and Tian (2016) used these two studies to show that yields of pine and eucalypts in South American plantations increased 1.0 to 2.1 percent per year over a 20-year period. These rates of yield increase surpassed rates observed in other countries or regions.

As a result of this investment in plantations, the region has increased pulp production by 7 percent per year, a rate faster than the global average. Its pulp production rose from 2–3 percent of total global pulpwood production in the 1960s to nearly 20 percent in 2017. Much of this increase has come at the expense of output in the United States and Europe, both of which account for a smaller proportion of global output. Southeast Asia has increased production more rapidly but lags LAC in terms of total output.

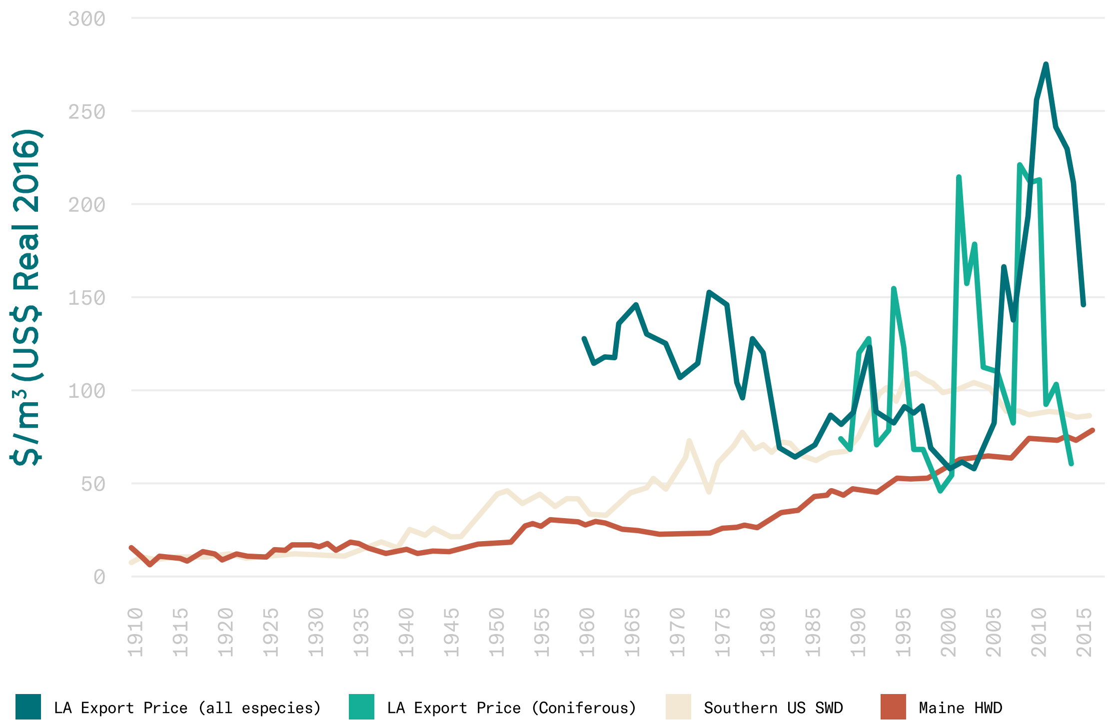

Figure 4. Prices for LAC Timber Exports, Southern US Softwood Stumpage, and Maine Hardwood Stumpage, 1910–2015

An increasing share of trade value from LAC has recently moved to China (Figure 5). In Brazil, the nominal value of wood products exported to China has increased 17 percent per year since the late 1990s, whereas the nominal value of wood products exported to other regions increased only 4.8 percent per year. Chile experienced similar changes, with the nominal value of exports to China increasing 11 percent per year but only 5 percent per year for exports to other regions. China now represents 30 percent of the value of exported forest products from Brazil and Chile, up from 3 percent in Brazil and 11 percent in Chile in 1997 (FAOSTAT 2019).

In summary, several important market factors have influenced industrial roundwood markets in Latin America. First are two demand factors: the increase in demand after China entered the WTO in 2001, and the bust in the US housing market after 2006. Second, continued investments in fast-growing plantations, as in Brazil, Chile, and Uruguay, have helped Chile and Uruguay in particular increase their industrial roundwood output. As output has expanded, exports have shifted from North America and Europe to China.

A factor that contributed to the expansion of plantations in Latin America and the Caribbean, as well as globally, has been the long-term increase in timber prices, a result of dwindling access to old-growth timber resources in many parts of the world. This price growth has moderated in the past 30 years, and renewable stocks of plantation forests now make up an increasingly large share of the global timber supply (Daigneault et al. 2008). We have entered a period when industrial wood production is renewable at the global level (Mendelsohn and Sohngen 2019).

The historical increases in timber prices that have characterized much of the past century may not continue, however. Slower price growth would affect profitability in timber plantations, where rising prices have encouraged expansion. This suggests that continued growth in plantation output will rely more and more on higher productivity—either by reducing costs or by increasing production—to maintain their economic viability. Efforts to reduce costs and increase production could have widespread benefits in the region, potentially spurring additional investments in countries that have not yet focused on plantations.

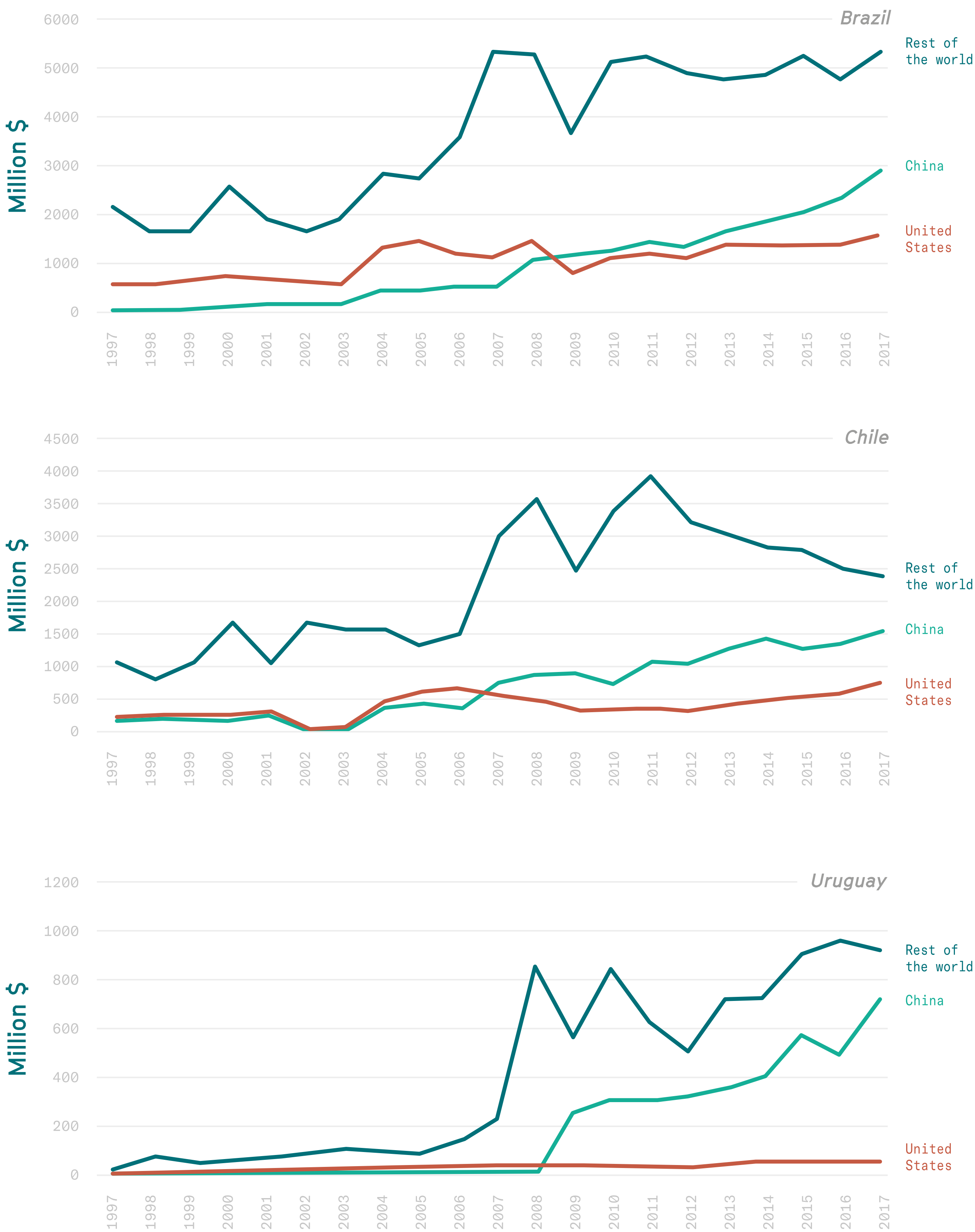

Figure 5a. Value of Forest Product Exports from Brazil, 1997-2017. Source: FAOSTAT (2019).

Figure 5b. Value of Forest Product Exports from Chile, 1997-2017. Source: FAOSTAT (2019).

Figure 5c. Value of Forest Product Exports from Uruguay, 1997-2017. Source: FAOSTAT (2019).

New Markets for Biomass Energy

Bioenergy demand, in the form of biofuels and wood fuel, has had a strong influence on land-related assets in recent years. This is especially true in wood markets, where some countries have explicit policy directives for using wood products to satisfy energy needs, under the assumption that wood is carbon neutral. It is useful to consider how expanded use of wood as an input into energy markets could affect regional wood markets. LAC biomass energy production is centered in three countries, Brazil, Uruguay, and Chile, because of their historical investments in forest plantations as well as pulpwood production. Black liquor, a by-product of the pulping process, can be used in energy production. Many large-scale pulp mills have on-site boilers and generators that burn wood waste to create energy. In recent years, a wider variety of wood inputs has been used to produce biomass energy in European markets. This market is starting to grow in Asia, and in particular in South Korea.

Brazil gets a large share of transportation fuels in the form of ethanol, but biomass use in the electricity sector has expanded and now provides about 9 percent of electricity production (BP 2019). The fuel input is largely waste product from ethanol production (bagasse, 17 percent of national energy production) and pulp production (black liquor, 6 percent) but also includes charcoal and wood in direct use (8 percent) (Energy Research Office 2018).

Another large wood products producer, Uruguay, has increased biomass energy production since the early 2000s to 18 percent of electricity production (MIEM 2017). Most of this increase in use comes from new boiler capacity installed to use black liquor residuals from the pulpwood industry. Pulpwood production has increased 14 percent per year in Uruguay since the early 2000s, providing a rich source of waste material for bioenergy production. As a result, by 2017, Uruguay had effectively eliminated the use of fuel oil as the marginal source of electricity production (MIEM 2017). Firewood and charcoal also remain relatively large sources of energy input, for both industry and households. Energy data from Uruguay, however, indicate increasing competition with a renewable source of energy, wind power.

In recent years, Chile also has experienced an increase in biomass energy production, which now amounts to about 3 percent of total electricity production (Ministerio de Energia 2018; Rodríguez-Monroy et al. 2018). As in Uruguay, the main inputs for biomass electricity production appear to be residues from pulpwood production (Rodríguez-Monroy et al. 2018), although there is potential for direct use of forest-based residuals in biomass energy production.

LAC biomass energy production is centered in three countries, Brazil, Uruguay, and Chile, because of their historical investments in forest plantations as well as pulpwood production.

One issue that will drive domestic consumption of wood material for electricity production is whether wood is considered carbon neutral (see review by Khanna et al. 2017)—a topic of considerable international discussion. The Intergovernmental Panel on Climate Change (IPCC) currently assumes that biomass used for electricity production is carbon neutral, and countries can thus use biomass electricity to help meet their nationally determined contributions to the Paris Climate Accord. The three countries discussed above all report electricity produced with biomass inputs as renewable, and hence carbon neutral.

Demand for biomass energy is increasing globally as well as domestically (Ireland 2018). The United States has developed a wood pellet export market, and exports of pellets to the European Union increased more than 70 percent from 2013 to 2017 (Ireland 2018). Global exports have increased more than 50 percent during the same time period (Ireland 2018), driven largely by demand in the European Union, especially the United Kingdom, as well as Denmark, Belgium, and South Korea. Latin America and the Caribbean have not participated significantly in these markets to date, with no large investments in wood pellet plants. However, as Schmid (2017) points out, countries with significant investments in plantations, Brazil in particular, have relatively low costs of production of pulpwood logs and thus could be in a position to attract investments in this area.

Advancement of biomass energy will depend on how the European Union, Asia, and the United States treat both domestic and imported biomass energy supplies. The European Union has been the largest consumer of wood pellets for bioenergy production, and although member countries may continue to advance biomass as a source of energy, they may or may not allow it to be imported. South Korea has also increased demand for biomass energy and is importing increasing quantities; policy in Asia could have important influence. If biomass energy is ultimately considered carbon neutral, a secondary factor will be competition from other renewable sources. Wind and solar costs have fallen dramatically in recent years, and these sources of electricity have grown substantially globally. Thus, the evolution of the levelized cost of energy for these sources will help determine demand for biomass wood energy.

Forest certification in Latin America and the Caribbean has lagged the rest of the world. At 1.5 to 1.6 percent of total forests, the proportion of forestland area under certification is also well behind the region's 13 percent share of industrial timber harvests globally.

Sustainable Forest Certification

Certification for sustainable forest management involves developing plans that reduce the impact of harvesting on forest ecosystems. The major certification groups—largely consumer-driven and voluntary initiatives—have expanded globally, according to FAO (MacDicken et al. 2016), to cover more than 415 million hectares, or around 12 percent of the world's forest area. FAO (2018) reports that 15 million hectares of LAC forestland is under sustainable forest management (Figure 6), which amounts 1.5 percent of the forest area in Central America and 1.6 percent of the forest area in South America.

The growth in forest certification in LAC may affect industrial wood harvests and other forest outcomes in the region. Two organizations that conduct certification globally are the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC). FAO (2015) reports data by country, but about 28 percent of the region's total certified area is certified by both organizations. Country-level data can be obtained from the individual organizations (FAO 2015) but are not shown here.

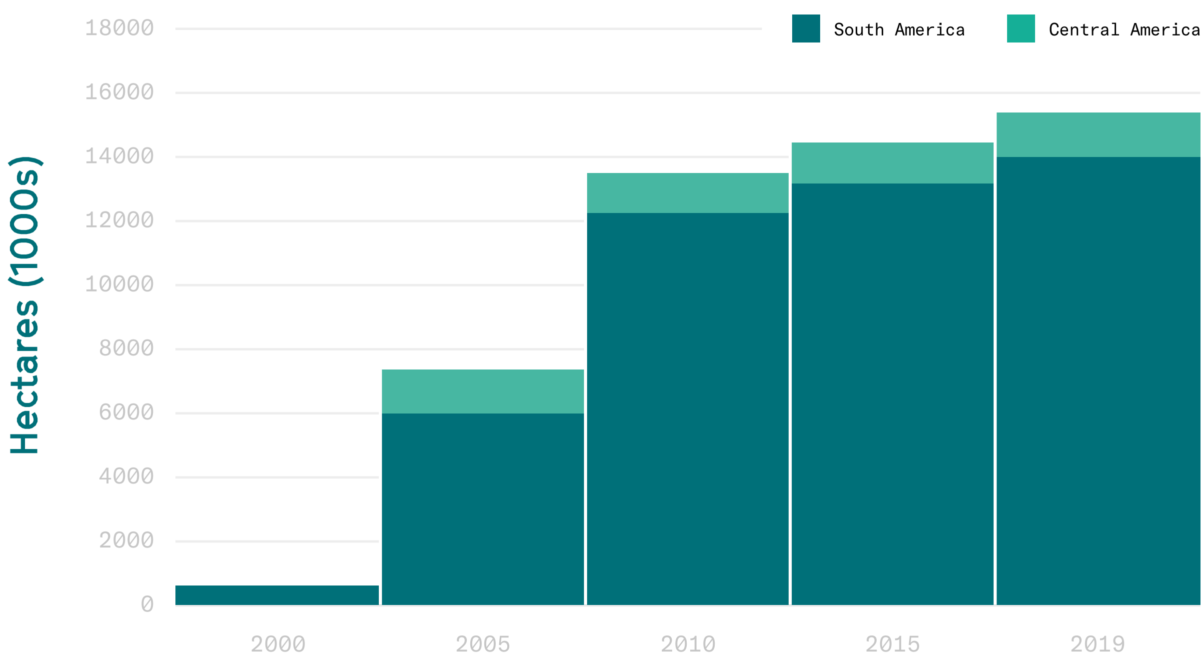

Figure 6. Area of FSC- or PEFC-certified forests in Latin America and Caribbean, 2000–2019

Sources: FAO (2018); MacDicken et al. (2016).

Forest certification programs began as voluntary efforts to encourage field forestry professionals to adopt less harmful harvesting practices. In some places, this could be mean reducing the size of clearcuts or eliminating them altogether; in other places it could mean reducing the amount of collateral damage caused by logging, such as minimizing the size of skid trails and landings and undertaking other practices to reduce biomass losses. To become certified, landowners need to develop plans that meet certain criteria, implement these management plans, and undergo audits by a certification group. Certification entails costs for developing the management plans, changing operations, documenting the results, and hiring auditors. Cubbage et al. (2009) estimated the costs in the Americas at $6.40 to $40 per hectare per year for small properties and $0.07 to $0.50 per hectare per year for larger properties.

Companies nevertheless may seek certification to receive two general benefits: market access and price premiums (Rametsteiner and Simula 2003; Siry et al. 2005). Current evidence suggests that market access is the more valuable benefit (Cubbage et al. 2009). With FSC certification, companies have access to a wider range of customers and markets that they otherwise would not have. Landowners who become part of a supply chain with chain-of-custody protocols, from raw material through processing into forest product, may benefit from stability in demand, particularly if they can become preferred suppliers. Price premiums for certified wood, however, have been found to be fairly modest at the landowner level. Willingness-to-pay studies have found premiums in the range of 5 to 40 percent (Yamamoto et al. 2014), but empirical evidence from markets suggests that the actual premium is smaller, in the 1 to 4 percent range, at least at the stumpage stage (Yamamoto et al. 2014). An earlier study by Kollert and Lagan (2007) found that certified tropical timber exported from Malaysia gained significant price advantages, of up to 57 percent; however, a review of studies by Blackman and Rivera (2011) did not find evidence of strong producer benefits from forest certification.

