A Forest's Worth

Policy options for a sustainable and inclusive forest economy in Paraguay

PARAGUAY COUNTRY FOREST NOTE

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Table of contents

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Executive summary

The decline of Paraguay's forests in recent decades has brought the country to a crossroads—Paraguay can integrate forests into its development agenda or lose a valuable resource base and the important ecosystem services it generates.

Endowed with rich forest resources, Paraguay has lost a large portion of its native forest cover in recent decades, primarily owing to the rapid expansion of the agricultural frontier and, to a lesser extent, the extraction of fuelwood, which underpins the country's energy security. A forest plantation subsector is emerging, in part to address the annual deficit of sustainably sourced biomass of around 9 million cubic meters (m3), but it remains small. Exports of forest products have been declining, forest value chains are underdeveloped, and the sector is facing high levels of informality and illegality, performing well below its potential. Meanwhile, large-scale forest loss threatens the continued provision of ecosystem services that support the economy. Paraguay has enjoyed solid economic growth and poverty reduction in recent decades, but questions arise on how to sustain these trends, as the factors that have propelled the economy may not serve as well in the future. Bound by the country's borders, the agricultural frontier cannot continue to expand indefinitely, and agricultural exports alone may not deliver continued increases in real income. Future growth will need to rely more on sustainable and intensive value-added agricultural and forest production and promote diversification.

In this context, this Country Forest Note provides an upstream analysis of the obstacles the forest sector faces and outlines a set of priority areas for policies and investments that could foment a more sustainable and dynamic sector that serves as an engine of growth.

Since forest management happens at the nexus of multiple sectors and actors, the note sheds light on the value of forests by comparing trade-offs between competing land uses. It estimates the economic value of native and planted forests alongside average commercial returns from agriculture, showing that forests can make economic sense in Paraguay **(see Figure ES.1)**. When compared to average returns from agriculture and livestock, plantation forestry can offer comparable rates of return of 10–14 percent, with attractive opportunities available in commercial forestry, including silvopastoral models. Native forests also represent tangible value embedded in the vital ecosystem services they generate, which can exceed commercial returns from other land uses.

More than meets the eye: Contribution of forests to the economy

Forests contribute to Paraguay's economic activity and job creation, but the sector represents missed opportunities.

In 2018, the forest sector contributed about 2.5 percent of Paraguay's gross value added (GVA) (BCP 2020). Based on 2011 data, it employs about 330,000 workers formally and informally (Szulecka and Monges Zalazar 2017). Yet there are signs that the sector operates below its potential. It suffers from high levels of informality, and in 2018 Paraguay had a trade deficit in wood products of $244 million. Forest value chains are characterized by high-volume, low-value products, with nearly all domestic wood supply being used as fuelwood. Exports of wood products, such as pulp, paper and cardboard, plywood and charcoal, have either declined or remained constant since 2010 (BCP 2020). Wood-processing capacity exists but remains largely artisanal and relies on native forests for raw materials.

The contribution of forests to the economy goes well beyond what is captured in traditional economic metrics, however, as forests have tangible economic value in the form of ecosystem services.

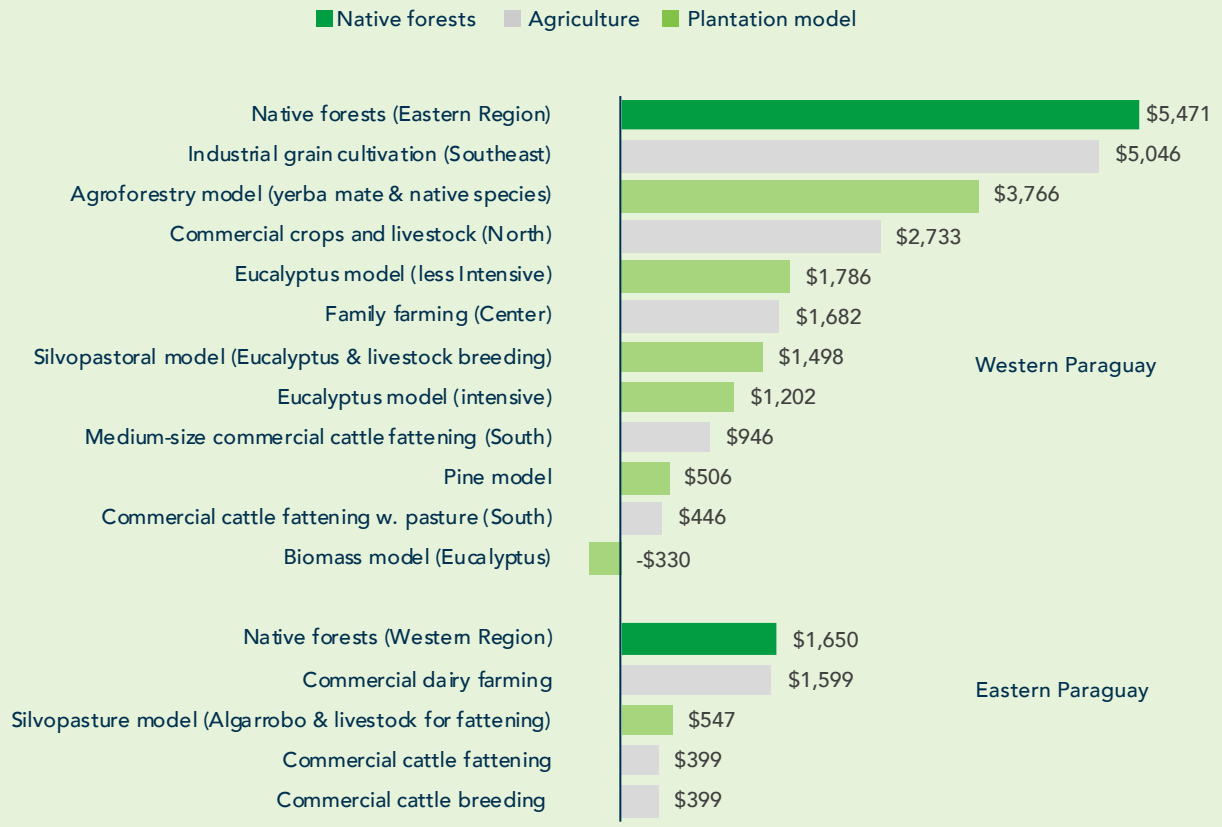
Native forests provide vital ecosystem services such as soil erosion protection, watershed protection services, sustainable bushmeat, timber and fuelwood provision, and carbon sequestration. The net present value of a hectare (ha) of native forest is estimated at $3,600–$7,300 in Eastern Paraguay and $1,100–$2,000 in Western Paraguay, oftentimes exceeding the commercial yields from alternative agricultural or livestock land use **(see Figure ES.1)**. These benefits are predominantly local in nature—they underpin rural and indigenous livelihoods and support productive sectors, including agriculture. Yet private landowners typically view standing forests as an opportunity cost, even though from an economic perspective, it can be more costly to convert forest to cropland and pasture. One key reason is the inability of private actors to capture the full value of standing forests.

Under the current trends, annual deforestation costs for Paraguay are estimated at $628 million, or 1.6 percent of gross domestic product (GDP) in 2017.

Under pessimistic deforestation scenarios, they could reach $1,196 million or 3 percent of GDP in 2017. Conversely, if deforestation drops to 125,000 ha per year in Western Paraguay, and net reforestation/afforestation reaches 10,000 ha in Eastern

FIGURE ES.1

Net present value of forest and agricultural land use (US$/ha)



Source: Original calculations conducted between 2017 and 2020.
*Note: The value of various land use models is expressed as the net present value of economic of commercial returns they generate (for underlying data, **see Table 3 and Table 5**).*

Paraguay, the cost could be limited to $164 million, or 0.4 percent of GDP in 2017. The economic costs from deforestation are felt first by the most vulnerable—rural and indigenous populations who depend on forests for livelihoods and safety nets. In the longer-term, losses of ecosystem services also undermine productive sectors.

Policy and governance gaps prevent the sector from reaching its potential

Forest management in Paraguay has historically been characterized by a laissez-faire approach, which has left policy and governance gaps that are hindering the development of a sustainable and dynamic forest sector.

With 95 percent of Paraguay's land under private ownership, forests are embedded in productive (predominantly agricultural) landscapes and the responsibility for (as well as the costs of) forest management rests on private landowners. Land tenure is highly concentrated, giving rise to political economy challenges. At the same time, environmental agencies do not have sufficient capacity to manage forests effectively and engage other sectors. Forest law enforcement is weak, transparency low, and systematic land use planning that incorporates forest values is lacking. The sector also lacks sound fiscal, financial, and regulatory incentives.

While the law mandates forest conservation on private land, its enforcement is limited.

Law 422/73 (Forest Law) requires that owners of land exceeding 20 ha preserve 25 percent of the native forest cover; those who fail to comply have a "forest deficit" and are required reforest or purchase offsets. In principle, the law offers protection to forests, but violations are widespread. By 2014 the nationwide forest deficit was estimated at 2.49 million ha, with little of it restored or offset (Vidal 2015). In Eastern Paraguay, the "Zero Deforestation Law" prohibits all clearing of native forests, but it has been only partially effective. Weak enforcement stems partially from ambiguities in the law itself and partially from weak capacity. Paraguay does not yet have a modern cadaster that incorporates forest data, and environmental agencies lack modern monitoring systems and have limited presence in the field. While the government has taken steps to improve enforcement, much work remains as there continues to be a general sense of impunity for forest violations.

Like other countries, Paraguay faces challenges in balancing trade-offs between different land uses.

Forest management happens at the nexus of multiple sectors and government agencies that govern land use, requiring coherent intersectoral policy and coordination. Paraguay does not currently have a comprehensive and up-to-date territorial and land use plan, and integrated landscape management has yet to be implemented. This makes it difficult to maximize and balance the productive and conservation functions of the land—including forests—in primarily agricultural landscapes. The government has yet to develop a coherent policy framework and coordination mechanisms for the land use sector that bring together all relevant sectors and institutions at the national and subnational levels.

There are insufficient economic incentives for landowners to pursue sustainable forest management.

Many ecosystem services of forests are public goods and cannot be easily monetized by private landowners in the absence of functioning environmental markets. In a weak regulatory climate where illegal forest clearing often carries no or limited consequences, native forests are generally perceived as an opportunity cost compared with returns from competing land uses. The government has taken some steps to address this challenge. A notable example is the Environmental Services Regime (ESR)—a market-based environmental offset mechanism established in 2006 to allow landowners who maintain forest cover over and above the legal forest reserve to sell Environmental Service Certificates to landowners with a forest deficit. However, so far the mechanism has not created a viable domestic offset market or reached foreign buyers. Despite the large nationwide forest deficit under the Forest Law, as of April 2019 only 214,000 ha of non-public forestland was ESR-certified, and only 20,500 ha worth of offsets had actually been traded. In terms of fiscal policy, there are limited incentives—and sometimes disincentives—for sustainable land use and there are no explicit green taxes or other fiscal instruments earmarked for environmental purposes.

Access to finance for forestry remains limited, curtailing investment.

The public second-tier development bank Agencia Financiera de Desarollo made only three loans through its forestry loan program, PROFORESTAL, between 2008 and 2019. The central bank has recently taken steps to improve the flow of finance for forestry, but more hurdles need to be overcome, notably the perception of forestry as a high-risk investment among financial institutions, which requires de-risking to improve access to finance.

The broader challenge is that the sector has yet to widely embrace sustainable forest management, and this points to regulatory gaps and insufficient support to producers.

Earlier this year, Paraguay established a regime for the certification of woody biomass for energy, taking an important step to promote sustainably managed native or planted forests; however, the regime does not apply to timber. The absence of a comprehensive national forest certification standard and of a timber traceability system implies that it is difficult to obtain independent ascertainment of the sustainability and origin of forest products. Moreover, the country does not have recognized management best practices for forestry. Government assistance remains limited despite the large gap between current forest management practices (particularly among smallholders) and the performance level required by international certification standards or best practice.

Seizing the potential of forests for Paraguay's development

A dynamic and sustainable forest sector presents win-win opportunities for Paraguay, and two broad opportunities can pave the way: a shift toward integrated landscape management that promotes forest-friendly agriculture, and the development of sustainable forest plantations.

Besides maintaining local ecosystem functions that support productive sectors and the population, these approaches can generate jobs, boost GDP, help diversify the economy, and broaden the export base—opportunities that can support Paraguay's recovery from the COVID-19 crisis and underpin long-term growth in an inclusive way. In addition to creating jobs in rural areas, where employment is scarce and poverty persists, formalization of forestry could improve labor conditions and unlock opportunities for greater participation of women.

A shift to improved landscape management and increased adoption of sustainable production practices would help Paraguay's agricultural and livestock producers mitigate risks.

Agricultural commodities are coming under growing scrutiny from consumers and investors globally over their environmental impact, driving a shift toward greater transparency over deforestation in supply chains and sustainable sourcing standards in global markets. The country's key export commodities—beef and soybeans—are lagging behind, and the limited uptake of sustainable practices in these industries can curtail their future ability to attract investors and access markets. Paraguay's model that relies on continued expansion of the agricultural frontier also depletes the ecosystem services that underpin agricultural productivity and pushes production into marginal areas. In contrast, acting to reduce deforestation risks minimizes future costs, even more so in light of climate change impacts. Green commodities can also provide access to more markets. To mitigate these risks and seize the related opportunities, Paraguay needs to adopt integrated landscape management that balances productive needs with conservation needs in an effort to maximize the functions of the land. In addition, sustainable agriculture and livestock production models, including integrated silvopastoral models, are emerging in Paraguay, but require strong policy signals to be scaled up.

Developing a sustainable forest plantation sector would allow Paraguay to unlock economic opportunities while also closing the domestic supply gap for sustainably sourced fuelwood.

The steadily growing domestic and international demand for solid and wood-based panels, pulp and paper, and biomass represent market opportunities for Paraguay to leverage. Meanwhile commercial forestry models in Paraguay are proving to be financially viable, with commercially attractive opportunities to explore in silvopastoral models and those that combine biomass and higher-value solid wood. Maximizing the economic potential of plantation forests requires an industrialization and value forest addition strategy, modernizing wood-processing industries and improving the investment climate to facilitate entry of strategic market players. Biomass offers another key opportunity: Meeting Paraguay's fuelwood demand through plantations can help formalize the sector, with attendant benefits for job creation and quality, tax revenues, and a potential increase in annual GVA by $154 million, or 0.5 percent.

Making it happen: Priorities for policy action and investment

To seize these opportunities, Paraguay needs to embrace a reform and investment agenda to create the enabling conditions for a dynamic forest sector.

Progress will require long-term commitment from the government and the engagement of stakeholders and partners. Priority areas for intervention include the following **(see also Table ES.1)**:

- **Governance and policy reform to stem the decline of native forests,** which should focus on (i) adopting integrated landscape management to balance competing land uses and include forests into land use planning and decision-making, as well as sector policy, (ii) improving compliance with the forest law, and (iii) strengthening incentives and the enabling environment for sustainable forest management. The forest sector needs to be supported by a clear legal and regulatory framework that is free of ambiguities. Incentives need to be in place to ensure that forest land use makes economic sense to landowners. One way to achieve this is to improve the simplicity, certainty, and fairness of the Environmental Services Regime to ensure it is fully operational and effectively supports land use decision-making. A coherent forest law enforcement program is also needed, spanning prevention, detection, suppression, and recovery of illicit activity. Some of the preconditions for transparency and good governance in the sector include up-to-date and publicly accessible digital forest data.
- **Development of the forest plantation sector** should be grounded on a well-structured government strategy for forest plantations, focusing on boosting both the demand and supply side of the sector to accelerate its development. A plan is needed to identify suitable plantation locations and formulate an industrialization and value-addition strategy that combines analysis of available inputs to production, processing capacity, as well as potential markets, and the enabling environment for the market. In turn, supportive public policies and programs are needed to implement the plan. These include best practices for productivity and sustainability, a national sustainability certification standard, a timber traceability system to verify legal origin, quality technical assistance services, and access to finance, including for small and medium producers. The latter should be supported by de-risking investments to foment a credit market, including through partial credit guarantees and development of a risk insurance product for forest plantations.

TABLE ES.1 Summary of recommendations

Key areas for policy action, reform, and investment	Short term (1–3 years)	Medium term (3–5 years)	Long term (5+ years)
Governance and policy reform to stem the decline of native forests			
Planning and integrated landscape management			
Adopt integrated landscape management to mainstream forests into territorial planning and sector policy	■	■	
Develop natural capital / forest accounts	■		
Legal and regulatory reform			
Eliminate ambiguities in Law 422/73 and implementing provisions	■		
Articulate environmental criteria in Law 422/73; update and reinforce regulation on forest corridors	■		
Reform instruments that are not implemented, such as obsolete provisions in Law 3001/06 (Environmental Services Regime); Law 536/95 on Promotion of Afforestation and Reforestation; and Law 4890/2014 on Forest Cover Property Rights	■		
Enforcement			
Prevention: Ensure legal clarity, appropriate penalties, traceability of illegally sourced products; invest in extension services and support for sustainable forest management and forest certification	■	■	■
Detection: Create a rural cadaster with forest data and central clearing house for land use information; invest in the National Forest Monitoring System; make forest-related data publicly available	■	■	
Suppression: Ensure cooperation between and functional capacity within institutions tasked with responding to illegality; clarity in institutional mandates; invest in training and equipment	■	■	
Recovery: Apply forest restoration and offsetting consistently; establish protocols for handing seized proceeds	■	■	
Economic incentives			
Improve the simplicity, certainty, and fairness of the Environmental Services Regime to apply it consistently	■	■	
Conduct intersectoral analysis of incentives affecting forests to create level playing field for forest land use	■		
Development of the forest plantation sector			
Develop a strategy and plan to develop the plantation sector and access international markets	■		
Invest in research and development on the adaptation of forestry practices to the Paraguayan context	■	■	■
De-risk investments in plantations by ensuring availability of technical assistance to ensure quality plantation management; certifying quality germplasm inputs; ensuring the availability of partial credit guarantees; improving fire, pest, theft, and land encroachment control; developing a risk insurance product for forest plantations	■	■	
Strengthen sector knowledge in financial institutions	■		
Include spatial plantation investment prospects in planning of roads and other infrastructure	■		
Develop and disseminate best management practices for productivity and sustainability	■		
Adopt an industrial policy for increasing local value addition		■	
Provide support to small and medium forest producers to organize into producer groups		■	
Promote Paraguayan wood products in international markets			■

Acronyms

AFD	Financial Development Agency (Agencia Financiera de Desarrollo)
ANDE	National Electricity Administration (Administración Nacional de Electricidad)
BAU	Business as usual
ESR	Environmental Services Regime
ESC	Environmental Service Certificate
FSC	Forest Stewardship Council
GDP	Gross domestic product
GHG	Greenhouse gas
GVA	Gross value added
HEI	High environmental impact
INDERT	National Institute of Rural and Land Development (Instituto Nacional de Desarrollo Rural y de la Tierra)
INFONA	National Forestry Institute (Instituto Forestal Nacional)
ITAIPU	Itaipu Dam (Central Hidroeléctrica Itaipú Binacional Usina Hidrelétrica Itaipu Binacional)
LULUCF	Land use, land use change, and forestry
MADES	Ministry of Environment and Sustainable Development (Ministerio del Ambiente y Desarrollo Sostenible)
MAI	Mean annual increment
MOPC	Ministry of Public Works and Communications (Ministerio de Obras Públicas y Comunicaciones)
NPV	Net present value
OECD	Organisation for Economic Co-operation and Development
PEFC	Programme for the Endorsement of Forest Certification
PES	Payments for ecosystem services
PPP	Purchasing power parity
PYG	Paraguayan guaraní (local currency)
RA	Risk-adjusted
REDD+	Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks
RTRS	Round Table on Responsible Soy Association
SEAM	Secretariat of the Environment (Secretaría del Ambiente, today Ministry of the Environment and Sustainable Development)
SENACSA	National Service of Quality and Animal Health (Servicio Nacional de Calidad y Salud Animal)
SINASIP	National System of Wild Protected Areas (Sistema Nacional de Áreas Silvestres Protegidas)
SNC	National Cadaster Service (Servicio Nacional de Catastro)

All dollars are U.S. dollars unless otherwise indicated

Introduction

The decline of Paraguay's forests in recent decades has brought the country to a crossroads—Paraguay can integrate forests into its development agenda or lose a valuable resource base and the important ecosystem services it generates.

Originally endowed with rich forest resources, Paraguay has lost a large portion of its native forest cover in recent decades to the rapid expansion of the agricultural frontier and, to a lesser extent, the extraction of fuelwood that continues to serve over 40 percent of final domestic energy consumption. A forest plantation subsector is emerging, in part to satisfy the domestic need for biomass for energy and timber, but it remains small. Exports of forest products from Paraguay have been on the decline, forest value chains are underdeveloped, and the sector is characterized by high levels of informality and illegality, flooding the local market with illegally sourced fuelwood and timber from native forests. As a result, the sector is performing well below its potential in attracting investment, creating rural jobs, and supporting economic growth and diversification. Meanwhile, deforestation represents economic costs, notably in the form of forgone ecosystem services that underpin Paraguay's economy. As the COVID-19 recovery ensues, pressures on forest resources may intensify, creating greater urgency for coherent and consistent policies to address forest loss and harness the sector's economic potential.

This Country Forest Note seeks to provide an upstream analysis of the obstacles Paraguay's forest sector faces and outline a set of priority areas for policy action that could foment a more dynamic and sustainable sector that serves as an engine of growth.

Since forest management happens at the nexus of multiple sectors and actors, the note sheds light on the trade-offs between competing land uses by presenting estimates of the economic value of native forests alongside average commercial returns from agriculture and forest plantations. On the basis of results that show that the economic value of standing forests and the financial value of plantations can in numerous instances outstrip the value of agricultural production, the report emphasizes the need for a sector vision centered on (i) integrated landscape management that promotes sustainable agricultural practices and preserves the native forest resources, and (ii) the development of a forest plantations subsector that could alleviate the pressures on native forests and unlock the development potential of the sector. The note is part of a broader technical assistance of the World Bank to the government of Paraguay.[1] It is intended to serve as a basis for further analysis and dialogue with key stakeholders on the way forward for the sector.

1. This technical assistance is part of a comprehensive World Bank program in the forest sector that includes an investment project, the Paraguay Forestry Project (P171351), and a policy lending operation that incorporated environmental legal and regulatory reform into the macroeconomic reform agenda—the First Economic Management Development Policy Loan (P169505). The Country Forest Note consolidates legal, economic, and financial analyses produced during these operations and technical assistance under the Inclusive Forest Economy in Paraguay (P169433) and Environmental Cost-Benefit Analysis and Best Practices for Forest Restoration (P162897) Advisory Services and Analytics projects.

The note is structured as follows:

CHAPTER 1

Lays out the development context in which the sector operates, including macroeconomic trends and the role of natural capital in Paraguay's economy.

CHAPTER 2

Describes the decline of native forests and its direct drivers and presents a snapshot of the emerging forest plantations subsector. This chapter also presents data on the contribution of forests to the economy, which includes an economic valuation of the ecosystem services generated by forests and the economic cost of deforestation.

CHAPTER 3

Analyzes the challenges that inhibit sustainable native forest management and the development of the plantations subsector by assessing the underlying governance and incentives frameworks in which the sector operates.

CHAPTER 4

Presents a vision for a more sustainable and dynamic forest sector, emphasizing two opportunities that could change its trajectory: (i) an integrated landscape management approach that promotes forest-friendly agriculture and preserves native forest resources, and (ii) a strong forest plantations subsector.

CHAPTER 5

Recommends a set of priority areas for policy action and investment that are needed to achieve this vision.

1 Country context: a strong economy propelled by natural resources

Over the last two decades, Paraguay has enjoyed solid economic growth supported by prudent macroeconomic policies and extensive leveraging of the country's natural resources, notably land and hydropower.

Between 2004 and 2018, Paraguay's gross domestic product (GDP) grew by 4.4 percent per year on average (World Bank 2020c). Growth was driven largely by agriculture and, to a lesser extent, hydroelectric generation (World Bank 2018a). Owing in large part to the strong performance of its agriculture sector, Paraguay stands out in the region for the positive contribution of net trade to growth. The rapid expansion of agribusiness—achieved in part through large-scale conversion of natural lands to agricultural use—has transformed the country into the world's fourth largest exporter of soybeans and tenth largest producer of beef (World Bank 2018a). The agriculture and livestock sectors account for 20 percent of Paraguay's GDP and generate two-thirds of exports (World Bank 2018b). Hydropower represents nearly 100 percent of electricity production, but 75 percent of this is exported (World Bank 2018a).

Paraguay has also made significant advances in reducing poverty and boosting shared prosperity.

A surge in commodity prices led to a sharp appreciation of Paraguay's real exchange rate and real incomes (IMF 2019), driving substantial poverty reduction. Measured as the share of individuals living on less than $5.50 (2011 PPP) per day, the poverty rate halved to 15.9 percent between 2003 and 2018 (World Bank 2020c), and the income of individuals at the bottom 40 percent of the population grew at an annualized rate of 4.2 percent (World Bank 2020b).

Poverty and inequality continue to be a challenge, however, particularly in the context of the COVID-19 crisis.

Paraguay's Gini coefficient is 46.2 (based on 2018 data; World Bank 2020c). In rural areas, the growth of commercial agriculture has not been matched by growth in family-based agriculture (World Bank 2020b). Some of the key sectors driving growth, such as export-oriented agriculture, are not labor-intensive. Poverty alleviation efforts are now stalled by the COVID-19 crisis, which is expected to result in a 3.5 percent decline in the country's GDP in 2020 as well as an increase in poverty (World Bank 2020a).

The key question for Paraguay's development pathway is how to sustain the past growth in real incomes, including in the recovery from COVID, as the factors that propelled the country's economy in recent decades may not serve as well in the future.

The country's GDP growth has been one of the most volatile in South America over the last decades, owing mostly to the volatility of agricultural GDP that fluctuates along with international commodity prices and weather-related shocks (IMF 2019) and to limited economic diversification. With agricultural commodity prices already high, they may not deliver continued increases in real income. Paraguay's record growth has also been accompanied by large-scale and unsustainable forest loss, which, as subsequent chapters suggest, carries high economic costs, feeds inequality, and threatens the continued provision of key ecosystem services. Bound by the country's borders, the agricultural frontier cannot continue to expand indefinitely. Future economic growth will need to rely on more sustainable and intensive value-added agricultural production and forest resource management and leverage the non-energy/nonagricultural export sectors (IMF 2019).[2]

2. Much of the recent expansion of agricultural export volumes has been driven by an increase in cultivation or pasture areas rather than in yields per hectare. Average yields have not increased much and production has expanded to more marginal land. At the same time, yields of major crops may be already close to the technological frontier. Thus, growth of a nonagriculture tradable sector is needed to sustain investment and productivity growth (IMF 2019).

Climate change adds to Paraguay's long-term vulnerabilities.

Over the past 50 years, temperatures have risen by about 1°c in the Dry Chaco region and 1.5°c in the Alto Paraná Atlantic Forest (USAID 2017). According to latest climate projections (Magrin et al. 2014), temperatures across Paraguay will continue to rise. Mean monthly temperatures are projected to rise by 2°c by the 2050s and by 4°c by the end of the century under a high-emissions scenario (RCP8.5). This will likely result in an increase in weather-related disasters, exacerbating existing vulnerabilities in the country. Rising temperatures and altered rainfall patterns, particularly more intense rainfall events, will pose significant challenges for water resource management and likely affect key sectors, including agriculture and forestry. Droughts, extreme heat, and flooding events are also projected to increase, primarily along the Paraguay River and the key watersheds in the Chaco. The frequency and intensity of El Niño and La Niña Southern Oscillation events may also increase, further exacerbating extreme weather (SEAM, PNUD, and FMAM 2017).

2 Paraguay's forest sector

2.1.

A rich but declining natural forest resource endowment

Paraguay has been endowed with rich forest resources, spanning 25.5 million hectares (ha) only 30 years ago and now covering some 16.6 million ha, or 40 percent of the national territory.

