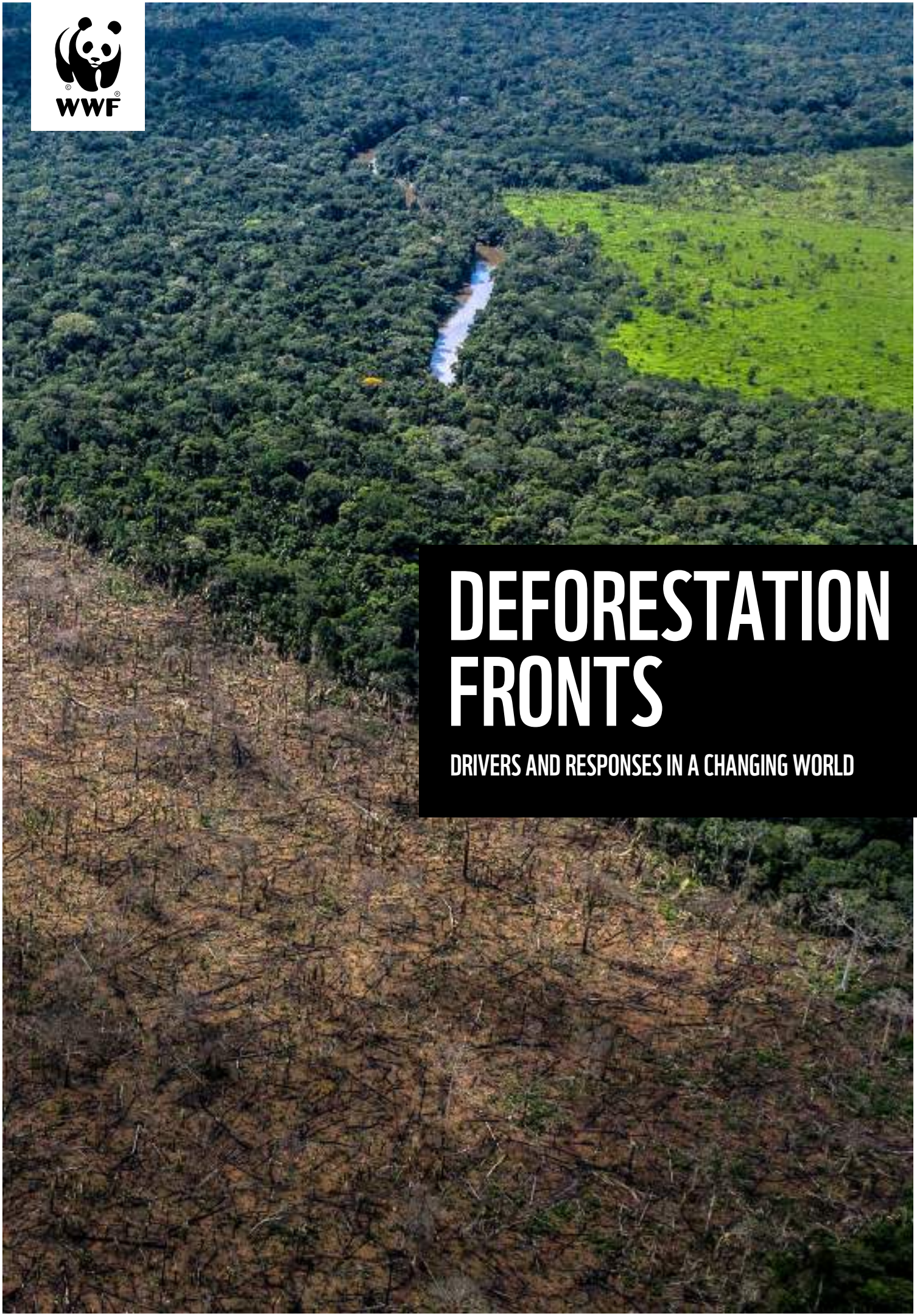


DEFORESTATION FRONTS

DRIVERS AND RESPONSES IN A CHANGING WORLD

WWF

WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

Citation: Pacheco, P., Mo, K., Dudley, N., Shapiro, A., Aguilar-Amuchastegui, N., Ling, P.Y., Anderson, C. and Marx, A. 2021. Deforestation fronts: Drivers and responses in a changing world. WWF, Gland, Switzerland.