Forest certification in Latin America and the Caribbean has lagged the rest of the world. At 1.5 to 1.6 percent of total forests, the proportion of forestland area under certification is also well behind the region's 13 percent share of industrial timber harvests globally. Reasons for this difference include the distribution of property rights over forestland and the costs and benefits. Efforts to expand property rights could increase the area of land under certification in the next decade. For example, in the Maya Biosphere Reserve of Guatemala, forest-based concessions must be certified by FSC to gain the rights to manage forests and to maintain the concessions. This model may be fairly specific to the case of the concessions in the Maya Biosphere Reserve, but rights are an important precursor for investments in certification.

One factor that may contribute to additional certification efforts is climate change. Reduced-impact logging practices reduce carbon emissions caused by damage to unlogged tracts (Pearson et al. 2014). Because sustainable timber harvesting reduces forest carbon emissions from logging sites relative to other practices (e.g., Griscom et al. 2014; Nasi et al. 2011; Putz et al. 2012; Roopsind et al. 2018), more widespread implementation of these practices could provide long-term benefits to the atmosphere. Guyana's 2018 national forestry plan, for example, explicitly includes a goal to reduce carbon emissions by requiring large concession holders to use reduced-impact logging and obtain third-party verification. Methods have been approved by various voluntary carbon crediting systems to account for and verify the carbon gains associated with reduced-impact logging, suggesting that if the value of carbon sequestration increases, or if carbon markets expand, LAC countries may see more efforts to expand certification programs that promote reduced-impact logging. Although certification provides carbon benefits by reducing emissions from harvesting, the literature is not conclusive on whether certification increases carbon stocks by reducing deforestation (see Blackman et al. 2018; Blackman and Rivera 2011; Burivalova et al. 2019; Panlasigui et al. 2018).

As the area of land devoted to certification has increased, the amount of timber produced from certified land has also increased. *State of the World's Forests* (FAO 2018) indicates that in 2018, FSC forests worldwide accounted for harvests of 427 million cubic meters, and in 2016, FSC and PEFC forests together accounted for 689 million cubic meters, when adjusted for double counting. Despite requests for information, neither group would provide estimates of the amount of LAC harvests. Data from the Global Timber Model (see below) suggest that around 24 million cubic meters of timber is harvested per year from FSC and PEFC lands in the region, or 10 percent of its total harvest. This is based on assumptions about the distribution of land that is certified across plantations and managed forests.

Certification programs have apparently had no effect, positive or negative, on the global supply of wood. Sohngen et al. (1999) examined whether removing land from timber production would lower supplies; removing up to 46 million hectares of managed forests from markets caused prices to rise modestly. Although harvests were eliminated over some hectares, because a large number of hectares are not harvested currently and unlikely to be harvested in the near future, additional forestland elsewhere was harvested instead. This suggests that even if certification programs influence harvesting on certified forestland, they will likely have small effects on total harvests in part because of slippage, or leakage. As a result, increasingly widespread implementation of certification is unlikely to have large implications for timber prices.

Illegal Logging

Illegal logging—typically defined as unlicensed logging or logging that results from illegal land conversion and harvesting—remains a concern in the forest policy landscape. Illegal logging can have several consequences for society. It could exacerbate land-use change if it provides value for standing trees that otherwise are illegal to harvest. Alternatively, to the extent that illegally logged timber increases timber supply, it influences market prices. Lower market prices can have benefits if they improve consumer welfare, but lower prices can also harm society if they make conservation less profitable and more difficult (e.g., Putz et al. 2012). It is thus important to examine the data and literature on illegal logging to determine its potential scale and implications for timber markets in Latin America and the Caribbean.

Recent studies have suggested that illegal logging constitutes up to 50 percent of the total timber harvest in some areas (Hoare 2015). Kleinschmit et al. (2016) put illegal logging at 70 percent for Ecuador and 80 percent for Colombia, Bolivia, and Peru. Globally, 10 to 30 percent of the wood consumed may be illegally harvested (Hoare 2015; Kleinschmit et al. 2016; Nelleman 2012). Studies on illegal logging in Central America are lacking, but recent evidence has shown that up to 30 percent of deforestation in Central America results from efforts to launder money associated with other illegal activities, such as the drug trade (Sesnie et al. 2017). Because these are point estimates, it is difficult to determine the trend in illegal logging, although Hoare (2015) present data suggesting that the trend in imports of illegal logs in many countries declined from 2000 to 2013.

In 2006, Brazil began allocating timber production concessions on state-owned land. According to Azevedo-Ramos et al. (2015), between 2006 and 2015, around 460,000 hectares moved into timber concessions, or about 3 percent of the available public land. One reason for allowing timber concessions was to provide rights to the land in exchange for the allowance to harvest trees legally. Over the long run, such efforts should help reduce illegal logging, as long as the concessionaires have the right incentives to protect the resources they are managing. Concerns have been raised, however, about interactions between legal logging in concessions and illegal logging in areas not under concession (e.g., Merry and Amacher 2005). These concerns seem to be growing as evidence suggests that illegally harvested timber may enter markets through harvesting in timber concessions (Brancalion et al. 2018).

To empirically test the effects of logging regulation on markets, Chimeli and Boyd (2010) examined the mahogany ban in Brazil in the early 2000s. The ban was intended to reduce harvesting of mahogany by making it illegal, but

Chimeli and Boyd (2010) found the opposite effect: it increased the supply of mahogany and other tropical timbers. They suggested that costs may be lower in illegal markets because many bureaucratic steps are eliminated and economies of scale emerge.

Chimeli and Boyd (2010) do not explicitly trace the effects of illegal logging on market prices or deforestation, but they show the limitations of policy approaches to market regulation. That is, even though legal institutions were put in place to address illegal logging and protect the resource, timber appears to have been extracted anyway. This example also illustrates the complications inherent in efforts to exert property rights over environmental resources, such as standing forest stocks. Brazil's logging ban, without concomitant efforts to regulate other elements of the supply chain, was apparently unsuccessful.

Although illegal logging, as defined above, likely occurs at a relatively large scale in LAC countries, according to the various reports discussed above, this study could find no evidence in the literature that it has large consequences for markets or land-use change. Broader control efforts throughout the supply chain would be needed to influence harvesting of ecologically important species in the region.

Property Rights, Community Management, and Land-Use Change

In recent decades, land-use change in some parts of Latin America and the Caribbean has slowed (e.g., Nepstad et al. 2014). The numerous explanations include property rights (e.g., Alix-Garcia 2007; Alix-Garcia et al. 2005; Blackman 2015; Deininger and Minten 2002, 1999; Fortmann et al. 2017), establishment of parks, programs that provide payments for ecosystem services (PES) (e.g., Alix-Garcia et al. 2012; Robalino and Pfaff 2013; Sims and Alix-Garcia 2017), broader implementation of existing regulations, and forest and agricultural supply chain management (Nepstad et al. 2014). The reduction in deforestation in Brazil between 2004 and 2010, from more than 2 million hectares per year to around 0.5 million hectares, is associated with policy actions undertaken by the government, primarily stronger law enforcement, according to studies using statistical methods (Arima et al. 2014; Assunção et al. 2019; Hargrave and Kis-Katos 2013).

According to the Rights and Resources Initiative (RRI 2018), from 2002 to 2017, the area of LAC forests under community management increased by 105 million hectares, with 291 million hectares under community management (of some sort) in 2017. The rate of increase in the area of community management, however, slowed between 2012 and 2017, from a pace of 8 million hectares per year to less than 4 million hectares.

An important question is whether community management can deliver conservation benefits as well as community benefits. Systematic reviews of earlier efforts at community management programs around the world suggest that this approach has been successful in reducing deforestation or at least increasing forest density, although the reviews also note that the earlier approaches were methodologically deficient (Bowler et al. 2012; Pagdee et al. 2006; Samii et al. 2014). Similarly, Robinson et al. (2014) found that property rights tended to reduce deforestation and improve forest outcomes. A more recent systematic review by Ojanen et al. (2017) finds less evidence that communal or private property rights are better than state control; however, that study missed several influential publications from Mexico and a recent analysis conducted in Guatemala. These studies have largely suggested that community management has successfully reduced deforestation (e.g., Alix-Garcia 2007; Alix-Garcia et al. 2005; Blackman 2015; Deininger and Minten 2002, 1999; Fortmann et al. 2017).

Another question is the role of certification in the distribution of property rights. In the Maya Biosphere Reserve in Guatemala, FSC certification and sustainable management are prerequisites for community access to forests. Not all of the communities have managed to maintain their certification status, and thus have lost their forest concessions, but over most of the areas in reserve where forests are available for community management, the communities have increased income and reduced deforestation (e.g., Blackman 2015; Bocci et al. 2018; Fortmann et al. 2017). In Guatemala, timber production remains the major income source for most communities; however, they also harvest nontimber forest products, such as *xate* (Bocci et al. 2018, Bocci 2019).

Communities in Brazil, which has 111 million hectares devoted to community management, harvest a wide range of both timber and nontimber forest products (Piketty et al. 2015). Angelo et al. (2016) suggest that certified timber harvests can improve the profitability of community management operations and potentially encouraging more communities to pursue certification. Similarly, in Bolivia, Ecuador, Peru, and Guyana, the role of community forests has increased, with attention paid to harvesting both timber and nontimber forest products (Gretzinger 2016).

The trend toward increased community ownership and/or management of LAC forest resources has continued in recent years, although data suggest that the annual increase in hectares under community management has slowed. There is growing evidence that community management can improve environmental outcomes, most notably by reducing deforestation or increasing forest densities. Evidence, from a smaller selection of locations, that it improves livelihoods is more limited. No studies appear to have assessed whether community forest management increases or decreases outputs in timber and nontimber forest products.

Nontimber Forest Products

Nontimber forest products represent an important ecosystem service. These products potentially provide an income stream that can sustain standing forests, particularly in Latin America and the Caribbean (e.g., Grimes et al. 1994; Peters et al. 1989), but whether the development and conservation goals of nontimber forest product harvesting can achieve equitable outcomes for the environment and for people is less certain (Arnold and Pérez 2001). A review by Stanley et al. (2012) finds that most nontimber forest product harvesting is largely sustainable from the ecology perspective—that is, examples where such harvests have degraded the forest resource are few; however, timber and nontimber forest products may not be complementary (Rist et al. 2012). Stanley et al. (2012) also find that in most areas with nontimber forest product harvesting, incomes exceed poverty thresholds, but the authors do not find that nontimber forest products alleviate poverty or improve tenure rights.

FAO (2018) reports that LAC's nontimber forest products account for about $3.6 billion in annual revenue. This relatively robust revenue stream, however, has not been documented over time. Similarly, no readily available data summarize the annual production of nontimber forest products, comparable to the FAO data on industrial wood products, so it is difficult to assess trends in production as well. FAO does keep statistics on one important nontimber forest product, rubber, which is harvested in Brazil and Bolivia. Shackleton and Pandey (2014) note that the lack of information on nontimber forest products is a problem for market development and sustainability.

Bolivia is the largest exporter of Brazil nuts, and exports have shown continued growth since 2005 (Figure 7a). Peru has also increased exports in recent years, while exports from Brazil have fallen. According to the International Nut and Dried Fruit Council (2019), Brazil nut production in 2017–2018 was down significantly because of environmental factors, although it bounced back in 2018–2019. This reduction in harvesting was largely due to dry conditions in the Amazon Basin. The data in Figure 7a predate this reduction.

Guatemala's exports of foliage for floral arrangements declined after 2007. Although data from community concessions in the Maya Biosphere Reserve suggest that harvests declined modestly after 2009 (CONAP 2018), they did not decline enough to explain the large reduction in exports in Figure 7b. Discussions with local experts suggest that after new regulations on xate were issued for the Maya Biosphere Reserve, the amount of illegal *xate* imported from Belize declined. This likely explains the relatively large reduction in *xate* exports from Guatemala after 2009, while production has remained higher.

International trade statistics are available for categories that cover some nontimber forest products: HS 80122 (brazil nuts, fresh or dried, shelled) and HS 604 (foliage, branches and other parts of plants, without flowers or flower buds, and grasses, mosses and lichens, being goods of a kind suitable for bouquets or for ornamental purposes, fresh, dried, dyed). This second category captures products like *xate*, which is widely used in floral arrangements and harvested in tropical forests in Central America in particular. Figures 7a and 7b illustrate trends in exports of these two product lines.

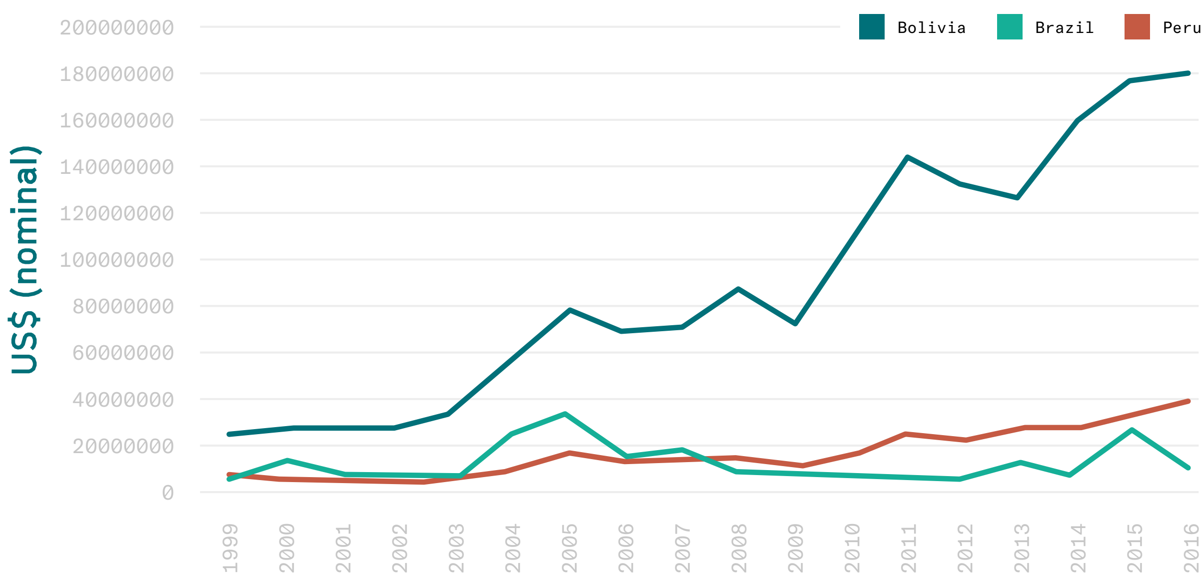

Figure 7a. Value of Exports of Brazil Nuts, 1999–2016

Source: Data from WTO.

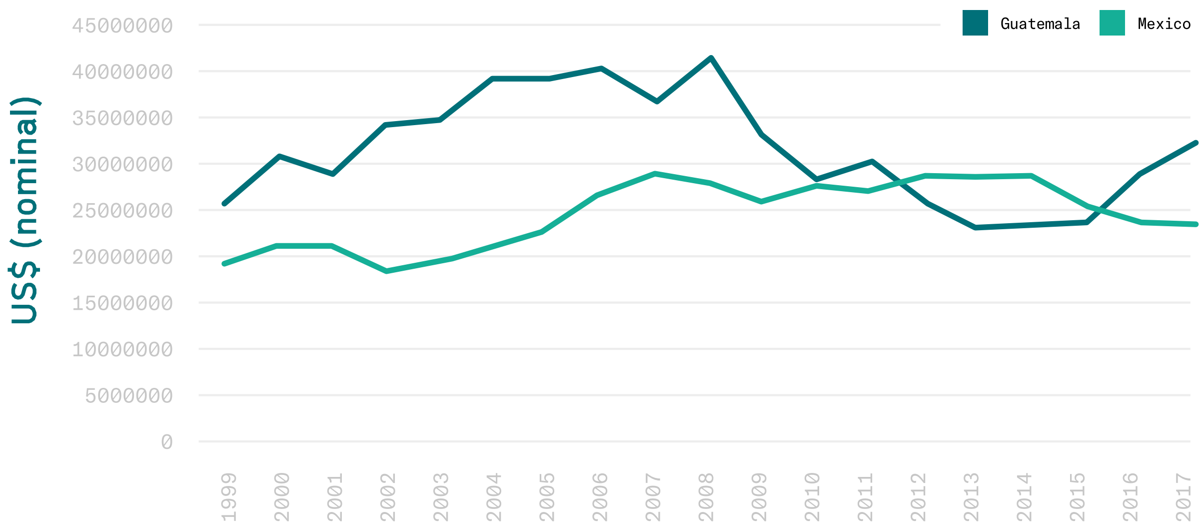

Figure 7b. Value of Exports of Foliage for Floral Arrangements, 1999–2017

Source: Data from WTO.

Natural rubber is produced in South America, mainly in Brazil and Bolivia (Figure 8). Although natural rubber was a major output from Brazil early in the 20th century, particularly as the automobile industry grew, Brazilian production waned after a fungus infected older trees, alternative synthetic sources were developed, and plantations were established in Southeast Asia (Lieberei 2007). Rubber production has increased in Brazil since the early 1990s, most of it as an extensive operation of rubber tappers working on forest concessions, largely in the state of Acre.

Gretzinger (2016) describes widespread accommodation for harvesting nontimber forest products on concessions and state-owned land throughout the American tropics. One conclusion from his analysis is that nontimber forest product harvesting, though important, is not a sufficiently strong economic driver to protect land. He argues that in closed forests, timber harvesting remains a major contributor to income. The data presented in Stults (2018), Bocci et al. (2018), and Bocci (2019) for the Maya Biosphere Reserve suggest that in Guatemala, the primary driver of income growth in concessions relates to timber harvesting, with timber harvests amounting to 67 percent of income in long-inhabited concessions and more than 90 percent in the uninhabited concessions. Piketty et al. (2015), however, provide data for concessions in Brazil suggesting that timber is only a small part of income. Data from (Guariguata et al. 2017) suggest a wide range of outcomes across communities or groups involved in harvesting Brazil nuts in Bolivia, Peru, and Brazil. Some groups derive up to 70 percent of their forest-based income from Brazil nuts, while other groups receive only 20 to 30 percent. One explanation for the differences likely arises from market access, with concessions in Guatemala having better market access for all products, including timber.