The Paraguay River divides the country into two regions: Eastern (representing 40 percent of the country and 14 percent of remaining forest cover) and Western (representing 60 percent of the country and 86 percent of remaining forest cover). Each contains distinct climatic characteristics and forest ecoregions. The most distinct are the Dry Chaco in Western Paraguay, consisting primarily of semi-deciduous forest interspersed with savanna, and the Alto Paraná Atlantic Forest—a tropical moist forest in Eastern Paraguay **(Table 1)**. Between these ecoregions are the Humid Chaco, a subhumid riparian forest and palm savannas along the Paraguay River, and the Cerrado, a savanna adjacent to the frontier with Brazil. The largest forest ecoregion is the Dry Chaco (10.2 million ha, or 62 percent of Paraguay's forest cover), followed by the Humid Chaco (4 million ha, or 24 percent) and the Atlantic Forest (2.2 million ha or 13 percent). The characteristics of each ecoregion are described in more detail in **Box 1.**

TABLE 1

Forest cover (2018) and deforestation (2001-2018) by ecoregion

Ecoregion	Forest extent, 2018		Deforestation, 2001–2018	
	Area (ha)	% of total forest cover	Deforestation (ha)	Av. deforestation (ha/yr)
Dry Chaco (Bosque Seco Chaqueño)	10,245,356	61.7	3,703,955	205,775
Subhumid riparian forest of the Paraguay River (Bosque Subhúmedo Inundable del Río Paraguay)	3,970,598	23.9	1,016,261	56,459
Atlantic Forest (Bosque Subhúmedo de la Región Oriental)	2,211,430	13.3	1,056,536	58,696
Cerrado (Bosque Subhúmedo del Cerrado)	164,796	1.0	33,527	1,862
Total forest cover	**16,592,181**	**100.0**	**5,810,279**	**322,793**

Source: The 2015–2018 data were obtained from INFONA (2020); the 2001–2015 data are from Republic of Paraguay (2016a). The 2017–2018 data are preliminary.

BOX 1
Characteristics of Paraguay's Forests

Paraguay's forests are part of major regional biomes containing significant biodiversity and ecosystem value. The Paraguayan Chaco represents 25 percent of the Gran Chaco—the second largest forest biome in South America after the Amazon (Veit and Sarsfield 2017). The Alto Paraná forest in the Eastern region is part of the Atlantic Forest—one of the world's most threatened forest ecosystems, which extends across Paraguay, Brazil, and Argentina. Both are key habitats for biodiversity. Even small patches of the Atlantic Forest contain important habitats for endemic and endangered species (Esquivel, Tiffer-Sotomayor, et al. 2019). The Chaco similarly hosts many endemic and unique species and, until recently, contained large expanses of contiguous and undisturbed forests—"intact forest landscapes" (Potapov et al. 2017). Forests are essential to preserving Paraguay's biodiversity, which includes 6,500–7,000 species of plants, 708 species of birds (including 79 endemic species, of which 23 are threatened), 63–75 species of amphibians, up to 150 species of reptiles, and as many as 167 mammal species (Kernan et al. 2010).

Structural analyses of the Chaco and Atlantic Forest, conducted during the development of Paraguay's Forest Reference (Emission) Level (Republic of Paraguay 2016a), reveals distinct climatic and ecological characteristics. The Dry Chaco is semi-deciduous xerophytic forest that is interspersed with savanna. Tree heights are relatively low, and the forest cover lightly stocked (with average aboveground biomass level of 50 tons per hectare [t/ha]). In contrast, the subhumid riparian forest (Humid Chaco) is characterized by forest islets that include palm groves and aboveground biomass levels of 141 t/ha. The Atlantic Forest is subtropical rain forest, with tree heights that can reach 34–40 meters and whose structure has three layers and a biodiverse understory. These forests are well stocked with aboveground biomass of 111 t/ha.

Trends in deforestation and degradation of native forests

Paraguay has one of the highest rates of forest loss in the world: Between 2001 and 2018 alone, the country lost 5.8 million ha of forest, predominantly in the Chaco.

According to government data (INFONA 2020; Republic of Paraguay 2016a) **(Table 1)**, between 2001 and 2018 the average forest loss amounted to 322,793 ha/yr, resulting in a cumulative loss of 5.8 million ha, or a 26 percent decrease in the forest cover. Of these, 64 percent was lost in the Dry Chaco (3.7 million ha) at an average rate of 205,775 ha/yr, notably in the departments of Boquerón, Alto Paraguay, and Presidente Hayes. Another 17 percent of the loss occurred in the Humid Chaco **(Table 1).** The Eastern Region accounted for 19 percent of the forest loss over the same period. **Figure 1** illustrates these trends by forest ecoregion. Regional analysis using a complementary data set on tree cover loss from the Global Forest Watch (WRI 2020a) reveals that Paraguay experienced the highest tree cover loss among its neighbors over this period **(see Figure 2)**.

FIGURE 1

Evolution of the forest cover, 2000–2018

Source: INFONA 2020.

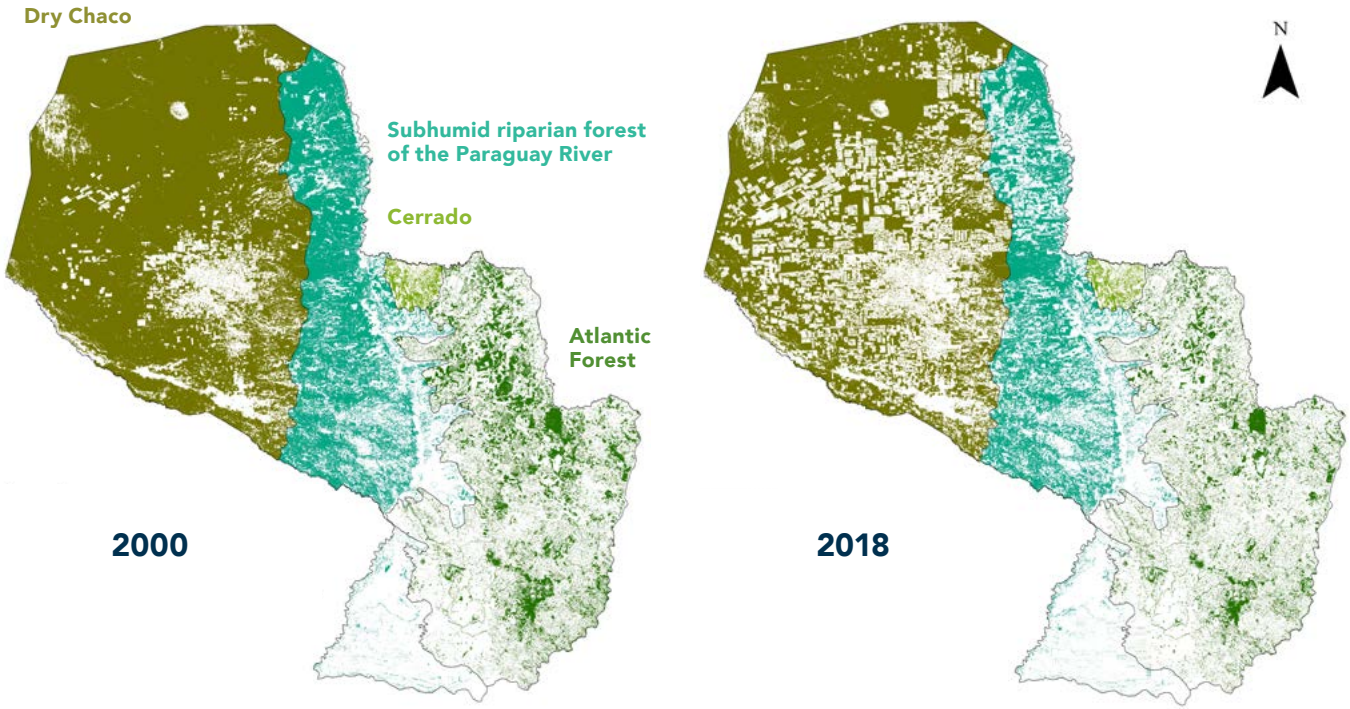
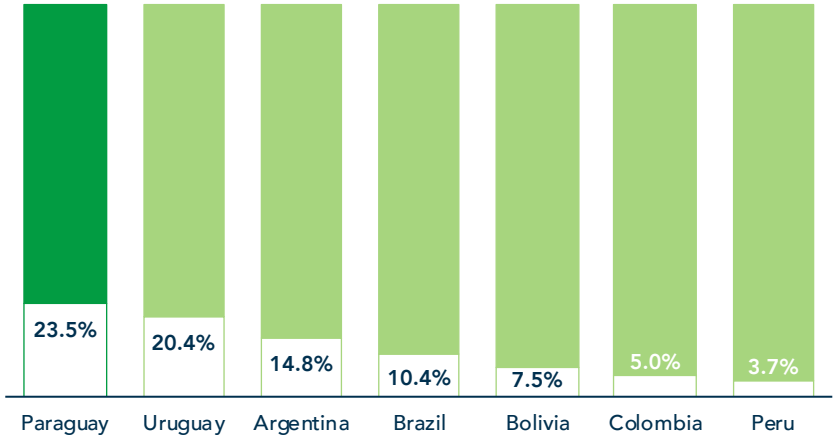


FIGURE 2

Tree cover loss by country, 2001–2018

Source: Original calculation based on data from Global Forest Watch (WRI 2020a).
Note: Rates represent gross tree cover loss relative to the 2000 tree cover, by country, using a canopy tree cover density of 30 percent. It does not include tree cover gain through restoration or regeneration. For methodological reasons, the results are indicative only.



Trends in Eastern Paraguay

In the Atlantic Forest, the conversion of forests to other land uses occurred mostly prior to the early 2000s.

In 1945, the forest cover in Eastern Paraguay stood at 7.8 million ha, of which 5 million ha were virgin forests (FAO 1948). Deforestation rates of 175,000 ha/yr in the 1970s and 1980s, and 123,000 ha/yr in the 1990s (Szulecka and Monges Zalazar 2017; Huang et al. 2007, 2009) wiped out most of the native forests, leaving behind fragmented and degraded forest remnants. Today, less than 10 percent of the original Atlantic Forest remains (Da Ponte, Kuenzer, et al. 2017).

The primary driver of deforestation and degradation of natural forests in Eastern Paraguay is expansion of cropland and cattle ranching.

Sixty-five percent of the soils are fertile and well drained and offer excellent conditions for both agriculture and pasture (Kernan et al. 2010). In the 1950s, export-oriented, capital-intensive agricultural production of monocultures (notably soybeans) and beef began rapidly expanding. The region saw an expansion of large and highly mechanized farms, displacing family agriculture. By 2009, pastureland and agriculture accounted for over 80 percent of total land use, and forests covered only about 13 percent, even in departments where the Atlantic Forest once dominated (Kernan et al. 2010; Republic of Paraguay 2009).[3]

Deforestation and forest degradation continue in the Eastern Region today, albeit at a slower rate, driven by distinct factors.

The Zero Deforestation Law took effect in 2004,[4] prohibiting any new authorizations for clearing forests in Eastern Paraguay, yet deforestation continued at an average rate of 41,400 ha/yr between 2004 and 2018,[5] especially in proximity to protected areas (Da Ponte, Roch, et al. 2017). Extraction of firewood remains a driver of deforestation and forest degradation because of high demand from households, industry, and agriculture. Land invasions and production of marijuana are also adding to the pressures. The outcome is a highly fragmented forest ecosystem. As early as 2009, large forest blocks covering more than 1,000 ha represented only 6 percent of the total land cover, and more than half of the remaining forest was estimated to be degraded and fragmented into blocks of less than 1,000 ha (Kernan et al. 2010). Together, forest fragmentation and degradation undermine ecosystem regeneration, making forest remnants even more likely to disappear.

Trends in Western Paraguay

Large-scale deforestation in Western Paraguay, primarily driven by cattle ranching, has accelerated recently.

Early deforestation began in the central Chaco region in the 1940s with the arrival of immigrant communities (Veit and Sarsfield 2017). However, it was not until the 2000s that large-scale land use change began, notably in the departments of Alto Paraguay and Boquerón. As controls tightened on felling Atlantic Forest remnants, pressure from extensive cattle ranching intensified in the Chaco, where the Zero Deforestation Law does not apply. **Figure 3** demonstrates this inter-regional dynamic using annual tree cover loss data (WRI 2020a).[6] Western Paraguay has a semiarid climate and soils of varying quality that can make for low-quality cropland. Conditions are favorable for cattle ranching, however. In the early 2000s, foreign investors started entering the market and the Chaco saw a rise of large landholdings with high levels of mechanization. The rate of deforestation accelerated rapidly and reached

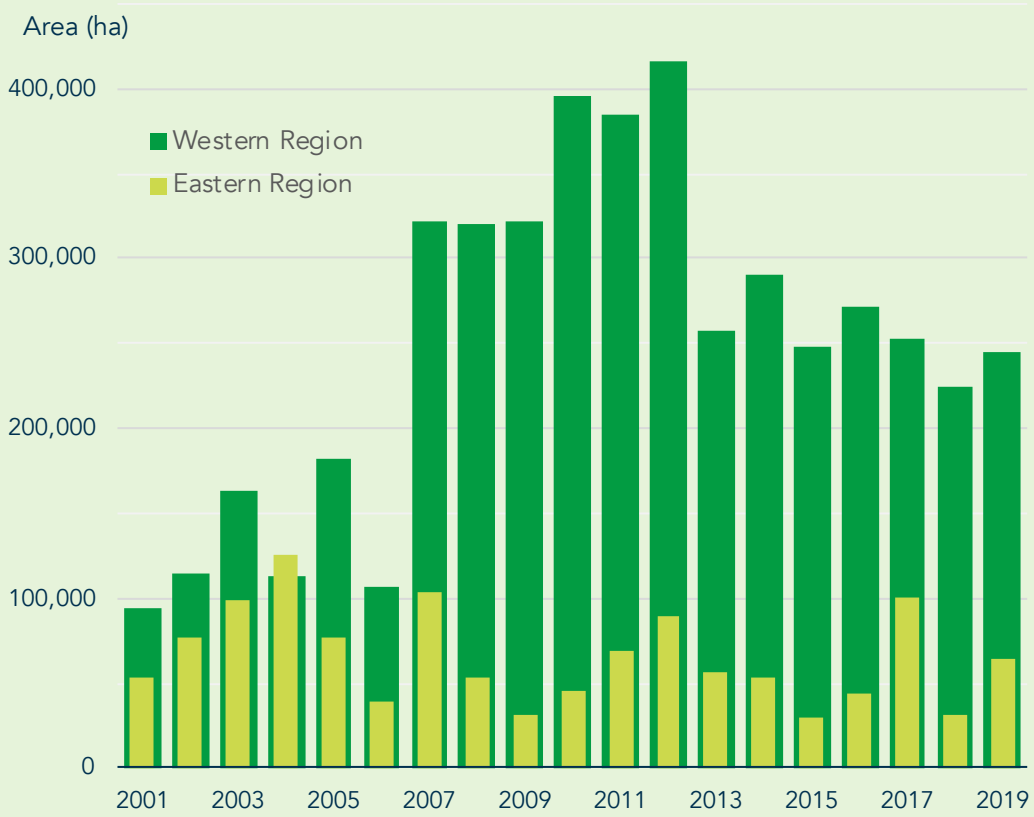
3. The single largest land use in Eastern Paraguay was pasture (~54 percent of the total land use), followed by industrial mechanized agriculture (15 percent), nonmechanized agriculture (13 percent), and mechanized small-scale agriculture (2 percent) (Kernan et al. 2010). In total, lands with agricultural use (including fallow lands) covered over 80 percent of land in Eastern Paraguay, while forest cover was only about 13 percent (Kernan et al. 2010; Republic of Paraguay 2009).

4. Ley 2425/04, "De prohibición en la Región Oriental de las actividades de transformación y conservación de superficies con cobertura de bosque." The law was extended in 2013 and again in 2018, extending its validity to December 2020.

5. The 2015–2018 data were obtained from INFONA (2020); the 2001–2015 data are from Republic of Paraguay (2016a). The 2017–2018 data are preliminary.

6. With restoration and regeneration being limited in Paraguay, tree cover loss serves as a useful proxy for deforestation.

FIGURE 3
Tree cover loss by region, 2001–2019



Source: Based on data from Global Forest Watch (WRI 2020a).

unprecedented levels as vast geometrical swaths of forest were cleared to make space for extensive cattle ranching, which now occupies 60 percent of the Paraguayan Chaco (Veit and Sarsfield 2017). Around 19 percent of the forest cover in the Chaco has been converted (Veit and Sarsfield 2017).

Forest fires are also a growing concern, especially in the Chaco.

While no comprehensive data tracking forest fires in Paraguay is available, fire alerts may serve as a proxy indicator. More than 10,600 and 15,700 fire alerts were recorded in the country in 2019 and 2020, respectively, and these were some of the highest levels recorded since 2012 (WRI 2020a). In August 2019, forest fires swept across Bolivia, Brazil, and Paraguay, affecting approximately 325,000 ha in Paraguay's Chaco, mostly in two protected areas (230,200 ha in Monumento Natural Cerro Chovoreca and 94,600 ha in Parque Nacional Río Negro) (WWF 2019). Climate change is expected to exacerbate the risk of forest fires. Temperature increases are projected to affect the departments of Boquerón and Alto Paraguay in the Dry Chaco, as well as northern parts of Paraguay, as early as 2030 (SEAM, PNUD, and FMAM 2017).

Extraction of forest biomass for energy

With woody biomass satisfying over 40 percent of total domestic energy needs, forests are key to Paraguay's energy security.

Paraguay is a world leader in hydropower generation, exporting as much as 75 percent of its hydroelectricity production (World Bank 2018a). While the surplus is available for domestic consumption, the country has achieved high levels of electricity access (100 percent) (World Bank 2020c), and energy tariffs are among the lowest in the region, the rising domestic demand for electricity in recent decades has not been accompanied by adequate expansion of transmission and distribution grids, resulting in low grid reliability and a deterioration in the quality of service (ANDE 2018). As a result, other sources remain prominent in Paraguay's energy mix. The country imports hydrocarbons; however, their price and supply uncertainties have limited their use in the industrial sector. In contrast, locally sourced biomass, comprising firewood, charcoal, residues, and ethanol, is perceived as an efficient, highly competitive and readily available energy source even in remote areas; thus, it remains a key source of energy for industry, agriculture, and residential sectors, satisfying 44.2 percent of all final energy consumption (Viceministerio de Minas y Energía 2018). Firewood accounts for 66.3 percent of domestic biomass consumption and charcoal for another 8.5 percent (Viceministerio de Minas y Energía 2018). This means that forests underpin energy security of households and industry[7]—ranging from grain dryers to ceramic and brick producing sectors. This situation is unlikely to change in the immediate future.[8]

With 80 percent of firewood and charcoal extracted from native forests, energy demand is a key driver of deforestation and forest degradation.

The resulting annual deficit of sustainably sourced forest biomass is estimated at around 9 million cubic meters (m^3) (Republic of Paraguay 2019).[9] Although it may not be the primary driver, the demand for forest biomass plays a role in deforestation and degradation of natural forests, typically working in conjunction with other pressures such as clearing of forest for agricultural expansion. This is especially true of Eastern Paraguay, where demand for wood fuel, including industrial demand, is concentrated. Assessments of the impact of Paraguay's energy mix on native forests are not available. However, experiences from other countries suggest that, while demand from dispersed rural populations is rarely a major threat to native forests, concentrated industrial or urban demand for wood fuel can be. In a weak regulatory climate, these may contribute to forest degradation and deforestation around major consumption centers (De Miranda et al. 2012). Transport costs weigh heavily on the price of fuelwood and charcoal, increasing the pressure on Atlantic Forest sources of wood that are closer to densely populated cities.

7. Households represent 53 percent of demand for firewood (among the households that use firewood, 85 percent are rural) and industry, 42 percent (Viceministerio de Minas y Energía 2018).

8. Preliminary results from a forthcoming survey of 56 industrial fuelwood users, predominately based in Eastern Paraguay, revealed that, despite growing awareness of diminishing availability of wood from native forests, 41 percent of industrial fuelwood users do not plan to switch to other energy sources over the next five years; 9 percent plan to switch to biomass from exotic species, and virtually none plan to transition to non-biomass energy sources (CONACYT 2020).

9. The Republic of Paraguay (2019) estimated the annual deficit at 8.93 million m3 (demand: 13.96 million m^3 versus a sustainable supply potential of 5.03 million m^3). An earlier study by Borsy et al. (2013) estimated the deficit at 10–13 million tons (demand: 13.9 million tons versus a sustainable supply of 3.7 million tons).

2.2.
The emerging forest plantation sector

With wood from native forests increasingly scare, private industry and the government are turning to forest plantations to ensure continued supply.

The National Plan for Reforestation in 2012 set the objective of establishing 450,000 ha of plantations over 15 years, primarily to satisfy energy demand. By 2019, Paraguay had 177,000 ha of plantations, representing an 11 percent increase since 2018, and a 46 percent increase since 2015 (INFONA 2020). Yet this falls short of the 330,000–430,000 ha of plantations needed to satisfy the domestic demand for wood, particularly firewood, in a sustainable manner (Borsy et al. 2013).[10]

At present, plantation forestry is developing primarily in the Eastern Region, in proximity to demand for fuelwood and timber.

The departments of Caazapá, San Pedro, Itapúa, Alto Paraná, Caaguazú Ñeembucú, and Guayrá represent 80 percent of the plantation area, while the Chaco—the departments of Boquerón, Alto Paraguay, and President Hayes—represents only 1.4 percent (see **Figure 4**). Plantations are typically established to produce fuelwood and are characterized predominantly by exotic species, particularly fast-growing eucalypts.[11] Preliminary results of an ongoing study show that typical plantation species include *Eucalyptus urograndis, Eucalyptus grandis, Eucalyptus camaldulensis, and Eucalyptus urophylla*, along with smaller areas of *Pinus taeda, Pinus elliotti,* and *Melia azedarach* (CONACYT 2020).[12] Some plantations produce timber or a mixture of fuelwood and timber. Despite local interest in models involving native species, few plantations contain indigenous trees. In Western Paraguay, plantations have sprung up for local wood supply, but this remains at a very small scale, as these plantations face long distance to markets. Native trees, such as algarrobo (*Prosopis spp.*), have been planted successfully in pastures to provide shade and fodder for livestock; however, that has been only on a very small and experimental scale.

The forest plantation sector currently operates well below its potential.

Paraguay has highly favorable environmental and economic conditions for forestry, including a subtropical climate that fosters rapid tree growth, ample land suitable for planting, and low labor costs. For example, around 1–2 million ha appropriate for plantation forestry can be found east of the Paraguay River (INFONA and FAO 2013); this number excludes native forests, the conversion of which is illegal. Reported yields of fast-growing species such as *Eucalyptus grandis* are high by international comparison, exceeding 30 m^3/ha/year mean annual increment (MAI), and could approach 40 m^3/ha/year MAI (PAYCO 2018a). With proper support—including technical assistance, advances in tree breeding, technology to match species to site, excellence in nursery production practices, and control of diseases and other enabling conditions—Paraguay could sustain a highly profitable plantation subsector. Yet investment in the sector remains low, and this keeps the area under forest plantations small relative to its potential, let alone in comparison to Chile's 3.25 million ha and Uruguay's 950,000 ha.

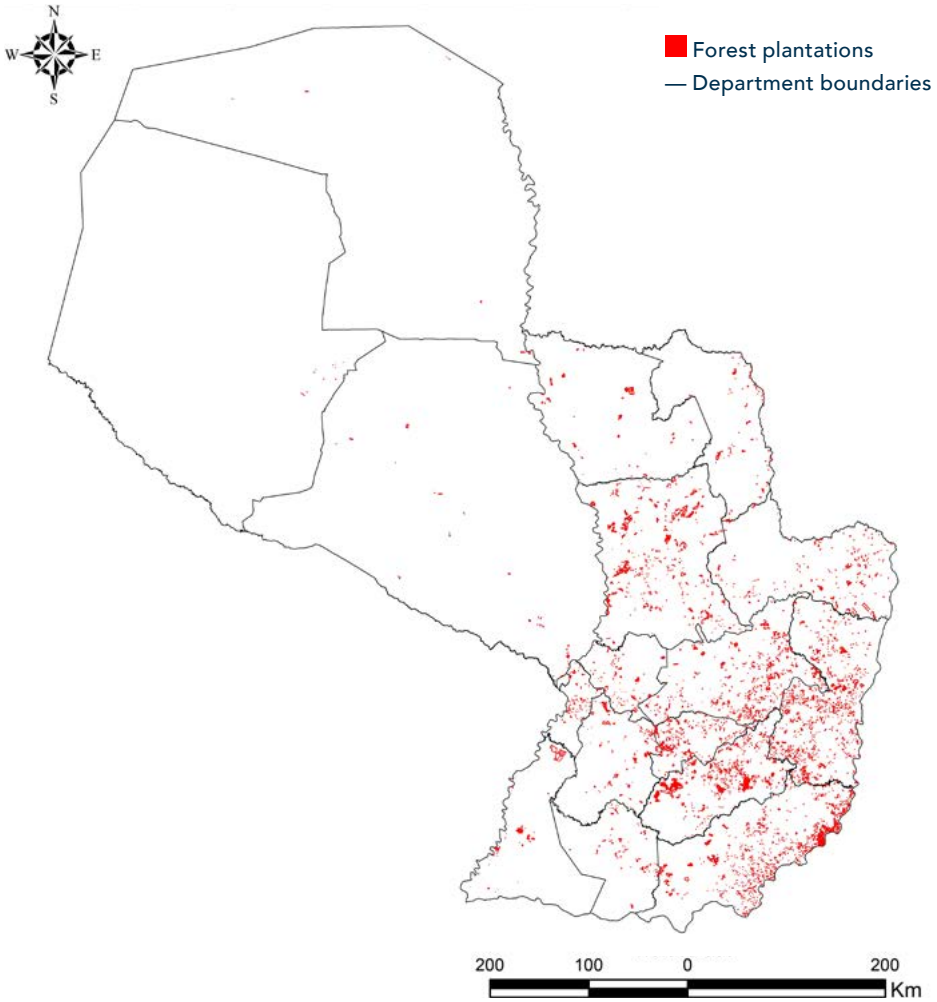
10. Borsy et al. (2013) estimated that to satisfy the 10–13 million m^3 deficit of sustainably sourced fuelwood, between 333.333 and 433.333 ha of plantations with a MAI of 30 m^3/ha/year and a rotation period of 12 years would be needed.

11. Per available data, 56 genetically distinct species and clones are currently commercialized in Paraguay: *E. urograndis* (35 clones), *E. grancam* (4 clones), *E. grandis* (3 clones), *E. urophylla* (1 clone), *E. delupta* (1 species), *E. urograndis x camaldulensis* (2 clones), *E. urocam* (9 clones), *E. europhylla x tereticornis x pellita* (1 clone). Over 70 percent of the genetic material comes from Brazil (CONACYT 2020).

12. Preliminary results from a forthcoming diagnostic study of productive forest value chains in Paraguay (*Análisis diagnóstico de la cadena productiva de madera con fines industriales y energéticos oriundas de plantaciones forestales del Paraguay*), led by Maria Laura Quevedo, were shared in a workshop in March 2020 (CONACYT 2020).

FIGURE 4
Forest plantations in Paraguay

a. Map of forest plantations, 2019



b. Area of plantations by department, 2015 and 2019

Department	2015 Area (ha)	2019 Area (ha)	% Increase
Caazapá	30,630	33,115	8.1
San Pedro	13,839	30,055	117.2
Itapúa	10,604	20,004	88.6
Alto Paraná	15,303	19,059	24.5
Caaguazú	9,988	14,177	41.9
Neembucú	12,361	12,532	1.4
Guiará	7,253	11,559	59.4
Paraguarí	3,187	8,607	170.1
Concepción	6,262	7,868	25.6
Canindeyú	3,928	6,345	61.5
Amambay	2,327	4,196	80.3
Misiones	1,588	3,167	99.4
Cordillera	1,866	2,497	33.8
Pdte. Hayes	916	1,640	79.0
Central	871	1,120	28.6
Alto Paraguay	456	720	58.0
Boquerón		114	
Total	**121,381**	**176,775**	

Source: INFONA 2020.

2.3.
Contribution of forests to the economy

Macroeconomic aspects

The forest sector, including both native and planted forests, generated approximately $893 million in gross value added (GVA) in 2018 (BCP 2020).[13]

Of this, 26 percent was generated in primary forest activities, 51 percent in production of paper and paper products, and 23 percent in wood processing. The sector contributed 2.4 percent to Paraguay's GVA in 2018. This level has remained relatively stable over the last decade (2008–2018), with the sector contributing, on average, $777 million, or 2.5 percent, to Paraguay's GVA each year. Given the high levels of informality,[14] the actual contribution to employment and economic activity of the sector is likely higher. Based on 2011 data, it employs about 330,000 workers formally and informally in collection of forest products and in forest value chains (Szulecka and Monges Zalazar 2017). While not captured in the data presented here, non-timber forest products, such as food and raw materials for cosmetic and medicinal products, support additional jobs and value addition in various sectors.

Paraguay's forest value chains are characterized by high-volume, low-value products, with nearly all domestic wood supply being used as fuelwood.

Forest value chains in Paraguay span tree nurseries, plantations growing biomass for energy production and timber, forestry service providers, and wood-processing enterprises (CONACYT 2020).[15] There are approximately 6,850 wood enterprises in the country, representing a combined processing capacity of nearly 19 million m^3 per year (Tomaselli and Vidal 2013). An estimated 95 percent of domestic wood supply is used for fuelwood, with very little value added; 3 percent is for sawn wood products; 1 percent for furniture; and another 1 percent for plywood, veneer, and flooring. There are about 4,500 small carpentry shops and 1,500 fuelwood vendors in the country, with at least half of them relying on wood originating from native forests[16] and operating clandestinely (Tomaselli and Vidal 2013).