ACKNOWLEDGEMENTS

We want to thank everyone who has contributed to this report. Our thanks to those who provided input into the factsheets, including Adewale Adeleke (WA BiCC), Adrian Choo (WWF-Malaysia), Aiesha Williams (WWF-Guianas), Analiz Vergara (WWF-US), Andrey Shegolev (WWF-Russia), Angga Prathama Putra, (WWF-Indonesia), Antonio Castellanos (CIMSUR, UNAM), Antonio Serra (WWF-Mozambique), Aye Myat Thandar (WWF-Myanmar), Ben Miller (King's Botanic Gardens, Perth, Western Australia), Benoit Mertens (IRD), Brian Huntley (consultant), Cesar Suarez (WWF-Colombia), Davison Gumbo (CIFOR), Edegar de Oliveira Rosa (WWF-Brazil), Eduardo Rendon (WWF-Mexico), Faisal Mohd Noo (WWF-Malaysia), George Schoneveld (CIFOR), Ghislain Vieilledent (CIRAD), Guillaume Lescuyer (CIFOR), Jaap van der Waarde (WWF-Cameroon), James Watson (University of Queensland), John Mendelsohn (consultant), Jorge Rivas (WWF-Ecuador), Jose Soto (WWF Guatemala), Kokok Yulianto (WWF-Indonesia), Koulang Chey (WWF-Cambodia), Krystof Obidzinsky (EFI), Laurent Some (WWF East & Southern Africa), Laurent Ludovic Miaro III (WWF Africa Programme), Maria Amalia Porta (WWF-Guatemala), Maria Eugenia Periago (Fundacion Vida Silvestre Argentina), Mariana Napolitano Ferreira (WWF-Brazil), Martin Taylor (WWF-Australia), Nike Doggart (University of Leeds), Paula Hanna Valdujo (WWF-Brazil), Quoc Nguyen Anh (WWF-Viet Nam), Rina Andrianarivony (WWF-Madagascar), Sandra Petrone Mendoza (WWF-Mexico), Sandra Valenzuela (WWF-Colombia), Sean Maxwell (University of Queensland), Selma van der Haa (CIFOR), Stefano Zenobi (WWF-Myanmar), Susannah Sallu (University of Leeds), Tam Le Viet (WWF-Viet Nam), Teak Seng (WWF-Cambodia), Teresia Olemako (WWF-Tanzania), Thibault Ledecq (WWF-Belgium), Yann le Polain de Waroux (McGill University), Yumiko Uryu (WWF-Indonesia). Thanks also to colleagues who were part of the consultation dialogues, including Alphonse Ngniado (WWF-Cameroon), Azalea Kamellia Abdullah (WWF-Malaysia), Barnabas Mawire (WWF-Zimbabwe), Bounchanh Sakounnavong, (WWF-Laos), Eugène Ndong Ndoutoume (WWF-Gabon), Flory Botamba RIP (WWF-DRC), Grace Tena, (WWF-Myanmar), Lawrence Mbwambo (WWF-Tanzania), Mallory Graves (WWF Greater Mekong), Miguel Pacheco-Ganoza (WWF-Colombia), and Teresia Olemako (WWF-Tanzania). We are also grateful to colleagues who spent time reviewing specific sections of the report, including Akiva Fishman (WWF-US), Allard Blom (WWF-US), Amy Smith (WWF-US), Kurt Holle (WWF-Peru), Kemen Austin (RTI), Hermine Kleymann (WWF International), Kristin DeValue (FAO), Lisa Rausch (University of Wisconsin), Luis Román (WWF-Peru), Nirmal Bhagabati (WWF-US), Remi D'annunzio (FAO), Valerie Passardi (WWF-Switzerland), Wendy Elliott (WWF International Wildlife Practice), and Yougha von Laer (WWF-Germany). Edegar de Oliveira Rosa (WWF-Brazil) and Jan Willem van Gelder (Profundo) contributed text for boxes, and Paolo Tibaldeschi (WWF-Norway) supported with data. We are also thankful to those who helped review the full report, including Aditya Bayunanda (WWF-Indonesia), Andrew Wardell (CIFOR), Charlotte Streck (Climate Focus), Craig Beatty (WWF-US), David Kaimowitz (CLUA's Senior Adviser), Fran Raymond Price (WWF International), Jean François Timmers (WWF-Brazil), Jeffrey Sayer (University of British Columbia), Jonah Busch (EII), Jordi Surkin (WWF-Bolivia), Martha Stevenson (WWF-US), Martin Taylor (WWF-Australia), Niki de Sy (WUR), Sheila Wertz-Kanounnikoff (FAO), Susanne Winter (WWF-Germany), and William Baldwin-Cantello (WWF-UK). Last but not least, our appreciation goes to Huma Khan (WWF International) who contributed in all stages to enhancing the quality and consistency of the report, helping us sharpen our messages, and be aware of the audience this report is intended for. We are also grateful for the funds received for undertaking this work from WWF-UK, WWF-Germany, WWF-Finland, WWF-France, WWF-US, WWF-Australia, WWF-Switzerland, WWF-Japan and WWF-China.