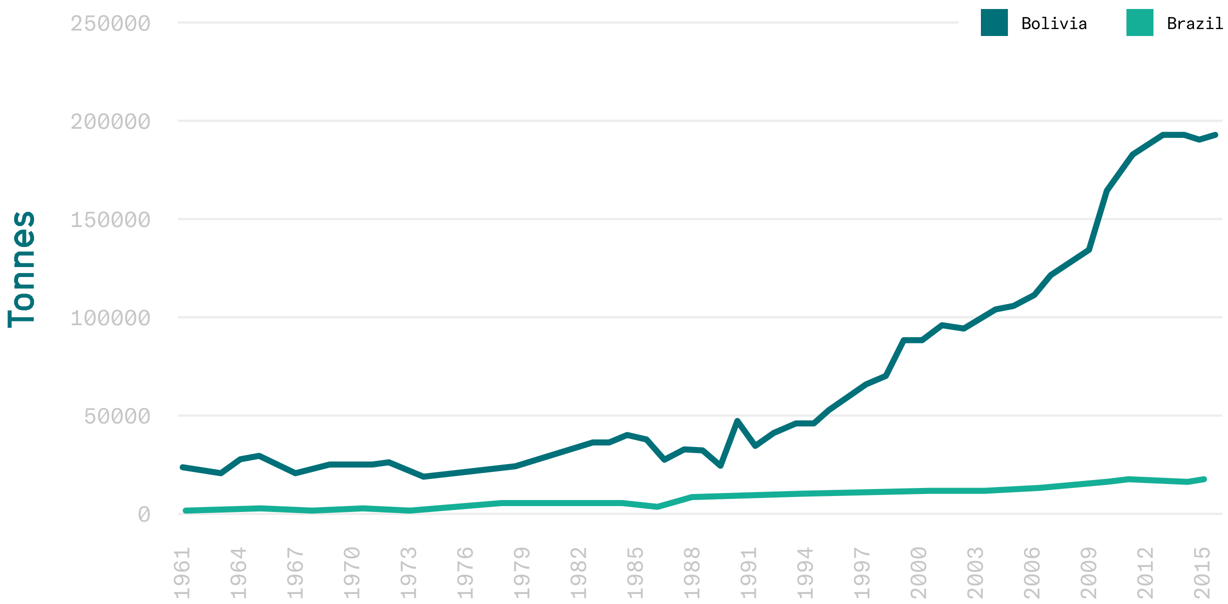

Figure 8. Natural Rubber Production, 1964-2017

Source: FAOSTAT (2019).

Peters et al. (1989) suggested that output from nontimber forest products substantially raised the value of tropical forests, and that attention to non-timber forest product markets could increase the value of standing forests and reduce their likelihood of being logged or deforested. Since that research appeared, substantial efforts have been undertaken to protect LAC forests by facilitating harvesting of nontimber forest products (see Gretzinger 2016 and Guariguata et al. 2017). Data from FAO suggest that at least one product, rubber, has seen increased production in Brazil. Another product, Brazil nuts, has been promoted as a source of protein, and annual production is now monitored by an industry group (International Nut and Dried Fruit Council 2019). *Xate* is locally important in parts of Central America and an important source of income for many communities that manage forest concessions.

Climate Change and Carbon

Climate change affects forests in Latin America and the Caribbean in two ways. First, climate change itself will directly affect forested resources, changing patterns of growth, forest dieback from fires or pest infestations, and perhaps even ecosystem boundaries. Second, the productivity of other land-use activities, such as agricultural production, could cause an expansion or contraction in the overall area of forests and agricultural uses; whether that means more deforestation or less depends on relative changes in productivity. Such shifts, of course, could have numerous secondary consequences for other ecosystem services that forests provide, such as water cycles, wildlife habitat, and carbon storage. Aside from the direct and indirect effects of climate change, using forests as a sink for storing carbon, thus sequestering it from the atmosphere, has attracted global interest. More carbon in forests equals less carbon in the atmosphere, and LAC countries' large existing carbon sink could be maintained or even increased. This section examines these two issues and their potential implications for industrial wood markets.

Among the threats to industrial wood markets, climate change could cause large-scale drought and dieback in the Amazon Basin. Although the 2013 Working Group II report of the IPCC synthesized analyses and data suggesting that the likelihood of this is small during this century (IPCC 2014), it did foresee possible drying in the eastern Amazon forest, with fires and other local disturbances that could degrade forests and carbon stocks. Research since then has confirmed some of these concerns, in particular the role of fire (e.g., Anderson et al. 2018; Le Page et al. 2017).

Two studies using a global model with LAC regional representation have examined the effect of climate change on timber markets (Favero et al. 2018a; Tian et al. 2016). Climate change, they find, will generally increase wood production in the next 20 to 30 years, with potentially small to negative effects in the longer run (Tian et al. 2016). Although dieback and disturbance are predicted to increase in Brazil and other parts of South and Central America, net primary productivity rises, leading to greater overall forest biomass in the region and higher timber production. Over the longer run, between 100 and 200 years, Favero et al. (2018a) suggest that output could decline as forestland area in the Amazon Basin declines because of climate change, and forestry becomes more productive in the temperate and boreal regions.

Climate change's effects on tropical forests and plantation species need to be considered separately. Forest plantations are more susceptible to price effects than to changes in productivity or dieback. Recent studies using dynamic global vegetation models to simulate effects on forest stocks and growth suggest that forest growth and stocks will likely increase (Kim et al. 2017; Stocker et al. 2013), and forest plantations in the tropics will therefore face lower prices and diminished profitability. Tian et al. (2016) show that this leads to a reduction in plantation area in Central America but no change in South America. Output from plantations increases, however, because plantation species are well suited to take advantage of carbon fertilization, warmer temperatures, and higher precipitation. The effects as determined by Tian et al. (2016) are most positive in Brazil; the rest of South America and Central America experience smaller gains.

Countries in Latin America have an important role in climate mitigation, given both their historically important contribution to global carbon emissions through deforestation and their leadership in the international discussion over reductions in emissions from deforestation and degradation–plus (REDD+). Some countries have specifically identified the role for forests in their nationally determined contributions for the Paris Climate Accord. Brazil, for instance, aims to reduce its 2005 carbon dioxide (CO2) emissions by 37 percent by 2025 through reductions in all sectors of the economy, including land use. In particular, Brazil will reduce land-use change and carbon losses from the Amazon Basin by continuing to implement and enforce rules and regulations that have already reduced deforestation since 2004. Chile has likewise focused on reducing carbon intensity measured across the entire economy, but it has also proposed reforesting 100,000 hectares of native forest. Uruguay proposes to maintain current natural and plantation forest areas and to potentially increase natural forests under its conditional measures. Interestingly, none of the countries explicitly mention increasing the area of exotic plantations (the types that have seen the largest gains in recent years) for carbon storage.

How industrial roundwood production and carbon sequestration in forests interact is unclear. Mendelsohn and Sohngen (2019), assessing the historical contribution of forests to global carbon emissions, point out that despite the relatively large emissions of carbon due to deforestation between 1900 and 2010 (130 Pg C), forests actually stored more carbon in 2010 than in 1900. Their results show that although carbon fertilization is important, nearly as much of this carbon gain is due to forest management for timber markets. As industrial wood demand grew throughout the 20th century, declining stocks of old-growth forests and rising prices encouraged forest investments that helped offset a large share of the carbon emissions. Despite the loss of more than 800 million hectares of forestland to other uses, mainly agriculture, the stock of carbon in forests expanded. These results suggest that the factors that encourage timber harvesting, and specifically investments in forests, likely also increase carbon storage.

Estimates of the change in industrial wood harvesting, tropical timber harvesting, and forest area by 2030 from an analysis by Baker et al. (2019) are presented in Table 2 for a scenario that includes carbon pricing. Carbon markets in this case lead to modest increases in wood harvesting in Brazil, largely because investments in timber plantations increase. Under this scenario, it is economically advantageous to reduce harvesting of tropical timber and set aside those forests from timber production in favor of payments for carbon sequestration. Forest area increases by 1.3 percent in Brazil, 6.5 percent in the rest of South America and 3.1 percent in Central America. The scenario assumes strong property rights, a willingness of governments to exert property rights over carbon that is stored in forests, and the ability of governments to pay individuals with tenure to maintain carbon stocks.

The carbon price is assumed to be $36 per ton CO_2 in 2015, rising at 3 percent per year.

	Brazil	Rest of South America	Central America
Industrial wood harvests	+7.0%	–33%	–3.5%
Tropical timber harvests	–5.9%	–100%	–73%
Forest area	+1.3%	+6.5%	+3.1%

Table 2. Projected Change by 2030 with Carbon Pricing through Markets

Source: Data from Baker et al. (2019).

Source: Photo by Vala E. 2016. Unsplash, Consulted 2020.

Future Timber Supply Potential

This section uses the Global Timber Model (Sohngen et al. 1999; Daigneault et al. 2008; Tian et al. 2018) to examine how alternative assumptions about forest sector policies or inputs, following the issues discussed above, may affect future timber output in Latin America and the Caribbean. The main output evaluated by the model is industrial wood output, but projections are also made for total forest area, planted forest area, management inputs, and carbon stocks. The analysis can give policymakers some insights into how various policy levers influence trends in forest area, forest investments, and carbon stocks.

Global Timber Model

The Global Timber Model has been widely used for policy analysis, is widely published, and has been widely cited in the literature. It evolved from the Timber Supply Model (see Sedjo and Lyon 2015) and was updated and expanded in 1999 by Sohngen et al. (1999) to consider forest conservation issues. Sohngen and Mendelsohn (2003) were the first to integrate a forestry model with a global integrated assessment model to assess whether forest carbon sequestration options—afforestation, avoided deforestation, forest conservation, longer rotations, and improved management—were an efficient climate change mitigation strategy. Kindermann et al. (2008) updated that analysis and developed marginal abatement cost curves for avoided deforestation in LAC and other tropical regions, and Favero et al. (2018b) integrated albedo to develop the first estimates of how albedo influences forest carbon sequestration globally. Daigneault et al. (2008) conducted timber market analysis and examined how exchange rates influence timber output. Tian et al. (2018) examined how market and climate factors could influence future carbon sequestration in the United States. Baker et al. (2018), Daigneault et al. (2012), Favero et al. (2017), Favero and Mendelsohn (2014), and Kim et al. (2018) used the model to analyze the effect of biomass energy demand. The model also has been used to consider climate change effects on timber production (e.g., Favero et al. 2018a; Sohngen et al. 2001; Tian et al. 2016, 2018).

Here, the model is used in novel ways to assess long-term trends in timber harvests, forest area, and timber and carbon stocks under various policy levers. It is a dynamic optimization model that runs in 10-year time steps and solves for a 200-year period. Results are shown through 2065. The optimization routines maximize the present value of consumer plus producer surplus using a 5 percent discount rate. The model assumes heterogeneous products, modeling demand for sawtimber and pulpwood separately. More than 250 forested land classes from around the world are included in the model, ranging from fast-growing plantation types and moderately managed forests to completely unmanaged forests. The plantation types include a fast-growing eucalyptus with a 10-year rotation period and a fast-growing softwood, modeled on southern or radiata pine, depending on the region, with a 20- to 30-year rotation.

One limitation is that the model does not keep track of country-level inventories, except for Brazil, so it cannot be used to provide country-level analysis. Accordingly, this analysis is provided for Brazil, the rest of South America, and Central America separately. To conduct long-term optimization efficiently, the model does not disaggregate demand by region or keep track of trade flows.

Forests in each land class supply the global wood market. Costs of management include the costs of planting, which range from $0 per hectare in unmanaged forests to more than $1,000 per hectare in intensively managed plantation forests. Costs are determined endogenously, depending on timber prices, costs of extracting, and costs of managing. Costs of extracting including the harvest costs and the transportation costs to get the cut wood to a mill. Also included are quality adjustment factors that affect the value of wood on the global market. For a full description of the model, see Kim et al. (2018) and Tian et al. (2018), and for the model code, see Tian et al. (2018).

Scenarios

In the baseline, GDP rises from $10,217 per capita in 2015 to $33,531 in 2065 (Figure 9). In the high-demand scenario, GDP rises to $56,634 per capita. Income elasticity in the model is 0.85, suggesting that increases in income have strong effects on demand. Population is assumed to rise from 7.3 billion in 2015 to 9.5 billion in 2065. Since the demand for wood is derived from the industrial production of wood in mills, a technical change coefficient in the demand function was included to slow the growth of demand over time. Under the technical change assumptions in our model, this means that by 2065, it takes only 60 percent as much industrial raw material wood input to create the same output as in 2015.

The baseline model projects that sawtimber prices rise at a rate of 0.9 percent per year from 2015 to 2065 (Figure 10). This is a slower pace of price increases than that observed over the past century but faster than that since

1980. LAC export prices fell from the 1960s through the 1990s but then rose sharply in the 2000s as demand in China grew (see above). Pulpwood prices are projected to rise modestly over the coming decades because production of pulpwood material can use a wider variety of wood inputs than can sawtimber. Globally, wood production is projected to rise 34 percent by 2065, with an increased share, 18 percent, coming from LAC countries. Globally, the relative proportion of sawnwood to pulpwood is projected to remain about the same in 2065 as in 2020, 60 percent sawnwood and 40 percent pulpwood. LAC's proportion of sawnwood is projected to fall modestly over time, from 51 to 47 percent of total wood production by 2065.

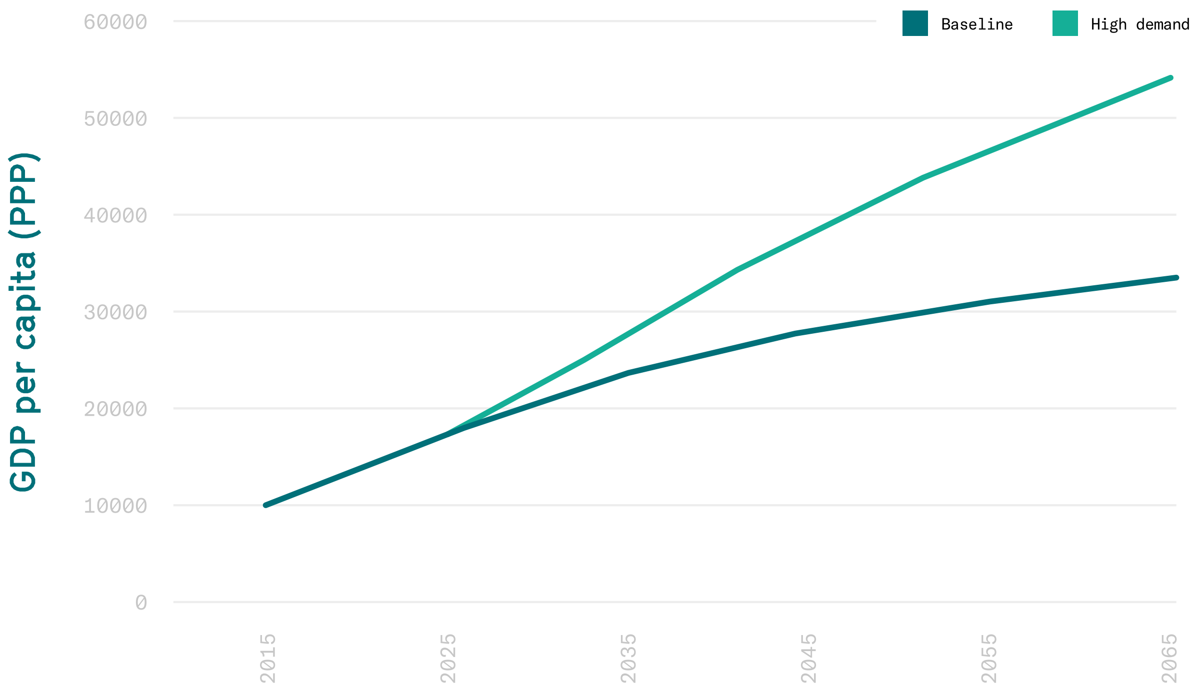

Figure 9. Projected GDP per Capita under Baseline and High-Demand Scenarios, 2015–2065

Outputs in Latin America and the Caribbean are projected to rise from 210 million cubic meters per year to 300 million cubic meters per year by 2065. This represents a slowdown in the growth of wood product production in the region relative to growth in the previous 50 years, but it is consistent with the projection of slower growth in wood consumption globally.

Scenario analysis is conducted to assess how output in the region may be affected by alternative assumptions about the future—issues that could affect output from LAC forests, and in particular the issues discussed in the preceding section:

1. **increased demand for all wood;**
2. **reduced global demand for pulpwood;**
3. **rising costs of intensive management in fast-growing plantations;**
4. **falling currency values;**
5. **stopping of deforestation;**
6. **mandated FSC or PEFC certification; and**
7. **carbon sequestration.**

Scenario 1, increased demand for all wood, assumes an increase in income per capita, as shown in Figure 10. Income growth in the first decade is the same as in the baseline, then quickens beyond 2025. Scenario 2 assumes that demand for pulpwood grows more slowly than in the baseline, such that demand for pulpwood by 2065 is 30 percent lower than demand for the pulpwood in the baseline. Scenario 3 increases the costs of managing fast-growing plantations. This is done by reducing the exogenous assumptions about increases in yields for LAC plantation types and by reducing the elasticity of management intensity. The elasticity parameter is used to shift yields as a function of the amount of investment in forests.

Scenario 4 considers currency fluctuations and assumes that LAC currencies are devalued 30 percent relative to the baseline. Following Daigneault et al. (2008), this is implemented as a 30 percent reduction in the costs of managing forests in the LAC region relative to other places. Scenario 5 assumes that LAC countries focus on policies to stop deforestation. It is implemented only in regions that are assumed in the model to be economically inaccessible—that is, regions that to date have lacked long-term timber management. Scenario 6 assumes that FSC or PEFC certification is mandated on all managed (nonplantation) land and that this raises costs of management by 10 percent. The model does not distinguish between certified and uncertified lands in the baseline, so this scenario is implemented by assuming that the mandate for all managed forests increases costs by 10 percent.[4] Finally, scenario 7 examines what happens under carbon sequestration, with carbon

[4] Although the current costs of certification in the region are not likely 10 percent (Cubbage et al. 2009), the hectares currently enrolled are likely low-cost alternatives. This scenario assumes that all hectares where timber is harvested are enrolled and that the government requires it, thus raising costs substantially at the margin.

prices starting at $35 per ton CO_2 and rising by 3 percent per year. Although significantly higher than the current market price for carbon, this price path approximates estimates of the social cost of carbon from Nordhaus (2017). In this scenario, the world implements stringent carbon policies globally, in all regions.