Paraguay faces a negative balance of trade in forest products.

In 2018, the country had a trade deficit in wood products of $244 million: Exports represented $109 million, while imports represented $352 million (ITC et al. 2020). Unlike other commodities in Paraguay, exports of wood products, such as pulp, paper and cardboard, plywood and charcoal, have either declined or remained constant since 2010 (BCP 2020).

13. The analysis used two central bank data sets: (i) estimates of the GVA of the primary subsector, production of paper and paper products, and the processing (timber) industry from the national accounts (*Sistema de Cuentas Nacionales*); and (ii) estimates of national GVA from the economic report (Anexo Estadístico – Informe Económico). The 2018 data are preliminary. Amounts in Paraguayan guaraníes (current prices) were converted to U.S. dollars using the official exchange rate for Paraguay (PYG 5,732.105 per dollar for 2018, and corresponding rates for 2008–2017) (World Bank 2020c).

14. Estimates from 2011 suggest that the forest sector contributed $566 million (2.4 percent of the GDP) formally to the economy, and $970 million (4.1 percent of the GDP) informally (Szulecka and Monges Zalazar 2017).

15. Limited data on forest value chains in Paraguay is available. A forthcoming study led by Laura Quevedo may shed light on the sector in a comprehensive manner for the first time. It has surveyed 399 forest enterprises, including 12 nurseries, 20 plantations, 303 processing enterprises, 56 consumers of biomass, and 8 service providers (CONACYT 2020).

16. Preliminary results of a survey of wood processing enterprises in Paraguay show that only 35 of 303 enterprises use exotic species (eucalypts and/or pine), 20 use only native species, and the rest a combination of native and exotic species (CONACYT 2020).

These trends suggest that the forest sector represents missed opportunities.

Wood-processing capacity exists but remains largely artisanal and continues to rely on native forests for raw materials. Exports of wood products have been on the decline. Value addition is limited and employment and economic activity in the sector are characterized by high levels of informality.

The economic value of forests

The contribution of forests to Paraguay's economy goes well beyond what is captured in traditional economic metrics, as native forests provide essential ecosystem services that have tangible economic benefits.

Among numerous ecosystem services, forests produce food, timber, and fuelwood; collect, store, clean, and transport water; protect soil; regulate climate; and harbor biodiversity **(Figure 5).** One of the most important regulating services of forests in Eastern Paraguay is the preservation of water resources of the Paraná River Basin, which provides water to Paraguay's population and the hydroelectric plants of Yacryetá and Itaipu. Maintaining the strategically important water resources in the Paraná watershed requires the presence of functioning forest ecosystems, since they recharge the water table, prevent soil erosion and sedimentation, reduce flood risks, and filter pollution. Forests prevent the loss of up to 38 tons of soil per hectare in certain watersheds in Eastern Paraguay (Labbate et al. 2016). Forests also have cultural and recreational value.

The net present value (NPV) of a hectare of Paraguay's native forest is estimated at $3,600–$7,300 in Eastern Paraguay and $1,100–$2,000 in Western Paraguay (Table 2).

Economic analysis conducted in 2017 suggests that the value of the key provisioning, regulating, and cultural ecosystem services[17] that forests generate ranges between $3,600/ha and $7,300/ha in Eastern Paraguay (of which 31 percent is attributed to carbon sequestration), and between $1,100/ha and $2,200/ha in Western Paraguay (of which 30 percent is attributed to carbon sequestration benefits). Besides carbon sequestration, the most economically valuable service is soil erosion protection, followed by sustainable timber and fuelwood provision, and watershed protection services.[18]

17. The analysis focuses on the three categories of ecosystem services that generate direct, measurable benefits—provisioning, regulating, and cultural services. A fourth category—the supporting ecosystem services (that is, the underlying ecosystem functions and biophysical processes that enable the other three types of ecosystem services)—is of less relevance in the context of forest valuation and is not included in the present analysis.

18. This analysis assumes that the forests unit value increases proportionally to the degraded area, and therefore these ecosystem services appreciate as the share of deforested land increases. The methodology is described in Appendix A.

FIGURE 5

Key ecosystem services provided by forests

Provisioning services
Bushmeat, fiber, medicinal products, fuelwood

Regulating services
Climate change mitigation, watershed protection

Supporting services
Nutrient cycling, soil formation, primary production

Cultural services
Aesthetic, spiritual, educational, recreational

Source: World Bank.

Thus, the economic value of native forest can in certain cases exceed the commercial yields from alternative land uses such as agriculture and livestock.

A 2016 study (Labbate et al. 2016) estimated the average NPV per hectare of agriculture and livestock activity of various farm sizes (family, medium size, commercial, and industrial) at around $4,800 in southeastern Paraguay, $2,600 in northern Paraguay, $1,600 in central Paraguay, $400–$1,500 in the Chaco, and $400–$900 in southern Paraguay **(Table 5)**.

The primary beneficiaries of these services are Paraguay's citizens and productive sectors, yet the economic benefits of forests are generally not immediately apparent to them.

Most benefits from forests, except for global public goods such as carbon storage and (to a lesser extent) biodiversity, are predominantly local in nature and accrue to Paraguay's citizens and productive sectors, notably to agriculture and industry. For example, forests play an important role in the water balance both in the Eastern and Western Regions and thus ensure a predictable water supply that underpins agricultural productivity. The same can be said about soil erosion. These benefits are likely to become even more pronounced in the context of climate change, which is expected to disrupt precipitation patterns, and given forests' key role for energy security. If managed sustainably, forests can provide these economic benefits in perpetuity. Yet many are not fully

TABLE 2

Economic value of native forests

	Type of benefit*	Type of service*	Eastern Paraguay (Atlantic Forest) (US$/hectare)	Western Paraguay (Chaco) (US$/hectare)
Provisioning services	Market benefits	Sustainable timber and fuelwood harvest	107/year	36/year
		Bushmeat harvest	24/year	8/year
Regulating services		Carbon capture and storage	165/year	43/year
	Quasi-market benefits	Watershed protection services	73/year	24/year
		Soil erosion protection services	150/year	25/year
Other services	Quasi-market and non-market benefits	Other forest services	7/year	7/year
Total annual services			**525/year**	**143/year**
Mean NPV of forest			**5,205**	**1,570**
NPV range (depending on deforestation scenario)			**3,600–$7,300**	**1,100–$2,000**

Source: Original analysis conducted in 2017 using 2017 U.S. dollars.

Note: The total value of a hectare of forest in each region is estimated as the NPV of the annual sum ecosystem services over a time horizon of 15 years, at a 6 percent discount rate, under different deforestation scenarios. The methodology is summarized in **Box 2** and described in detail in Appendix A. NPV = net present value.

* The analysis differentiates between those goods and services that have a market, those that do not and/or those that contribute to the production of goods and services that are tradable in markets. The category "other forest services" includes forestland (recreation), option value (bioprospecting—when forest can be a source of new medicines), and the existence value associated with preservation (nonuse) of forests.

captured by markets and, as a result, they may not be apparent to private landowners making land use decisions. This challenge is discussed in detail in subsequent chapters.

Social development and poverty alleviation

Forests are a vital source of subsistence and income for rural communities, indigenous populations, and small farmers.

Rural areas are where poverty rates are high and opportunities are limited, and forests generate employment and provide non-timber forest products such as food, fiber, medicine, and fuelwood. Limited data is available on informal substance. However, a recent study of the Eastern Region (Da Ponte, Kuenzer, et al. 2017) shows that, on average, the Atlantic Forest contributes about 20 percent to the income of small farms and 10 percent to the income of medium farms. For about 4 percent of small and 3 percent of medium farms, forests contribute more than 50 percent of their income. Indigenous populations also rely deeply on forests. Bushmeat is a key contributor to their livelihoods and economic activity, and forests are a key source of their drinking water. Forests and the biodiversity they host also represent immense cultural, spiritual, and medicinal value for indigenous communities.

Forests also represent opportunities to improve female economic participation.

Analysis conducted by the World Bank[19] shows that gender gaps in economic opportunities in Paraguay have multiple dimensions and are present in all possible forms of economic participation, whether in unpaid labor, wage labor, or in entrepreneurship. This is especially true of rural areas, where the role of family agriculture is declining in favor of large-scale agriculture for export. In agriculture, female salaries were half of male salaries in 2005. Paraguayan women face higher unemployment and, when employed, they tend to have lower-quality and lower-paid jobs. Wage gaps can be as high as 40 percent. A gender gap is evident also in the forest sector. Preliminary results of gender-disaggregated analysis of employment in the forestry sector (CONACYT 2020) found that women occupy 3 percent of jobs created by service providers, 8 percent of jobs in forest industries, and 58 percent of jobs in forest nurseries. Women tend to be less financially included and own proportionally less land and natural resources. Yet women play a critical role in the forest sector and the creation of a sustainable economic model in Paraguay, as they are often the promoters of forest conservation, sustainable production practices, and environmentally friendly products. In turn, economic diversification through forest value chains in rural areas can provide new economic opportunities for women.

19. The World Bank conducted a gender analysis as part of the preparation of the Paraguay Forestry Project (P171351) in 2020. The analysis involved (i) a quantitative analysis of different data sources; (ii) qualitative interviews with the private sector (medium to big producers), nongovernmental organizations (Fundación Paraguaya, Alter Vida), the public sector (INFONA, Ministry of Agriculture, Ministry of Women, INDERT, SIRG, INDI), international organizations (UNDP and FAO), a rural women's association (CONAMURI), research institutions (CDE and UNA), and financial entities (CAH, Fundación Capital).

BOX 2

Overview of the methodology used in the economic analysis

The analysis conducted estimates of the economic value of native forests in Paraguay and the cost of deforestation at the national and subnational levels (Eastern and Western Regions). It uses a holistic approach to forest valuation, linking the scale of deforestation and the value of forests.

The analysis involved a four-step process: (i) a literature review to estimate the value of ecosystem services of forests; (ii) computation of the cost of deforestation with a *non-risk-adjusted*[a] total value of forests per hectare by region; (iii) computation of the cost of deforestation with a *risk-adjusted*[b] total value of forests per hectare by region; and (iv) a sensitivity analysis.

The total value of a hectare of forest in each region was estimated as the net present value (NPV) of the annual sum of values of select *provisioning, regulating,* and *cultural* ecosystem services forests generate, over a time horizon of 15 years and at a 6 percent discount rate. The monetary values of ecosystem

services were drawn from the academic literature. The NPV was computed for six different deforestation scenarios (three in Eastern Paraguay and three in Western Paraguay) based on historic deforestation trends—a business as usual scenario that reflects a 20-year average, as well as potential pathways for forest utilization moving forward—low and high deforestation rates **(Table 3)**.

The rationale behind introducing deforestation scenarios into this analysis is that large-scale changes in the forest cover and thus the provision of forest ecosystem services can result in changes in the marginal value of these services. When a relatively small share of the forest biome is converted into agricultural land, the lost regulating services (such as erosion control and watershed protection) can be relatively easily and cheaply substituted by water management and infrastructure. In contrast, if a substantial part of the forest biome is lost, this can translate into significant losses of ecosystem services for which no adequate substitutes are available. The literature (Viglizzo and Frank 2006; de Groot et al. 2010) suggests that forests' unit values increase proportionally to the degraded area.

To account for this, the economic analysis applied an adjustment coefficient to the value of ecosystem services as a function of undisturbed forest area. For example, if the share of forestland drops by 30 percent, the value of ecosystem services per hectare provided by undisturbed land may increase twofold. Monte Carlo simulations were then used to compute the risk-adjusted value of deforestation per hectare. The risk-adjusted total deforestation cost for each region and for Paraguay as a whole is presented by deforestation scenario. For model parameters and the full methodology, see **Appendix A.**

a. The non-risk-adjusted value is the NPV of the total value of lost ecosystem services per hectare in each region without taking into account positive feedback between the share of agricultural land and losses of ecosystem services.

b. The risk-adjusted value accounts for the positive feedback between the share of agricultural land and losses of ecosystem services; it is calculated to reflect the risk of irreversible damage to the forest ecosystems or permanent loss of the option value of ecosystem services.

2.4.
The economic cost of deforestation

Under the current deforestation trends, annual deforestation costs for Paraguay are estimated at $628 million, or 1.6 percent of GDP in 2017

(Table 3). Even under this conservative approach that only takes into account the value of the forgone ecosystem services and does not consider the associated macroeconomic losses (for example, jobs, exports, and GDP), the economic costs are nontrivial, and often outweigh commercial gains from agriculture or livestock activity, particularly in small-scale farming. Yet this is typically not factored into land use decisions of private landowners, since much of the economic cost of deforestation is an externality.

Depending on the deforestation scenario selected, the annual cost of deforestation and degradation of forests in Paraguay could be as low 0.4 percent of GDP and as high as 3 percent of GDP in 2017.

Using extreme annual deforestation rates of 550,000 ha/yr (the level they reached in 2012), the annual deforestation cost reaches $1.2 billion, or 3 percent of GDP in 2017. Conversely, if deforestation dropped to 125,000 ha/yr in Western Paraguay,

and net reforestation/afforestation reaches 10,000 ha/yr in Eastern Paraguay, the annual cost of deforestation in Paraguay would drop to $164 million, or 0.4 percent of GDP in 2017.

Two key factors determine the extent of economic losses: the deforestation rate in Western Paraguay (Chaco), where most forests remain, and how much of any given ecosystem is lost.

First, what happens in the Chaco matters. Forest loss in the Chaco currently contributes 70–100 percent of the total for the different scenarios. Second, large-scale forest conversion can drastically reduce the ability of a forest biome to provide ecosystem services and increase the marginal value of the remaining forest and its ecosystem services. When a relatively small share of the forest biome is converted to agricultural land, the forgone regulating services (such as erosion control and watershed protection) can be relatively easily and cheaply substituted by water management and infrastructure, such as reservoir construction. In contrast, if a substantial part of the forest biome is lost, this translates into significant losses of ecosystem services that sustain economic activity and human well-being, for which no adequate substitutes may be available. For example, in the Eastern Region, where much the Atlantic Forest ecosystem is already lost, further losses are expected to trigger appreciation of ecosystem value for remaining forests. This analysis assumes that the forest unit value increases proportionally to the degraded area—the more forest is lost in Paraguay, the higher the economic costs of deforestation.

These losses may fall disproportionately on vulnerable populations, such as indigenous populations, who rely deeply on the provisioning and regulating functions of forests.

In the Census for Indigenous Population in Paraguay (DGEEC 2012), about 55 percent of all surveyed indigenous communities in Eastern Paraguay and 42 percent of all surveyed communities in the Chaco reported some environmental challenges, including soil layer destruction, water contamination, salinization, and water reservoir sedimentation. Also, in both areas 20–30 percent of the indigenous communities report a sharp decrease in the presence of wild animals they depend on for food and cultural value. In the Chaco, the intensifying large-scale deforestation often occurs in proximity to indigenous territories, exacerbating preexisting resource constraints. Water availability is an immediate concern in the

TABLE 3
Annual cost of deforestation

	Deforestation scenario	Expected deforestation cost (US$, millions)	Risk-adjusted (RA) deforestation cost (US$, millions)	Share of RA deforestation cost in Paraguay's GDP, 2017 (%)
Eastern Paraguay	Reforestation/afforestation 10,000 ha per year	-52	-60	-0.2
	30,000 ha per year (BAU)	156	180	0.5
	50,000 ha per year	260	299	0.8
Western Paraguay	125,000 ha per year	196	224	0.6
	250,000 ha per year (BAU)	393	449	1.1
	500,000 ha per year	785	897	2.3
Paraguay	Lower deforestation/reforestation scenarios in Eastern and Western Paraguay	144	164	0.4
	BAU deforestation scenario in Eastern and Western Paraguay	549	628	1.6
	Higher deforestation scenarios in Eastern and Western Paraguay	1,045	1,196	3.0

Source: Original calculations based on a literature review.
Note: The analysis was conducted in 2017. For details of the methodology, see Appendix A. BAU = business as usual.

Chaco, where the water balance is mostly negative (from 0 millimeters to 899 millimeters), indicating substantial pressure on water resources even under current land use. Under the high deforestation scenarios, the water balance could deteriorate further. Soil erosion and soil loss will probably increase also, with direct implications for indigenous populations and local producers. Indigenous people can also be affected by forest fragmentation and loss of traditional livelihoods outside of their reserves, since they are accustomed to free migration in forests.

Implications of deforestation for climate change mitigation and adaptation

Forest loss also has implications for climate change mitigation and Paraguay's international commitments.

Between 2005 and 2016, gross greenhouse gas (GHG) emissions increased by 75 percent from 100 million tons to 195 million tons (WRI 2020b). This is attributable largely to land use, land use change, and forestry (LULUCF), which increased emissions by 89 percent over the same period and is currently the largest contributor, representing 76 percent of Paraguay's gross GHG emissions.[20] Forest loss is the main source of emissions in the LULUCF sector. By comparison, emissions from other sectors, including agriculture, energy, waste, and industrial processes, grew by 40 percent between 2005 and 2016. While Paraguay contributes just 0.08 percent to global GHG emissions and remains one of the lowest emitters in Latin America because of the extensive leveraging of hydropower in its energy mix, deforestation still represents missed climate change mitigation opportunities for the country. Paraguay's Nationally Determined Contribution, submitted in 2015, includes an unconditional 10 percent emissions cut by 2030 relative to business as usual, or a 20 percent cut conditional on international support (Republic of Paraguay 2016b). To achieve this target, Paraguay identified sustainable forest management, sound forest governance, forest plantations, biofuels, and silvicultural practices among priority action areas, but progress on this has been limited to date.

Climate change adaptation may also become more challenging as deforestation continues.

Climate change is expected to cause major losses in agricultural production and represent flood and drought risk in Western Paraguay. Given forests' role in control of soil erosion, watershed protection, flood control, microclimate regulation, as well as support of livelihoods, their loss complicates the task of climate adaptation.

20. Data on net GHG emissions shows a slightly different pattern. In 2015, the sectoral contributions to Paraguay's net GHG emissions were estimated as follows: agriculture and livestock, 53 percent; LULUCF, 31 percent; energy, 12 percent; waste, 2.5 percent; and industrial processes, 1.8 percent (Republic of Paraguay 2018).

SYNTHESIS

Contribution of forests to the Paraguayan economy

The forest sector contributes to Paraguay's economy by providing raw materials, energy, jobs, and livelihoods for rural and indigenous communities. Yet the sector operates well below its potential:

1. Forest value chains are characterized by high-volume, low-value products, with nearly all domestic wood supply being used for fuelwood. Wood-processing capacity exists but remains largely artisanal and relies on native forests for raw materials.
2. The disappearance of native forests carries tangible economic costs in the form of lost ecosystem services—ranging from soil erosion control to watershed protection. The economic costs of forest loss are on the order of $628 million, or 1.6 percent of GDP in 2017. Under pessimistic deforestation scenarios, they could reach $1.2 billion, or 3 percent of GDP.
3. Standing forests are typically seen as an opportunity cost by private landowners, yet from an economic perspective it is often more costly to convert forest to cropland and pasture because the value of ecosystem services that forests provide can outweigh commercial gains from agriculture.
4. The economic costs from deforestation are felt first by the most vulnerable—rural and indigenous populations who depend on forests for livelihoods and safety nets. In the longer term, losses of ecosystem services will inevitably undermine Paraguay's productive sectors.
5. The forest plantation sector could reduce pressure on native forests, but it is significantly underperforming relative to its potential.

3 Forest policy and institutional analysis

A well-managed and dynamic forest sector uses the resource base sustainably and converts it into economic and social value. Unlocking the economic potential of forests in Paraguay and managing them sustainably requires both (i) conserving native forest stocks to maintain the resource base and the ecosystem services they generate, and (ii) creating dynamic forestry value chains that maximize native and planted forest productivity and sustainable use, and that support the country's development objectives.

Well-functioning forestry sectors have several broad characteristics, including (i) good governance,[21] which ensures that the way forest resources are managed and controlled is considered to be fair, legitimate, transparent, and predictable by most stakeholders, and (ii) appropriate incentive structures that make users aware of the scarcity of resources, ensure land is used in a socially beneficial way, and allow actors to capture the economic value of forests and use the benefits of forests for developmentally important purposes. This chapter presents an initial assessment of the Paraguayan forestry sector with regard to these key characteristics, identifying the key barriers that are hindering the development of the sector and need to be overcome to change its trajectory. While the analysis focuses on the enabling conditions for sustainable *native* forest management, the barriers identified inevitably affect planted forests as well, by influencing the investment climate, market transparency, and competitiveness of sustainably sourced products.

21. Good forest governance is based on three main pillars: (i) political, legal, institutional, and regulatory frameworks; (ii) planning and decision-making processes; and (iii) implementation and compliance (Kishor and Rosenbaum 2012).

3.1. Governance

For a long time, economic, institutional, and regulatory approaches resembling a laissez-faire approach to forest management facilitated unsustainable use of forest resources in Paraguay.

The country's economy developed under a state with limited regulatory reach and low taxation and public expenditure (OECD 2019). At the same time, land ownership is highly concentrated. Strong private sector interests, notably in the agriculture sector, have permeated economic and land use policy. Paraguay also suffers from widespread corruption,[22] which further undermines effective environmental regulation. Environmental institutions do not have sufficient resources, or the engagement of other economic sectors, to effectively monitor and manage the forest sector.

Patterns of land tenure

Land tenure in Paraguay has several key characteristics relevant to forest management: Land is predominately private and ownership is highly concentrated.

Approximately 95 percent of the land is privately owned by domestic and foreign individuals, corporations, and cooperatives (Veit and Sarsfield 2017).[23] Most forestland, even forestland with a designated conservation status, is also

22. Paraguay ranked 137th among 180 countries in the 2019 Corruption Perceptions Index (Transparency International).

23. Inexpensive land and a lack of restrictions on foreign ownership attracted foreign investors from Brazil, Uruguay, and Europe.

held, or at least claimed, under private ownership. In turn, the Gini coefficient of land ownership stands at 0.93. More than 70 percent of productive land is occupied by 1 percent of farms that resemble latifundia-style holdings, making Paraguay the country with the highest level of land inequality in the world (World Bank 2018a; Oxfam 2016).[24] This pattern of land ownership puts much of the burden of forest management on private actors, often large-scale and commercially oriented agricultural or livestock producers.

Privately owned land displays the highest deforestation rates in Paraguay.

In the Chaco, 89 percent of land is private, with many landowners holding large tracts for extensive cattle pr oduction. Less than 5 percent is legally held by indigenous peoples and around 6 percent is designated as protected areas, which are predominantly public. Between 2001 and 2014, deforestation rates were the highest on private land (1.5 percent per year), compared with indigenous lands (0.6 percent) and protected areas (0.3 percent) (**Table 4**). In absolute terms, 96 percent of all deforestation in the Chaco between 2001 and 2014 took place on private lands (Veit and Sarsfield 2017). An assessment of forest loss in the Eastern Region for 1970–2000 identified a similar trend (Huang et al. 2007).

Despite widespread private ownership, land tenure is not particularly secure or transparent.

Paraguay scores only a 45 out of 100 in the property rights index, a component of the Index of Economic Freedom (Heritage Foundation 2020). The index considers such factors as the degree to which a country's laws protect private property rights, the enforcement of those laws by the government, and the likelihood that private property will be expropriated. The low score is mainly due to the weak national cadaster and overlapping land rights (Veit and Sarsfield 2017). To date, Paraguay does not have a modern—complete, centralized, and digitized—cadaster system that is accessible to multiple public agencies and incorporates forest data. Up-to-date cadastral information exists only for 15 percent of properties (World Bank 2018d) and most municipalities do not have complete cadastral information, despite it being a constitutional mandate since 1992.

These factors create several major obstacles for the forest sector.

First, the unequal land distribution structure affects the ability of Paraguay to maximize economic returns from forests in an inclusive way. From a political economy standpoint, it also creates tension between large and commercially oriented landowners who tend to pursue agriculture and livestock and forest policy that sets mandatory forest area retention standards. Second, the lack of a modern cadaster

TABLE 4.

Deforestation in the Chaco by tenure type, 2001–2014

	Total area (ha)	% of total area	Total forestland, 2001 (ha)	Forested area, 2014 (ha)	Deforested land, 2001–2014 (ha)	Average annual forest loss, 2001–2014 (ha)	Average annual forest loss, 2001–2014 (%)
Indigenous lands	1,035,351	4	807,220	736,107	71,113	5,079	0.6
Protected areas	1,565,659	6	1,485,518	1,415,814	69,704	4,979	0.3
Private (excluding indigenous and protected areas)	21,554,883	89	15,655,235	12,355,612	3,299,624	235,687	1.5
Total Chaco	**24,155,893**	**100**	**17,947,973**	**14,507,532**	**3,440,441**	**245,746**	**1.4**

Source: Veit and Sarsfield 2017.

24. Data from the 2008 National Agricultural and Livestock Census provide additional insights: A third of Paraguay's territory (nearly 28 million ha) was held just by 7,500 agricultural and livestock producers with properties larger than 500 ha, while around 311,000 Paraguayans were categorized as "landless." There is also evidence that land inequality has become more pronounced over recent decades. In 1991, Paraguay had 307,000 registered agropastoral properties (*fincas*) representing 24 million ha; by 2008, the number of properties dropped by 6 percent to 290,000, but the area collectively held by them increased by 30 percent to 31 million ha (Republic of Paraguay 2009).

with integrated forest data creates uncertainty over where property boundaries are located and how existing forests relate to those boundaries, which renders monitoring of illegal deforestation difficult. Third, discrepancies between the registry and actual property boundaries lead to overlapping tenures and disputes. Both large landholders and smallholders report tenure insecurity and the risk of invasions (Szulecka and Monges Zalazar 2017). This disincentivizes long-term investments—for example, in forest plantations—and may encourage deforestation.

Institutional framework overseeing forests and arbitrating competing demands on land

Forest management happens at the nexus of multiple sectors and government agencies that govern land use.

This includes institutions tasked with territorial planning at national and subnational levels, environmental agencies, as well as those in key economic sectors such as agriculture and energy.

The primary government institutions in the forest sector are the National Forestry Institute (INFONA) and the Ministry of Environment and Sustainable Development (MADES).

Together, they set priorities and policies for conservation, management, and use of forestlands in the country; issue regulations that implement forest laws; and lead monitoring and enforcement efforts. INFONA is the dedicated agency in the sector, tasked with the administration, promotion, and development of forest resources and value chains, to maximize the sector's economic potential. In contrast, MADES is in charge of environmental policy more broadly (Law 1561/00). Forests fall within the ministry's scope since it issues and implements environmental regulation, such as the Environmental Services Regime (Law 3001/06) that affects forests and their ecosystem services. MADES also oversees the protected areas.

INFONA and MADES have highly complementary but, at times, overlapping mandates, requiring close coordination.

The productive functions of forests fall primarily under INFONA's remit, while the conservation of forests, biodiversity, and ecosystem services falls primarily to MADES. This calls for a coordinated strategy for forest resource management. Other examples of complementarity include forest monitoring, as both institutions are tasked with implementing the National Forest Monitoring System (Decree 3246/2020), and authorizations of land use change—while MADES conducts environmental impact assessments (Law 294/93), INFONA issues permits for legal conversion of forestland to agricultural land.

Other institutions play a role, too, as forests are embedded in landscapes that produce food, water, and energy and generate economic activity.

The Ministry of Agriculture and Livestock (Ministerio de Agricultura y Ganadería, MAG) oversees agriculture and agroforestry. Through the National Service for Quality and Health of Plants and Seeds (Servicio Nacional de Calidad y Sanidad Vegetal y de Semillas, SENAVE), it implements legislation that requires forest buffer areas and forest windbreaks to be maintained around farms. The Vice Ministry of Mining and Energy (Viceministerio de Minas y Energía del Ministerio de Obras Públicas y Comunicaciones) oversees policies and regulations related to the use of biomass for energy. At the broader territorial planning level, two institutions play a key role: the National Institute of Rural Development and Land (Instituto Nacional de Desarrollo Rural y de la Tierra, INDERT), tasked with securing the participation of rural populations in the country's development, by means of effective access to land that is productive and environmentally sustainable; and the Technical Secretariat for Planning (Secretaría Técnica de Planificación, STP), whose mandate includes land use and territorial planning for development. In turn, the Institute for the Agrarian Technology (Instituto Paraguayo de Tecnología Agraria, IPTA) and the National Scientific and Technological Counsel (Consejo Nacional de Ciencia y Tecnología, CONACYT) promote innovation, ranging from technology to new production practices for a more sustainable and competitive agricultural sector, and forestry value chains.

Enforcement is ensured on one hand by INFONA and MADES, which are tasked with monitoring, and on the other by various levels of the judicial branch.

The latter includes the Public Prosecutor (Ministerio Público), the Supreme Court that protect citizens' rights to a clean environment and enforces compliance with environmental criminal law (Law 716/96 on Criminal law of violations against the environment), as well as the Comptroller General (Contraloría).