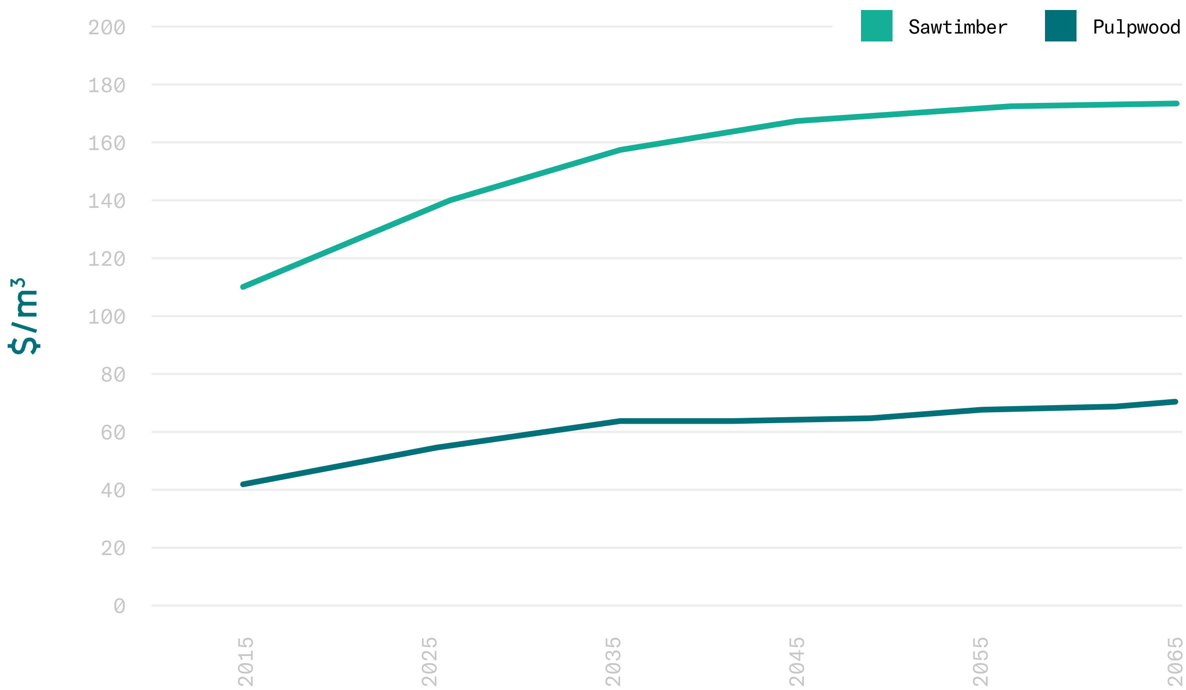

Figure 10. Baseline Scenario: Projected Global Timber Prices for Sawtimber and Pulpwood, 2015-2065

Results

The largest shifts in timber production occur in the currency (4) and carbon sequestration (7) scenarios (Table 3). The currency scenario assumes a strong 30 percent reduction in the value of LAC currencies and holds those changes into the future. This means that the effective costs of managing and harvesting forests in the region decline by 30 percent relative to the rest of the world. This size change is plausible, at least in the near term, given historical data presented in Daigneault et al. (2008) that illustrate a more than 50 percent decline in LAC currency values after the oil and financial crises of the 1970s and again after the financial crisis of the late 1990s. Interestingly, however, falling currency values have stronger effects on sawtimber production than pulpwood production in absolute terms, and even lead to reductions in pulpwood production in Latin America and the Caribbean. This is perhaps surprising, but it indicates a shift in capital and other resources from plantations to more valuable hardwoods during a currency devaluation. Thus, even though a currency devaluation can improve the competitiveness of many industries, in some parts of the region it reduces the competitiveness of the pulpwood sector.

The carbon sequestration scenario leads to significant reductions in timber harvests throughout Latin America and the Caribbean. The carbon prices used in the scenario are high compared with actual carbon prices ($2 to $10 per ton CO2) for carbon projects in the region. Given the potential damages from climate change, however, these prices are realistic if global policies become binding in the future. The results indicate that timber production would decline substantially in the region if carbon stocks were maintained in standing forests. There would be modestly stronger effects in sawtimber production, except in Central America.

Higher global demand for all wood products increases timber production throughout the LAC region. Because the largest effects of higher demand occur in 2050–2070, the largest effects on timber production occur after 2050. The near-term effects are modest, given no change in demand in the scenario over the next decade. The reduction in pulpwood demand has predictable effects—it reduces pulpwood production in the region—but also encourages a slight increase in sawtimber production. The increase in costs for plantation management lower production of both sawtimber and pulpwood but have larger effects on pulpwood. This result occurs because the main source of pulpwood material is plantations, whereas sawtimber is sourced from other managed and unmanaged inaccessible forests. The effects are stronger in the rest of South America and Central America than in Brazil because plantations in those regions are assumed to have slower rates of technological improvement in the baseline and thus are more heavily affected by rising costs.

The stop-deforestation case, interestingly, reduces pulpwood output but increases sawtimber output. This result is perhaps surprising but has an explanation: a relatively small amount of timber comes from deforestation activities in the region, and if that timber is eliminated from markets (because deforestation is eliminated), then markets will use more material from plantations in sawlog markets and less in pulpwood markets. Mandating certification, and hence increasing costs, causes output for sawtimber and pulpwood in Brazil to fall. In the rest of South America and Central America, only sawtimber outputs fall; pulpwood outputs increase, albeit modestly. This imposes a 10 percent increase in costs across 144 million hectares in the region and on 33 percent of the timber production, so it is somewhat surprising it does not have a stronger effect. However, as noted, these costs are imposed only on managed nonplantation forests, and so production shifts toward plantations.

	Baseline	Increased global demand	Reduced pulpwood demand	High plantation cost	Falling currency	Stop-deforestation	Mandated certification	Carbon sequestration
	Million m³/yr	Percentage change						
Brazil								
Sawtimber								
2030	62.0	1.5%	0.4%	-1.8%	25.9%	0.0%	-1.6%	-34.2%
2050	75.5	11.6%	0.4%	-2.5%	27.5%	0.1%	-1.4%	-23.9%
Pulpwood								
2030	87.6	-0.4%	-10.1%	-8.2%	14.9%	-2.3%	-11.5%	-43.6%
2050	108.6	17.6%	-13.8%	-9.8%	7.4%	-0.8%	-7.1%	-16.2%
Rest of South America								
Sawtimber								
2030	44.0	0.8%	0.6%	0.0%	20.4%	3.6%	-0.5%	-74.4%
2050	50.2	6.4%	1.2%	-0.2%	20.8%	3.2%	-0.5%	-68.1%
Pulpwood								
2030	37.5	0.7%	-5.8%	-19.5%	-14.7%	-0.7%	0.2%	-17.4%
2050	43.6	3.6%	-12.2%	-36.2%	-11.0%	-1.1%	0.7%	-10.0%
Central America								
Sawtimber								
2030	10.0	1.6%	1.9%	0.2%	24.4%	0.2%	-1.7%	-37.9%
2050	12.1	10.6%	2.2%	-1.6%	23.5%	0.4%	-0.4%	-22.5%
Pulpwood								
2030	2.3	1.8%	-20.6%	-32.1%	-91.2%	-2.9%	6.1%	-32.6%
2050	2.0	6.4%	-43.3%	-54.9%	-100.0%	-8.7%	1.9%	69.8%

Table 3. Sawtimber and Pulpwood Output and Percentage Change Relative to Baseline, 2030 and 2050

Similarly to the changes in timber production, the largest shift in timberland area occurs under the carbon sequestration scenario (Table 4). This scenario incentivizes maintaining the standing stock of forests and, given the high prices for carbon, encourages a cessation in deforestation and an increase in total forest area through reforestation. There are more than 100 million additional hectares in forests in Brazil by 2050 under the carbon sequestration scenario, 42 million in the rest of South America, and 9 million in Central America. Plantation areas also expand. Output on the plantations expands substantially, but not enough to offset the reductions in harvesting that occur on other natural and managed forests.

	Baseline	Increased global demand	Reduced pulpwood demand	High plantation cost	Falling currency	Stop-deforestation	Mandated certification	Carbon sequestration
	Million hectares							
Brazil								
Plantation								
2030	4.0	4.4	3.8	4.1	5.1	4.0	4.0	5.7
2050	5.0	5.5	4.7	5.0	5.8	4.9	5.0	6.5
Total forestland								
2030	537.6	539.6	536.8	537.7	540.6	540.5	536.7	634.5
2050	524.8	525.8	523.9	524.5	525.5	533.9	524.1	634.5
Rest of South America								
Plantation								
2030	3.7	3.8	3.7	3.7	3.8	3.7	3.7	4.1
2050	4.0	4.3	3.9	3.9	4.1	4.0	4.0	4.5
Total forestland								
2030	288.8	288.3	289.1	288.9	288.7	290.1	288.8	308.5
2050	265.5	262.9	266.1	265.3	265.6	281.4	265.5	307.7
Central America								
Plantation								
2030	1.1	1.1	1.0	1.1	1.1	1.1	1.1	1.2
2050	1.1	1.2	1.1	1.1	1.2	1.1	1.1	1.3
Total forestland								
2030	54.0	53.8	54.0	54.0	54.0	53.9	53.9	58.6
2050	51.7	51.4	51.8	51.7	51.8	51.8	51.7	59.8

Table 4. Plantation and Total Forestland Area, by Scenario

The stop-deforestation case also affects total forestland area. Note that the strict constraint on deforestation is imposed only in regions that are inaccessible; in managed regions, some deforestation continues, albeit at modest rates. Nonetheless, more land is forested in 2050 in all regions under the stop-deforestation case than in the baseline. The area of fast-growing plantations remains about the same because the price increase is not strong enough to drive additional investments in plantations.

The falling-currency case has strong effects on plantation forests, increasing their area by 800,000 hectares in Brazil and by 100,000 hectares in other parts of South America by 2050. Interestingly, the falling-currency case increases the total forestland area in part because the shift in exchange rates does not drive more deforestation. Note that the reduction in exchange rates applies only in the forestry sector, and not in the agricultural sector. If the agricultural sector also becomes more productive under the altered exchange rates, then one would expect more deforestation in the LAC region.

One uncertainty not yet addressed is climate change. Analyzing climate change presents challenges in forestry because changes in disturbance patterns affect stocking rates, tree growth is influenced by carbon fertilization as well as changes in temperature and precipitation, and areas where certain forestland classes can grow will shift. Analyzing all these effects requires projected outcomes from dynamic global vegetation models tied to climate models, and then the results must be integrated into the forestry model, as in Tian et al. (2016) and Favero et al. (2018a). Such an analysis exceeds the scope of this paper, but the effects described in Tian et al. (2016) can be compared with those above. Tian et al. (2016) used the same Global Timber Model, although the baseline is different because of different starting years, different assumptions about growth in income and population, and some updates and changes to inventory data.

The results in Tian et al. (2016) illustrate that by 2050, forest growth increases 16 percent in Brazil, 11 percent in the rest of South America, and 2 percent in Central America. Annual rates of dieback, however, also increase in the region, rising from close to 0 percent in most regions to 0.8 percent in 2050 in Brazil and 0.1 percent in the rest of South America, and remaining stable (near 0 percent) in Central America. Given these climate effects, the Global Timber Model projects that by 2050, sawtimber output in Brazil rises by 10 million cubic meters per year and pulpwood output increases by 20 million cubic meters per year, for a 13 percent increase in sawtimber and a 19 percent increase in pulpwood output. This shift in output is comparable to the effects of increased demand or falling currency values. The effects of climate change in other parts of South and Central America are modest in comparison.

Those results suggest that climate change presents a potential challenge to the region, and in particular to Brazil, with potentially increased rates of disturbance over the next 30 years. The higher disturbance rates are balanced by increased productivity, and the overall effect on output is positive. Similarly, the results in Tian et al. (2016) suggest that total carbon storage in the region increases with climate change, albeit with less land devoted to forests because of land-use change. These results are consistent with the updated analysis in Favero et al. (2018a), although that study looked further out in time.

Conclusion

This analysis reviews important issues affecting forest management and trade in timber and nontimber forest products in Latin America and the Caribbean. Beginning with industrial wood markets, it illustrates that the region's wood products sector has grown at a more rapid pace than the global wood products sector since the 1960s and now amounts to 13 percent of the world's total industrial wood production. All of this increase is due to growth in three countries, Brazil, Chile, and Uruguay, which have invested in fast-growing plantations. Plantations, however, have faced significant competitive pressure in recent years because of declining markets for paper products globally, and the pressure will intensify in the future, given global trends. It is thus important to explore opportunities for new markets, new products, and enhanced productivity—that is, yield.

Beyond Brazil, Chile, and Uruguay, other LAC countries have opportunities to expand timber production, both in natural forests and in plantations. Plantations have contracted in some parts of Central America, and harvests per hectare in natural forests are also lower than in South America; understanding the differences could help the timber sector expand sustainably.

The region currently lags other regions in the area of forestland certified as sustainably managed by one of the major certification groups. The high costs and limited market benefits likely explain the lower rate of adoption in this region. Brazil and Guyana, however, have required reduced-impact logging and lower harvesting rates on their timber concessions, so elements of sustainable forest management are nonetheless being implemented on many forests. Given the increasing importance of forest ecosystem services, foresters, public agencies, and NGOs have good reason to continue researching sustainable forest management opportunities in the region, should markets for these benefits arise.

Illegal logging continues to cause widespread concern. Illegal deforestation was extensive historically but has abated in recent years, in particular in Brazil. Illegal logging also occurs in state forests that are not protected, either by government or by private organizations with rights to manage them, such as communities and private timber concessions. Efforts to regularize

Source: Photo by Rota T. 2020. Unsplash, Consulted 2020.

property rights by providing for community forest management or timber concessions likely will help reduce illegal logging in the long run, despite short-term leakage and other problems.

Community forest management has promise in many LAC locations. Evidence suggests that community management has reduced deforestation across many forests. That it has improved incomes or livelihoods is less certain. The increasing number of applications of community forest management, along with an increasing number of hectares, suggests that researchers will have many opportunities to assess the benefits and costs of this emerging approach to forest protection and management. One promising area where community forests may provide opportunities is nontimber forest products. Community forest management has been promoted as a way to protect forests where community members harvest nontimber products, but information about the scale of production is incomplete. Such data, even if the products are not brought to formal markets, would provide valuable information for forest protection efforts.

Projections from the Global Timber Model suggest that output will increase throughout the region from 2020 through 2040–2050. Pulpwood output is fairly sensitive to the various scenarios, with relatively large potential changes in the future for all scenarios except that with reduced deforestation. The sensitivity of pulpwood outputs in particular to a range of scenarios illustrates why it is important to evaluate investments in improving the productivity of plantations.

Climate change presents both challenges and opportunities for Latin America and the Caribbean. The region has a large carbon stock that remains one of the planet's most important buffers against carbon emissions. This carbon stock, however, has been under threat from market and institutional factors causing deforestation. At the same time, market and institutional factors have contributed to second-growth forests in plantations, and social movements have promoted strong enforcement of property rights and community forest management. The factors that encourage increased carbon stocks can also encourage economic growth and improved livelihoods. A threat from climate change itself is forest dieback. Current estimates suggest that gains in productivity will outweigh the losses due to dieback, leading to higher overall timber output, but these results do not hold for every location. The eastern Amazon forest, for instance, appears particularly vulnerable to drought and possibly more forest fires due to climate changes.

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4.

Forest Projects at the Inter-American Development Bank

Simone Carolina Bauch

Index

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Forest Projects at the Inter-American Development Bank

Home to almost a quarter of the world's forestland (FAO 2011), Latin America and the Caribbean (LAC) have been at the forefront of discussion on forests for decades. The significant reduction in deforestation in the Amazon Basin in the late 2000s and early 2010s (Arima et al. 2014) and the very high productivity of planted forests (Brown 2003) count as major achievements, but the Amazon forest fires since 2018 (BBC 2019) and the deforestation of the Cerrado biome show that enormous challenges remain.

Although multilateral development banks play an important role in defining policy and investments in the environmental sector, analysis of their effectiveness is not widely available (Gutner 2002). Some studies evaluate individual projects, but evaluations or even reviews of sector-wide investments are generally lacking, and systematic, independent assessments of international organizations' projects are missing from the literature (Fox 1997; Gutner 2002; Rich 2013). Moreover, forest investments are generally viewed as a subsector of environmental investments. This chapter seeks to shed light on forest projects that the Inter-American Development Bank Group (IDBG)[1] has implemented in LAC.

Since 2006, the IDBG has invested almost US $1.5 billion in LAC forest projects aimed at conserving, restoring, or sustainably managing natural forest resources, as well as promoting forest plantations and agroforestry. This study examines the IDBG forest project portfolio and summarizes the motivations, objectives, and results. It follows a previous internal review of forest investments at the IDBG, conducted in 2005 (Norheim 2005), and contributes to filling the literature gap by summarizing IDBG forest investments from January 2006 through June 2019. It constructs a timeline of investments, looks at the amounts and sources of funding, identifies the main objectives and themes, and describes how the projects came into being.

[1]The Inter-American Development Bank Group comprises the Inter-American Development Bank (IDB), IDB Invest (the commercial name of the Inter-American Investment Corporation), and IDB LAB (the commercial name of the Multilateral Investment Fund, which is administered by the IDBG). In this paper we do not differentiate among these different entities and group all three as IDBG.