Forest resource management also happens at the level of departments and municipalities,[25] but their engagement in general is limited.

The law (Carta Orgánica Municipal) mandates municipalities, also referred to as districts, with the preservation of the environment and the ecological balance, the creation of forest reserves, and the promotion sound resource management. In practice, however, local governments' lack of capacity to deal with the environmental management, along with limited coordination with the central government in this agenda,26 restricts their ability to manage natural resources at the local level.

25. This includes the Governors' Council and the Paraguayan Organization for Intermunicipal Cooperation.

26. One example is the environmental licensing process (Law 294/93), in which local governments have a limited say.

Like other countries, Paraguay faces challenges in formulating a coherent land use plan and policy framework that engages all the sectors and agencies that oversee forest management and balances the economic benefits of various land use types.

The forest sector does not have a coherent policy framework and the tools (for example, ecological zoning) to balance the short-term private interests in the agricultural and energy sectors and long-term public interests (please see subsequent sections of this chapter). There is also a lack of coordinated response to the challenges the sector is facing—widespread illegal deforestation, high levels of informality, limited progress in reforestation, and forest fire management, among others. There is also scope for more clarity in the mandates of and for better coordination between MADES and INFONA, and other relevant agencies.

Institutional capacity is another challenge: Agencies in the environment sector, notably INFONA and MADES, face underinvestment that undermines their efficiency and effectiveness.

INFONA suffers from a lack of modern systems, and it is not geared to supporting productive forestry, which needs effective forest law enforcement, modern traceability systems, a framework for sustainable production methods, and support to the development of forestry value chains. The limitations that these factors put on enforcement are discussed further below. In 2019, allocated budgets of INFONA and MADES were roughly $7.05 million and $9.1 million, respectively.[27] Budget execution stood at 86 percent and 81 percent, respectively (Ministry of Finance 2020). Institutional analysis to assess whether these budgets are sufficient to support their mandates and objectives, and are used efficiently, would be beneficial to strengthen the effectiveness of the institutions.

The forest law in theory and in practice: The limited role of the public sector

While Paraguay's law sets clear forest area retention standards, the legal framework has weaknesses and its enforcement is limited.

Article 42 of Law 422/73 (the Forest Law) is the central legal instrument prohibiting indiscriminative deforestation, dating back to 1973. It mandates that private owners of land exceeding 20 ha in "forest zones"[28] preserve as "legal forest

27. Amounts converted from reported 2019 budgets of PYG 43,984,674,935 for INFONA and PYG 56,998,155,986 for MADES.

28. Article 42 of Law 422/73: Forest zones are understood as those areas that were covered with natural forest when this article was regulated through Decree 18.831 on December 16, 1986, which is now accepted as the baseline. The definition of natural forests *(bosques naturales)* that determines these forest zones was issued by Decree 175/2018.

reserve" at least 25 percent of the original native forest cover (as recorded in the 1986 baseline forest map). Decree 175/18 in turn prescribes that those who fail to comply with the Forest Law have a "forest deficit" on private land and are required to either (i) reforest a surface equivalent to 5 percent of their property area; (ii) restore the forest cover;[29] or (iii) purchase environmental offsets (Environmental Service Certificates). In principle, the law offers some degree of protection to forests, but violations are widespread.[30] In 2014, the forest deficit nationwide was estimated at 2.49 million ha, with little of it restored or offset (Vidal 2015).

In the Eastern Region, Law 2524/04, also known as the Zero Deforestation Law, prohibits all clearing of native forests, but it has been only partially effective in reducing deforestation.

This temporary blanket ban on conversion of forests to other types of land use was first enacted in 2004 and more recently extended by Law 6256/18 until December 2020. While the law has helped slow deforestation in Eastern Paraguay, it has failed to stop it entirely. On average, the Eastern Region has been losing 41,400 ha/yr since the introduction of the ban in December 2004 (**see Section 2.1**). The law is also relatively silent on degradation, which continues to heavily affect forests in the region. **Box 3** provides an overview of these and other key legal instruments governing the forest sector.

Weak enforcement stems partially from ambiguities in the law itself.

The forest sector is still regulated by more than 50 legal instruments—laws, codes, decrees, regulations, and resolutions—some of which are dated, and some of which contain ambiguous provisions that undermine enforcement. The Forest Law (Law 422/73) is regulated by more than six decrees for example, including Decree 175/18, which contains provisions open to multiple interpretations. One uncertainty is whether the mandatory riparian protection forests[31] and forest protection strips[32] are considered part of the legal forest reserve. There is also no official delineation of "forest zone" and forest cover deficit. This calls for a clarification of the definition of the forest deficit and exceptions to the obligation to maintain the legal forest reserve. The Forest Law itself is a dated instrument that is challenging to apply to the realities in the field; it also does not articulate the role of environmental criteria in forest conservation. For example, the concept of the "forest reserve" does not prioritize forest in terms of ecological and ecosystem services value, so what forest is left standing in legal land conversion is arbitrary.

Weak monitoring and enforcement capacity undermines enforcement efforts.

Environmental agencies lack modern systems for forest cover and forest carbon monitoring that exploit the potential of remote sensing technologies, and they have limited presence in the field to exert control over its forest stock. For example, INFONA has 185 employees in their Asunción headquarters and another 195 employees in regional offices. Some regional offices are understaffed, such as those in Boquerón and Alto Paraguay, which count only three employees each to oversee an area of 9.17 million ha and 8.23 million ha, respectively.[33] Combined with limited integration of data and coordination with other enforcement agencies—such as the national cadaster, tax authorities—this results in uneven application of the law. Weak enforcement in turn lowers the expected value of penalties, which then fail to serve as deterrents. To effectively deter illegal activity, the expected value of the enforcement disincentive—determined not only by the monetary value of the fine but also by factors such as the likelihood of being caught—has to be high enough to make the net profits of illegal activity negative (Akella and Cannon 2004). The outcome of weak enforcement is a general sense of impunity for forest violations, providing insufficient deterrents for illegal deforestation.

29. According to Article 3.3 of Decree 175/18, the reforestation could be done with native species, or within an agroforestry system of mixed plantation where the portion of native species has to exceed 40 percent.

30. Landowners can apply for an authorization to change land use from forests to alternative uses, provided they obtain (i) an environmental impact license from MADES, and (ii) an authorization for land use change by INFONA. Only removal of forest areas that fall within the legal forest reserve, or those that are identified as protective forests (for example under Law 4241/2010), or those that have not been authorized as described above, is considered unlawful.

31. Ley No 3239/07 de *"Recursos Hídricos"- Cap. VII "Restricciones de Dominio" – Inc. b y c del Art. 2 - Ley No 4241/10 "Restablecimiento de bosques protectores de cauces hídricos" y Decreto No 9824/12 por el cual se reglamenta esta ley (ver Cap. III de la extensión de bosques protectores – Art. 5 al 9.*

32. Per Article 5 of Decree 18831/86, 100 m strips are to be left between cleared land parcels of 100 ha.

33. Interviews with INFONA.

BOX 3

Key legal provisions supporting sustainable forest management in Paraguay

Paraguay has enacted more than 50 legal acts (laws, decrees, regulations, and resolutions) to regulate the conservation and management of forests. Key forest-related provisions include the following:

Law 422/73 ***(Ley Forestal)*** regulates the sustainable use and management of forests, forestlands, and renewable natural resources of public and private property. Article 2 states that it is in the public interest to both use forest resources and conserve, enhance, and increase them. Article 42 mandates that private owners of land exceeding 20 ha in forest zones preserve as "forest reserve" at least 25 percent of the original native forest cover (as recorded in the 1986 baseline forest map), creating a legal basis for control of deforestation. The law also creates an obligation for property owners to restore any "forest deficits" arising from violations of Article 42 and outlines the corresponding regime of penalties in Article 54. The application of the Forest Law is in turn regulated through a series of decrees and resolutions, including Decree 175/2018[a], as well as Decree 3312/2020 and INFONA Resolution 094/2020[b], that lay out the enforcement measures.

Law 6256/18 ***(Ley que prohíbe las actividades de transformación y conversión de superficies con cobertura de bosques en la Región Oriental)***, also known as the Zero Deforestation Law, extends the ban to conversion of native forests to other land uses in Eastern Paraguay[c], as well as issuance of any permits and authorizations to convert native forests, for a further two-year term from December 2018.

Decree 3246/2020 ***(Por el cual se reglamenta el Sistema Nacional de Monitoreo Forestal del Paraguay)*** establishes the National Forest Monitoring System (Sistema Nacional de Monitoreo Forestal, SNMF) to collect, manage, and publish forest data with the goal of improving forest management. The law mandates that MADES and INFONA operationalize it.

Law 4241/10 ***(De restablecimiento de bosques protectores de causes hídricos dentro del territorio nacional)*** makes it mandatory to restore and conserve native riparian forests in watersheds, with an emphasis on restoration in Eastern Paraguay and conservation in Western Paraguay.

Decree 4056/15 ***(Que establece Regímenes de Certificación, Control y Promoción del Uso de Bioenergías)***, led by the Vice Ministry of Energy, establishes a mandatory gradual elimination (over five years) of illegal firewood by requiring the private sector to use 100 percent wood from certified sources. Ministry of Public Works and Communications (Ministerio de Obras Públicas y Comunicaciones, MOPC) Resolution 933/2020 establishes a certification process and extends the time horizon to 2025.

Law 3001/06 ***(De valoración y retribución de los servicios ambientales)*** and Resolution 1093/13 create an instrument that allows environmental service providers (landowners with forest cover in excess of the legal forest reserve) to sell offsets to landowners with a forest deficit under Law 422/73, and define the economic value of these ecosystem services.

Law 536/95 ***(De Fomento a la Forestación y Reforestación)*** defines government support for afforestation and reforestation once a forest management plan is approved. But despite of its existence since 1995, the law's application has been limited, mainly owing to a lack of funding.

a. Decree 175/2018: *"Por el cual se deroga el Decreto 7702 del 14 de septiembre de 2017, se instruye a la Presidenta del Instituto Forestal Nacional (INFONA) a proponer una nueva reglamentación, y se establece un régimen provisorio que reglamenta el Articulo 42 de la Ley 422/1973 'Forestal'."*

b. Decree 3312/2020: *"Por el cual se reglamenta el Articulo 53 de la Ley 422/1973 'Forestal,' y se otorgan facultades administrativas al INFONA a los efectos de establecer garantías en materia de procedimientos sumariales."* INFONA Resolution 094/2020: *"Por el cual se establece el Régimen de Infracciones y Sanciones Forestales y el Reglamento de Trámites Administrativos Relativo a los Sumarios Administrativos por Infracciones a la Legislación Forestal."*

c. Law 6256/18 replaces the original instrument, Law 2524/04, *"De Prohibición en la Región Oriental de las Actividades de Transformación y Conversión de Superficies con Cobertura de Bosques,"* thus extending the validity of the ban.

The government is taking steps to address weaknesses in the legal framework and to improve enforcement; however, more work remains to be done.

Supported by the Paraguay First Economic Management Development Policy Loan (P169505), the government recently reformed Decree 1743/14,[34] addressing several key weaknesses in the framework for dealing with forest law violations and penalties, including procedural hurdles that had prevented timely initiation and resolution of administrative proceedings for forest violations. In 2020, Paraguay also created the regulatory basis for the National Forest Monitoring System (Decree 3246/2020). INFONA signed a memorandum of understanding with the World Resources Institute's Global Forest Watch program to compile official forest data into a publicly accessible Paraguayan Forest Atlas. In a coordinated effort of INFONA and MADES, the National Forest Monitoring System will collect, analyze, and publish remote sensing information on forests, creating the first national platform for systematic monitoring of the forest cover with sufficient resolution to detect unauthorized land use change at the property level. The government, led by MADES, is also preparing an Environmental Code (Código Ambiental). Much work remains, however, to strengthen the inter-institutional coordination and enforcement capacity of environmental agencies, as well as to tackle the legal ambiguities and integrate environmental criteria into law more effectively.

34. Decree 1743/14 was replaced by Decree 3312/20, *"Por el cual se reglamenta el artículo de la Ley 422/1973, 'Forestal,' y se otorgan facultades administrativas al INFONA a los efectos de establecer garantías en materia de procedimientos sumariales,"* and INFONA Resolution 094/20, *"Por el cual se establece el Régimen de Infracciones y Sanciones Forestales y el Reglamento de Trámites Administrativos Relativo a los Sumarios Administrativos por Infracciones a la Legislación Forestal,"* in April 2020.

Landscape management and planning

Lack of territorial planning that leverages the economic and ecological value of forests is another key challenge from a resource management perspective.

Land use planning is relatively new in the Paraguayan context. Only a few municipalities, such as Filadelfia and Bahía Negra, have taken steps toward territorial planning *(ordenamiento territorial)*.[35] No comprehensive and up-to-date national territorial and land use plan exists, although efforts led by the Technical Secretariat for Planning (STP) are under way to establish the legal basis for one. Crucially for the forest sector, the principles of integrated landscape management are currently not applied.[36] In 2013, MADES issued Resolution 614,[37] which established Paraguay's ecoregions and officially characterized and recognized the different types of forests. Yet these ecoregions are not being integrated into private land use decisions.

35. In the past, some departments in the Chaco have tried to advance toward a territorial planning but failed, mainly because of a lack of central government approval.

36. Integrated landscape management is the long-term collaboration among different groups of land managers and stakeholders to achieve the multiple objectives required from the landscape (FAO 2020).

37. Resolution 614/13, *"Por la cual se establecen las ecorregiónes para las regiones oriental y occidental l del Paraguay."*

In practical terms, this means that forest management plans or permits for land use change issued by INFONA and the environmental licensing issued by MADES do not apply landscape management principles and do not look beyond the individual property level.

These instruments cannot promote continuity of forest habitats or preservation of ecosystem services across properties even if the latter are legally compliant and maintain the 25 percent of the native forest cover as prescribed by the Forest Law. MADES Resolution 200/01 introduces a new management category of biological corridors and could provide entry points for landscape planning,[38] but it has only been applied in the Alto Paraná Atlantic Forest Corridor. Paraguay's three UNESCO biosphere reserves may be the closest examples of the application of landscape management.[39] Besides such exceptions, the general outcome of this policy is a patchy mosaic of forest remnants maintained at the private property level to comply with the Forest Law and the mandatory protection of riparian forests.

38. Resolution 200/01, *"Por el cual se asignan y reglamentan las categorías de manejo; la zonificación y los usos y actividades."*

39. The biosphere reserves are Bosque Mbaracayú, El Chaco, and Itaipu (UNESCO 2020).

There is also little guidance for private landowners on good overall forest management practices, either on the permanent forest legal reserve or on areas open to conversion.

Relevant research on silviculture of native species and technical support to forest owners is lacking. For example, forest management plans with defined management objectives, appropriate silvicultural systems, and forest protection methods are rare and remain largely at the discretion of landowners. In many cases, when more obvious strategic natural blocks should remain to ensure ecosystem service provision, the current approach does not encourage landowners to go beyond a mosaic of forest remnants, failing to promote ecosystem connectivity. Meanwhile, sustainable forest management planning benefits from economies of scale. The cost of developing an inventory and sustainable practices is generally too high for smallholders. It is therefore unsurprising that formal scientific management planning is limited among private landholders.

These patterns make effective forest resource management challenging.

The lack of territorial planning and integrated landscape management makes it difficult to maximize the potential of forests in both their productive functions and conservation needs, to ensure that valuable ecosystem services or highly threatened ecosystems are maintained. This undermines forests' functioning and economic value, which are less likely to be reflected in land use decisions at the property level, where the costs and benefits of maintaining forest or converting it to alternative land uses are ultimately weighed. Application of an integrated landscape management approach could produce more economically efficient, sustainable, and equitable outcomes.

Protected area management

Paraguay's protected areas network plays an insufficient role in safeguarding forests.

Literature points to incomplete institutionalization, lack of control and funding, which undermine its effectiveness (Cartes and Yanosky 2020; Espínola-Torres, Amarilla-Rodríguez, and Pinazzo 2020). Based on 2019 data that are being updated by the government,[40] Paraguay has created 102 protected areas since 1948, totaling 2,797,642 ha, or 6.9 percent of the national territory, excluding biosphere reserves (Cartes and Yanosky 2020), and 6,199,984 ha, or 15 percent of the national territory, including biosphere reserves (Espínola-Torres, Amarilla-Rodríguez, and Pinazzo 2020). Paraguay's protected area network (Sistema Nacional de Áreas Protegidas del Paraguay, SINASIP)[41] was established in 1994 via Law 352/94 to manage these protected areas, to promote conservation. Law 352/94 establishes the official designations of protected areas and envisages a Wild Protected Areas Fund and a National Council of Wild Protected Areas to ensure the system is adequately financed and managed; neither have been implemented. Management and control of protected areas are limited and suffer from chronic underfunding[42] and legal disputes. Few protected areas have been registered in the National Protected Area Registry (Registro Nacional de Áreas Silvestres Protegidas). Most are located on private land and in some instances were established without prior consultation with the affected landowners, indigenous groups, and stakeholders, resulting in the repeal of nine protected areas to date (Cartes and Yanosky 2020).

40. The government is currently updating the Strategic Plan for the Protected Area Network *(Plan Estratégico del Sistema Nacional de Áreas Silvestres Protegidas (SINASIP) 2018 – 2028)* and updating data on the number of protected areas and their coverage. Preliminary results suggest that these are higher than the estimates presented here.

41. Law 352/94 establishes the official designations of protected areas. Paraguay's categories do not correspond formally to those established by the IUCN World Commission on Protected Areas. Law 352/94 and MADES Resolution 200/01 classify protected areas in Paraguay into three levels: (i) strict protection (corresponding to IUCN categories I, II, and III), (i) flexible use (corresponding to IUCN category IV), and (iii) special use (corresponding to IUCN categories V and VI). The newly established categories under Resolution 562/17, which covers "special management categories," such as indigenous conservation territories, biological corridors, and fishery reserves, would be equivalent to IUCN categories IV or V (Cartes and Yanosky 2020).

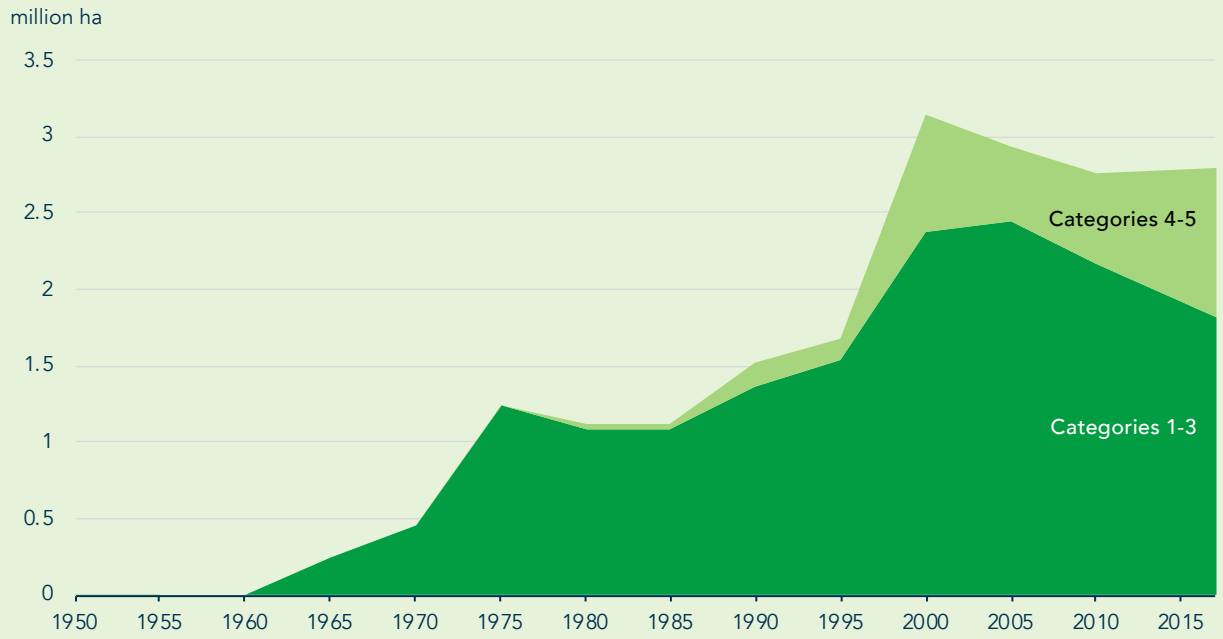
42. A comparative analysis of protected area management costs and financing needs in Latin America in 2010 showed that Paraguay had one of the largest financing gaps in the region (World Bank 2013).

Since the protected area network's establishment, only 42 out of 102 protected areas have created a management plan.

Of these, 14 were under public management, 18 were under private management, and 10 had a special status (Espínola-Torres, Amarilla-Rodríguez, and Pinazzo 2020). Lack of funding to prepare such plans is often cited as the reason for their low availability. Another recent trend is the downgrading of national parks (Cat. II) to managed resources reserves (Cat. VI) (**Figure 6**). The latter can contain private farms and allow up to 50 percent of the territory to be used for agricultural and forestry uses, effectively halving the area dedicated to conservation (Cartes and Yanosky 2020). Akin to the legal forest reserve, forests under formal protection status are succumbing to weak enforcement and pressures from commercial land uses. As subsequent sections suggest, few economic incentives also exist to promote successful implementation of the network on mostly privately owned land.

FIGURE 6

Protected area coverage (ha) by management category, 1950–2017



Source: Cartes and Yanosky 2020.
Note: Categories I–III are restrictive; categories IV–VI are less restrictive.

SYNTHESIS

Forest policy and institutional analysis: Governance

Forest governance in Paraguay faces significant challenges. It happens at the intersection of many economic sectors and institutions, and it displays weak enforcement, low levels of transparency, and lack of systematic land planning that incorporates forest value. Key obstacles include the following:

1. Land tenure is predominantly private and highly concentrated; forests are embedded in productive (predominantly agricultural) landscapes, placing the responsibility for forest management on private landowners, often large-scale agricultural producers.
2. The country does not yet have a modern rural cadaster that incorporates forest data, which undermines enforcement and planning.
3. The institutional framework is complex and coordination between relevant agencies is limited.
4. The Forest Law sets forest area retention standards; however, enforcement is limited, with an estimated 2.49 million ha deforested in violation of the law as of 2014. Several key legal instruments are dated or obsolete and, arguably, not commensurate with the magnitude and complexity of the pressures that forests are facing today.
5. Landscape management planning has not been adopted, and it could produce more economically efficient, sustainable, and equitable outcomes.
6. The protected area network is underfunded and insufficient for preserving forest resources.

3.2.
Incentives

The forest sector responds to a range of fiscal, financial, and regulatory incentives both within the sector and in other economic sectors.

Fiscal incentives can include taxes, royalties, tariffs, and various forms of subsidies. Compensation mechanisms for investments in sustainable activities and practices, tradable permits, and licenses also act as economic incentives. Financial incentives include factors such as availability of attractive credit. Regulatory incentives include export regulations and existence of traceability systems. Together, these determine whether actors in the forest sector face a level playing field compared to other economic activities, notably agriculture, and are able to adequately capture rent from forests and get rewarded for adopting sustainable practices that maintain ecosystem services.

Why are economic incentives important in the forest sector?

Sustainable forest management in Paraguay needs to be supported by incentives to place it on a level playing field with other land uses.

From an economic perspective, optimal land use entails maximizing the net present value of social benefits derived from land (OECD 2020). As earlier sections of this paper show, many ecosystem services of forests, such as watershed regulation services, are public goods that are not captured by markets, accruing to Paraguay's citizens and productive sectors mainly as positive externalities. Thus, the economic value of forest resources **(Table 2)** cannot be monetized by landowners in the absence of functioning environmental markets. Monetizing the provisioning services of forests—such as timber and fuelwood—is also challenging if domestic markets are flooded with illegally and unsustainably sourced forest products. As a result, forest land use is underprovided.

Native forests continue to be perceived as an opportunity cost, particularly in comparison to agriculture and livestock.

Returns from industrial grain production can reach $4,800/ha in Eastern Paraguay, and returns from commercial agriculture and livestock can reach $2,600/ha in the north and $1,600/ha in the south **(Table 5)**. For large farmers, standing native forest represents opportunity costs and there are currently no mechanisms that reward them for their conservation. For small and medium farms, maintaining forests makes somewhat more economic sense, considering that the average NPV of agriculture or livestock activity varies from $800/ha to $1,200/ha and there is a substantial one-time cost of logging and preparation of land for agricultural use (up to $500/ha). Small farms are more likely to see the value of the ecosystem services generated by standing forest. In the Chaco's arid watersheds, for example, silvopastoral options and sustainable forest management practices that help water retention may already be the model of choice for small landholders. Still, in the weak regulatory climate whereby illegal forest clearing under the Forest Law and the Zero Deforestation Law may carry no practical consequences, native forests are generally perceived as a cost and this creates perverse incentives for landowners of all sizes to convert them.

Forest conservation *can* make economic sense for landowners if they are able to internalize the positive externalities generated by conserving forests and profit from their productive uses.

As this analysis shows, the value of economic benefits from native forests can, in certain cases, exceed the commercial returns from alternative land uses such as agriculture and livestock **(Figure 7)**. Putting in place the right economic incentives is key to incorporating this value into private land use sections.

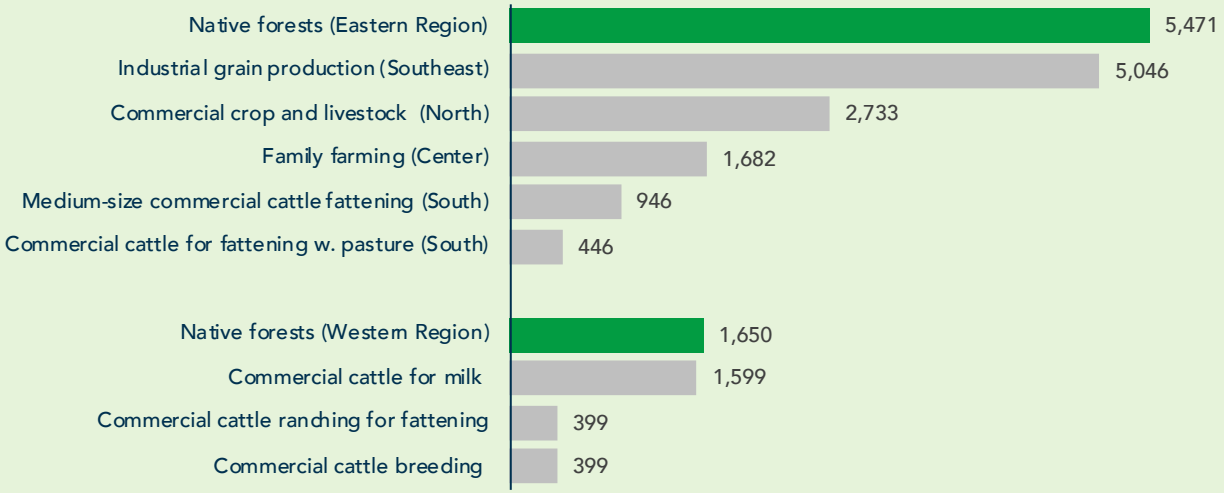
TABLE 5
Characteristics of typical farms by agricultural zone

Zone	Central	Southeast	North	South		Chaco		
Type of farm	Family farms that produce grains, cotton, and sesame, and animals for sale and own consumption	Industrial grain producing farms with a classic rotation of soybeans-wheat-corn exclusively for sale	Commercial crop and livestock (cattle ranching and leases of land for grain production with livestock as main income item)	Medium-size commercial cattle fattening exclusively for sale	Commercial cattle fattening with natural pastures exclusively for sale	Commercial cattle fattening exclusively for sale	Commercial cattle breeding exclusively for sale	Commercial dairy farming exclusively for sale
Agricultural NPV (US$/ ha)	1,600	4,800	2,600	900	424	380	380	1,521
Average lot (ha)	5	12,000	5,200	150	800	13,000	10,000	110
Cropland (%)	46	41	53	3	1	0	0	0
Natural/ planted pastures (%)	17 (natural)	0	2 (planted)	86 (53% natural, 47% planted)	40 (natural degraded)	54 (80% natural, 20% planted)	40 (80% natural, 20% planted)	86 (planted pastures)
Natural forest (%)	11 Degraded, with plantations of eucalyptus / native species	53	43	3	40 Degraded, with natural regeneration	31 Degraded, with natural regeneration	15 Degraded, with natural regeneration	9
Forest plantation (%)	See above	3 – eucalyptus	1 – eucalyptus	1 – eucalyptus	0	0	0	0

Source: Based on information from Labbate et al. (2016).
Note: The net present value (NPV) calculation assumes a time horizon of 15 years and a 6 percent discount rate.

FIGURE 7

Net present value of native forests and agricultural land use (US$/ha)



Source: Original calculations conducted between 2017 and 2020.
*Note: The value of various land use models is expressed as the net present value of economic of commercial returns they generate (for underlying data, please see **Table 3** and **Table 5**).*

Overview of incentives in the forest sector

The government has taken some steps to correct these market failures and provide some incentives for sustainable forest management; however, not all of them have been fully implemented.

There are two main market-based instruments relevant to forests:

- Environmental Services Regime (ESR). A market-based environmental offset mechanism that allows landowners who maintain forest cover over and above the legal forest reserve requirement to obtain Environmental Service Certificates for preserving ecosystem services and sell them to landowners with a forest deficit or to other interested buyers. While a promising mechanism in principle—capable of correcting the market failures described above—its implementation has been limited to date (see below).
- Carbon credits. Paraguay is part of the Forest Carbon Partnership Facility's REDD+ Readiness Fund and in 2019 the Green Climate Fund approved $72.5 million worth of payments for results to Paraguay for avoided deforestation between 2015 and 2017 (UNEP 2019).

The use of environmental taxes remains limited in Paraguay.

Revenues from such taxes amounted to just over 1 percent of GDP in 2017, made up primarily of taxes on energy products (0.64 percent), transport (0.38 percent), pollution (0.02 percent), and natural resources (0.01 percent) (OECD et al. 2020).[43] What matters most for forests is that taxes on natural resource extraction are negligible and there are no explicit green taxes or other fiscal instruments earmarked for environmental purposes. Early in 2020, the government considered introducing a 5 percent "green tax" on the exports of conventional soya beans—that is, noncertified, nonorganic soya beans—to offset some of the environmental costs embedded in these exports; however, the proposal failed to obtain parliamentary approval (La Nación 2020). In contrast, some countries in Latin America and the Caribbean have introduced significant green tax reforms in recent years that could be promising also in Paraguay's context. For example, Colombia introduced a carbon tax ($5 per ton of carbon dioxide

43. The analysis uses data from the OECD Policy Instruments for the Environment (PINE) database, which includes taxes on energy, transport, pollution, and resources. In the 22 countries in Latin America and the Caribbean for which data are available, environmentally related tax revenues amounted to 1.1 percent of GDP on average in 2017, which is lower than the OECD average of 2.3 percent of GDP.

from combustion of liquid fossil fuels) and earmarked the revenues to a fund designed to address specific environmental issues, such as coastal erosion, conservation of water sources, and ecosystem protection (OECD et al. 2020).

While crucial to understanding any distortions affecting land use decisions, a comprehensive cross-sectoral analysis of fiscal incentives relevant to the forestry sector could not be identified.

However, even the limited evidence available points to weak economic incentives in the forest sector, compared to other land uses. For example, the agriculture sector enjoys more favorable tax rates—a 5 percent VAT rate is levied on agricultural products compared to 10 percent for forest products, an implicit subsidy of the agriculture sector. In 2016, the agriculture sector received $214.3 million in support. On average, the sector benefited from $144.4 million worth of direct support and $136.1 million worth of general services annually between 2009 and 2016 (IDB 2018). No equivalent support exists in the forestry sector.

Property taxes are also important to consider, as the current land tax system does not encourage intensification and offers limited incentives for sustainable forest management.

Until 2018, rural properties containing native forests enjoyed a 50 percent reduction in property tax, but Decree 8299/2017 eliminated this exception.[44] The exemption now applies only to properties with reforested/afforested land, as defined by Law 536/1995, with an approved forest management plan.

A missed opportunity: the market for environmental services

Paraguay's Environmental Services Regime is a market-based environmental offset mechanism that can support sustainable forest management.

Established under Law 3001/06, its objective is to reward landowners for the environmental services that their lands provide as a result of management, conservation, or restoration of ecosystem functions.[45] Providers of such services as mitigation of GHG emissions through forests, conservation of biodiversity, scenic beauty and protection, and restoration of damages caused by natural disasters can obtain an Environmental Service Certificate (ESC). In turn, these certificates can be transacted on the voluntary market or sold to entities that are obligated by law to buy them.[46] Law 3001/06 established the obligation to purchase ESCs in three cases:

- Investment projects and activities considered to be of high environmental impact.[47] The law obliges projects to purchase ESCs in an amount of at least 1 percent of the investment value, or in case of activities, at least 1 percent of their annual operational budget.
- Reparation for environmental damages and/or fines for environmental crimes ordered by a judge.
- Compensation for "forest deficits" of the legal forest reserve under Law 422/73.

44. Decree 8299/2017, *"Por el cual se fijan los valores fiscales inmobiliarios establecidos por el Servicio Nacional de Catastro, dependiente del Ministerio de Hacienda, que servirán de base imponible para la determinación del impuesto inmobiliario y sus adicionales para el ejercicio fiscal del año 2018."*

45. Law 3001/2006 and SEAM Resolution 611/17 accept the following different types of land tenure: (i) private or collective (indigenous) landowners with a land title, *"Propietarios: titulares de dominio, usufructuarios o superficiarios; comunidades indígenas"*; and (ii) private landholders in good faith, *"poseedores de buena fe,"* and indigenous communities that do not have a land title. Different means to prove land tenure "in good faith" for the latter cases are described in Article 2 of SEAM Resolution 611/17. This report uses the term "landowners" to describe all types.

46. ESCs can be issued as two different categories: (i) "non-tradable" certificates, defined in SEAM Resolution 199/2013 as those that shall not be converted into *"títulos valor libremente negociables,"* and (ii) Environmental Service Securities, which can be freely traded in the stock market and could be used to offset up to 50 percent of taxes, including property and income tax (Art. 8, Law 3001/06), if underwritten by MADES and the Ministry of Finance and regulated by the National Stock Exchange Commission.

47. Article 8 of Decree 11202/2013 and Annexes I and II of MADES Resolution 81/2019 define which investments and activities are considered to be of high environmental impact: These include in Annex I, investments in national road construction, hydroelectric and nuclear power plants, pipelines, electric power lines and power stations, ports and airports; and in Annex II, activities of hydroelectric, thermic, fossil and nuclear power production, oil refining, mining, cement, and the chemical industry, which includes facilities that bottle beer or produce alcoholic beverages, bottled refreshments, or produce pesticides or pharmaceutical products. In 2019, MADES issued Resolution 255/19, repealing paragraph (f.) of Annex II of MADES Resolution 81/2019. As a result, all activities under "Chemical Industry" are exempt from buying ESCs.

Environmental Service Certificates have the potential to make conservation of native forests more economically viable.

The mechanism was introduced after the Zero Deforestation Law, which had previously disadvantaged landowners who had conserved natural forest areas without receiving compensation, even though they were entitled to convert these forest areas into other, often more lucrative land use forms. The reference values for ESCs, established in 2013 per unit of area (ha), are based on the opportunity cost that takes into account the yields from alternative (agricultural) land uses, risks, and ecological value. These range between $143 (PYG 894,933)/ha and $826 (PYG 5,152,526)/ha and average $437 (PYG 2,724,827)/ha. Some uncertainty as to the frequency of payments exists: The certificates are valid for five years; however, it is not clear in the legislation if the nominal value is to be paid once during the five-year validity period, or yearly within the period.[48]

While a promising mechanism, the regime has failed to create a functioning market for environmental offsets in Paraguay.

The potential demand of ESCs to compensate the legal forest deficits nationwide was last estimated in 2014 to be 2.49 million ha (Vidal 2015). According to MADES, between the establishment of the mechanism and April 2019, 213,712 ha of nonpublic natural forestland had been certified under the ESC regime **(Table 6)**,[49] but only 20,465 ha had actually been traded. This means that for every ten ESCs privately offered, only one is bought. On the other hand, the potential demand—if the legal forest reserve were to be enforced—is an order of magnitude above the supply of ESCs.

The demand for ESCs has been driven mostly by public investments and activities considered to be of "high environmental impact," which account for more than 90 percent of the ESC transaction volume.

Public works contracted by ITAIPU (hydroelectric production), ANDE (power and electricity infrastructure), and the MOPC (public infrastructure, roads, and communications) alone accounted for 73 percent of the total volume of $8.03 million in ESC transactions registered by MADES until April 2019. Only four of these transactions, accounting for 8.2 percent of the financial volume traded, are listed as offsets for a "forest deficit," and only 0.1 percent are the result of fines from two legal processes. After more than 15 years of implementation, Law 3001/06 has contributed only marginally to its objective of conserving forests and its biodiversity, representing a missed opportunity.

48. While MADES has established the ESC price reference and their contract duration, these are subject to negotiation between ESC providers and buyers.

49. This figure does not include 10,344 ha of grasslands but does include 43,499 ha certified from the nongovernmental organizations Moisés Bertoni and Guyra Paraguay, and 9,669 ha from three indigenous communities.

The offer of ESC is displayed at http://www.mades.gov.py/areas_certificadas/. No other trading mechanism to match demand and offer appears to be in place.

TABLE 6

Natural forest area certified under the Environmental Services Regime

Type of land tenure	Eastern Paraguay		Western Paraguay		Total	
	Area (ha)	#	Area (ha)	#	Area (ha)	#
Private or corporate	45,619	30	114,925	25	160,544	55
Nongovernmental organization	39,901	3	3,598	1	43,499	4
Indigenous community			9,669	3	9,669	3
Total forest cover	**85,520**	**33**	**128,192**	**29**	**213,712**	**62**

Source: Interview with the Directorate of Environmental Services, MADES, April 2019.
Note: Data as of April 2019, excluding protected areas.

Few other incentives exist in the forest sector, even though the legal framework contains several (obsolete) instruments for the promotion of sustainable commercial forestry.

Law 536/1995 establishes government-funded incentives under the Forest Fund for landowners who invest in reforestation or plantations—it envisages to offset up to 75 percent the cost of site preparation and plantation, and 75 percent of the costs of maintenance during the first three years after plantation, and makes plantations eligible for tax exemptions (up to 50 percent of taxes such as income and property tax). Despite two decades of existence, the application of this law has been limited by a lack of funding. The same is true for the National Forestry Plan and the National Environmental Fund.

Access to finance

Financing for forestry in Paraguay is virtually nonexistent and this hinders the development of forest plantations.

Producers surveyed as part of this analysis cited lack of suitable financing as the single most important reason behind the slow rate of growth of commercial forestry, particularly plantations.[50] Financial institutions' capacity to lend to the sector is low. The public second-tier development bank, Agencia Financiera de Desarollo (AFD), operates a forestry loan program, PROFORESTAL; however, between 2008 and 2019, it lent funds to only three borrowers. Among the reasons cited are a lack of understanding among first-tier banks of the characteristics of the forestry sector and how to conduct appropriate risk assessments. This leads to a perception of high risks attached to the sector, which in turn generates high interest rates and unattractive repayment terms. As commercial forestry, notably plantations, entails large up-front investments and long payback periods, and financial regulations for competitive lending to the forestry sector have been deficient, commercial banks have been reluctant to finance forestry projects.

The operating environment for forest finance has improved over the last year.

The Paraguay First Economic Management DPL (P169505) supported the modification of two AFD resolutions,[51] in which the government extended the validity of PROFORESTAL, removed the ceiling for loan amounts, and loosened some of the collateral requirements. In turn, the Central Bank's Circular 00088/2019 clarified that commercial banks that apply grace periods of more than one year to long-term investment projects will not incur a sanction in terms of their credit classification. The circular also specifies that long-term investments could very well incur short-term losses, and that this will not be considered a weakness in the financial standing of the bank providing the loan. In addition, the Central Bank recently issued guidance recognizing the vuelo forestal, established by Law 4890/13, as potential loan collateral.[52] These measures are expected to remove some of the obstacles to access to finance. More hurdles need to be overcome, however, in particular the perception of forestry as a high-risk investment among financial institutions, which requires de-risking to improve access to finance. Finally, small and medium producers, women, rural communities, and indigenous peoples' groups have difficulty meeting the eligibility requirements for credit and thus face limited access to finance.

50. The World Bank held a workshop with 11 stakeholders in June 2019 to identify bottlenecks in the forest investment climate.

51. AFD A68R01F140819 and AFD A11R02F060220, which removed both the ceiling for maximum loan amounts and the explicit requirement to put the land on which the pertinent forest project is based as a collateral.

52. Resolution 1, Act 61, November 12, 2020, "Normas de clasificación de activos, riesgos crediticios, previsiones y devengamiento de intereses – incorporación del derecho real de superficie forestal como garantía." In simplified terms, the vuelo forestal refers to the standing timber, which can be used as loan collateral as per Law 4890/13, "Ley de vuelo forestal," a law that in practice remains largely unimplemented.

Regulatory incentives

Private sector operators and investors in forestry, as well as their lenders, expect to operate in markets with a stable and predictable policy and regulatory environment that minimizes information asymmetries.

In a sector dominated by informality and illegality, it is key to establish a regulatory framework for sustainable commercial activity that allows actors to easily distinguish sustainable and legally compliant forest practices from illicit and unsustainable ones. This transparency is crucial for the fate of Paraguay's native and planted forests alike—unsustainable use of native forests is rapidly depleting the resource base and creating an uneven playing field (including price competition) for legitimate operators, particularly forest plantations. Traceability and certification are the key regulatory instruments typically used to achieve that. In addition, it is important to ensure that the regulatory framework does not impose excessive restrictions on export of sustainable wood products. Paraguay recently amended Law 515/92, which took a precautionary approach and imposed a ban on exports of logs and beams of native and exotic species. The amendment allows for the export of exotic species, although it is important to avoid potential laundering of native species in exports of exotic species.

Inefficiencies in public forest administration may be disincentivizing legal forest operators.

The ability to trace a forest product from its origin in the forest to its final domestic destination, whether a sawmill or a point of export, is based not only on the legal mandate of the forest administration to do so, but also on its capacity to establish and manage a modern georeferenced forest register, to approve and supervise forest management and harvesting plans, and to control that only approved volumes and species are harvested and transported/exported. These functions could be administered within an integrated information management system to allow for efficiency, transparency, and accountability. Yet INFONA still operates on a paper-based basis and in silos. This causes inefficiencies and raises transaction costs, disincentivizing legitimate forest operators, notably forest plantations.

A comprehensive framework for forest certification is still lacking and coincides with low levels of adoption among private actors.

By the end of 2019, Paraguay had only 42,000 ha of forests (26 percent of total plantation area) certified as sustainably managed by the Forest Stewardship Council (FSC), compared with 724,000 ha (76 percent) in Uruguay and 2.3 million ha (71 percent) in Chile (FSC 2020). There are no Programme for the Endorsement of Forest Certification (PEFC)- or Sustainable Forestry Initiative (SFI)-certified forests in the country. Paraguay is one of only four countries in South America without any national standards for certification, even though, at least for biomass used for energy production, Decree 4056/2015 requires the private sector to switch to certified wood by 2020 and mandates that a certification system for sustainable biomass be established. Earlier this year, MOPC Resolution 933/2020 established the supporting regulatory framework—the regime of certification, control, and promotion of bioenergy.[53] It envisages a government-supported certification scheme and sets standards for sustainably sourced biomass, while giving the possibility to FSC- and PEFC-certified producers to be qualified under the resolution. While the regime represents an important step to promote trade of forest products originating in Paraguay's sustainably managed native or planted forests, it does not yet cover products other than woody biomass for energy production, which is where higher value added can be generated. Except for some larger producers, the gap between current forest management practices and the performance level required by certification standards is large, requiring upgrading of skills and knowledge, facilitated by INFONA and with the involvement of technical service providers who can serve the market. In addition, special provisions may be necessary for smaller forest producers with limited human resources to access group certification and be able to integrate into sustainable value chains.

53. Resolución 933/2020, "Por la cual se aprueba el reglamento que establece los regímenes de certificación, control y promoción del uso de bioenergías provenientes de plantaciones forestales o bosques nativos manejados, para asegurar la sustentabilidad de estos recursos renovables dentro del territorio nacional."

The broader challenge is that the country's forestry sector has yet to widely embrace the principles of sustainability.

Paraguay trails behind its neighbors on the adoption of sustainable forest management.[54] The focus on short-term financial gains through extractive logging and fuelwood-cutting in native forests has already led to shortages of timber and fuelwood and is hindering the development of higher-value products. There is a lack of recognized best management practices or other mandatory or voluntary standards covering land use change, tree planting, silviculture, or harvesting. The cost of engaging technical assistance from private technical service providers, averaging $30–$60/ha, is higher than in comparable countries,[55] resulting in limited uptake and therefore limited outcomes in efficient and sustainable management practices.

54. Sustainable forest management aims to maintain and enhance the economic, social, and environmental values of all types of forests, for the benefit of present and future generations (UNFF 2007).

55. Field data collected as part of the analysis of plantation models (Appendix B) show that the overall costs for plantation models of saw timber, as well as biomass, vary around $2,000/ha during the first three years, which is high by international standards (Cubbage et al. 2020). These costs are driven by high costs of technical assistance as well as potentially excessive plantation preparation and management practices.

SYNTHESIS

Forest policy and institutional analysis: Incentives

1. The forest sector in Paraguay is supported by weak fiscal, financial, and regulatory incentives.
2. Standing forest is perceived as an opportunity cost, as agricultural returns range from $380/ha to $4,800/ha, while many ecosystem services that forests provide are public goods that are not captured by markets. They accrue to the public as positive externalities and are thus underprovided by private landowners in the absence of mechanisms that reward conservation.
3. The Environmental Services Regime is a promising mechanism that could help correct the market failure; however, its implementation has been limited: Despite a nationwide forest deficit of 2.49 million ha as of 2014, the private market for Environmental Service Certificates is nonexistent.
4. Access to finance remains limited; long time horizons for forestry projects and the perception among financial institutions that forestry is a high-risk activity result in high interest rates and unattractive repayment terms.
5. Regulatory incentive gaps include lack of traceability systems and recognized sustainable forest best management practices.

4

Seizing the potential of forests for Paraguay's development

A dynamic forest sector presents win-win opportunities for Paraguay, both in development and environmental outcomes. A shift toward sustainable management of forests is a key step for the country to realize the domestic benefits from natural capital in an inclusive way—maintaining local ecosystem functions that support productive sectors and the population and maximizing the economic opportunities stemming from forests. Benefits to reap include job and GDP creation, diversification of the rural economy, and broadening of the country's export base—opportunities that can support Paraguay's recovery from the COVID-19 crisis and underpin long-term growth. Experiences from neighboring countries like Uruguay show that a transition toward more sustainable growth that tries to limit deforestation can reduce externalities while improving domestic productivity and competitiveness (World Bank 2018b) **(see Box 4)**.

Two opportunities can pave the way: A transition toward forest-friendly agricultural practices based on managing productive landscapes and the sustainable development of forest plantations. They would simultaneously support forest conservation and production that must coexist for the full potential of forests to be realized. A shift toward integrated landscape management that promotes forest-friendly agricultural practices would help manage the forest resource base more sustainably and efficiently. In turn, forest plantations and the development of related value chains could fulfill more productive needs while helping reduce informality in the sector and contributing to jobs and growth (World Bank 2008). This section examines these two opportunities in more detail.

BOX 4

Green growth country experience: Uruguay

More and more countries are embracing green growth principles globally to combine environmental and productivity objectives, job creation, technology adoption, and higher value added.[a] Regional examples include Colombia, Costa Rica, and Uruguay (OECD 2017; World Bank 2018c). The Uruguayan experience is particularly relevant because the country's exports—mostly agricultural commodities—depend heavily on renewable natural resources and environmental services.

Over the last decade, Uruguay has developed the concept of sustainable intensification of agriculture and is implementing an innovative policy for soil protection by enforcing mandatory management plans for the preservation of soils and water with agricultural purposes and the recovery of eroded soils. A monitoring system for phytosanitary products, beef, and other agricultural products; an irrigation strategy; and an action plan to promote a climate-smart agriculture sector accompany these strategies (World Bank 2018c).

These examples testify not only to Uruguay's efforts to promote environmental sustainability but also to the need to stimulate economic growth. Uruguay stands out from its peers by having increased its total capital by nearly 4 percent per year between 1995 and 2014 and reinvested it in agricultural land and forest capital. This has opened opportunities to target markets that offer higher markups, for example for sustainable beef, and improve trade competitiveness. The sustainable intensification of agriculture not only improved environmental risk management but also helped increase productivity, which increased by an annualized rate of 3.1 percent in the livestock sector over the last decade, for example (World Bank 2018c).

a. Green growth is about fostering growth and development while ensuring that natural assets continue to provide the resources and environmental services on which societal well-being relies. To do this, it must catalyze investment and innovation that will underpin sustained growth and give rise to new economic opportunities (OECD 2011)

4.1.
Optimizing forests' role in productive landscapes

The agriculture and livestock sectors face emerging risks and opportunities that suggest that their practices should change.

A model that relies on continued expansion of the agricultural frontier rather than intensification depletes the very ecosystem services that underpin agricultural productivity and, if forest conversion continues, it will increasingly extend into marginal areas with declining agricultural potential and growing environmental issues. The sectors also face significant violations of domestic law and, as enforcement improves, this creates contingent liabilities for producers to rectify their forest deficits. Crucially, agricultural commodities are coming under growing scrutiny from consumers and investors over their environmental impact (see below), representing a shift of the markets toward greater transparency. From the opportunity side, a transition to sustainable practices can open access to new commodity markets.

Evidence from markets: risks and opportunities related to agricultural sustainability

Awareness of the environmental impact of agricultural commodities is growing globally and is influencing markets.

Large-scale commercial agriculture—primarily cattle ranching and cultivation of soy and oil palm—accounted for 40 percent of tropical deforestation between 2000 and 2010 (FAO and UNEP 2020). This puts agricultural commodities at the forefront of global efforts to address climate change and biodiversity loss—deforestation is the second largest source of anthropogenic GHG emissions (Pendrill et al. 2019), and land use change is the greatest driver of biodiversity loss in terrestrial ecosystems (IPBES 2019). Forests also play an essential role in livelihoods. Indigenous and low-income rural communities depend on forests in many parts of the world, raising concerns over social implications of deforestation.

Agricultural value chains are coming under growing scrutiny as investors look to reduce their exposure to the risk of deforestation.

With the recent development of environmental risk reporting frameworks (for example, the Task Force on Climate-related Financial Disclosures), agricultural producers and the finance sector are realizing that environmental risks can be financially material and affect their organization's financial position. Physical, transition, and systemic risks associated with climate change and biodiversity loss carry implications for future cash flows, capital expenditure, and asset values in company and financial balance sheets.[56] Given the far-reaching implications of these risks, the pressure to assess and disclose them is growing, particularly in European and Northern American markets. Transparency over companies' deforestation footprints and risk disclosure is still incipient; however, this is already changing as reporting on environmental risks becomes more mainstream in financial markets. Regulatory and voluntary action is also

56. Physical risks to assets stem from the dependencies on nature and exposure to the potential physical disruptions caused by climate change and loss of ecosystem services; transition risks are the potential effects of new regulation and evolving consumer expectations as part of the transition to a low-carbon and sustainable economy; and systemic risks are related to extreme physical or transition risks (World Bank 2020d).

decisively pushing markets in this direction. Examples of voluntary initiatives include the Equator Principles, and Climate Action 100+.

Investors and trade partners are starting to use their leverage and push for change in commodity value chains, including beef and soy, through engagement and capital allocation.

For example, Norway's $1 trillion sovereign wealth fund recently divested from 60 investments because of deforestation risk (Norges Bank Investment Management 2018). In July 2020, an investor coalition representing over $4.6 trillion expressed concerns over escalating deforestation and dismantling of environmental policies in Brazil that created "uncertainly about the conditions for investing in or providing financial services to Brazil," prompting the government to commit to a temporary ban on fires in the Amazon (Responsible Investor 2020). Concerns over deforestation in Brazil have also put the ratification of the $19 trillion EU-Mercosur Trade Agreement between Brazil, Argentina, Paraguay, and Uruguay at risk (Boadle 2019), as new research revealed that 20 percent of soy exports and at least 17 percent of beef exports from the Amazon and the Cerrado biomes to the European Union could be linked to illegal deforestation (Rajão et al. 2020).

While the last decade has seen a significant shift in generally accepted agricultural commodity sourcing standards, much work remains, and Paraguay has yet to seize the opportunities in sustainable commodity markets.

Among the major drivers of tropical deforestation, the global beef industry is arguably one of the least progressive. There is currently no globally recognized certification or standard-setting body, and there is little uptake of basic sourcing criteria or global, time-bound commitments by major multinational players (Veit and Sarsfield 2017). In Paraguay, beef exporters do not target higher-value beef markets such as the European Union, the United States, and Japan, exporting primarily to Chile, the Russian Federation, and other markets that do not require environmental traceability. As a result, Paraguay's beef industry has been less affected by global sustainability pressures, focusing on volumes and price. By and large, investment in geospatial data and traceability in the livestock sector remains limited compared with the general trend in the agricultural world, while land use and land ownership history are of little concern for cattle buyers (Veit and Sarsfield 2017). In the soy industry, the Round Table on Responsible Soy (RTRS) created an international standard and a certification mechanism for implementing sustainable practices in the sector. Leading global companies such as Unilever and Cargill have set sourcing targets for 100 percent sustainable soy in their supply chains (Unilever 2020; Cargill 2020), and efforts are under way to push for a greater uptake of RTRS certification in Paraguay. Yet in 2020, only five producers in Paraguay were RTRS certified (RTRS 2020), covering an area of 32,905 ha, or about 1 percent of the total soy cultivation area.[57] As these processes evolve further, Paraguay's limited uptake of sustainability principles in livestock and agricultural production risks curtailing investment and access to markets.

A shift to more sustainable practices could help the domestic agricultural sector mitigate the risks related to deforestation and facilitate access to higher-value markets.

Acting on deforestation risks minimizes future costs. Changing consumer preferences are driving demand for more sustainable and "healthier" agricultural products. From a producer's perspective, green commodities can provide access to more attractive markets that are associated with higher willingness to pay from consumers. There are important growth prospects and attractive price margins in the niches of sustainable beef, nongenetically modified soy, and organic milk powder, for example.[58]

57. The total area cultivated with soy in Paraguay is estimated at 3 million ha (Reuters 2019).

58. Market analysis conducted in Uruguay (World Bank 2018c) showed a strong demand for green commodities. Sustainable beef was expected to grow by 6 percent and nongenetically modified soy by 16 percent per year over the course of the following five years, and both were expected to obtain higher markups compared to conventional beef and soy.

BOX 5

Integrated and sustainable production systems in Brazil

The global agricultural industry is at a crossroads. The sector's expanding environmental footprint on climate and natural ecosystems is unsustainable, yet its output is key for supporting a growing population. More efficient, climate-smart,[a] and sustainable agricultural practices are needed to ensure continued growth in agricultural output, food security, and effective management of environmental risks. The example of such approaches in Brazil offers lessons.

Brazil currently has 11.5 million ha of integrated livestock-forest systems,[b] with nearly 1 million ha located in the State of Goiás and the Federal District (Silva, Ferreira et al. 2010). Of the four possible configurations of such a system, an integrated crop-livestock-forest is the most common. Empirical studies (Silva, Ferreira et al. 2010) have found that the tree component in such production systems do not negatively influence crop productivity; on the contrary, it increases agricultural and livestock yields while reducing production costs as a result of soil improvements. Other environmental benefits in such models include sequestration of carbon dioxide, improved hydrology, and reduction of pressures on adjacent native forests, particularly if the model involves a forest plantation. One way the government is supporting adoption of such models is through the "Carbon-Neutral Beef" certification that allows producers to signal sustainability.

a.Climate-smart agriculture is an integrated approach to managing landscapes—cropland, livestock, forests, and fisheries—that addresses the interlinked challenges of food security and climate change. It aims to simultaneously achieve three outcomes: increased productivity, enhanced resilience, and reduced emissions (World Bank 2020c).

b.The concept is summarized in EMBRAPA (2020a): "ICLFS seek to integrate systems producing food, fiber, energy and timber and non-timber forest products in the same area, in combination, succession or rotation, to optimize the biological cycles of plants and animals, inputs and their respective residues. It additionally aims at maintaining and reconstituting the forest cover, recovering degraded areas, adopting sound agricultural practices and increasing machinery, equipment, work force efficiency […]"

Photo series: Illustrative example of an integrated livestock-forest system.
Credit: EMBRAPA 2020b.

In Paraguay's context, forest-friendly agriculture could be framed as compliant with forest law and embedded in sustainable landscapes that optimize ecosystem functions.

At the landscape level, this means applying an integrated landscape management approach to balance the trade-offs and potential synergies between competing land uses in forest areas, to ensure the ecosystem services of forests and other ecosystems are maintained. At the property level, this means promoting agroforestry and agro-silvo-pastoral production systems, involving native and plantation forests. Such production systems have multiple co-benefits—from promoting energy security to maintaining regulating services of forests and climate change mitigation. **Box 5** illustrates this with the example of Brazil.

Promising approaches at the level of municipalities, producers, and investors are under way to tackle deforestation in supply chains and could be scaled up.