Background

The IDBG was founded in 1959 as a partnership between 19 Latin American countries and the United States. Today it is owned by 48 member states, of which 26 are borrowing members in LAC. These 26 borrowing members together have slightly more than 50 percent of the voting power on the IDBG board. "As the world's oldest and largest regional multilateral development bank, the IDBG is the main source of multilateral financing for economic, social, and institutional development in Latin America and the Caribbean" (IDBG 2019, ii). By the end of 2018, the IDBG had approved more than US $286 billion in loans and guarantees to finance projects with investments totaling $567 billion, as well as $7.3 billion in grants. In 2018 alone, the IDBG approved $14.25 billion in loans (IDBG 2019).

Project Funding

Projects are funded mostly through two financial instruments, loans and grants.

Loans

The funding for loans usually comes from IDBG ordinary capital. The IDBG has an ordinary capital of US $105 billion, 96 percent of which consists of callable capital and 4 percent is paid by member countries.[2] Managing these funds is the core business of the IDBG. It lends to member countries usually through sovereign guaranteed (public) loans or through private sector loans. Given that these funds need to be repaid to the IDBG, countries usually have a strong say in how they will be used.

The IDBG also hosts and manages a suite of donor funds, such as the Climate Investment Fund, that can also provide loans and sometimes grants to countries. These donor funds usually involve more concessional terms (e.g., lower interest rates) and smaller loans than are provided by the IDBG in its business model.

[2] https://www.iadb.org/en/about-us/idb-financing/ordinary-capita-resource-callable-capital-and-paid-capital-idb-member.

Grants

Many donor funds provide grants in addition to loans. Some are trust funds set up in the IDBG by a specific donor. Others are independent funds that channel funding through the IDBG; examples include the Global Environment Facility, the Climate Investment Fund, and the Green Climate Fund. The IDBG first implemented Global Environment Facility projects in 2004. Norheim (2005) cites this development as the main reason for the increase of grant-financed instruments in the 2003–2005 period. Climate finance, channeled mainly through the Global Environment Facility, the Climate Investment Fund, and Forest Carbon Partnership Facility, became available in 2012.

These funds are nonreimbursable (i.e., they are disbursed as grants), and donors usually provide guidelines on how the money can be used. Countries can submit proposed projects for funding based on these guidelines. The size of grant-financed projects varies significantly depending on country priorities, donor priorities, and available funds.

Organizational Shifts

The IDBG's internal organization is structured around regions and countries and by sectors and technical areas. In 1994, the IDBG underwent a reorganization in which the regional focus was elevated, but every region had teams organized by technical activities.

In 2007, the IDBG went through another realignment process. The bank created two vice-presidencies: one for regional departments and one for the technical departments. It also created the Sustainable Energy and Climate Change Initiative, which in 2013 became the Climate Change and Sustainability division. The 2007 realignment has been considered a big shift for forests at the IDBG because most of the forest experts who worked at the bank at the time retired. The organizational changes also reflect changes at global scale, with climate change being recognized as a threat.

In the 1990s, bank teams consisted of engineers, agronomists, and other technical experts plus financial and institutional specialists, who would judge the financial viability of projects, and economists, who would assess the project benefits. Over time, the bank ceased hiring technical specialists, and in the mid 1990s, the bank began to hire more generalists and emphasize skills in managing project origination, design, and execution.

Earlier Strategy on Forests

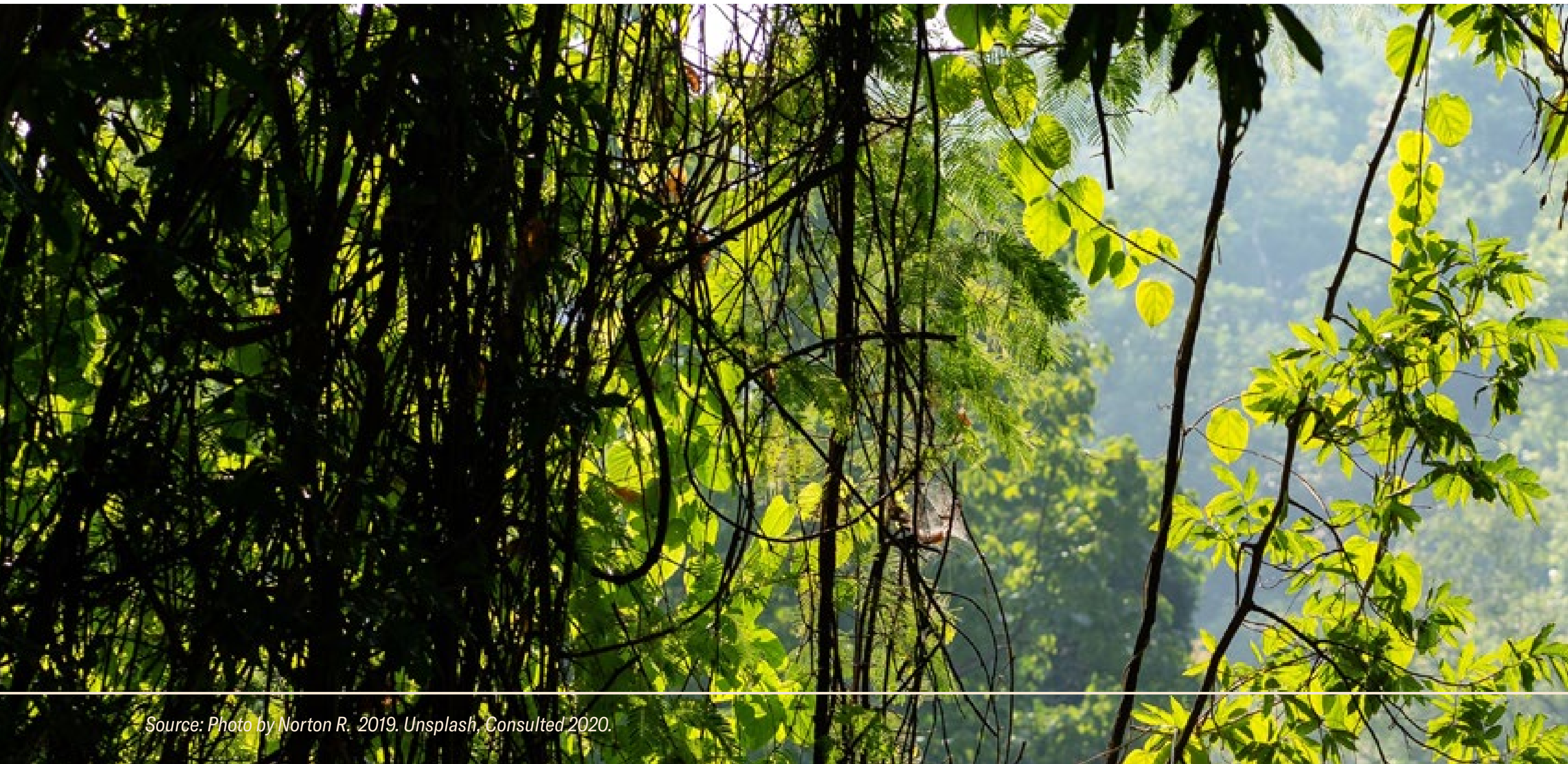
A literature review identified only one earlier IDBG forest strategy (Rente and Norheim 2006).[3] This strategy covered countries in what was then known as Region 2 (Central America, Mexico, Dominican Republic, and Haiti) and identified improvements needed in the forest sector in two axes:

- **The investment climate in individual countries, looking at intrasector (e.g., promoting sustainable land use and training for private sector), intersector (e.g., resolving land-tenure issues), and suprasector aspects (e.g., macroeconomic stability); and**
- **Competitiveness and productivity, based primarily on awarding public lands to the private sector in a transparent and competitive process.**

The strategy stated that “a vision of the forest businesses in the region implies that the private sector has a mission to contribute significantly to the sustainable development of national economies, based on sustainable management of forest resources; increases in productivity in the supply chain; export of competitive products and diversification of forest land income” (Rente and Norheim 2006, 1).

This strategy evaluated the operations that could be developed in each of the Region 2 countries and assessed what the IDBG could do in the next six to eight years.

[3] According to one interviewee, there was also a forest strategy in the late 1980s or early 1990s, but no documentation was found.



Source: Photo by Norton R. 2019. Unsplash. Consulted 2020.

Data and Methods

Two types of information were examined for this evaluation of the forest projects approved by the IDBG: the bank's database of projects and project documents (loan proposals and technical cooperation documents), and interviews with current and former bank staff. Forest projects were defined as those for which the bank database listed forests as a sector or subsector. Interviewees were asked what forest projects they had worked on, and any projects not already included were added to the initial list.

Bank Database and Project Documents

For all projects identified in the initial list and through interviews, available project documents were analyzed. In this report, quantitative analyses of project information are limited to projects approved in the past 12.5 years (January 2006 through June 2019); excluded are projects that were being implemented after 2006 if their approval date was before 2006.

For all projects identified, the project documents were analyzed to identify the following information.

Project Objectives

Projects generally had one or more of the following objectives:

- **forest conservation:** reduction of pressure on existing forests, including protected area management;
- **forest restoration:** rehabilitation and restoration of degraded ecosystems;
- **agroforestry:** implementation of agroforestry and silvopastoral systems;
- **sustainable forest management:** the sustainable harvest of forest products, both timber and nontimber;
- **forest plantations:** the planting and management of exotic and native species plantations;
- **markets:** the marketing, commercialization, and market development of forest products, whether commercial or livelihood approaches, and improvements to the value chain (e.g., sawmill efficiency);
- **land tenure:** clarification and enforcement of land-tenure rights to promote sustainable land use;
- **forest monitoring:** the tracking of deforestation, forest management, fires, reforestation, and other land-use changes;
- **governance:** policy and capacity building to create an enabling environment.

Amount and Source of Funds

This information includes the amount financed by the IDBG and external donors, and the source of the funding. Projects were divided into two categories: loans and grant-funded projects.[4] In addition, because interviewees reported that climate finance was important for forest projects, the amounts and sources of climate finance were included. Climate finance was defined as funding coming from specific funds for mitigating climate change—the Green Climate Fund, GEF climate change windows, Forest Carbon Partnership Facility, Forest Investment Program, and Climate Investment Fund.

[3] According to one interviewee, there was also a forest strategy in the late 1980s or early 1990s, but no documentation was found.

Climate finance was generally provided as either a grant or a loan. Two of the 99 IDBG projects considered in this analysis involved both grant and loan components. Even though the two kinds of financing were approved separately, for this chapter they were considered as one so as not to inflate the number of projects approved.

Funding Levels

Project descriptions in project documents were reviewed to identify direct investments in forest-related objectives, as listed above. Only the budgets for these activities were considered direct forest funding. For example, a US $600 million policy-based loan project in Mexico (ME-L1268) had only one forest-related component, with a budget of $165.8 million.

Project Themes

The hypothesis was that forest project themes would change over time as different issues arose in national, regional, and global discourse. The keywords that identify the themes are as follows:

- **Forest certification.** These projects promote forest products that come from certified plantations and sustainably managed native forests, including certified chain-of-custody and market activities. Forest certification was introduced in the early 1990s to promote sustainable forest management, but initial implementation lagged behind expectations (Rametsteiner and Simula 2003) and has not picked up much since.
- **Protected areas.** Interest in this command-and-control strategy to promote conservation has waxed and waned, given the differing findings about its benefits. Discussions about "paper parks" date to at least the late 1990s (Dudley and Stolton 1999), although more recent assessments are more positive (Joppa and Pfaff 2011).
- **Watershed management.** "Watershed management is the process of organizing and guiding land, water, and other natural resources used in a watershed to provide the appropriate goods and services while mitigating the impact on the soil and watershed resources ... In essence, it is resource management with the watershed as the basic organizing unit" (Wang et al. 2016, 968). Such projects organize or promote land-use management at the watershed level.
- **Coastal management.** Some projects in coastal areas aim at conservation and rehabilitation of coastal ecosystems, such as mangrove forests. These activities are usually further justified as climate change adaptations linked to economic sectors, such as fisheries, that depend on coastal ecosystems.

- **Livelihoods.** Forests support local livelihoods and communities around the world (Wunder et al. 2014), and forest projects are often justified by social and economic benefits.
- **Ecosystem services.** Ecosystems provide many benefits to humans, from regulation of ambient temperatures, sequestration of carbon, provision of clean water, and pollination of crops to cultural services (Millennium Ecosystem Assessment 2005). "The origins of the modern history of ecosystem services are to be found in the late 1970s. It starts with the utilitarian framing of beneficial ecosystem functions as services in order to increase public interest in biodiversity conservation" (Gómez-Baggethun et al. 2010, 1209).
- **Payments for ecosystem services (PES).** Like certification, PES is a market mechanism for forest conservation, intended to improve land management. Payments can accrue for different types of ecosystem services. Although ecosystem services have been sold in markets for a long time, in the early 2000s this concept appeared more formally. Since then, implementation of these schemes has increased rapidly (Gómez-Baggethun et al. 2010).
- **Biodiversity.** Sustaining the variety and variability of animals, plants, and micro-organisms at the genetic, species, and ecosystem levels is important for maintaining an ecosystem's structure and processes. Biodiversity supports many ecosystem services (FAO 2019).
- **Carbon and climate change mitigation.** International debate on climate change and alternatives to reduce carbon emissions has focused attention on forests as a carbon stock (the carbon is released into the atmosphere through forest loss and degradation) and a carbon sink (growing trees capture carbon). Forests are now considered a promising and inexpensive means of tackling climate change (Canadell and Raupach 2008).
- **Avoided deforestation.** Avoiding deforestation avoids carbon emissions into the atmosphere and therefore mitigates climate change. The inclusion of avoided deforestation in the United Nations Framework Convention on Climate Change came in 2007. Despite the considerable technical hurdles, including questions about its effectiveness and agreement on methods (Humphreys 2008), this strategy has been included in several IDBG projects.
- **Community forest management.** These activities are aimed at involving local communities in forest management.

The above themes are by no means exclusive. A project promoting coastal forest management might both improve local livelihoods and mitigate climate change, for example. The purpose of analyzing these themes is to assess how the rationale for forest projects at the IDBG has changed between 2006 and 2019.

Interviews with Current and Former Staff

The interviews followed a semistructured process, based on a list of questions (Appendix 1.2). Interviews solicited opinions on how forest projects at the IDBG have changed over time, the reasons for these changes, the value added of the IDBG on forests, and the process of project origination.

Thirty-three current and former IDBG employees were invited to participate in the interviews, and 23 accepted the invitation (68 percent response rate). Four respondents were retired. The current employees represented several divisions: 9 worked at headquarters in Washington, and 10 worked in country offices. Table 1 lists the details of IDBG work for the 23 respondents.

		Interviews
Location	Headquarters	9
	Country offices	10
Division	Climate Change	6
	Environment Rural Development and Disaster Risk Management	7
	Environmental Safeguards Unit	1
	Strategic Planning and Development Effectiveness	1
	Multilateral Investment Fund	1
	Vice Presidency for Countries	1
	Climate Change and Sustainable Development	1
	Capital Markets and Financial Institutions	1
Retired staff		4
Total interviews		23

Table 1. Interviews with Retired and Current IDBG Staff

The IDBG approved US $1.485 billion in forest activities from 2006 through June 2019, or about $120 million per year. … The increase in grants from 2013 onward coincides with the availability of climate finance for forest projects, which more than doubled the grant funding for forests.

Findings

Results of the interviews and document analyses are divided into four sections. The first section presents the recent history of the IDBG's work on forests, and the second describes how projects are developed, based on information gathered through the interviews. The third focuses on the number of projects approved over time, and the last evaluates the types of projects approved over time; both of these sections are based on the analysis of project documents.

Recent History of Forest Projects

The timeline starts in the 1980s, when the most experienced respondents started working at the IDBG. The historical perspective in this section is based on the interview respondents' views on what shaped the organization's forest policy over time.

By 1980, IDBG leaders had discussed whether forests would be considered from an industry perspective or as part of agriculture. Agriculture was chosen as the host site for forests, and therefore forest projects were developed alongside rural development projects, which then included forestry. For large infrastructure projects, such as dams and roads, forestry was also included as a mitigation strategy, to compensate for environmental damage of the infrastructure development and often including forestry activities or objectives.

In the 1990s, forestry was perceived in a wider environmental perspective that encompassed disaster prevention and conservation of existing forests. Forest conservation began to be seen as one way to reduce the damage of extreme weather events (particularly after hurricane Mitch hit Central America in 1998) and reduce high reconstruction costs. Conservation of the Amazon forest was also a priority for IDBG President Enrique Iglesias, who presented a telecast for all countries on his vision for forestry.

With this broadened role for forestry, more people with a technical forestry background joined the bank. These specialists formed a strong team that could prepare technical guidelines and projects for Region 2 (Central America, Mexico, Dominican Republic, and Haiti) on topics ranging from reforestation and sustainable forest management to watershed management and forest industry.

This team's evaluation (Norheim 2005) described IDBG forest projects in Region 2 from 1998 to 2005, covering not only final projects but also those still in development, and including not only forest projects per se but also other types of projects with forestry activities. In the eight years, the IDBG approved 103 projects that included financing for forest activities: 32 loans, 56 technical cooperations, 7 Multilateral Investment Fund operations; 8 Social Entrepreneurship Program projects and small projects, and 10 special operations. Of these projects, 70 were approved between 2003 and 2005, indicating an increase in the importance of forestry over the period. The countries with the most forest operations were Guatemala and Honduras. The increase in Global Environment Facility–funded projects was said to explain the increase in forest activities in the later years of the analysis (Norheim 2005).

Funding for the Region 2 projects considered in Norheim (2005) added up to US $1.4 billion during 1998–2005 (of which $1.38 billion consisted of loans). However, because forest activities were sometimes included in much larger projects, the author could not determine how much money went to forest activities directly.

Norheim (2005, 16) concluded that projects followed discipline-wide trends in renewal natural resources management:

[begin excerpt]

In the 70s there were many projects that supported the development of the forest industry, but there were less of these financed in the 80s and were replaced by so called integral projects (e.g. integrated rural development, community silviculture, etc) and among these watershed management projects that started more strongly in the 90s. Other "new" themes that have been coming with more force in the last years of the evaluation are biodiversity/protected areas, forest certification and forested land use ... In the last years there has also been a tendency to "return to the roots", in the sense of a renewed interest in developing forest sector specific projects. This tendency has a relation with the decrease in the public sector and an emphasis on the private sector (competitiveness), combines with the large potential the forest sector has in several countries.

[end excerpt]

Table 2 shows the kinds of projects approved for funding in Region 2 between 1998 and 2005.

Theme	Approved loans	Other approved projects	Total
Sustainable forest management	19	22	41
Plantations, restoration	14	18	32
Forestry for watershed management	17	13	30
Protected areas	11	13	24
Agroforestry	10	11	21
Forestry for soil conservation	11	10	21
Forest industry	4	15	19
Forest policies	6	12	18
Biodiversity	7	8	15
Forestry for disaster risk reduction	8	6	14
Forest financing	5	5	10
Ecotourism in forest areas	1	8	9
Community silviculture	4	3	7
Commercialization	2	5	7
Forest certification	2	4	6
Aquifer recharge	2	3	5
Carbon capture	1	3	4
Forest fires and pests	2	0	2
Total	**126**	**159**	**285**

Table 2. Forest Project Themes in Region 2, 1998–2005

Source: Adapted from Norheim (2005).

The definition of forest projects by Norheim (2005) was less strict than that used in this chapter. For example, he considered all projects implemented in forested areas to be forest projects, and thus a tourism project in a forest was considered a forest project even if it funded no direct forest-related activities. He also did not break out funding for forest activities from the total project budget.

Project Development

The interviews conducted with current and former IDBG staff help explain the political economy factors that drove trends in forest projects over time. Respondents identified the following major forces influencing project development:

- **Country demand.** For all projects, the IDBG works with client countries to implement country priorities. Letters of support are needed for a project to be considered.
- **Donor rules.** Donor funding is usually concessional, with "soft" credit extended to the borrower, compared with loans at market rate.[5] Given the preferential funding terms, donors attach conditions or eligibility criteria for borrowers to access and use their funds. The criteria and conditions are specific to each fund and donor and can range from country-specific allocations (such as the STAR allocations for the Global Environment Facility, in which a country is allocated a prefixed amount of funding in thematic areas) to general guidelines (as with the Green Climate Fund).
- **IDBG priorities.** IDBG technical teams have prepared sector framework documents[6] to guide the priorities in the project pipeline. These documents vary in their specificity, detail, background, and strategic information. Also, the IDBG's 26 country offices (one in each of its borrowing member countries) vary in size and structure but include technical specialists in the field. This gives the IDBG a competitive advantage in terms of engagement with local stakeholders and their interaction with IDBG priorities.
- **Idiosyncratic inputs of IDBG specialists.** Because of the technical expertise of IDBG staff, individuals can have significant influence in defining the portfolio, especially in defining the scope and specifics of projects they develop.

[5] As defined by the Organisation for Economic Co-operation and Development (https://stats.oecd.org/glossary/detail.asp?ID=408).

[6] The sector frameworks documents are available here: https://www.iadb.org/en/about-us/sector-policies-and-sector-framework-documents.

How new projects are developed and activities are chosen for funding involves a balance between the driving forces influencing project formulation. In the interviews, respondents said that this equilibrium varies with the source of funds and also the ability of individual specialists to influence the process.

For sovereign guarantee loans, country priorities carry weight because the country must repay these loans and therefore has a strong influence on the nature of the project. Sometimes, especially in smaller countries, the government determines the sector focus or the problem to be addressed, and it is up to the in-country specialist (or the specialist leading the project preparation) to determine what project activities will be implemented to address these issues. For grant-financed projects, donors' rules are paramount because they determine the eligibility criteria; country priorities and specialists' input are secondary.

In summary, what projects were funded depended primarily on whether a country prioritized them. This prioritization could be done at a high level and determined what specific activities the project would implement. Even with high-level country government guidance, the specialists on the project development team had leeway in proposing how the funds would be spent. The project goals would be detailed by the team to fulfil donor requirements and country priorities as needed. The specialists worked with bank guidance at a high level in terms of what the bank wanted to fund.

Number of Projects

The results presented in this section are based on the forest projects approved since 2006 (as defined in the Data and Methods section).

Between February 2006 and July 2019, a total of 99 forest projects were approved by the IDBG. Figure 1 shows the number of project approvals in each year, with approved grants in blue and loan projects in yellow. The figure shows an initial decrease in forest projects (only grants) from 2006 to 2008, followed by a steady year-on-year increase with a spike in project approvals in 2013 (17 projects), then a decrease until 2016 (4 projects), and increases in 2017 (11 projects) and 2018 (10 projects).

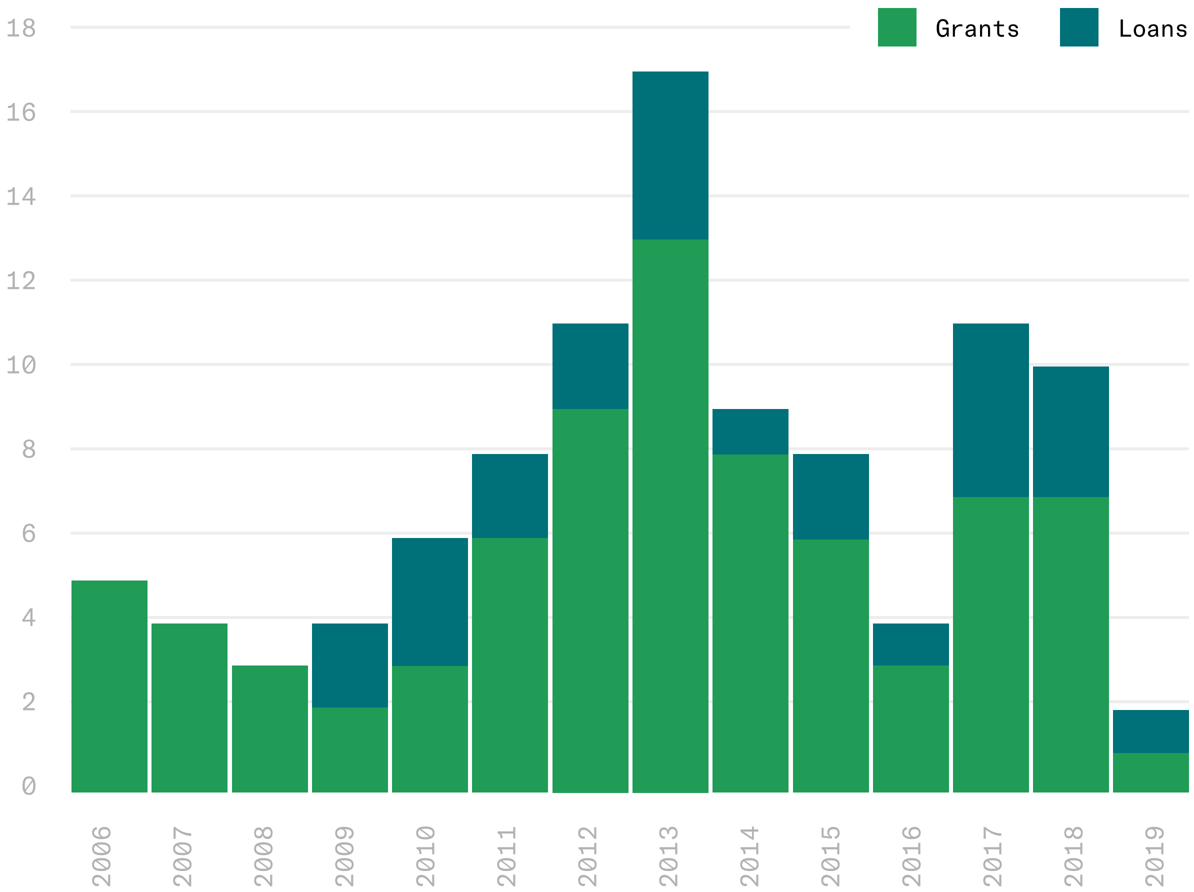


Figure 1. Forest Project Approvals, 2006-2019

Although more grant projects than loan projects have been approved, the number of loans does not vary much over the years (from zero to 4 projects in any given year), whereas grants are more variable (from 1 to 13 projects annually). The increase in the number of grants from 2012 to 2013 is explained by the increase in funding available to countries through the Climate Investment Fund and the Forest Carbon Partnership Facility. For loans, the reasons for the decrease over time are difficult to pinpoint because projects usually take more than a year to prepare.

The figures refer to the entire IDBG forest portfolio and thus may hide significant regional differences. IDBG regions are as follows:

- **Southern Cone:** Brazil, Argentina, Paraguay, and Uruguay;
- **Andes:** Bolivia, Peru, Ecuador, and Colombia;
- **Central America:** Nicaragua, Honduras, El Salvador, Guatemala, and Mexico;
- **Caribbean:** Haiti, Dominican Republic, Jamaica, Bahamas, Suriname, and Guyana.

"Regional" projects are not country or even region specific; they are used to fund development of knowledge products or other general activities.

Table 3 shows the number of projects per region. The region with the most projects approved over the 12.5-year study period was the Andes (23), followed by Central America (22), Southern Cone (21) and the Caribbean (16). The Andes region also had the highest number of grants (21), and the Caribbean, the lowest number (11). Central America had the most loans (10), and the Andes had the fewest (3).

Region	Loans		Grants		Total	
	(n)	%	(n)	%	(n)	%
Andes	3	13	21	27	23	23
Central America	9	38	15	19	22	22
Southern Cone	7	29	14	18	21	21
Caribbean	5	21	11	14	16	16
Regional	0	0	16	21	17	17
Total	**24**	**100**	**77**	**100**	**99**	**100**

Table 3. Grants and Loans Approved from 2006 to June 2019, by Region

Note: Two projects had both grant and loan components and therefore the sum of loans and grants is higher than the total number of projects.

Figure 2 shows the forest project approvals per region per year.

Approved projects in the Southern Cone increased until 2013 and then decreased significantly. Central America shows a similar pattern. The number of project approvals in the Andes was more consistent, at one, two, or three per year.

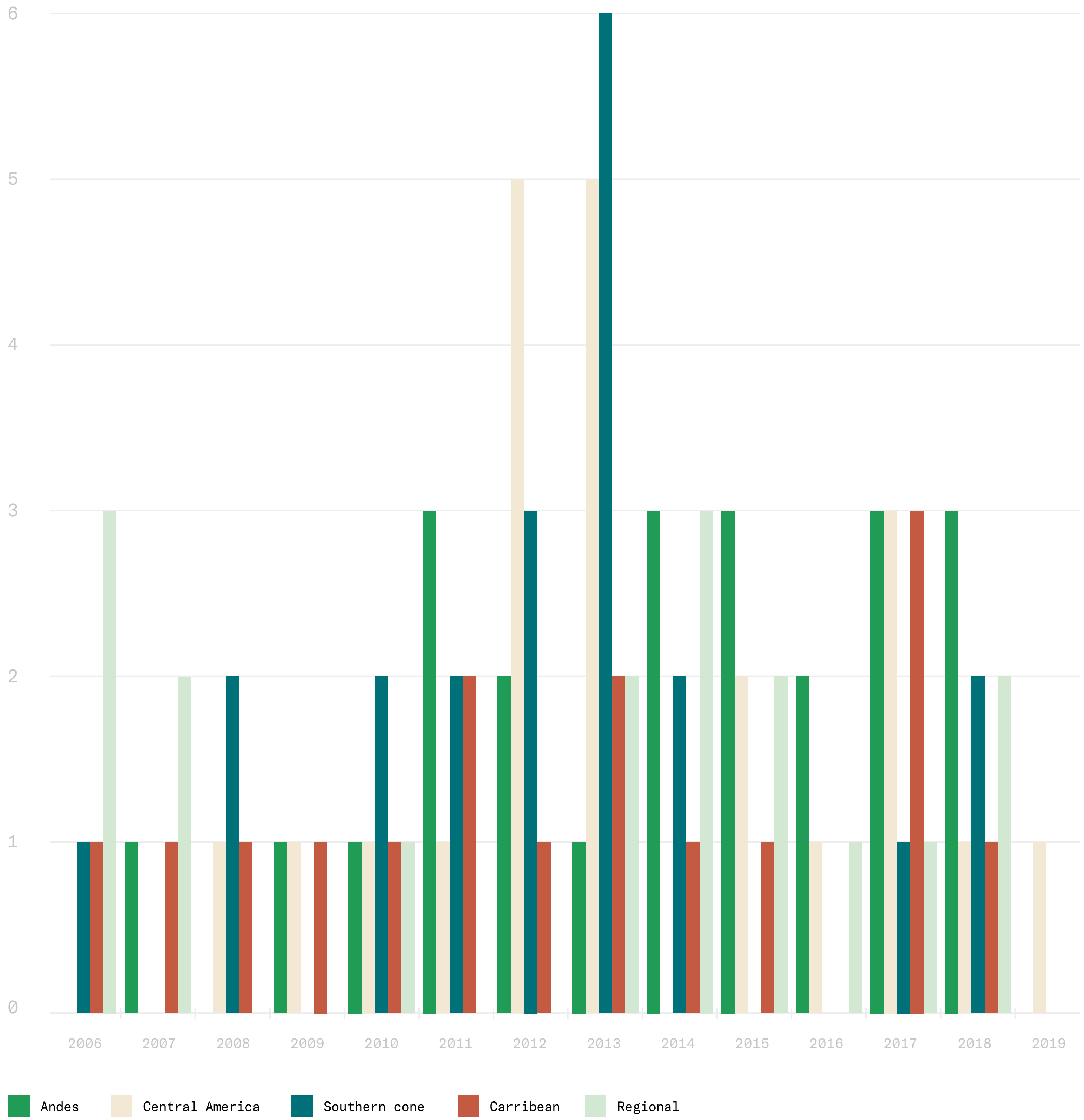


Figure 2. Forest Project Approvals, 2006-2019, by Region

Project Funding

Trends in project numbers tell part of the story of how forest projects have changed over time at the IDBG, but changes in the amount of funding are also important. Figure 3 shows the approved forestry funding for the same projects in Figure 1.

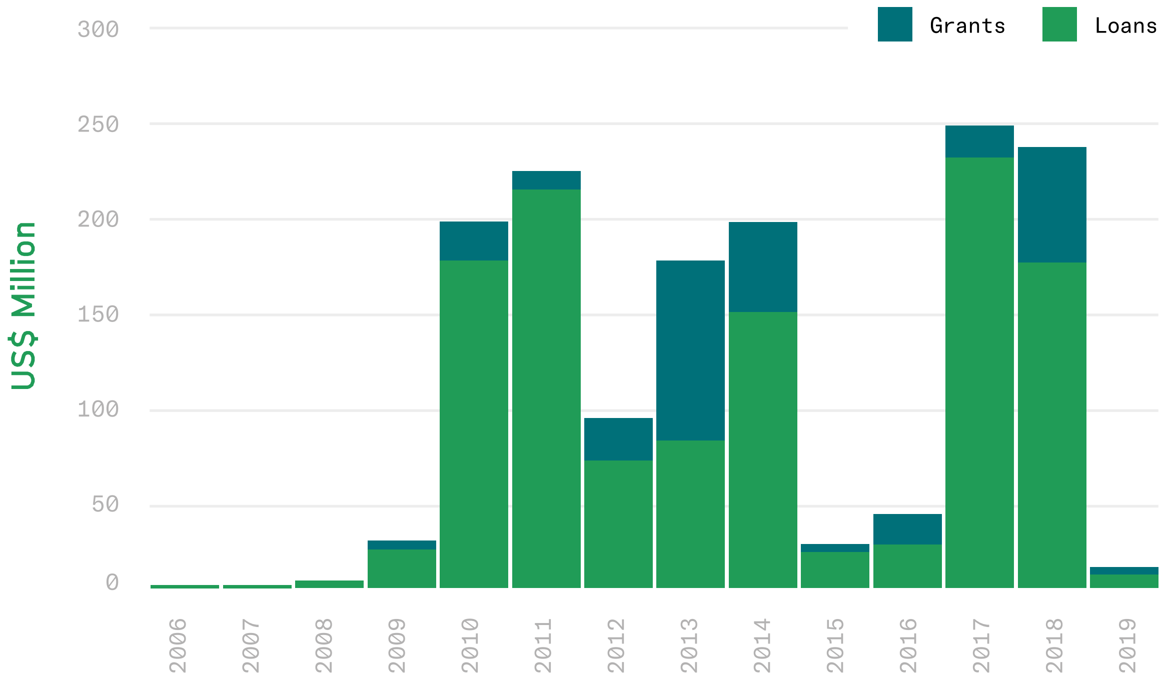


Figure 3. Forest Project Funding (US$ million), 2006-2019

Only funding for direct forest activities is considered here, not the total project budget. For some projects, however, the two figures are the same. The IDBG approved US $1.485 billion in forest activities from 2006 through June 2019, or about $120 million per year. This number cannot be compared with the estimate by Norheim (2005), who studied only one region of IDBG operations and defined forest projects more loosely (see Recent History section, above).

Although more projects have been funded by grants than by loans (see Figure 1), Figure 3 shows that the loan projects have much larger funding. In the first four years of the analysis, the amounts approved, both grants and loans, were very small, and another slowdown happened again between 2015 and 2016. The increase in grants from 2013 onward coincides with the availability of climate finance for forest projects, which more than doubled the grant funding for forests. In early 2012, US $37 million in grants had been approved over the previous six years, but in the next six years, the IDBG approved $239 million in grants. Figure 4 shows the total forest project funding approved in the same period and the proportion of climate finance.