Examples of efforts to improve environmental compliance of agribusiness include the following:

- **Municipalities**. In the Central Chaco, local authorities and agricultural cooperatives have developed plans to conserve the legal reserve and create connectivity between properties. The objective is to achieve compliance with the Forest Law, pilot silvopastoral models, and maintain wildlife within the forest remnants through biological corridors connecting properties (Mereles et al. 2020). This initiative is the first and only example to date of a biological corridor established in Paraguay.
- **Business operators**. PAYCO, an agribusiness company with more than 100,000 ha under management, was the first producer in Paraguay to obtain an FSC certificate for forestry. The company plans to establish silvopastoral systems involving 9,000 ha of forest plantations (PAYCO 2018b). PAYCO also holds one of the first legally recognized private nature reserves with more than 20 years of implementation. The business combines forestry, conservation, nature-based tourism, and crops and also interacts with indigenous people living adjacent to its property.
- **Producer associations**. The Paraguayan Roundtable for Sustainable Beef is encouraging its members to adopt forest-related best practices in the beef value chain.
- **Small producers**. As part of the establishment of the Mbaracayú-San Rafael conservation corridor, supported by a World Bank project,[59] farmers and the Aché indigenous peoples were engaged in forest restoration and planting of yerba mate in agroforestry systems. In turn, companies such as Guayaki source the yerba mate grown, helping these communities generate sustainable returns from the forest. This serves as an example of forest restoration, native forest enrichment, and use of native species *Ilex paraguayensis* to improve resilience and generate incomes and food security for indigenous people while maintaining native forests.
- **Finance sector**. The Sustainable Finance Roundtable of Paraguay (Mesa de Finanzas Sostenibles) was established in 2012 and now represents 90 percent of the banks and lending portfolios in Paraguay. The roundtable has made important efforts to promote better land use practices among borrowers and has issued several guidelines to promote better compliance with environmental regulations and with voluntary land use practices for cattle ranching and soybean production. Financial institutions, such as BBVA, Continental, ITAU, and Banco Regional, are exploring ways to mainstream these practices in their lending. Other private voluntary initiatives promoting best environmental and social practices in the productive and financial sectors include the Global Pact Chapter Paraguay (Pacto Global Red Paraguay).

59. Conservation of Biodiversity and Sustainable Land Management in the Atlantic Forest of Eastern Paraguay Project (P094335).

4.2.
Plantation forestry

Leveraging the favorable environmental and economic conditions for plantation forestry, Paraguay can seize opportunities in the growing domestic and international markets for forest products.

Globally, plantation forestry satisfies more than a third of industrial wood demand (Pirard, Dal Secco, and Warman 2016) and an increasingly important part of the timber industry. The global consumption of roundwood is predicted to grow on average by 1–1.2 percent annually until 2030 (Buongiorno and Zhu 2019). The share of wood products derived from planted forests is expected to increase globally as natural forests decline, are degraded, or are set aside for conservation purposes. Paraguay could follow a similar trend, provided the right economic and regulatory signals are put in place. Expansion of production forestry and promotion of local value chains can help formalize the domestic wood product markets and create value addition. Market opportunities lie in three primary areas: solid wood products and wood-based panels, pulp and paper, as well as biomass for energy.

Solid wood products and wood-based panels.

Global consumption of solid wood and wood panels is estimated to grow 2.3–2.8 percent annually until 2030 (Buongiorno and Zhu 2019). Domestic demand for solid wood products and panels is expected to increase as the population expands. The thousands of carpentry shops and sawmills in the country suggest that Paraguay already has considerable expertise and capacity in processing and woodworking. However, most of the workshops and mills have outdated machinery and low recovery rates (50 percent), diminishing the country's ability to compete in international markets. By developing an industrialization and value forest addition strategy, and modernizing its wood-processing industries,[60] Paraguay could boost its international market share.

Pulp and paper.

Global pulp and paper manufacturing was valued at $63 billion in 2019 (WWF 2020) and global consumption is forecast to grow by 1.9–2.3 percent annually until 2030 (Buongiorno and Zhu 2019). Until recently, investments in pulp and paper in Paraguay have been underdeveloped as a result of a conundrum of insufficient plantations being dedicated to pulpwood and the absence of domestic buyers. With the entry of new market players such as Paracel,[61] Paraguay can consider how to facilitate more strategic investment such as this and maximize the benefits of this subsector.

Biomass for energy.

Given the importance of forest biomass (notably firewood) for Paraguay's energy security and its contribution to deforestation and forest degradation, there is an urgent need to develop domestic supply of sustainable biomass. Many neighboring countries have moved away from energy markets dependent on fuelwood from native forests toward those relying on plantations (Ceccon and Miranda 2012). Shortages of native wood are emerging along the corridor between Asunción and Ciudad del Este, where industry and household demand are greatest. Policy signals, such as the Zero Deforestation Law and Resolution 933/2020 of the Ministry of Public Works and Communications,[62] are also pushing the market in this direction. Yet meeting domestic biomass needs sustainably represents

60. To produce fine-wood products, larger diameter saw timber needs to be grown and plantation species diversified to include high-value hardwoods such as teak (*Tectona grandis*), Chinaberry (*Melia azedarach*), and Chinese cedar (*Toona sinensis*).

61. Paracel is in the planning stages for a $3 billion pulp mill with a capacity of 1.5 million tons annually. An estimated 140,000 ha of new FSC-certified eucalypt plantations will be required to supply the mill.

62. Resolution 933/2020, *"Que establece los regímenes de certificación, control y promoción del uso de bioenergías provenientes de plantaciones forestales o bosques nativos manejados, para asegurar la sustentabilidad de estos recursos renovables dentro del territorio nacional."*

a challenge while fuelwood from native forests[63] remains at nearly zero cost; the market would need to stem the flow from illegal sources and boost sustainable production (through plantations, mixed silvopastoral or silviagricultural models). In addition, export opportunities could be explored. Meeting more of Paraguay's fuelwood demand through plantations would have the added benefit of formalizing the sector, with attendant benefits for job creation and quality, tax revenues, and more. Fully meeting the 9 million m3 supply gap for sustainable fuelwood through plantations instead of native forests would increase the annual GVA by $154 million, or 0.5 percent.[64]

Commercial forestry models in Paraguay are proving to be financially viable.

A survey conducted by the government, the World Bank, and FAO in 2020 identified seven reference plantations models (**Table 7**),[65] five of which show returns comparable to those from agriculture and livestock in the northern, central, and southern regions.[66] One of the key findings of the survey is that the most profitable models combine both biomass and higher-value solid wood, offering internal rates of return of 10–14 percent over their lifetime. There are attractive opportunities to explore in silvopastoral models and those that combine plantations with other products such as yerba mate. The latter provides a model that can be applied in Western Paraguay, where access to markets for wood products is limited. When compared to returns from other competing land uses, plantation forestry can offer returns on par with small, medium, and family-run agriculture, notably in the central and southern regions. While returns from intensive mechanized agriculture are difficult to match, those from extensive cattle grazing can be exceeded, even more so where soils are degraded.

63. Benchmark price of fuelwood is estimated at $13/m^3 (field research).

64. The underlying estimate applies a break-even price of $14/m^3 for biomass. The average price for biomass determined during field research is $11/m^3 for standing timber, in part because of competition from illegal wood sourced from native forests.

65. The analysis surveyed 19 plantations across Paraguay and identified seven reference models: (i) for eucalyptus, one low-density saw timber model, one high-density saw timber model, one saw timber silvopastoral model, and one biomass model with regrowth; (ii) two additional models for other species: an agroforestry model with planted native species and yerba mate, and one silvopastoral model with algarrobo (*Ceratonia siliqua*) in the Chaco region.

66. The NPV of agriculture and livestock activity of various farm sizes (family, medium size, commercial, and industrial) is around $4,800/ha in southeastern Paraguay, $2,600/ha in northern Paraguay, $1,600/ha in central Paraguay and $400–$900/ha in southern Paraguay; as well as $400–$1,500/ha in the Chaco.

TABLE 7

Indicative financial returns for select plantation models

Model	Total costs (yrs 0–3) (US$/ha)	Income (US$/ha)	Internal rate of return (%)	Net present value (US$/ha)
Eucalyptus – saw wood model (intensive)	1,984	7,217	12	745
Eucalyptus – saw wood model (less Intensive)	1,904	9,156	14	1,186
Eucalyptus – biomass model (with regrowth)	1,988	5,025	4	-578
Silvopastoral model (Eucalyptus - saw wood & livestock breeding)	2,173	9,005	12	873
Pine model - saw wood	1,494	9,908	8	-77
Silvopastoral model (Algarrobo – saw wood & livestock for fattening)	639	5,044	10	180
Agroforestry model (Native species – saw wood & yerba mate)	4,427	10,050	12	2,012

Note: Model uses assumptions and data collected during interviews with producers. Projections do not include any concessionary finance or assistance to producers. The average price of biomass used in the model is $11/m^3 (or $19/t); average prices of saw wood used are $30–$33/t for eucalyptus; $31/t for pine; $34/t for algarrobo; and $59/t for the yerba mate model involving native species. Appendix B provides the detailed methodology.

SYNTHESIS

Seizing the potential of forests for Paraguay's development

1. Forests—both native and planted—can make economic sense to private landowners in Paraguay. When compared to average returns from agricultural and livestock, plantation forestry can offer comparable rates of return of 10–14 percent over its lifetime, suggesting there are attractive commercial opportunities to explore in commercial forestry, including silvopastoral models. As earlier chapters suggest, native forests also represent tangible value, embedded in the vital ecosystem services they generate.
2. Two approaches can help pave the way for a dynamic and sustainable forest sector in Paraguay: (i) a shift toward integrated landscape management that promotes forest-friendly agriculture, and (ii) sustainable development of forest plantations.
3. The rationale for a shift to forest-friendly agricultural practices is twofold: (i) risk mitigation: agricultural commodities are coming under growing scrutiny globally over their environmental impact from consumers and investors, representing a shift toward greater transparency and, ultimately, sustainable sourcing standards in global markets; agricultural production also relies on ecosystem services that are being degraded; and (ii) opportunity: the transition to sustainable practices can unlock access to markets.
4. Paraguay has yet to seize opportunities in sustainable commodity markets. The domestic beef industry is focusing on volumes and price, and underinvesting in traceability systems. Only 1 percent of the total soy cultivation area in Paraguay is RTRS certified.
5. Paraguay can leverage the growing domestic and international wood markets; opportunities span solid wood products and wood-based panels, pulp and paper, and biomass for energy; expansion of production forestry and promotion of local value chains can help formalize the domestic wood product markets and create value addition.

5

Recommendations for a more sustainable and inclusive forest sector that contributes to Paraguay's development

The key takeaway from the analysis is that Paraguay's forest sector has potential, but it is hindered by underlying policy, enforcement, and governance weaknesses.

This chapter outlines a potential reform and investment agenda, identifying priority actions that could help Paraguay maximize the economic and ecological values of its forestry sector in a way that supports the country's development, with a focus on the two opportunities identified in the previous chapter: (i) a transition toward integrated landscape management that promotes forest-friendly agricultural practices, and (ii) the sustainable development of forest plantations. Achieving this entails the adoption of territorial planning; a comprehensive legal reform agenda; measures to strengthen enforcement; a revision of the economic, fiscal, and financial incentives at play in the forest and related sectors; and the development of strategies to scale plantation forestry and increase domestic value addition. Progress will require long-term commitment from the government and engagement of stakeholders and partners.

A summary of the recommendations can be found in **Table ES.1**.

5.1. Governance and policy reform to stem the decline of native forests

5.1.1. Planning and integrated landscape management

Adoption of integrated landscape management is a key step to mainstream the value of native forests into territorial planning.

Defined broadly as a "long-term collaboration among different groups of land managers and stakeholders to achieve the multiple objectives required from the landscape" (EcoAgriculture Partners 2013) **(Box 6)**, integrated landscape management would enable Paraguay's policy makers to effectively manage the trade-offs and potential synergies between competing land uses in forest zones. This means assessing the ecological and productive value of forests and designing a land use plan that maximizes the economic value of different land uses in the landscape, whether agriculture, livestock, forest production, conservation, or others, including mining, infrastructure, and urban land uses.

Integrated landscape management considers variables such as land capability, infrastructure and access, development costs, and ecosystem services.

To be effective, planning needs to be supported by (i) high-quality data, often from remote sensing, and a modern rural cadaster that includes forest data; (ii) standards and criteria to support decision-making, often in the form of "Codes of Practice" or similar guidance and reference materials; (iii) opportunities for stakeholder input and participation; and (iv) mechanisms for enforcement **(see Section 5.1.3)**. While integrated landscape management would yield medium- and long-term benefits, in the shorter term it could also help manage land use change in a more coordinated way as well as guide requirements for reforestation resulting from requirements to comply with the Forest Law's provision for addressing the forest deficit.

BOX 6

Key principles of integrated landscape management

Integrated landscape management is "the long-term collaboration among different groups of land managers and stakeholders to achieve the multiple objectives required from the landscape. These typically include agricultural production, provision of ecosystem services (such as water flow regulation and quality, pollination, climate change mitigation and adaptation, and cultural values); protection of biodiversity, landscape beauty, identity and recreation value, as well as local livelihoods, human health and well-being. Stakeholders seek to solve shared problems or capitalize on new opportunities that reduce trade-offs and strengthen synergies among different landscape objectives. Because landscapes are coupled socio-ecological systems, complexity and change are inherent properties that require management" (definition proposed by the Landscapes for People, Food, and Nature Initiative; EcoAgriculture Partners 2013).

To address data gaps, forest-relevant ecosystem and natural capital accounts need to be developed and native forests of high ecological value identified at the landscape level.

Paraguay should consider adopting comprehensive natural capital accounting that incorporates timber at the national and subnational levels. Building on this, the country can develop ecosystem accounts to measure the economic value of services such as pollination, watershed protection, soil erosion control, and protection of assets from extreme weather, which are a key tool for informed policy making. The remaining native forests of high biodiversity and ecosystem services need to be identified and strategies to preserve them, including connecting ecological corridors, developed. Since data gaps reinforce silos between economic sectors, making data on forest resources and their ecosystem services publicly available is key to quantifying the true trade-offs between converting or maintaining forest cover at the landscape and, ultimately, property level. It can also inform decisions over environmental licenses and land use change permits issued by MADES and INFONA and inform the design of restoration projects and nature-based solutions that are overlooked.[67] Finally, this information is useful for ex ante analysis of policy reform in various sectors, including the design of more effective fiscal policy that creates incentives for sustainable land use and forest management practices.

67. IUCN (2020) defines nature-based solutions as "actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."

5.1.2. Legal and regulatory reform

A priority area for legal reform is the revision of the regulating provisions of Law 422/73, the Forest Law.

A revision of Decree 175/18—the key implementing provisions of Law 422/73—is required to resolve ambiguities in the definition of the forest deficit and exceptions to the obligation to maintain the legal forest reserve, as well as in the time frames and steps to be taken by landowners to restore the forest deficit. This is a key step to strengthen enforcement of the Forest Law and clarify the ambiguities between the legal forest reserve and requirements to maintain riparian forests *(bosques protectores de cauces hídricos)* protected under Law 4241/10. It is also important to articulate environmental criteria more effectively in the implementing provisions of the Forest Law. To strengthen the effectiveness of the protected area network, it is further necessary to review the protected areas regulations and update the definition of corridors to the current reality where corridors cross private and agricultural lands (SEAM Resolution 562/17).

Key economic instruments would also benefit from revision to allow private landowners to monetize the value of their native forests, incentivize restoration of deforested areas, and unlock better access to finance, including the following:

- **Law 3001/06** on the Environmental Services Regime. This law contains obsolete provisions such as those relating to the Environmental Service Securities (see recommendations below).
- **Law 536/95** on Promotion of Afforestation and Reforestation. This law has become obsolete because of a lack of public funding for the forest fund it established; it may be updated and complemented with alternative mechanisms for mobilizing resources to finance restoration and plantations, such as earmarked green taxes or market-based mechanisms.
- **Law 4890/2014** on Forest Cover Property Rights. This law could be revised to clarify the status of planted forest cover in the property rights regime and the eligibility of forests to be recognized as collateral by financial institutions; the reform could also consider the possibility of including native forests in the instrument.

5.1.3. Enforcement

The design of a coherent enforcement program in the forest sector consists of effective applications of measures in prevention, detection, suppression, and, as needed, recovery.

While a more comprehensive analysis using, for example, the Wildlife and Forest Crime Analytic Toolkit (UNODC 2012), would be advisable, this section sets out some preliminary recommendations, summarized below and in **Figure 8**. Achieving these requires institutional capacity building and modern technologies. Preconditions for effective enforcement are (i) a clear regulatory framework, resource management plan, and baseline to determine what is legally compliant and what isn't, as well as (ii) accurate, up-to-date, and publicly accessible digital forest data (on the forest cover, forest deficits, and permitting and licensing), to promote transparency and participation of the general public and civil society in enforcement and minimize the risks of corruption. The benefits of such data also exceed enforcement. It is a crucial step for Paraguay's value chains and their investors to adequately assess and disclose environmental risks in their balance sheets and financial portfolios.

Prevention

Effective prevention ultimately relies on sound governance and public sector effectiveness in the forest sector, and this encompasses enabling laws and incentive structures.

As mentioned earlier, legal ambiguities and loopholes (particularly in the implementing regulations of the Forest Law) as well as low penalties, make the task for enforcement agencies more difficult and create a sense of impunity for forest Law violations in Paraguay; they need to be addressed to strengthen enforcement.

Forest certification can provide a complement to Forest Law enforcement, acting as an independent instrument to safeguard the contribution of forest production to sustainable development.

With the domestic market flooded with illegally and unsustainably sourced biomass and timber, transparency over the origin of the forest products is key. Certification is already required by regulations for biomass used for energy production in Paraguay (Decrees 4056/2015 and MOPC Regulation 933/2020). However, the process is incipient and does not cover forest production outside of that subsector. In addition, there currently is no cross-cutting national forest certification standard, whether for forest management or chain of custody. Such a standard could be viewed as more

FIGURE 8
Summary of measures to strengthen enforcement in the forest sector

Source: Adapted from World Bank (2008).

independent, especially if recognized by a reputable standard setting body such as the Forest Stewardship Council or the Programme for the Endorsement of Forest Certification. Developing a national standard would require the involvement of producers, civil society, and the government to jointly adapt such general international norms to the Paraguayan context.

Certification can also be used to improve the competitiveness of Paraguay's forest value chains.

By guaranteeing compliance with the law and internationally accepted forest management standards, certification can open access to higher-value consumption markets that increasingly demand certification. These have traditionally included Western Europe, Japan, and North America, but increasingly emerging economies such as Brazil, China, India, and Russia serve as destinations for certified timber for processing and subsequent re-export to final high price markets (World Bank 2008). Certification also helps ensure that production forests, including exotic species plantations, provide environmental services while supporting local livelihoods.

Producer support is needed for wider adoption of certification.

To foster the uptake of certification among producers, government agencies promoting commercial forestry, notably INFONA, could develop best-practice management guidance, offer training on sustainable practices to forestry producers

through an extension service, and establish programs that assist small or disadvantaged producers who might otherwise not be able to obtain third-party certification because of knowledge or insufficient resources to finance the up-front investment costs associated with such certification. This would help ensure inclusive development of the sector. Another priority area for support is promotion of access to domestic and international markets for sustainable wood products.

To fully reap the benefits of forest certification, a timber traceability system is required.

Exposing illegally sourced biomass and timber is a key step to leveling the playing field for sustainable forestry practices, at least for products destined for export. Timber traceability systems provide an ability to provide chain-of-custody certification by capturing information on the journey of wood from the forest to consumers, including storage and transport. They verify that raw materials stem from sources that are legal and responsible, providing a necessary complement to forest management certification.

Detection

Forest monitoring and presence of environmental agencies in the field are key hurdles for effective detection of illegal deforestation.

Priority actions to address this challenge include the adoption of satellite monitoring tools to monitor land and forest cover changes using remote sensing data and detect infractions in an automated and near-real-time manner, and the establishment of a rural cadaster with a centralized clearinghouse of land use information (akin to the cadaster system implemented in Brazil).

The recent decision to establish the National Forest Monitoring System and ongoing collaboration with Global Forest Watch will facilitate real-time data collection and analysis.

This can help overcome limited field-level capacity, as INFONA's staff are not a position to conduct field monitoring given the land area they need to cover. This can substantially improve efficiency but requires building the capacity of INFONA and installing modern information and communications systems, including in the regional offices. It may also mean developing specialized forest monitoring tools for drier forests, where traditional monitoring tools may not be effective. With the growing threat of forest wildfires because of climate change, such systems also need to support forest fire detection and control efforts. Digital and publicly available mapping and demarcation of forest zones and forest deficits, as well as information on forest permits, licenses, and administrative proceedings for violations of forest laws, are also needed and can be generated through the National Forest Monitoring System. A spatial registry of forest plantations can inform land use planning, in particular for plantations, to reduce threats from pests and forest fires. The information generated should be up-to-date and publicly accessible so that associated government agencies (for example, the Ministry of Agriculture and Livestock, the National Service of Quality and Animal Health, the Ministry of Environment and Sustainable Development), civil society, and researchers could utilize it.

Suppression

Strengthening the government's response capacity should focus on ensuring cooperation between and functional capacity within government institutions tasked with responding to illegality.

It is also important to clarify the roles, mandates, and responsibilities of all government agencies responsible for forest management and prosecuting environmental crimes in the Western and Eastern Regions, including both regional and district-level agencies (such as municipalities and the police). One key ingredient for this is a fluid exchange of information on forest license and permit violations with the judiciary system, the fiscal authorities (Ministerio de Hacienda), and the

National Directorate of Customs. Given the magnitude and systematic nature of forest law violations, the burden of suppression cannot be borne by environmental agencies alone. Effective enforcement requires political leadership and allocation of appropriate resources, budgets, planning, and reporting provisions to all relevant institutions. Another avenue is to support the ratification and implementation of the Escazú Agreement,[68] and to integrate in the National Forest Monitoring System a function so the general public can lodge reports of forest permit violations and crimes for follow-up by the authorities.

Given the complexity of the law and the introduction of new data, law enforcement agents and judiciary personnel may benefit from training.

This includes training on procedures and protocols, or on how to assess environmental damage. Enforcement staff in the field may also need basic or advanced forensic science capabilities to collect and analyze evidence, personal safety equipment for officers and staff, communications, transportation means, navigation and survey equipment, and other resources. A broader issue to overcome are the limited budgets of the ministries and institutions in charge of protecting forests and the environment.

68. The Regional Agreement on Access to Information, Public Participation and Justice in Environmental Matters in Latin America and the Caribbean (Escazú Agreement) was adopted on March 4, 2018, in Escazú, Costa Rica; it "seeks to ensure that all people have access to timely and reliable information, and are able to access justice regarding environmental matters" (CEPAL 2020).

Effective enforcement also requires anti-corruption strategies in the agencies involved.

Measures to control corruption can be introduced gradually, beginning with specifying human resource policies and standards emphasizing recruitment and hiring of a workforce fully informed of expectations of noncorrupt conduct, regular training, incorporation of anti-corruption provisions into procedures for applications to government agencies, and other low-cost but visible innovations. In addition, digitizing key administrative processes can facilitate transparency and accountability as well as boost efficiency and effectiveness.

Recovery

To address damages from illegal deforestation, an effective regime is needed to ensure recovery of the damaged environment.

Decisive policy action is needed with respect to management of illegally deforested lands, considering, among other things, restoration of natural cover through natural regeneration, planting or other silvicultural treatment, or offsetting (for example, through the Environmental Services Regime). Given the scale of the current forest deficit in Paraguay, it is crucial to formulate these policies in ways that place the burden on the perpetrator, are predictable and not easily subjected to political influence or corruption, and serve as a sufficient deterrent to illegal deforestation in the first place. Monitoring of the implementation of recovery conditions could be supported by the National Forest Monitoring System.

Where deforestation is driven by demand for illegal forest products, effective domestic and customs controls are required.

The control function could be supported by a timber traceability system (see above), which would also support the implementation of the lifting of the ban on export of timber logs and beams from exotic species (Law 515/94). To ensure this policy reform does not have perverse effects on natural forests and to avoid the loosening of the timber export regime resulting in leakage from the natural forest stock, customs control will need to be strengthened. This includes measures such as in situ controls of export-bound containers, requirement for containers to be sealed at the point of loading, and verification of their weight at the point of loading and export.

Effective recovery also requires that proceeds from illegal deforestation and assets involved can be seized.

This includes timber products, wildlife, equipment, and monetary and other proceeds. It is further necessary to ensure that there are appropriate rules for handling them. Furthermore, the legal regime should be evaluated for its ability to include environmental crimes as predicate offenses for other crimes, such as money laundering.

5.1.4. Economic incentives

A comprehensive analysis of the relative incentives in the agriculture, livestock, and forest sectors is needed to understand the cross-sector conditions the government is setting to guide land use decisions.

Such a cross-sectoral assessment of the economic incentives and distortions that affect the financial and economic returns to each land use and thus determine land use decisions would allow for the alignment of economic policy in sectors competing for land. The exercise would involve reviewing incentives such as explicit subsidies and implicit subsidies, such as differing value added tax rates between the agriculture and forest sectors, or property taxes. For example, regional and global experiences, such as from Uruguay, show that preferential property tax programs for forests can serve as effective tools to incentivize ecosystem services of forests (including provision of timber and other materials) while leading to only a modest reduction in government revenues (World Bank 2008).

Sustainable forest management ultimately has to make economic sense for property owners, and economic incentives are essential for achieving this.

The underlying principle is that landowners and communities should reap the benefits of managing their land in such a way that desired ecosystem goods or services are maintained, while payments should, where possible, be made by those who benefit from the provision of these ecosystem services (Kilgore et al. 2017). This allows private landowners to monetize forest assets and reduce the long-standing bias against forests as unproductive land use, thus aligning private land use decisions with societal goals.

Paraguay's Environmental Services Regime can serve as an effective mechanism to reward landowners for preserving native forests, but several interventions are needed to improve the regime's simplicity, certainty, and fairness.

The regime would greatly benefit from a simplification and consolidation of the rules and procedures and the elimination of ambiguities in the underlying legal and regulatory framework—notably Article 42 of Forest Law 422/73 and its implementing provisions. There are opportunities to improve the design of the overall mechanism, operationalize the Environmental Services Securities, and adjust the taxation of high environmental impact activities, as well as clarify the role of the *"Fondo Ambiental."* The ESR and the obligations for private landowners to maintain the legal forest reserve must be perceived as fair and feasible for the mechanism to have an impact. Potential actions to achieve that include the following:

a. Issue an official map of the forest zone and deficits, as well as zones with high ecological value.

b. Update the nominal values for Environmental Service Certificates and eliminate ambiguities over their payment frequency; introduce qualitative metrics that also capture the quality of the forest preserved and the value of ecosystem services it provides—such as a biodiversity index or carbon sequestration.

c. Streamline requirements and simplify procedures, and, if possible, reduce transaction costs and levies for landowners looking to certify natural forest under the regime.

d. Assess the viability and market potential of the Environmental Services Securities instrument, including opportunities to tap into international voluntary markets for environmental offsets, without fiscal implications for the Paraguayan state.

e. Differentiate rates for high environmental impact activities that result in forest cover loss or affect the provision of environmental services (>1 percent of investment value), from those that do not have a direct impact (<1 percent of investment value).

f. Differentiate ESCs offered by national parks from those offered by private owners and communities so the former do not compete with the latter, either by withdrawing their eligibility or

ensuring they do not compete in the same market or on similar terms as certificates obtained by private landowners.

g. Develop a common vison for sustainable use and conservation of forests and associated environmental services under the ESR through a participatory process.

h. Integrate the ESR into the national REDD+ strategy and its operational instruments, such as monitoring, reporting, and verification and enforcement instruments.

Paraguay's recent joining of the Coalition of Finance Ministers for Climate Action and its subscription of the Helsinki Principles further opens up opportunities for reviewing and expanding the country's application of carbon pricing.

Including the land use sector in such a policy initiative would further the goal of pricing land use according to its impact on the climate and on ecosystems more broadly. Revenues thus collected by the government could be recycled to boost economic productivity, compensate households, and further environmental goals.

5.2. Development of the forest plantation sector

Successful scaling up of the forest plantation sector requires a plan.

Commercially viable tree plantations are a technically demanding pursuit, requiring expertise, planting stock with high-quality genetics suited to local conditions, well-managed nurseries accessible to planting sites, and technical excellence in the many activities that are required up to harvest. Private enterprise can deliver many of these and other necessary elements, but international experience suggests that rapid subsector development typically requires active public support. In broad terms, a well-structured government plan would identify suitable plantation locations and develop a complementary industrialization and value-addition strategy that combines analysis of available inputs to production, processing capacity, as well as potential markets, and the enabling environment for the market to get there—the legal, regulatory, financial, capacity constraints to be overcome.

Supportive public policies and programs that span both the demand and supply side of the sector can accelerate progress.