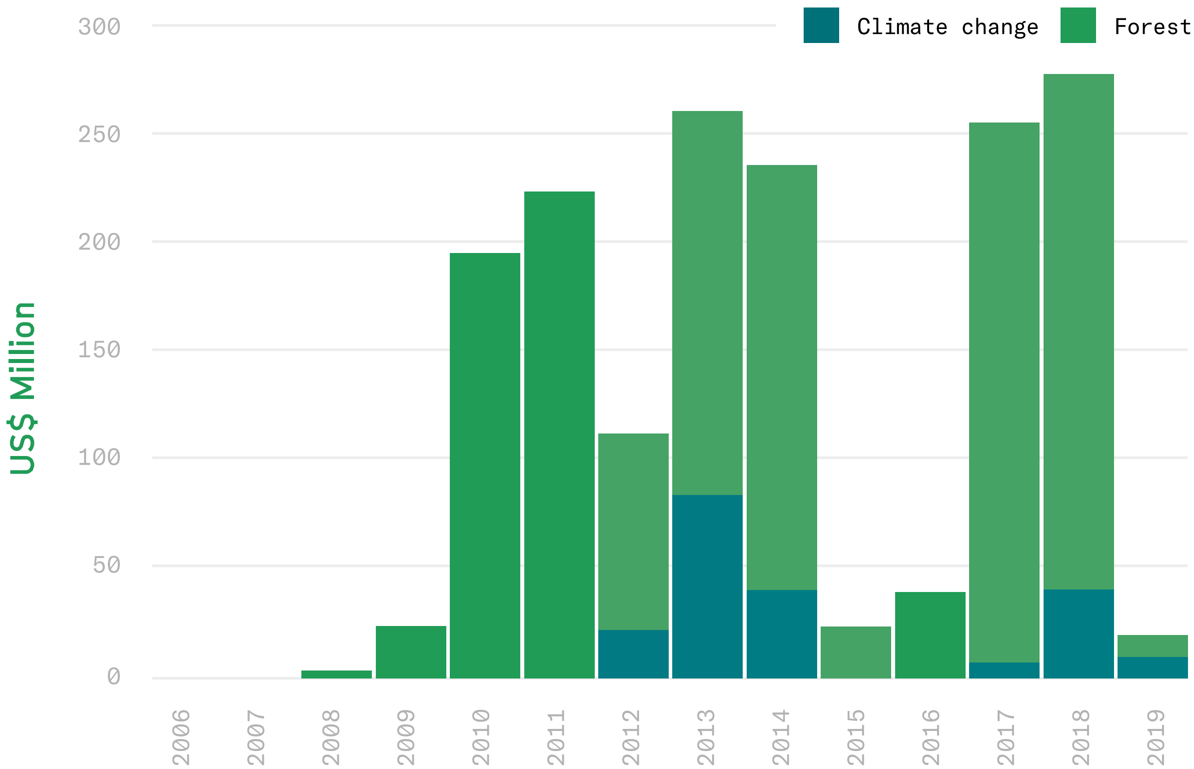


Figure 4. Funding for Forest and Climate Change Projects (US$ million), 2006-2019

Climate change finance began in 2013, with the Climate Investment Fund and the Forest Carbon Partnership Facility, and this source now accounts for 14.2 percent of all forest project funding approved by the IDBG. According to interview respondents, the contribution of climate finance is expected to increase with the approval of some projects in the pipeline, such as the Guatemala Forest Investment Program and also with potential new forest projects funded by the Global Environment Facility 7 and the Green Climate Fund.

Funded Forest Objectives

Table 4 shows how often each forest objective was part of funded projects, by region. The percentages indicate the relative importance of these activities in the regional and total portfolios.

Objective	Andes		Central America		Caribbean		Southern Cone		Portfolio	
	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%
Sustainable forest management	10	43	11	50	7	44	12	57	43	42
Governance	10	43	12	55	7	44	10	48	42	41
Conservation	10	43	11	50	6	38	7	33	35	34
Restoration	3	13	13	59	5	31	8	38	30	29
Markets	6	26	6	27	5	31	8	38	28	27
Monitoring	6	26	9	41	7	44	4	19	27	26
Agroforestry	2	9	12	55	5	31	4	19	24	24
Forest plantations	0	0	7	32	2	13	8	38	18	18
Land tenure	1	4	2	9	3	19	4	19	10	10
Number of projects	**23**	**100**	**22**	**100**	**16**	**100**	**21**	**100**	**102**	**100**

Table 4. Forest Project Objectives, by Region[7]

As Table 4 indicates, sustainable forest management (included in 42 percent of all projects) and governance (41 percent) were the most common objectives in the general forest project portfolio. Conservation was included in 34 percent, forest restoration in 29 percent, avoided deforestation in 22 percent, markets in 27 percent and monitoring in 26 percent. However, there

[7] The portfolio includes regional projects not added in individual region tallies.

were also significant regional differences. In the Andes, conservation, governance, and sustainable forest management were the top three objectives, each accounting for 43 percent of projects, but forest plantations were not included at all and land tenure was part of only one project. In Central America, projects focused on restoration (59 percent), governance (55 percent), agroforestry (55 percent), and conservation (50 percent). In the Caribbean, forest monitoring, governance, and sustainable forest management were common objectives. And in the Southern Cone, sustainable forest management and governance were the main objectives (48 percent each), followed by restoration, forest plantations, and markets (38 percent each). Land tenure, an objective of just 10 percent of the projects in the portfolio, still varied among regions: it accounted for 19 percent of the Southern Cone and Caribbean projects but only 4 percent of the Andes projects.

These same objectives are graphed in Figure 5 to show how emphases have shifted over time for the portfolio of forest projects.

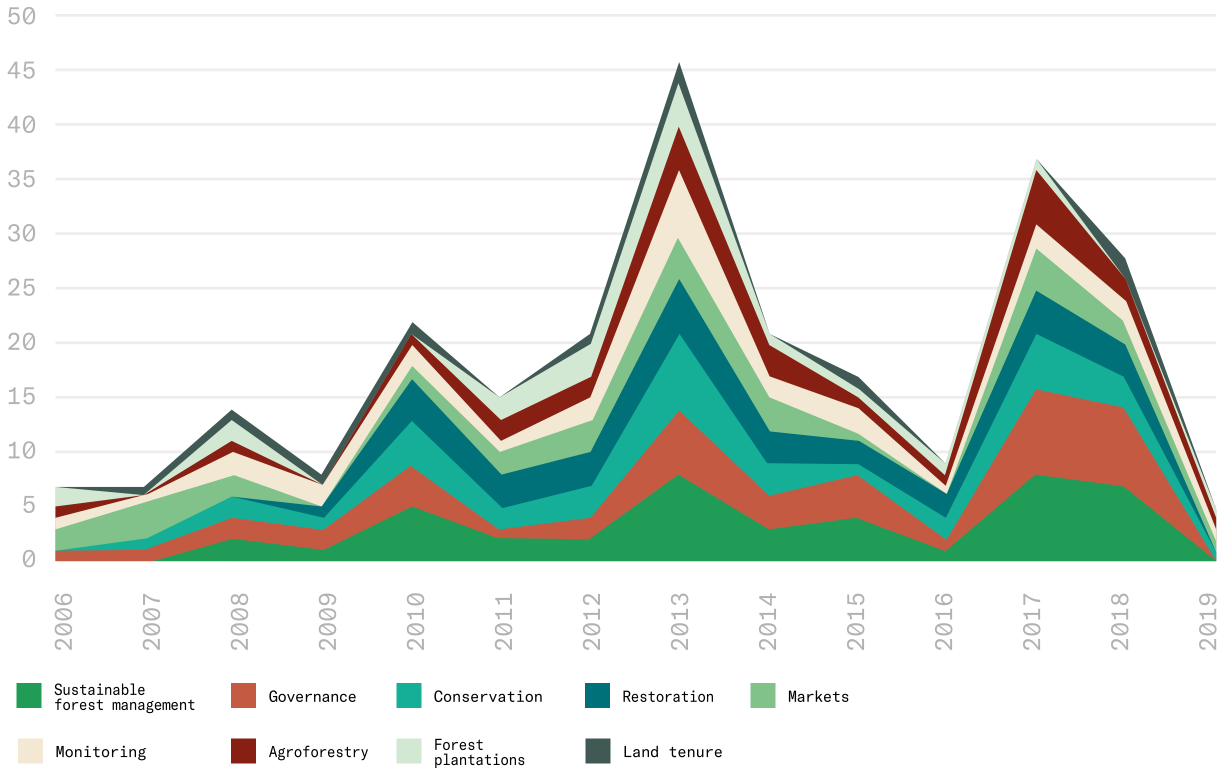


Figure 5. Forest Project Objectives, 2006–2019

Because a single project may have several forest-related objectives, the number of objectives in a given year may not be the same as the number of projects approved. Earlier projects focused more on markets for forest products, including creating a business environment, supporting small and medium forest enterprises, and developing or improving forest products and value chains. Conservation has generally been included in more projects than forest plantations, and restoration of forests for climate change mitigation has been a more common objective since 2013 (when climate change finance became available).

Table 5 shows the investment types in grant projects, loan projects, and climate finance projects.[8]

Project objective	Grant		Loan		Climate funds		Portfolio	
	(n)	%	(n)	%	(n)	%	(n)	%
Sustainable forest management	33	42	11	42	12	50	43	42
Governance	32	41	10	38	12	50	42	41
Conservation	28	36	9	35	10	42	35	34
Restoration	22	28	9	35	9	38	30	29
Markets	20	26	10	38	10	42	38	27
Monitoring	24	31	4	15	5	21	27	26
Agroforestry	17	22	7	27	8	33	24	24
Forest plantations	11	14	5	19	8	33	18	18
Land tenure	5	6	3	12	6	25	10	10
Number of projects	**78**	**100**	**26**	**100**	**24**	**100**	**102**	**100**

Table 5. Forest Project Objectives, by Type of Funding

As the table shows, sustainable forest management was an objective in 42 percent of all grant and loan projects and 50 percent of all climate finance–funded projects. Some project objectives, such as forest plantations and market investments, can generate private profits, and thus they are financed more through loans (which are then repaid) rather than grants. For objectives that generate purely public benefits, such as monitoring, grants are the main source of funds.

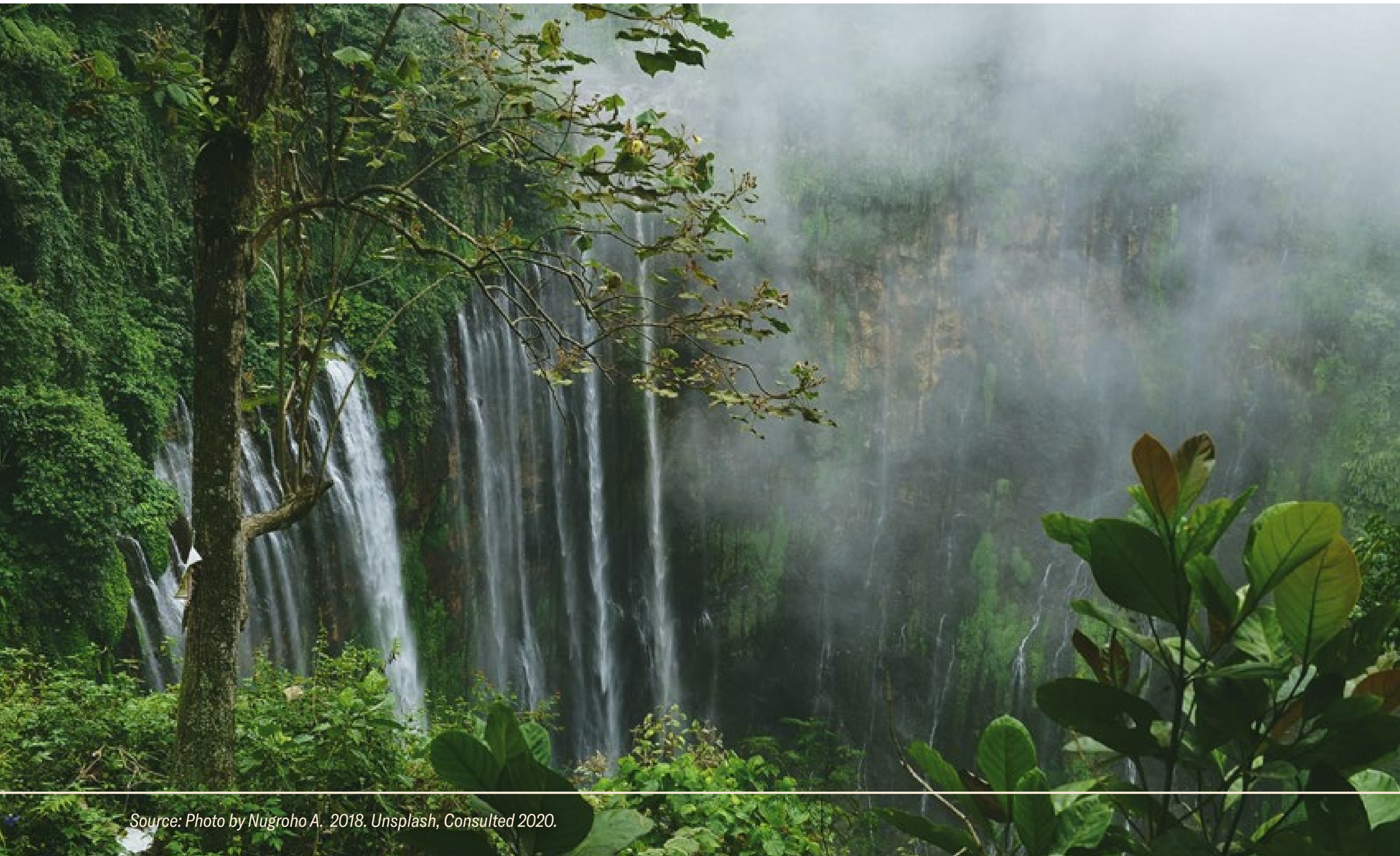
[8] Climate finance can take the form of grants or loans (see Data and Methods section).

Forest management and governance were the most common focus for forest projects, whether those projects were funded by grants or loans and despite the differences in how grant versus loan projects are designed: grant projects usually have to meet donors' criteria, and projects that must repay loans have stronger country ownership.

Finally, climate finance contributed funding for 24 of 102 projects (23.5 percent). These projects also focused on governance and sustainable forest management (50 percent each), followed by markets and conservation (42 percent each).

Project Themes

The themes are keywords used in the project documents to justify or explain a project. Themes are related to policy and discussions at national and international levels and have changed over time. Table 6 lists the themes for projects in each region and the portfolio as a whole. These themes may be directly linked to project objectives (e.g., protected areas relate to conservation) but can also reflect broader goals (e.g., watershed management can comprise several objectives). Thus they provide important information on how projects were justified and the context in which they were prepared.



Source: Photo by Nugroho A. 2018. Unsplash, Consulted 2020.

Forest management and governance were the most common focus for forest projects, whether those projects were funded by grants or loans...

Theme	Andes		Central America		Caribbean		Southern Cone		Portfolio	
	(n)	%	(n)	%	(n)	%	(n)	%	(n)	%
Carbon	13	57	10	45	6	38	8	38	38	46
Biodiversity	5	22	4	18	3	19	9	43	28	34
Livelihoods	7	30	8	36	5	31	5	24	27	33
Ecosystem services	4	17	5	23	3	19	3	14	22	27
Avoided deforestation	4	17	8	36	6	38	4	19	22	22
Protected areas	3	13	4	18	3	19	6	29	18	22
Community forest management	4	17	8	36	2	13	2	10	17	21
Watershed management	3	13	2	9	3	19	1	5	10	12
Payment for ecosystems services	1	4	4	18	1	6	0	0	6	7
Forest certification	1	4	1	5	0	0	3	14	6	7
Mangroves	0	0	1	5	1	6	1	5	3	4
Coastal management	0	0	0	0	1	6	1	5	2	2
Total	**23**	**100**	**22**	**100**	**16**	**100**	**21**	**100**	**82**	**100**

Table 6. Forest Project Themes, by Region

Almost half of all projects (46 percent) included carbon in the description or justification of the project. This was by far the most common theme, followed by biodiversity (34 percent) and livelihoods (33 percent).

Regional differences were significant. In the Andes, carbon was a very common theme (with 57 percent of projects using this term), and the second most common theme was livelihoods (cited in 30 percent of projects).

In Central America, carbon was again the most common theme (45 percent of projects), followed by livelihoods and community forest management (36 percent). Mangroves and coastal management were not mentioned at all in the Andes, but it is surprising that in the Caribbean, where coastal zones are important for economic, social, and environmental reasons, few forest projects (6 percent) focused on mangroves and coastal management; carbon was still the most referenced theme (38 percent), followed by livelihoods (31 percent). In the Southern Cone, however, biodiversity was cited more often (43 percent of projects) than carbon (38 percent). Figure 5 shows how the standings have changed over time.