Priority areas to tackle on the supply side include clarifying land availability and suitability, access to plantation finance, and development and dissemination of improved technologies suited to Paraguayan conditions; and on the demand side, supporting access to international markets, incentives for expansion of local wood-based industry, development of market-related standards (such as log grading systems, forest practice codes, and more), and dissemination of information on prices and market trends.

Supply side

Identification of land availability and suitability.

In addition to the actions related to land use planning proposed above **(see Section 5.1.1)**, efforts to address land availability constraints relevant to plantation investors, including tax treatment of forested land and plantation investment, could facilitate increased plantation establishment. Including spatial plantation investment prospects into planning of roads and other infrastructure could also have qualitative impacts on land availability. Transport costs in the forestry sector are high and transporting wood for more than 100 km may not make financial sense in Paraguay. A territorial plan for plantation development that identifies appropriate locations of plantations, based on transport costs and distance to consumption centers, as well as export markets—for example, proximity to major navigable rivers—would be a key step for helping producers

overcome these barriers. In addition, grouping of small producers, who would otherwise have difficulties in negotiating attractive terms for transport, could help reduce transport costs for this segment.

Access to finance.

The long-term nature of forest plantation investments makes their profitability sensitive to the terms on which finance is available. Interest rates are obviously key, but the estimated rates of return available from a large number of plantation models **(see Table 7)** suggest that potential exists, under current financial market conditions, for significant expansion in the subsector. This potential can be strengthened by implementing additional de-risking measures, such as ensuring availability and use of best management practices; certifying quality germplasm inputs; technical assistance to ensure quality plantation management, including fostering a cadre of private service providers with certified knowledge; the ability to use the *vuelo forestal* as collateral; the availability of partial credit guarantees; and effective fire, pest, theft, and land encroachment control. Moreover, sector knowledge in financial institutions needs to be strengthened to improve their ability to assess risks and appraise and supervise investments in forestry. Additional steps would include developing a risk insurance product for forest plantations and ensuring the viability of avenues of recourse in the event of default (principally the ability of the lender to foreclose on collateral or other security). Many of these are public services and are unlikely to be adequately provided by private action.

Technology and knowledge.

The plantation practices now being applied on a growing but still relatively small area in Paraguay are largely based on international experience in reasonably similar environments and agro-ecologies. These include the range of species available for planting (now primarily exotics, and frequently *Eucalyptus spp.*), nursery practices, planting density and geometry, stand tending (thinning, weeding, and so on), site preparation, and various other practices. As the plantation area develops and the subsector matures and moves into different and more varied sites, conditions, and in pursuit of different objectives, these largely imported techniques will need to be modified and refined to be more closely adapted to Paraguayan circumstances. In addition, field data show that the costs for plantation models of saw timber and biomass for energy vary around $2,000/ha during the first three years, which is high by international standards (Cubbage et al. 2020). Factors that may be keeping these costs high include gaps in technical know-how and efficient plantation preparation and management practices, which could be closed through better research, the establishment and dissemination of best management practices, and public and/or private forest extension services. Paraguay currently lacks a forest research, development, and education system that can be expected to develop and deliver the needed results. Public investment will be needed to initiate the required research and development effort, but there are many models of public-private collaboration that could be relevant to Paraguay. Among the immediate priorities for research are documentation and assessment of native species relative to their potential for tree improvement breeding.

Establishment of best management practices:

Forest plantations, like many modern agricultural systems, carry risks, especially when using monocultures. At the same time, maximizing production requires technical knowledge and information adapted to the country context. To manage those risks and put Paraguay's plantation sector on a sustainable footing while promoting productivity, best management practices should be developed, disseminated, and, where possible, required of producers. These should contain guidance on planting, silviculture, pest and fire management, and harvesting on the productivity side, but they also should address ecosystem integrity (including the water, nutrient, and carbon cycles) as well as biodiversity management in an effort to avoid potential pitfalls in plantation growth.[69] The guidance should be particularly tailored to consider climate change, as the selection of silviculture practices today will need to take into account the climate of 2030–2050 at the least. The application of best management practices should be promoted and monitored by INFONA.

Demand side

Sequential phasing out of illegally sourced biomass.

Illegally harvested wood undercuts market prices, making it harder for investors to justify the costs and effort involved in sustainable forest management.

69. See New Generation Plantations (https://newgenerationplantations.org) for sample good practice materials.

This is especially true of illegal harvests based on outright theft on public or private timberland, where sellers (thieves) incur no "user cost" in the disposal of stolen goods.[70] Arguably this is not the case for timber illicitly generated from an owner's private land—for example, as part of land clearance without the required permits, in violation of forest retention requirements, or in contravention of various other possible legal requirements. In these cases, these illegal suppliers could be expected to incorporate the full value of their resource use into their decision-making.[71] This mixed composition of timber clouds the credibility of market prices and adds to the urgency of legislative reform and rationalizing enforcement. As reforms, including the requirement for biomass certification (Decree 4056/2015), are implemented, some interim forms of regulation or subsidy to encourage investment in sustainable plantation production may be justified. Generally, more targeted subsidies (direct payments, input rebates, and so on) would be preferable to less targeted ones (for example, subsidized lending).

At the same time, a coordinated effort is required with the energy, agriculture, and industrial sectors to explore and promote alternative technology options that would reduce demand for fuelwood in households, agricultural drying, and brick making.

Since improvements in the quality and reliability of the electric grid cannot happen overnight, industry and households will likely continue to rely on biomass, which is affordable and available even in remote areas. An integrated strategy for simultaneously curbing demand for forest biomass by improving energy efficiency while enabling investments in alternative energy sources is needed. One approach would be to evaluate the production of solid biomass fuels using industrial and forestry residues. These could serve as substitutes for firewood among industrial users of biomass, particularly if combined with investment in technologies for direct burning of sawdust and other residues. Investments in energy efficiency, particularly among industrial users, could be promoted by public financing programs. Opportunities to diversify energy supply with decentralized renewable energy solutions, such as solar photovoltaic energy (already included in ANDE's Master Plan for 2016–2025), should also be leveraged.

Strategic development of value chains.

Wood energy and pulp markets are natural and accessible targets for plantation production during early stages of subsector development. These product markets will be especially important while volumes are likely to be limited and issues of consistency of supply, infrastructure reliability, log quality (uniformity and form), and other problems of new enterprises are worked out. However, these commodity markets offer low returns relative to those for saw logs and sawn wood, or for finished and semi-finished wood products. Opportunities for Paraguayan plantation producers to supply these higher-value markets could emerge as plantations mature into production of larger and better-quality logs. Additionally, local processors could invest in facilities suited to handling smaller diameter material, production of engineered lumber products, finger jointed lumber, and more, as has been done in Brazil and Chile, for example. To guide such gradual movement up the chain of value addition, the government could adopt an industrial policy to systematically assess and resolve bottlenecks and foster the conditions for increasing local value addition.

Access to international markets.

Outside of the low-value charcoal sector, Paraguayan wood exports have until recently been limited by the export ban on roundwood, beams, and pieces. As a result, links to large international markets for forest products are relatively undeveloped in Paraguay. Yet low-cost river transport to Uruguayan deepwater ports offer opportunities for linking to international markets. Building a strategy for accessing international markets in collaboration with INFONA, REDIEX, and the private sector would be a first step in leveraging the new opportunities the lifting of the ban presents. In a second step, promoting Paraguayan wood products in competitive international markets will become important. This would be aided by the adoption of forest certification (see above) to build a sustainable forestry brand for Paraguay and aid access to sensitive markets.

70. "User cost" refers to the opportunity cost involved in the one-time sale of a natural resource asset.

71. The full value could be negative for timber generated in the process of land clearing.

Conclusion

The dramatic decline of Paraguay's forests in recent decades has brought the country to a crossroads.

Forests contribute to Paraguay's economy by providing vital ecosystem services, supporting jobs and livelihoods for rural and indigenous communities, and contributing to energy security. Yet standing forests continue to be perceived as an opportunity cost by private landowners since many ecosystem services that forests provide are public goods that are not captured by markets. Forests are embedded in productive, predominantly agricultural landscapes and have a long history of succumbing to pressures from competing land uses—notably, crops, livestock, and demand for biomass for energy production that is currently met primarily with biomass from native forests. Deforestation carries a significant economic cost—under current trends it is estimated at $628 million, or 1.6 percent of GDP in 2017. While the forest plantation sector could reduce pressure on native forests, it is significantly underperforming relative to its potential, which represents a missed opportunity.

Forest management happens at the nexus of multiple sectors and government agencies, making coordinated planning and policy challenging.

Forest governance faces significant challenges—gaps in the legal framework, weak enforcement, low levels of transparency, and lack of systematic land planning that incorporates the value of forests. The forest sector is supported by weak fiscal, financial, and regulatory incentives. The promising Environmental Services Regime mechanism could help correct the market failure; however, its implementation has been limited, and the private market for environmental offers is practically nonexistent. Access to finance in the sector also remains limited, and regulatory incentive gaps, such as the lack of traceability systems and recognized best management practices, remain.

A transition toward a dynamic and sustainable forest sector in Paraguay makes economic sense, and two opportunities can pave the way: a shift toward integrated landscape management that promotes forest-friendly agriculture and the sustainable development of forest plantations.

The rationale behind a shift to forest-friendly agricultural practices is twofold: (i) risk mitigation—agricultural commodities are coming under growing scrutiny globally over their environmental impact from consumers and investors, representing a shift toward greater transparency and, ultimately, sustainable sourcing standards in the global markets; and (ii) opportunities—the transition to sustainable practices can unlock opportunities, such as access to markets. In turn, the development of a sustainable forest plantation sector can unlock opportunities in the growing domestic and international solid and wood-based panels, pulp and paper, and biomass markets.

A potential reform and investment agenda that focuses on the shift toward forest-friendly agricultural practices and the sustainable development of forest plantations includes

a comprehensive legal reform agenda; measures to strengthen enforcement; a revision of the economic, fiscal, and financial incentives at play in the forest and related sectors; a comprehensive strategy to develop plantation forestry; and the gradual development of domestic value addition. Progress will require long-term commitment from the government and engagement of stakeholders and partners across different sectors.

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Appendix

Appendix A. Economic analysis

General approach

The purpose of this analysis is to estimate the economic value of conserving native forests in Paraguay and the cost of deforestation at the national and subnational levels (Eastern and Western Regions). Conventionally, the cost of deforestation is treated as nil. Forest-related ecosystem services tend to be public goods and are free or virtually so, accessible, and open to all. Externalities, information asymmetries, and public goods are some of the market failures that misalign the private and social costs of deforestation and create the need for an artificial valuation.

The economic analysis in this Country Forest Note builds on international experience in estimating the cost of deforestation and utilizes estimates, for some parameters, drawn from work related to neighboring countries. The valuation method uses a holistic approach to forest valuation, linking the scale of deforestation and the value of forests based on different deforestation scenarios. In other words, it considers the increasing marginal cost of deforestation. The analysis involves a four-step process: (i) a literature review to estimate the value of ecosystem services forests in Paraguay; (ii) computation of the cost of deforestation with a non-risk-adjusted total value of forests per hectare by region;[72] (iii) computation of the cost of deforestation with a risk-adjusted total value of forests per hectare by region; and (iv) a sensitivity analysis. The parameters of the model are described in **Box A.2**.

Quantification of ecosystem service values

The total value of a hectare of forest in each region is estimated as the net present value (NPV) of the annual sum of values of the ecosystem services it generates, over a time horizon of 15 years, at a 6 percent discount rate. The analysis uses estimates of value of select provisioning, regulating, and cultural ecosystem services that are relevant in Paraguay's context,[73] drawn from literature as described below and in **Table A.1**. Since only select ecosystem services are considered, the valuation is conservative.

72. The non-risk adjusted value is the net present value of the total value of lost ecosystem services per hectare in each region without taking into account a positive feedback between the share of agricultural land and losses of ecosystem services.

73. The analysis focuses on three categories of ecosystem services that generate direct, measurable benefits: *provisioning*, *regulating*, and *cultural services*. A fourth category, the *supporting* ecosystem services (that is, the underlying ecosystem functions and biophysical processes that enable the other three types of ecosystem services), is of less relevance in the context of forest valuation and is not included in the present analysis.

Sustainable timber harvest

Harvesting timber at a low rate can be a sustainable use of forest resources in Paraguay if regeneration and the long-term well-being of the forest are considered. Pirelli and Rossi (2018) assessed the potential sustainable flow of a limited timber harvest from natural forests in the Eastern Region and Western Region at 2–3 cubic meters per hectare per year (m3/ha/yr) and 0.5–2 m3/ha/yr, respectively. The same source reported the state of timber and firewood sustainably produced per hectare in both regions. Borsy et al. (2016) reported prices for wood chips at $100 per ton (t) in 2011 and for fuelwood at $20/t in 2013. After adjusting the economic value of sustainable timber harvest to 2016 with the gross domestic product (GDP) deflator (World Bank 2020c) and allocating 50 percent of the market value to cover production cost, sustainable timber and fuelwood production value per hectare is estimated at $107 in the Eastern Region and $36 in the Western Region.

Bushmeat harvest

Hunting for wild meat is one of the most important economic activities for some indigenous groups and is practiced by *campesinos* and large landowners. Since bushmeat is not traded on markets, beef was used as a proxy for the value of bushmeat. Bushmeat constitutes a reasonable substitute to meet protein requirements for humans. The estimated amount of bushmeat (in kilograms) that can be hunted

sustainably is multiplied by the local market price of a kilogram of beef. Hunting can be an important tradition, especially for indigenous groups, and can be of economic value over and beyond this estimation. After adjusting the value of the 2016 bushmeat harvest (Naidoo and Ricketts 2006) with the GDP deflator, bushmeat was valued at $24/ha for Eastern Paraguay and $8/ha for Western Paraguay (30 percent of the estimate for Eastern Paraguay).

Climate and carbon

Carbon captured and stored in forests is included as an annual equivalent of the value of carbon stock released at the time of deforestation. A conservative estimate of $5 per ton of carbon dioxide equivalent (tCO_2e) is applied in this report. The average carbon stock in Eastern Paraguay is estimated at 115 tC/ha (Labbate et al. 2016). The total value of the carbon stock in Eastern Paraguay is estimated at $2,100/ha or $165/ha as an annual equivalent of the total value, assuming a 25-year rotation and a 6 percent discount rate. The average carbon stock in the Chaco Forest is estimated at 33 tC/ha (Labbate et al. 2016). The total value of the carbon stock in the Chaco is estimated at $605/ha or $43/ha as an annual equivalent of the total value, assuming a 25-year rotation and a 6 percent discount rate.

TABLE A.1.
Estimated monetary values of key ecosystem services used in the analysis

Ecosystem service	Eastern Paraguay (US$/ha/yr)	Western Paraguay (US$/ha/yr)	Relevant literature[a]
Sustainable timber and fuelwood provision	107	36	Pirelli and Rossi (2018); Borsy et al. (2016)
Bushmeat harvest	24	8	Naidoo and Ricketts (2006)
Carbon sequestration and storage	165	43	Labbate et al. (2016)
Watershed protection	73	27	Brancalion et al. (2012); Siikamäki, Santiago-Ávila, and Vail (2015)
Soil erosion protection	150	25	PNC ONU-REDD+ Py et al. (2016); Guerrero et al. (2013)
Other (biodiversity conservation, recreation, cultural)	7	7	Siikamäki, Santiago-Ávila, and Vail (2015)

Source: Original calculations based on the named literature.
a. All values drawn from literature for this analysis were adjusted with the GDP deflator (World Bank 2020c).

Watershed protection

This ecosystem service is particularly important for Paraguay because of the country's economic dependence on the Paraná (for hydropower generation) and Paraguay (for transportation of agribusiness goods) Rivers. This report uses a range of values: (i) in Western Paraguay, the value of $27/ha estimated by Siikamäki, Santiago-Ávila, and Vail (2015) for watershed protection in the Chaco; and (ii) in Eastern Paraguay, $73/ha, which is the average between the lower value applied for the Chaco and $118/ha that was proposed by Brancalion et al. (2012) for a payments for ecosystem services (PES) scheme in Brazil.

Established by Brazilian law, watershed committees charge for water use within a watershed and return a part of the fee through a PES mechanism to landowners who implement forest restoration projects. In southeastern Brazil, the municipal government pays about $118/ha/yr to more than 100 landowners who have substituted forest restoration plantings for cattle ranching in low-productivity pastures on riverbanks and around natural springs. The PES program in Brazil covers all the costs of forest restoration and compensates farmers for the opportunity cost of not converting the land use to pasture. The electricity generated by the Itaipu hydroelectric plant in Paraguay utilizes a reservoir on the Paraná River (Eastern Paraguay) located between Paraguay and Brazil. If the Brazilian PES scheme is applied in Paraguay, $118/ha/yr would be the upper bound of water protection services produced by the Atlantic Forest. This is lower than the estimate produced for San Rafael (Atlantic Forest Corridor) of $170/ha/yr for

environmental payments upstream to increase watershed protection downstream.[74]

Soil erosion protection

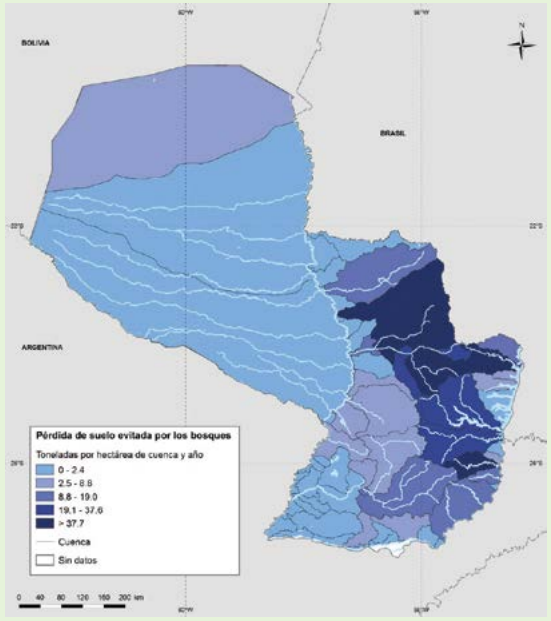
Forests help retain soil. This is particularly important for downstream impacts of vegetation in forests that protects soils from nutrients loss. PNC ONU REDD+ Py et al. (2016) calculated the soil loss per hectare of the basin using the WaterWorld model. **Figure A.1** shows the average soil loss by the subwatershed, reflecting the importance of forests for control of soil loss as a result of water erosion.

In the Eastern Region, the soil loss is valued at $4.48/t, as estimated by Guerrero et al. (2013). The value of forests in soil erosion protection is estimated as a product from the weighted annual soil loss by the unit value. This benefit is concentrated mainly in the Eastern Region (average value of $150/ha), where rainfall and topography can increase the risk of soil erosion. In the Western Region, the value of soil erosion control is estimated at $25/ha. This value is estimated in the same way as in Eastern Paraguay.

Other forest values

Estimates of the value of other direct uses of forests (such as recreation), the option value (such as bioprospecting when forest can potentially serve as a provider of new medicines), and the existence value associated with preservation (nonuse) of forests differ in the literature. Many studies use contingent valuation methods, especially in high-income countries, where there seems to be higher willing to pay for the costs of preserving natural ecosystems for enjoyment and conservation of biodiversity for future generations. This report uses a conservative estimate of $7/ha (Siikamäki, Santiago-Ávila, and Vail 2015) for biodiversity preservation, recreation, and cultural services of forests. Other reports use higher estimates, including Grossman (2015), which estimated $30/ha for similar services in the Atlantic region.

FIGURE A.1
Annual soil loss watershed (t/ha)



Source: PNC ONU REDD+ Py et al. 2016.

Estimation of the value of forests and the cost of deforestation in Paraguay

The total value of 1 ha of forest in each region is estimated as the NPV of the annual sum ecosystem services it generates over a time horizon of 15 years, at a 6 percent discount rate, under different deforestation scenarios. The cost of deforestation depends on the total value of 1 ha of forest and the number of hectares converted into other land uses every year. The deforestation model combines uncertainty analysis, utilizing the Monte Carlo method, with the scenario approach that allowed for consideration of different deforestation rates. Uncertainty analysis is applied to estimate the effect of large-scale irreversible losses of the forests.

Deforestation scenarios

Six different policy scenarios were applied for Eastern and Western Paraguay. These scenarios are based on (i) historic deforestation trends, with the business-as-usual (BAU) scenario reflecting a 20-year average; and (ii) potential pathways for forest utilization moving forward, with low and high deforestation rates.

- **Eastern Paraguay**: The average annual deforestation rate is about 40,000 ha; however, deforestation spiked drastically in some years, such as 2017. The following scenarios were used:
  - **i.** 30,000 ha of annual deforestation (BAU)
  - **ii.** 50,000 ha of annual deforestation (high conversion scenario)

74. This study was developed by Peter Hansen, who was hired by the World Land Trust and Guyra Paraguay for the feasibility studies of the REDD+ project.

iii. 10,000 ha of annual reforestation (low conversion scenario)

- **Western Paraguay**: The current range for annual deforestation is 200,000–300,000 ha; however, in early 2000s, the rate reached 500,000 ha. The following scenarios were used in this analysis:

  i. 250,000 ha of annual deforestation (BAU)
  ii. 500,000 ha of annual deforestation (high conversion scenario)
  iii. 125,000 ha of annual reforestation (low conversion scenario)

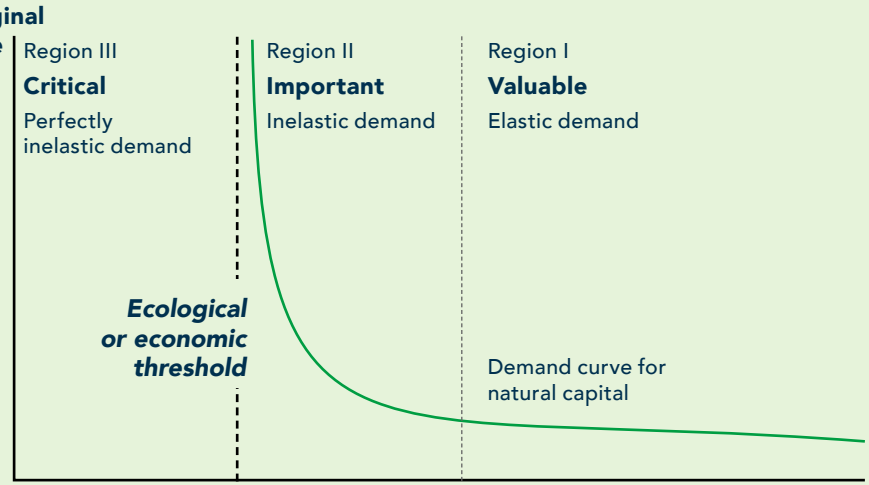
Economic valuation of a biome and scaling up

Large-scale changes in the provision of ecosystem services can result in changes in the marginal value of these services. When a relatively small share of the forest biome is converted into agricultural land, the lost regulating services (such as erosion control and watershed protection) can be relatively easily and cheaply substituted by water management and infrastructure, such as reservoir construction. In contrast, if a substantial part of the forest biome is lost, this can translate into significant losses of ecosystem services that sustain human life, for which no adequate substitutes are available. Thus, it is assumed that the forests unit value increases proportionally to the degraded area. Considering the significance of forests and the high risk of large-scale deforestation in Paraguay, estimation of deforestation cost needs to consider the nonlinear positive feedback between the scale of degradation and the unit value of environmental degradation. Uncertainty analysis also needs to be applied to account for the potentially large-scale irreversible losses of the forest biome.

Estimating the cost of losses of a significant part of a forest biome using the traditional benefit transfer approach presents significant challenges. As suggested in de Groot et al. (2010), in such "scaling-up" situations when valuing ecosystem services over a large area, the value of ecosystem services over an entire biome cannot be found simply by adding up estimated values from smaller ecosystem sites. Large-scale changes in the provision of ecosystem services can result in changes in the marginal value of services or simply increases in the unit cost of ecosystem services (**Figure A.2**). Therefore, the analysis needs to estimate elasticities with respect to ecosystem scarcity.

In conducting economic analyses, it is important to use a holistic approach to local and regional ecosystem services valuation. Several studies, such as Viglizzo and Frank (2006) confirm a positive feedback between a level of ecosystem disturbance through agricultural development and an average value of lost ecosystem services. De Groot et al. (2010) suggest an accelerated decrease in a value of ecosystem services of savanna as a decreasing function of a share of cropped land there. Viglizzo and Frank (2006) provide some quantitative estimates that are applied in this study to calibrate the model. Empirical data from Mato Grosso, Brazil (on slowing down

FIGURE A.2
Natural capital stock exhaustion and ecosystem services demand curve



Source: Farley 2008.

of deforestation and intensification of agriculture) on productivity of agricultural land (Macedo et al. 2012) was also considered. The methodology of the adjustment coefficient estimation is presented further.

Figure A.3 shows the function of the adjustment coefficient for the value of ecosystem services as a function of undisturbed forest area. The average value per hectare of forest is therefore proportional to its scarcity, and intensive deforestation results in relative appreciation of forestland. This also amplifies the estimate of the economic costs of deforestation, for instance:

- When the share of forest land drops by 30 percent, the value of ecosystem services per hectare provided by undisturbed land may increase twofold.
- When the share of forest land drops by 80 percent (now representing only 20 percent of the total land area), the value of ecosystem services per hectare provided by undisturbed land may increase tenfold.

A conservative estimate of the adjustment coefficient depending on the share of undisturbed forestland (S), k(S)=2, is applied to each additional deforested hectare in the Atlantic Forest to calculate cost of deforestation in 2016. Forests value adjustment coefficient increases as a function of the remaining share of land covered by trees. For each deforestation scenario, adjustment coefficient could reach 3.9–5.8 in Eastern Paraguay over 15 years. In the reforestation/afforestation scenario, the adjustment coefficient remains the same in Eastern Paraguay given that reforestation rates are very uncertain. In contrast, if the share of deforested land is relatively low (10–20 percent), the value of the adjustment coefficient is at about 1.5. In this situation, the scaling-up effect is lower, and so is the cost of deforestation.

An adjustment coefficient of k(S)=1.5 is applied to the Chaco forest values in 2016 since the cumulative deforestation in 2016 reached 20 percent of the forest area observed in 2000. Depending on the deforestation scenario, the adjustment coefficient could reach 2.1–6.0 in Western Paraguay over 15 years. For further details of the methodology, see **Box A.1**.

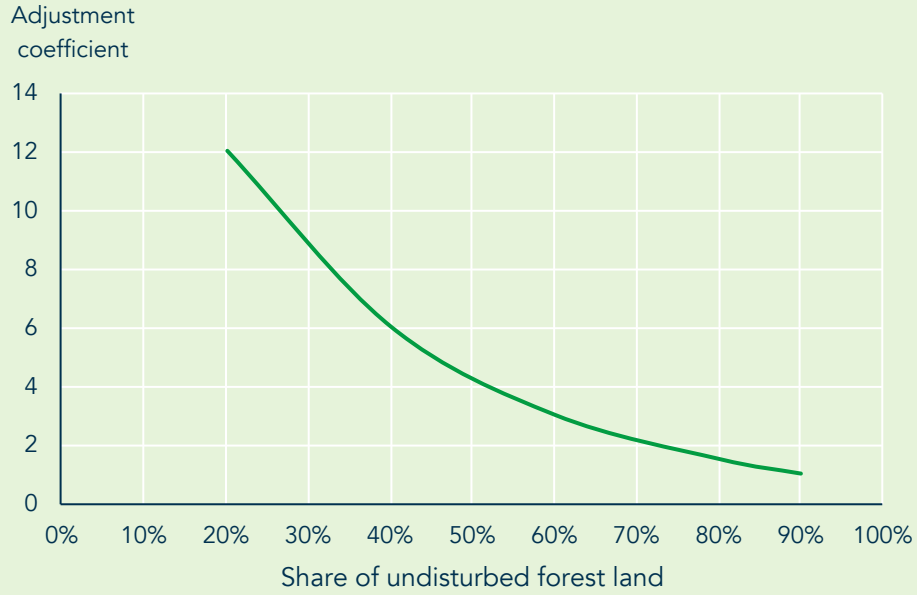
Sensitivity analysis

Table A.2 combines the results of a probabilistic model calculations of the total forest values per hectare for Eastern and Western Paraguay. In turn, **Table A.3** presents the risk-adjusted value of deforestation per hectare,[75] calculated using the Monte Carlo simulation.

75. The RA value is calculated as a permanent loss of an option value of ecosystem services in the long term that at the moment is uncertain.

FIGURE A.3

Estimated adjustment coefficient for economic value of ecosystem services as a function of an undisturbed forestland



Source: Original calculations based on a literature review.