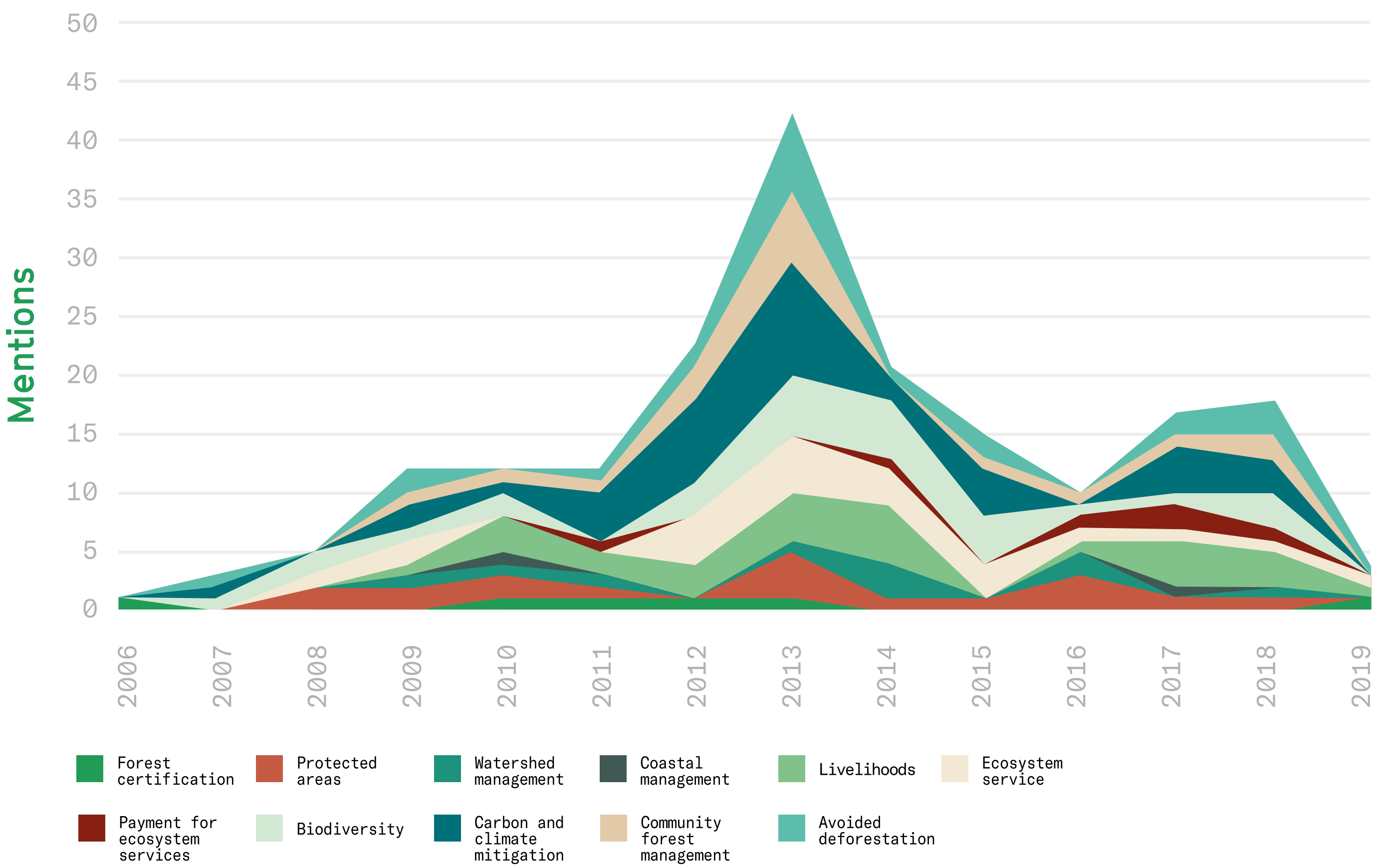


Figure 6. Forest Project Themes, 2006–2019

The figure shows the steep rise of carbon as a theme in project documents, from a first mention in 2008 to dominance by 2011. This is also the case for avoided deforestation, although it is not as prevalent after 2013. Biodiversity was also a common theme. Livelihoods and ecosystem services were both important until the latter lost ground around 2017–2018. Forest certification was increasingly mentioned until 2013, when it stagnated. Table 7 shows how the use of these discourses change between loan funded projects, grant financed projects and climate financed funded projects:

Theme	Grant		Loan		Climate funds		Portfolio	
	(n)	%	(n)	%	(n)	%	(n)	%
Carbon	33	42	10	38	7	29	38	46
Biodiversity	24	31	7	27	5	21	28	34
Livelihoods	18	23	11	42	11	46	27	33
Avoided deforestation	18	23	9	35	7	29	22	22
Ecosystems services	20	26	7	27	3	13	22	27
Protected areas	12	15	5	19	6	25	18	22
Community forest management	12	15	10	38	7	29	17	21
Watershed management	8	10	2	8	2	8	10	12
Forest certification	4	5	2	8	3	13	6	7
Payment for ecosystem services	3	4	0	0	3	13	6	7
Mangroves	1	1	1	4	2	8	3	4
Coastal management	0	0	0	0	2	8	2	2
Total	**78**	**100**	**26**	**100**	**24**	**100**	**82**	**100**

Table 7. Forest Project Theme, by Type of Funding

Judging from their frequent mention in grant-funded projects, carbon (42 percent) and biodiversity (31 percent) were clear donor favorites, as were livelihoods, avoided deforestation, and ecosystem services. Coastal management was not mentioned in any grant projects, and mangroves in only one. Livelihoods (42 percent) were the main theme in loan projects, followed by community forest management and carbon (38 percent each), indicating a focus on linking forests with socioeconomic outcomes. Finally, almost half (46 percent) of climate finance–funded projects mentioned livelihoods, followed by carbon and community forest management (29 percent each). Forests' importance for both mitigation and adaptation in climate change explains these results: carbon is not the only justification for including forests in climate change projects.

Conclusion

This chapter analyzes the 99 forest projects approved by the IDBG between 2006 and June 2019 (12.5 years). Results are based on analyses of project documents and interviews with 23 current and former IDBG staff. Project approvals have changed over time in both number (with a peak in 2013) and funding (fewer but larger loans). The focus of the investments in forests has not changed significantly over time, with sustainable forest management, governance, and conservation being the lead project objectives. Finally, carbon, biodiversity, and livelihoods were the most common topics or themes used to justify forest projects. The semistructured interviews provided information on how forest projects at the IDBG have changed over time, the reasons for these changes, the IDBG's added value for forests, and how projects originate and are developed.

Given the bank's shift in the 1990s from hiring technical experts to building teams of specialists who act as pipeline and project managers, it is important to evaluate the role the IDBG wants to have in a technical area like forestry. The number of projects and their funding have increased significantly over the evaluated timeframe, mostly because of the increased availability of climate finance (which accounted for 14.2 percent of all forest funding approved by the IDBG in the study period). This increase was driven largely by country demands and individual specialists' influence, without much strategic guidance from the bank, its thought leadership, or its technical expertise; rather, project development is mostly opportunistic.

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Annex 1.
Projects Included in the Analyses

Country	Region	Project ID	Project or program	Approval date
Regional	—	RG-T1145	Sustainable Development of the Agroforestal Resources of Border Areas: BR,CO,PE	13-Feb-06
Regional	—	RS-T1259	Instruments for Implementing Forest Vocation Land Policy	06-Jun-06
Uruguay	SO	UR-T1019	Environmental Certification for Forestry Production	10-Aug-06
Regional	—	RS-T1277	Mobilizing Capital Markets for Forestry Financing in LAC Countries	11-Oct-06
Haiti	CA	HA-T1046	Policy and Forestry Action Plan for Haiti	20-Dec-06
Regional	—	RS-T1351	Improving Forest Investment Attractiveness at Sub-national Level	04-Jun-07
Ecuador	AN	EC-T1103	Improving the Business Climate for Forest-based Investments in Ecuador	01-Aug-07
Regional	—	RS-T1281	Sustainable Forest Business Specialist for Rural Development	16-Aug-07
Guyana	CA	GY-T1058	Climate Change and Biodiversity Mainstreaming through Avoided Deforestation	18-Dec-07
Guyana	CA	GY-M1007	Sustainable Forestry in Protected Areas	29-Feb-08
Paraguay	SO	PR-T1056	Forest Vocation Land Policy Implementation in Paraguay	10-Mar-08
Paraguay	SO	PR-T1077	Mobilizing Banking System to Finance Forest-based Businesses	16-Jul-08
Guatemala	CE	GU-X1001	Improvement Of Management Effectiveness Of The Maya Biosphere Reserve	03-Dec-08
Colombia	AN	CO-T1145	Mainstreaming Biodiversity Conservation through avoided Deforestation	04-Mar-09

AN = Andes; CA = Caribbean; CE = Central America; SO = Southern Cone; “Regional” projects are general activities not specific to a country.

Country	Region	Project ID	Project or program	Approval date
Guatemala	CE	GU-L1014	Establishing Cadastral Registry & Strengthening Legal Certainty Protected Areas	17-Jun-09
Haiti	CA	HA-X1002	Sustainable Land Management of the Upper Water-sheds of South Western Haiti	23-Sep-09
Bolivia	AN	BO-L1053	Misicuni Watershed Environmental Management Project	01-Jan-10
Brazil	SO	BR-L1103	Bahia Environmental Development Program	17-Feb-10
Regional	—	RG-M1123	Forest Conservation through Certification, Commer-cialization and Strengthening o	10-Mar-10
Brazil	SO	BR-L1241	Serra do Mar and Atlantic Forest Mosaics System Socioenvironmental Recovery	08-Sep-10
Nicaragua	CE	NI-L1048, NI-X1011	Environmental Program for Disaster Risk and Climate Change Management	29-Sep-10
Guyana	CA	GY-T1076	Developing Capacities in Implementing REDD+	08-Dec-10
Peru	AN	PE-T1225	REDD pilot projects with local communities in the 3 regions of Peruvian Amazon	06-Jan-11
Brazil	SO	BR-T1194	Improving Tropical Forest Management as a Strategy for CC Mitigation	18-May-11
Guyana	CA	GY-T1085	Strengthening of Iwokrama Phase II	14-Jun-11
Uruguay	SO	UR-L1068	Montes del Plata	02-Aug-11
Peru	AN	PE-T1238	Designing the Forest Investment Program Strategy for Peru	12-Aug-11
Colombia	AN	CO-X1008	Mechanism For Voluntary Mitigation Of Greenhouse Gas Emissions In Colombia	31-Aug-11
Haiti	CA	HA-L1059	Technology Transfer to Small Farmers	31-Aug-11
Nicaragua	CE	NI-X1005	Integral Management of the Apanas and Asturias Watershed	04-Nov-11
Guyana	CA	GY-G1002	Institutional Strengthening in support of Guyana LCDS	01-Feb-12
Mexico	CE	ME-T1210	Forest Investment Program Preparation	29-Feb-12

AN = Andes; CA = Caribbean; CE = Central America; SO = Southern Cone; “Regional” projects are general activities not specific to a country.

Country	Region	Project ID	Project or program	Approval date
Colombia	AN	CO-X1011	Biodiversity Conservation in Palm Cropping Areas	19-Apr-12
Peru	AN	PE-T1275	Internship Forest Investment Program (FIP) in Mexico	16-Jul-12
Brazil	SO	BR-T1264	Preparation of the BR-G1003 Project	23-Jul-12
Brazil	SO	BR-T1265	Project Preparation Grant for the Forest Information Project	17-Sep-12
Costa Rica	CE	CR-T1094	Support to the design of project Sustainable Management Of Ecosystem Services	31-Oct-12
Mexico	CE	ME-L1120, ME-G1002	Financing Low Carbon Strategies in Forest Landscapes	14-Nov-12
Mexico	CE	ME-G1002	Financing Low Carbon Strategies in Forest Landscapes	14-Nov-12
Argentina	SO	AR-L1067	Forest Sustainability and Competitiveness Program	28-Nov-12
Guatemala	CE	GU-M1044	Recovery of Natural Capital of the Dry Corridor Region and Climate Adaptation	05-Dec-12
Regional	—	RG-X1166	Strengthening IDB Operational Expertise on REDD+TFA	08-Feb-13
Brazil	SO	BR-X1024	Low Carbon Agriculture and Avoided Deforestation for Reducing Poverty	03-Apr-13
Brazil	SO	BR-L1289	The Acre Sustainable Development Program (PDSA-II)	10-Apr-13
Mexico	CE	ME-M1079, ME-T1217, ME-L1139	Support for Forest Related MSMEs in Ejidos-Implementation of Forest Investment	10-Apr-13
Peru	AN	PE-T1298	Designing the Forest Investment Program Strategy for Peru	14-May-13
Haiti	CA	HA-G1023	Sustainable Management Upper Watersheds South Western Haiti-Macaya National Park	31-Jul-13
Guatemala	CE	GU-T1194	National Strategy for Reducing Emissions through Avoided Deforestation and Fores	12-Sep-13
Brazil	SO	BR-T1275	Linking climate change mitigation to community based forest management in Amapá	28-Oct-13
Guyana	CA	GY-T1097	Forest Carbon Partnership Facility Project in Guyana	04-Dec-13

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Country	Region	Project ID	Project or program	Approval date
Brazil	SO	BR-T1277	Forest Information to Support Public and Private Sectors in Management Initiative	13-Dec-13
Brazil	SO	BR-T1287	Planning and Capacity Building of the Transition Fund for ARPA for Life	13-Dec-13
Brazil	SO	BR-T1293	Planning and Capacity Building of the Transition Fund for ARPA for Life	13-Dec-13
Regional	—	RG-T2353	Knowledge Generation on Forest and Climate Change	16-Dec-13
Colombia	AN	CO-G1002	Adaptation to Climate Impacts in Water Regulation and Supply for the Area of Chi	01-May-14
Peru	AN	PE-T1294	Implementation of the Readiness Preparation Proposal (R-PP) for Reducing Emissio	14-May-14
Regional	—	RG-T2444	Developing Opportunities for Private Sector Investment in Biodiversity and Ecosy	04-Jun-14
Regional	—	RG-T2462	Developing Opportunities for Private Sector Investment in Biodiversity and Ecosy	04-Jun-14
Regional	—	RG-T2369	Poverty Alleviation and Protected Areas	13-Jun-14
Peru	AN	PE-T1317	Mitigating Deforestation in Brazil Nut Concessions in Madre de Dios, Peru	24-Jul-14
Brazil	SO	BR-G1003	Recovery and Protection of Climate and Biodiversity Services in Brazil's outheast Atlantic Forest Corridor	31-Jul-14
Jamaica	CA	JA-G1001	Integrated Management of the Yallahs-Hope Water-shed Management Area	09-Sep-14
Brazil	SO	BR-L1404	Klabin - Puma Project	29-Oct-14
Colombia	AN	CO-T1381	Preparation of the GEF project "Consolidation of the SINAP at National and Regio	26-Jan-15
Guyana	CA	GY-L1043	Strengthening of the Environment Sector II	11-Feb-15
Regional	—	RG-T2532	Natural and Human Systems of the Amazon Basin: An interactive map to raise publi	11-Mar-15
Peru	AN	PE-T1287	Technical Assistance for the Preparation of the FIP-PERU's Programs	20-Mar-15

AN = Andes; CA = Caribbean; CE = Central America; SO = Southern Cone; "Regional" projects are general activities not specific to a country.

Country	Region	Project ID	Project or program	Approval date
Regional	—	RG-T2545	Developing PES Guidelines for the Amazon Region	14-May-15
Honduras	CE	HO-T1227, HO-T1229	Update local mangrove inventories, conservation, mitigation and adaptation to c	19-Nov-15
Colombia	AN	CO-T1395	Assessing Tropical Dry Forest Biodiversity and Ecosystem Services	10-Dec-15
Mexico	CE	ME-L1192	Ejido Verde Reforestation	17-Dec-15
Regional	—	RG-Q0038	EcoEnterprises Biodiversity Fund to Support the Nagoya Protocol through Impact Investing	07-Dec-16
Colombia	AN	CO-T1412	Sustainable Management and Conservation of Biodiversity in the Magdalena River Basin	08-Dec-16
Colombia	AN	CO-T1387	Consolidation of the National System of Protected Areas at the National and Regional Levels	08-Dec-16
Honduras	CE	HO-L1179	Sustainable Forest Management	14-Dec-16
Regional	—	RG-T2942	Enhancing climate smart and forest-friendly practices and technology in LAC	10-Apr-17
Honduras	CE	HO-L1152, HO-T1255	Boosting the Competitiveness of Small Forest Producers and Communities in Honduras	17-May-17
Peru	AN	PE-T1358	Climate-smart Agriculture Development Impact Bond Model for Productive Improvement of Agroforestry Products and the Conservation of the Forest of Asháninka Communities in the Peruvian Amazon	19-Jul-17
Brazil	SO	BR-Q0019, BR-T1333	Development of a Macauba-Based Silvopastoral System and Value Chain	26-Jul-17
Guatemala	CE	GU-T1272	Phase II of Preparation of the National Strategy for Reducing Emissions through Avoided Deforestation and Forest Degradation in Guatemala	13-Oct-17
Haiti	CA	HA-L1107, HA-G1038, HA-G141	IFAD Cofinancing to HA-L1107 - Agricultural and Agroforestry Technological Innovation Program - PITAG	01-Nov-17
Bahamas	CA	BH-L1043	Climate Resilient Coastal Mangement and Infrastruc-ture Program	08-Nov-17
Colombia	AN	CO-L1166	Sustainable Colombia Program	01-Dec-17

AN = Andes; CA = Caribbean; CE = Central America; SO = Southern Cone; “Regional” projects are general activities not specific to a country.

Country	Region	Project ID	Project or program	Approval date
Peru	AN	PE-T1383	Support to Peru in the implementation of the Peru Fund of the Joint Statement of DCI (REDD+) Intentions	04-Dec-17
Suriname	CA	SU-T1096	Introducing a Natural Capital Asset Class in Global Exchange Markets: The Central Suriname Nature Reserve Company	06-Dec-17
Mexico	CE	ME-L1268	Land Management for the Achievement of Results of the Climate Change Agenda	13-Dec-17
Brazil	SO	BR-G1004	Conservation, Restoration and Sustainable Management in the Caatinga, Pampa and Pantanal - GEF Terrestre	12-Mar-18
Peru	AN	PE-T1385	Phase II of Support for Implementation of the National Strategy for Reducing Emissions from Avoided Deforestation and Forest Degradation in Peru	12-Apr-18
Nicaragua	CE	NI-T1266	Knowledge Exchange in Forest Management	26-Jun-18
Dominican Republic	CA	DR-L1120	Sustainable Agroforestry Development Program	27-Jun-18
Regional	—	RG-T3223	Sustainability as an Instrument for the Development of Strategic Productive Sectors	06-Aug-18
Peru	AN	PE-L1232 & PE-G1003	Forest Investment Projects in Peru	19-Sep-18
Brazil	SO	BR-L1497	Program of Urban Improvement and Citizen Security Program (Phase One of the Sustainable Vitória Action Plan)	28-Sep-18
Regional	—	RG-T3177	Water Funds: A Conservation/Climate Resilient Model for Stressed Watersheds in Latin America and the Caribbean	04-Oct-18
Colombia	AN	CO-G1012	Strengthening of Forest Governance	13-Dec-18
Guatemala	CE	GU-L1165, GU-G1005	Sustainable Forest Management Project	26-Jun-19

AN = Andes; CA = Caribbean; CE = Central America; SO = Southern Cone; “Regional” projects are general activities not specific to a country.

Annex 2.
Semistructured Interview Guide

Name: ______________________________

Position at IDB: ______________________________

Location based at: ______________ **since:** ______________

What year did you enter the Bank? (If left, when did you leave?) ________

(If prior to date since based at current location, ask where also has been based)

I'm doing an assessment on Bank funded projects related to forests in the last 20 years.

1. What forest projects have you worked with in the Bank?

2. I'd like to get your opinion on how Bank funded forest projects have changed since you entered the Bank. How/why have these changes occurred?

3. Have the type of forest activities being implemented changed over time? E.g. protected forest, rehabilitated forest, sustainable forest management, governance.

4. Show graph of forest project approvals over time. What do you think?

5. Show graph of forest themes over time. What do you think? How does this reflect your reality/country?

6. Given that bank projects depend on national priorities, how much do you think the forest projects you worked on were push (IDB led) vs pull (country demand)?

7. Why is the IDB called to work on forest projects?

Source: Photo by Norton R. 2019. Unsplash, Consulted 2020.

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