BOX A.1

Calibration of the adjustment coefficient for the forests value

The model (1)-(2) presents the value of lost ecosystem services as a function of *the total deforested area.*

$V(S) = V_0 * k(S)$ (1)

$k(S) = \alpha e^{\gamma S}$ (2)

Where,

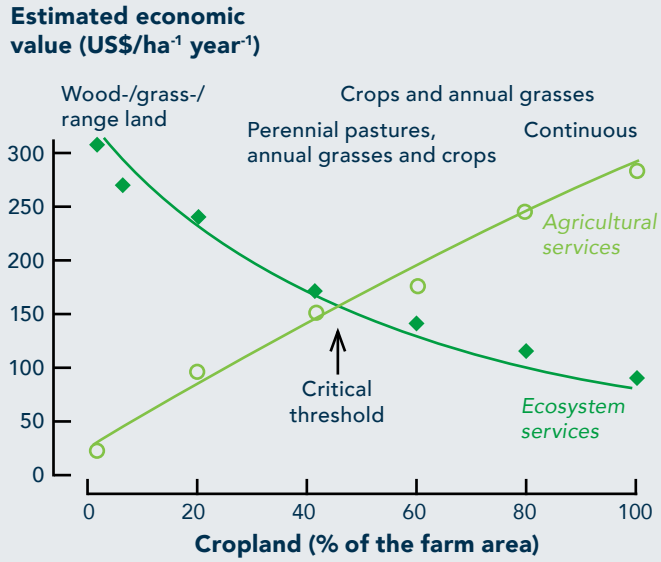
- S *the share of deforested land;*
- $V(S)$ *an average value of lost ecosystem services per 1 ha of land involved in agriculture as a function of deforested land in Paraguay;*
- $k(S)$ *an adjustment function that links unit value of deforestation with the share of deforested land;*
- V_0 *the initial value of lost ecosystem services without taking into account a positive feedback between the share of agricultural land and losses of ecosystem services; and*
- α, γ *scaling constants, estimated using literature taking into account a positive feedback between a scale of expansion of agriculture and lost value of ecosystem services.*

The share of deforested land is calculated relative to forest-covered land in 2000. For instance, if in Eastern Paraguay it was 2.530 million ha in 2000 and 1.74 million ha in 2015; then S=0.7. The analysis calibrates parameters of k(S) using available literature on the value of tropical forest and tropical grasslands from neighboring countries, given the lack of relevant data in Paraguay. It is advisable, however, to estimate this function using physical data on deforestation and corresponding ecosystem losses. This information should be collected with special attention to water recharge and erosion control services. Availability of such data would improve economic valuation and reduce uncertainty in decision-making concerning conservation targets.

Viglizzo and Frank (2006) suggest a general shape of an adjustment function in the Del Plata Basin (Argentina). The study finds that with about 40 percent of agricultural expansion in the basin, the value of ecosystem services losses is equal or greater to the value from additional agricultural production (see below). In this analysis, the 40 percent of forest biome loss is the threshold that maximizes economic value of both agricultural productivity and ecosystem services **(Figure A.1.1)**. In other words, the opportunity cost of conservation is equal to the lost net revenues from the agriculture sector, which are taken as the shadow value of forest and used to calibrate the adjustment function of forests in Paraguay.

FIGURE A.1.1

Relationship between the value of agricultural (gross margin) and ecosystem services in the Argentine Pampas under different agricultural and ecosystem typologies



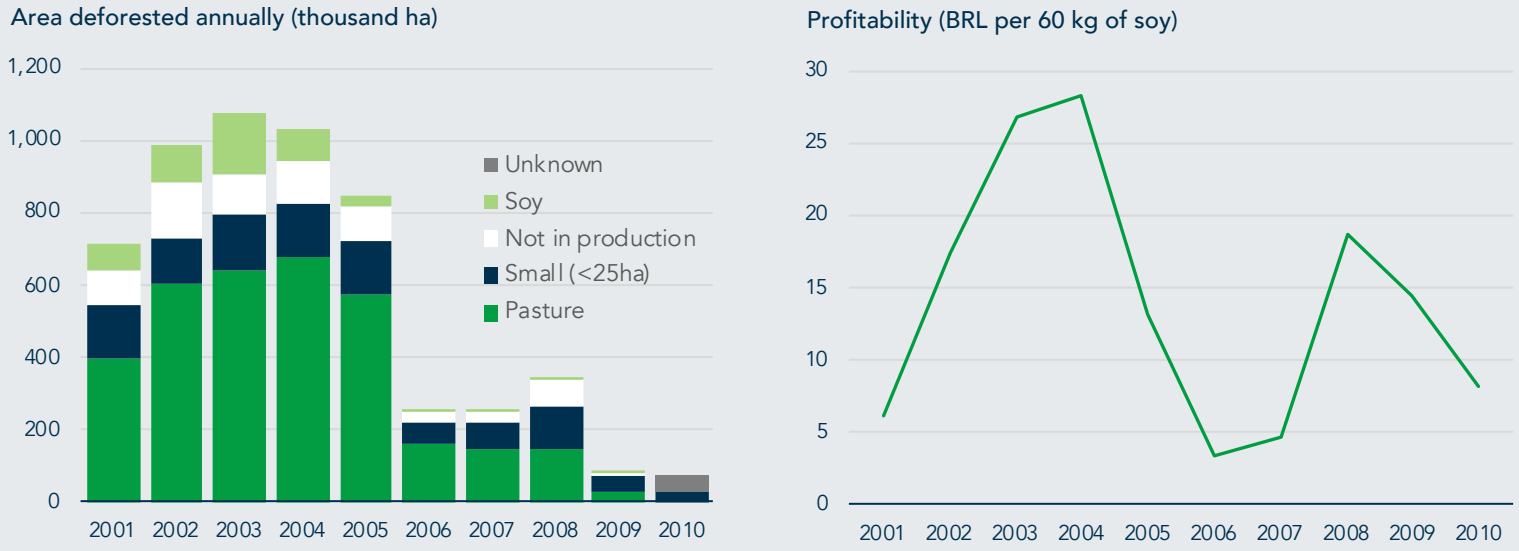
Source: Viglizzo and Frank 2006.

Further, an existing value of agricultural land in a similar biome in Brazil—Mato Grosso—is used as a benchmark for a potential value of agricultural land in Paraguay. Mato Grosso is selected as a proxy because the expansion of the agricultural frontier in Mato Grosso and in Paraguay's Atlantic forests takes place in similar, adjacent biomes (De Almeida et al. 2015) and the share of agricultural lands in Mato Grosso is about 43 percent, which is almost the same as the suggested break-even point in Viglizzo and Frank (2006).

The net revenue per hectare of agricultural land under soy in Mato Grosso was about $750 in 2010.[a] To apply the scaling function, the value of $200/ha is assumed as the initial value of ecosystem services in Mato Grosso (Macedo et al. 2012) and $750/ha when cumulative deforestation reaches 40 percent of the land area. **Figure A.1.2** demonstrates that when deforestation reaches about 40 percent of the available forest, then soybean yield is not directly correlated with the deforestation rate. Starting with 2006, the motivation to increase cropland is no longer a driver of deforestation.

a. The gross revenue from agricultural land under soybean production is about $1,230/ha (IBGE 2020), and the agricultural cost is about $480/ha (Martins and Oliveira 2012).

FIGURE A.1.2
Deforestation vs. agricultural yields in Mato Grosso, 2001–2010



Source: Based on data from Macedo et al. 2012.

The total cost of deforestation in Paraguay

The total annual deforestation cost in Paraguay is $164 million–$1.196 billion, or 0.4–3 percent of GDP in 2017 (**Table 3**). Under the higher deforestation scenarios in both Eastern and Western Paraguay, the annual deforestation cost is estimated at $1.2 billion, or 3 percent of GDP in 2017. If it is assumed that the forests unit value is increasing proportionally to the degraded area, the estimate of the annual deforestation cost can double in Paraguay, reaching 0.8–6 percent of GDP in 2017. The annual cost of deforestation is calculated as a product of the RA forest values per hectare (**Table 3**) and annual deforestation in hectares for each scenario.

TABLE A.2
Statistics for the total forest value per hectare (US$)

	Deforestation Eastern Paraguay	Deforestation Western Paraguay
Trials	10,000	10,000
Mean	$5,205	$1,570
Standard deviation	$1,957	$557
Forest values		
10%	$3,583	$1,100
20%	$3,887	$1,200
50%	$4,696	$1,400
80%	$6,109	$1,819
90%	$7,325	$2,169

Source: Original calculations based on a literature review.
Note: The net present value of a hectare of forest is calculated over 15 years at a 6 percent discount rate.

TABLE A.3
Estimated risk-adjusted forest value

	Total value (US$/ha)	Risk-adjusted forest value (US$/ha)
Eastern Paraguay	5,205	5,988
Western Paraguay	1,570	1,793

Source: Original calculations based on a literature review.

BOX A.2

Model parameters and specifications of variables in Monte Carlo simulation

The model developed for the analysis and parameters used for each distribution are described below.

1. Cost of deforestation with a non-adjusted total value of forests per hectare (initial forest value) in region k, year i (D_{ik0})

$$D_{ik0} = d_{ikt} * R_{0k}$$

$$R_{ik} = \sum_{j=1}^{5} V_{ijk}$$

$$R_{ok} = (1 - q_k)(\sum_{i=1}^{15} \frac{R_{ik}}{(1+r)^i} + P_C * C_k) + q_k * l_k * (\sum_{i=1}^{15} \frac{R_{ik}}{(1+r)^i} + P_C * C_k)$$

- R_{0k} the total value of lost ecosystem services in region *k* without taking into account a positive feedback between the share of agricultural land and losses of ecosystem services
- R_{ik} annual forest value for the region *k* in year *i*
- V_{ijk} additive annual forest values per hectare by the type of ecosystem services *j* in region *k*
- P_c carbon price
- C_k average carbon stored per hectare in the forests in region *k*
- q_k average share of fragmented forest in region *k*
- l_k average loss of value in fragmented forest in region *k*
- r discount coefficient (real interest rate)
- d_{ikt} annual deforestation in year *i* in scenario *t* in the region *k*

2. Cost of deforestation with an adjusted total value of forests per hectare in region k, year i, scenario t (D_{ik0})

$$D_{ikt} = d_{ikt} * R_{ka}$$

$$R_{ka} = (1 - q_k) * \left(\sum_{i=1}^{15} f_i(M_{it}) * \left(\frac{R_{ik}}{(1+r)^i}\right) + P_C * C_k\right) + q_k * l_k * (\sum_{i=1}^{15} f_i(M_{it}) * \left(\frac{R_{ik}}{(1+r)^i}\right) + P_C * C_k)$$

$$\frac{\sum_{i=1}^{i} d_{ikt}}{S_k} = M_{ikt}$$

$$f_i(M_{ikt}) = \alpha e^{\gamma * M_{ikt}}$$

$$R_{ik} = \sum_{j=1}^{5} V_{ijk}$$

- R_{ka} the adjusted value of lost ecosystem services in region *k* taking into account a positive feedback between the share of agricultural land and losses of ecosystem services
- S_k forest area in 2000 in the region *k*
- M_{ikt} the share of deforested land in year *i* scenario *t* in the region *k*
- $f(M_{ikt})$ an adjustment function that links the unit value of deforestation with the share of deforested land in year *i* scenario *t* in the region *k*
- α, γ scaling constants, estimated using literature taking into account a positive feedback between a scale of expansion of agriculture and lost value of ecosystem services

3. Monte Carlo simulations, selected functions and specifications

Variable	Functional form	Specifications
γ	BetaPERT	Min=6; Likeliest=22; Max=26
a	BetaPERT	Min=-4; Likeliest=-3.2; Max=-2.8
P_c	Lognormal	Location=0; Mean=5, SD=5
Eastern Paraguay		
C_k	BetaPERT	Min=104; Likeliest=115; Max=127
V_1 (sustainable timber harvest net value)	Lognormal	Location=0; Mean=107, SD=27
V_2 (bushmeat harvest net value)	Lognormal	Location=0; Mean=8, SD=2
V_3 (soil protection net value)	Lognormal	Location=0; Mean=24, SD=6
V_4 (water protection net value)	BetaPERT	Min=27; Likeliest=73; Max=118
V_5 (other net values)	Lognormal	Location=0; Mean=7, SD=2
q	BetaPERT	Min=0.35; Likeliest=0.4; Max=0.45
l	BetaPERT	Min=0.2; Likeliest=0.35; Max=0.5
d_1	BetaPERT	Min=27; Likeliest=30; Max=33
d_2	BetaPERT	Min=45; Likeliest=50; Max=55
d_3	BetaPERT	Min=-9; Likeliest=-10; Max=-11
Western Paraguay		
C_k	BetaPERT	Min=27; Likeliest=30; Max=33
V_1 (sustainable timber harvest net value)	Lognormal	Location=0; Mean=36, SD=9
V_2 (bushmeat harvest net value)	Lognormal	Location=0; Mean=8, SD=2
V_3 (soil protection net value)	Lognormal	Location=0; Mean=25, SD=7
V_4 (water protection net value)	BetaPERT	Min=20; Likeliest=25; Max=30
V_5 (other net values)	Lognormal	Location=0; Mean=7, SD=2
q	BetaPERT	Min=0.76; Likeliest=0.84; Max=0.92
l	BetaPERT	Min=0.5; Likeliest=0.1; Max=0.15
d_1	BetaPERT	Min=100; Likeliest=125; Max=150
d_2	BetaPERT	Min=200; Likeliest=250; Max=300
d_3	BetaPERT	Min=400; Likeliest=500; Max=600

Limitations

The first key limitation is that the economic analysis utilizes secondary data sources to estimate the cost of deforestation. Only quantifiable benefits of forests are included. Thus, while the analysis covers a significant portion of the relevant issues, it is not exhaustive. Methodological limitations and the lack of available country data make it difficult to quantify any additional costs and benefits, including opportunity costs, such as the loss of recreational forests values, protective forest values, and the health-related costs stemming from exposure to forest fires, to name a few. The absence of such estimates does not imply that their value is zero. The second key limitation is that the macroeconomic impacts of environmental degradation—for example, on food security, exports, GDP growth—are not considered. Therefore, the results should be interpreted as conservative. Future research can consider these parameters to develop a more comprehensive estimate of the economic cost of forest loss in Paraguay. This is a first approximation of a cost of deforestation in Paraguay, and the model used can be upgraded or expanded as more information becomes available.

Appendix B. Financial analysis of forest plantation reference models

This appendix presents the methodology used in the financial analysis of seven forest plantation reference models, conducted as part of the preparation of the Paraguay Forestry Project (P171351) of the World Bank.

Data collection and development of reference models

Because of the lack of consistent high-quality data for the forestry sector in Paraguay, this analysis relies on original field data collected by a team comprising the World Bank, the FAO, and the government of Paraguay. Nineteen plantations were evaluated via a survey, from which seven model reference models were developed. Data collection and analysis involved the following steps:

- **Fieldwork**. The World Bank–FAO team scheduled 22 interviews and 3 pilot interviews with plantation owners or technical forestry advisers. A variety of productive models in the Eastern and Western Regions were considered, spanning pure saw timber models with exotic species, silvopastoral models with saw timber and exotic species, and agroforestry with native species and yerba mate. The survey targeted medium-small to medium-large plantations (10–1,000 ha). Six interviews were discarded for no-show or information scarcity, resulting in 19 completed questionnaires available for analysis. Given the rarity of productive plantations involving native species in Paraguay, it was not possible to survey pure native species plantations, nor was it possible to survey silvopastoral models with biomass for energy.
- **Verification and validation**. The fieldwork resulted in five completed questionnaires on biomass, eight on saw timber plantations, three on silvopastoral models, and two on agroforestry models, as well as one partially completed questionnaire on silvopastoral models with algarrobo (lacking information on livestock). Findings from the survey were verified and validated with secondary information from the private sector, academia, literature, and government agencies. The team also compared the reference models against historic data in Paraguay, as well as against models from other countries, such as Argentina and Vietnam.
- **Development of reference models**. The analysis generated seven generalizable plantation model types for the financial valuation. Those involving eucalyptus are: (i) a low-density, intense management saw timber model;[76] (ii) a high-density saw timber model with less intense management;[77] (iii) a saw timber silvopastoral model; and (iv) a biomass model with regrowth.[78] Two additional models for other plantations species were built based on case study and secondary information: (a) an agroforestry model with planted native species and yerba mate for Eastern Paraguay, and (b) a silvopastoral model with algarrobo (*Ceratonia siliqua*) for the Chaco region. Given the potential identified for high-quality pinewood, an additional reference model was constructed for pine combining secondary data with data from a case study.

76. This model has a 10-year rotation cycle and a final density of 250 *Eucalyptus grandis* trees; there is commercial thinning in year 3, 5, and 7; pruning takes place seven times in years 1 to 4.

77. This model has a 10-year rotation cycle, and a final density of 220 *Eucalyptus grandis* trees; there is one commercial thinning in year 5; pruning takes place five times in years 1 to 4.

78. This model assumes a 6-year rotation cycle and a regrowth cycle of another 6 years.

Key assumptions

Table B.1 summarizes the key assumptions used for the creation of the forest plantation or agroforestry reference models. The general assumptions applicable to these models include (i) plantation preparation includes a soil study, harrow (*rastroneada*) and subsoiling, weed and ant control, application of fertilizer (applicable to all models except the silvopastoral one in the Western Region), as well as road construction; (ii) plantations benefit from economies of scale and the use of machinery; (iii) plantations employ permanent and seasonal labor, with the latter category employed mainly for plantation preparation and pruning; (iv) the general cost of machinery is assumed to be the average of the cost of rental through tertiary service providers or the cost of depreciation; (v) technical assistance is around $30/ha/yr for all reference models except for yerba mate (which has higher technical costs because of monthly and intensive follow-up with small farmers); and (vi) total taxes vary with the amount of wood (and yerba mate leaves) sold. The analysis did not estimate or include the cost of land. As for silvopastoral and agroforestry models, the key assumptions can be summarized as follows:

Reference model silvopastoral with algarrobo (Chaco). The plantation model is designed with 43 algarrobo trees per hectare with a 15-year rotation cycle and no thinning. The model assumes a mean annual increment (MAI) of 10 m3/ha and a density of 1,070 kilograms per cubic meter (kg/m3) for humid wood. Four prunings takes place between years 2 and 6. Plantation preparation only includes vegetation cleaning (plantation setup: grassland). Establishment costs are $72/ha in total. Periodic operations consist of vegetation cleaning during the first three years, and seedling selection every two years, amounting to an average of $59/ha/yr. The plantation owner sells timber at the final market at a price of $55 per tree, or about $31/m3. The plantation generates 150 m3/ha over its 15-year rotation cycle. Administrative costs are $19/ha/yr, depreciation is 0, and local forestry advisers carry out technical assistance for $0.06/ha/yr. Transport costs are $0.17/m3, and the cost of harvesting is $2.28/m3. The distance to final wood markets is assumed to be 10 km. The livestock part of the model is based on a variety of secondary sources from technical articles and information published by the Rural Association of Paraguay (ARP). The analysis assumes yearly production of 200 kg of meat/ha (112 kg of productive meat), at $2.38/kg. Establishment costs are $1,165/ha; periodic costs are $190/ha.

Reference model for eucalyptus silvopastoral (Eastern Paraguay). The reference model for saw timber is based on Eucalyptus grandis clones and cattle ranching. The results here only describe the forestry part of the business, assuming that the plantation is built on a preexisting pure livestock production model. The planting density is 920 trees per hectare with six prunings over the first three years. Two commercial thinning are undertaken at year 3 and year 6. The MAI of the plantation is 30 m3/ha/yr and the rotation is a 12-year cycle. Establishment costs are $1,017/ha and maintenance and other yearly costs are slightly higher than for plantations without cattle. Depreciation is lower since most machinery is hired. The average price of saw and hardwood is $33/m3 and these are sold standing.

Reference model for agroforestry (Eastern Paraguay). The total costs for the first three years are especially high for the agroforestry system with yerba mate and natives, as these costs consider both cost items generated by yerba mate as well as native species. Pure establishment costs in year 0 vary around $1,000/ha and average operational costs vary around $100/ha. Average maintenance costs vary from $19/ha to $73/ha, with yerba mate being an outlier. The high administrative costs of nearly $1,000/ha/yr come from the inclusion of monthly salaries for smallholders taking care of the plantations. For the agroforestry model with yerba mate and native species, the analysis assumed the distance to final wood markets to be 35 km.

TABLE B.1
Key assumptions used in the plantation reference models

		Eucalyptus – saw wood (intense)	Eucalyptus – saw wood (less intense)	Eucalyptus for biomass	Agroforestry (native species and yerba mate)	Pine – saw wood
Factor	**Unit**	Values				
Physical characteristics						
Size of plantation (in hectares)		13–170	13–170	100–4,000	1,300 for 300 smallholders	200
Species		Eucalyptus grandis	Eucalyptus grandis	Eucalyptus camalndulensis clones	I.Paraguariensis, Cordia trichotoma (peterevy), Anadenanthera colubrina (curupa'y), and Tabebuia spp. (lapacho o tajy)	Taeda
Planting density	**Trees/ha**	1,000	833	1,330	833 and 600[a]	1,111
Final density	**Trees/ha**	250	220	1,330	44 (native species)	230
Mean annual increment (MAI)	**m^3/ha/yr**	32	35	40[b]	10	25
Total yield	**m^3/ha**	320	350	456	170[c]	420
Density (humid wood)	**kg/m^3**	900	900	-	946	840
Density (dry wood)	**kg/m^3**	480	480	560	-	-
Suitable region	**W/E**	E	E	E	E	E
Management						
Rotation cycle	**Years**	10	10	6[d]	17	20
Commercial thinning	**Years**	3, 5, 7	5[e]	-	7, 13	3, 7, 12
Pruning (years 1–4)	**Number**	7	5	-	-	3[f]
Establishment costs						
Average total establishment costs	**US$/ha**	1,030	957	1,227	846	873
Average annual costs						
Administrative	**US$/ha/yr**	68	73	67	979	50
Depreciation	**US$/ha/yr**	17	11	17	5	NA
Technical assistance	**US$/ha/yr**	31	30	29	83	21
Maintenance costs	**US$/ha**	103	107	89	104	93
Total tax	**US$/ha**	696	1,377	498	7,193	1,119
Forest products (Standing timber)						
Product #1	**Name**	Biomass	Biomass	Biomass	Yerba mate	-
Product #1 average price	**US$/t**	13	13	19	S0.19/kg	-
Product #2	**Name**	Saw and hardwood	Saw and hardwood	-	Timber	Timber
Product #2 average price	**US$/$m^3$**	30	32	-	59	31

Note: Assumptions on establishment and periodic costs, yields, and physical characteristics of plantations, originate primarily from field questionnaires and qualitative interviews with local producers; the reported prices of timber from native species are based on a study by Borsy et al. (2016).
a. The agroforestry reference model for yerba mate and native species is based on a plantation model with 833 trees per hectare of I.Paraguariensis, and 600 native trees per hectare. Native species are Cordia trichotoma (peterevy), Anadenanthera colubrina (curupa'y), and Tabebuia spp. (lapacho o tajy).
b. A reduction of 10 percent in the MAI is assumed for the second six-year regrowth cycle.
c. The plantation generates 170 m3/ha of timber and 188 t/ha of green leaves of yerba mate over its 17-year rotation cycle, a yearly average production of 10.4 t/ha from year 3 onward.
d. The model assumes a six-year rotation cycle and a regrowth cycle of another six years.
e. The thinning includes a 50 percent share of biomass, compared to 14 percent of biomass production during final timber harvesting.
f. The model assumes three prunings, in years 2, 4, and 6.

TABLE B.2

Estimated financial returns of the plantation reference models

Model	Total yield (m^3/ha)	Total costs (yrs 0–3) (US$/ha)	Income (US$/ha)	Internal rate of return (%)	Net present value (US$/ha)
Eucalyptus – saw wood model (intensive)	320	1,984	7,217	12	745
Eucalyptus – saw wood model (less Intensive)	350	1,904	9,156	14	1,186
Eucalyptus – biomass model (with regrowth)	456	1,988	5,025	4	-578
Silvopastoral model (Eucalyptus - saw wood & livestock breeding)	360	2,173	9,005	12	873
Pine model - saw wood	420	1,494	9,908	8	-77
Silvopastoral model (Algarrobo – saw wood & livestock for fattening)	150	639	5,044	10	180
Agroforestry model (Native species – saw wood & yerba mate)	170	4,427	10,050	12	2,012

Source: Original calculations based on field data collected and a literature review.

Results of the financial analysis

The analysis demonstrates that plantation models can be financially viable from the perspective of private beneficiaries even without any assistance from the government (see **Table B.2**). The internal rates of return range from 4 percent for the eucalyptus plantation models established to produce biomass with regrowth to 14 percent for the eucalyptus plantations grown with less intensive management practices and saw wood purposes. The net present value calculation assumes a 6 percent discount rate.

Sensitivity analysis

A sensitivity analysis was carried out for two important variables that are characterized by uncertainty in Paraguay: final product prices and the tree growth rate (the MAI). In summary, the models are robust to changes in these key variables, mostly maintaining positive profits (see **Table B.3**). The models are generally more sensitive to a reduction in prices than to a reduction in MAI. The eucalyptus plantation established solely to produce biomass for energy is the only one that turns unprofitable when either prices or tree growth rates drop by 20 percent.

TABLE B.3
Summary of sensitivity by model

Scenario	Reference model		Internal rate of return (%)	Net present value (US$)
Base case	Eucalyptus (clones)	Saw wood eucalyptus model (intensive) (biomass thin.)	35	1,270
		Saw wood eucalyptus model (less intense) (biomass thin.)	36	1,638
		Biomass model (eucalyptus) with regrowth	21	175
		Saw wood silvopastoral model (eucalyptus & livestock breeding) (biomass thin.)	33	1,423
Prices - 20%	Eucalyptus (clones)	Saw wood eucalyptus model (intensive) (biomass thin.)	23	620
		Saw wood eucalyptus model (less intense) (biomass thin.)	26	905
		Biomass model (eucalyptus) with regrowth	-17	-259
		Saw wood silvopastoral model (Eucalyptus & livestock breeding) (biomass thin.)	23	761
Prices + 20%	Eucalyptus (clones)	Saw wood eucalyptus model (intensive) (biomass thin.)	44	1,920
		Saw wood eucalyptus model (less intense) (biomass thin.)	43	2,370
		Biomass model (eucalyptus) with regrowth	42	608
		Saw wood silvopastoral model (eucalyptus & livestock breeding) (biomass thin.)	40	2,084
MAI - 20%	Eucalyptus (clones)	Saw wood eucalyptus model (intensive) (biomass thin.)	25	543
		Saw wood eucalyptus model (less intense) (biomass thin.)	26	905
		Biomass model (eucalyptus) with regrowth	--	-232
		Saw wood silvopastoral model (eucalyptus & livestock breeding) (biomass thin.)	26	728
MAI + 20%	Eucalyptus (clones)	Saw wood eucalyptus model (intensive) (biomass thin.)	40	1,943
		Saw wood eucalyptus model (less intense) (biomass thin.)	43	2,370
		Biomass model (eucalyptus) with regrowth	31	534
		Saw wood silvopastoral model (eucalyptus & livestock breeding) (biomass thin.)	37	2,117

Source: Original calculations.

Limitations

The present financial analysis has several limitations. First, the research team noted a lack of systematic knowledge and information available on the forestry sector in Paraguay. The team attempted to fill the data gaps observed in the field by consulting the local producers and secondary data sources. Still, no systematic data about wood and biomass for energy stumpage prices could be identified and therefore this information is considered highly uncertain. The same applies to the final market prices of timber products and biomass for energy production, and transportation costs. For this reason, it was not possible to cover transportation, although it is as a key factor affecting the profitability of plantations, and the analysis is restricted to standing timber. The reference models were built on interviews with landowners; therefore, they do not consider any costs of renting land. Several other variables could not be quantified with sufficient confidence and thus were not incorporated in the analysis:

- Costs and benefits of national forest certification.
- Costs related to permits and legal processes needed to establish a plantation. These direct costs varied widely between plantation types and plantation sizes and were mentioned as burdensome. Moreover, previous studies that have accounted for these costs (Borsy et al. 2016) as well as the opportunity costs of the time lost while undertaking these processes show that the opportunity costs are much higher than the direct costs of these processes. Analyzing such opportunity costs is outside the scope of this analysis.
- Risks of fires, pests, diseases, as well as other risks related to access to markets, competition from illegally sourced forest products, land tenure insecurity, and potential bureaucratic costs associated with land titles.

A further limitation of the analysis is that the reference models presented above are mostly based on large plantations of more than 100 ha, or smaller plantations forming part of large farms, since these tend to be accessible plantations and with systematized data. These plantations are technically advanced and benefit from economies of scale as well as modern machinery. The reference models developed may therefore differ from the models implemented by small and medium landholders. While the yerba mate and the algarrobo model do correspond to the typology of smallholder plantations, this analysis could only identify one example of each in the field, which may affect the representativeness of these results.

The analysis also assumes that plantations are established on elevated ground, while plantations can also be established on low-lying ground. This would mean additional drainage costs, which may be as high as $400/ha and therefore render a plantation unprofitable. This analysis did not cover the differences in soil characteristics, assuming soils were apt for plantation.

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