Design by Miller Design UK

WWF, 28 rue Mauverney, 1196 Gland, Switzerland. Tel. +41 22 364 9111 CH-550.0.128.920-7

For contact details and further information, please visit our international website at wwf.panda.org/deforestationfronts

Cover photography: © Marizilda Cruppe / WWF-UK

© Marizilda Cruppe / WWF-UK

CONTENTS

SUMMARY		6
1.	INTRODUCTION	16
1.1	Deforestation: a wicked problem	17
1.2	A framework linking drivers and responses	18
2.	DEFORESTATION FRONTS	20
2.1.	Setting the scene	21
2.2.	Deforestation fronts	23
2.3.	Key facts across fronts	26
3.	DRIVERS OF DEFORESTATION	28
3.1.	Drivers of deforestation — taking stock	29
3.2.	Direct drivers and shifting trends	30
3.3	Indirect drivers putting pressure on deforestation fronts	33
4.	RESPONSES TO DEFORESTATION	37
4.1.	Framing the analysis: multiple responses	38
4.2.	Developments in responses across fronts	42
4.3.	Review of the effectiveness of select responses	46
4.4.	Why, despite a multitude of responses, does deforestation continue?	52
4.5.	Main challenges ahead	55
5.	AN AGENDA FOR ACTION	56
APPENDICES		60
REFERENCES		70
A CLOSER LOOK AT THE DEFORESTATION FRONTS		76

Photo © WWF / Richard Stonehouse

A HEALTHY PLANET BEGINS WITH HEALTHY FORESTS AND PEOPLE

Last year brought a profound realization that our health as individuals and as a society is deeply connected to the health of nature and the many services it provides. The spread and emergence of zoonotic diseases such as Covid-19 is yet another tragic consequence and indicator of the accelerating pressure we're putting on natural systems, and the precipitous loss of nature driven by our current unsustainable development models.

Forests are a lifeblood of our economies and our health – from the air we breathe to the wood we use. Covering nearly one-third of the Earth's land area, forests are home to more than half of the world's land-based species and are the source of 75% of the world's freshwater. More than a billion people live in and around forests, and they are the physical and spiritual home to many indigenous peoples and local communities. Forests are key carbon sinks – tropical forests alone store seven times more carbon than humanity emits every year and draw down up to 1.8 gigatonnes of carbon annually.

Yet forests today are in crisis, devastated by fires, converted and degraded for agriculture, for fuel and for timber. The mismanagement of the world's forests is ramping up carbon emissions, ravaging biodiversity, destroying vital ecosystems, and affecting the livelihoods and wellbeing of local communities as well as societies globally. And the situation is getting worse. The world's current unsustainable food systems mean that instead of repurposing degraded land for sustainable agricultural use, forests, savannahs and grasslands continue to be destroyed.

Deforestation and forest degradation are major drivers of zoonotic diseases. When healthy, forests are a buffer against diseases like Covid-19. But when forests are under attack, their safeguards are weakened, leading to a spillover of diseases.

It's time to value what nature provides to us, and a key focus for that action has to be our forests. As this report shows, we need collective action to implement tailored and integrated solutions that work for people and nature. And this shift needs to happen across the chain – from the countries that are home to forests to countries where consumption patterns and lifestyles are contributing to deforestation.

All this lends further weight to the need for a New Deal for Nature and People that puts nature on a path to recovery by 2030 and sets us on course to achieve real sustainable development, and a carbon-neutral, nature positive, equitable society. Among other goals, we're calling for an end to the loss of natural spaces like forests, and measures to halve the negative impacts of production and consumption.

We know what has to be done: protect critical biodiversity areas and sustainably manage forests, halt deforestation and restore forest landscapes, recognize and protect the tenure rights of indigenous peoples and local communities, support local people to build sustainable livelihoods, enhance landscape governance, and transform our economies, food and financial systems to better account for the value of nature. With a strong enough global coalition of the willing – governments, businesses, local communities, Indigenous Peoples, civil society organizations and consumers – we can do it.

Let's use this crisis as a wake-up call to halt nature loss, and safeguard forests, one of our world's most precious resources.

Marco Lambertini,
Director General
WWF International

Aerial view of the Ajajú River crossing at Chiribiquete National Park in the Colombian Amazon, Colombia.

SUMMARY

The causes, pace and magnitude of deforestation and forest degradation have changed over time. The way that different causes of deforestation link together and the effects they have on forests varies across regions.

Globally, a multitude of approaches have been implemented to halt deforestation and forest degradation. While progress has been made in halting forest loss and degradation, both continue at alarming rates.

This report provides a comprehensive analysis of deforestation connecting drivers and responses globally by taking a closer look at 24 “deforestation fronts” – places that have a significant concentration of deforestation hotspots and where large areas of remaining forests are under threat. Over 43 million hectares were lost in these fronts between 2004 and 2017, an area roughly the size of Morocco.

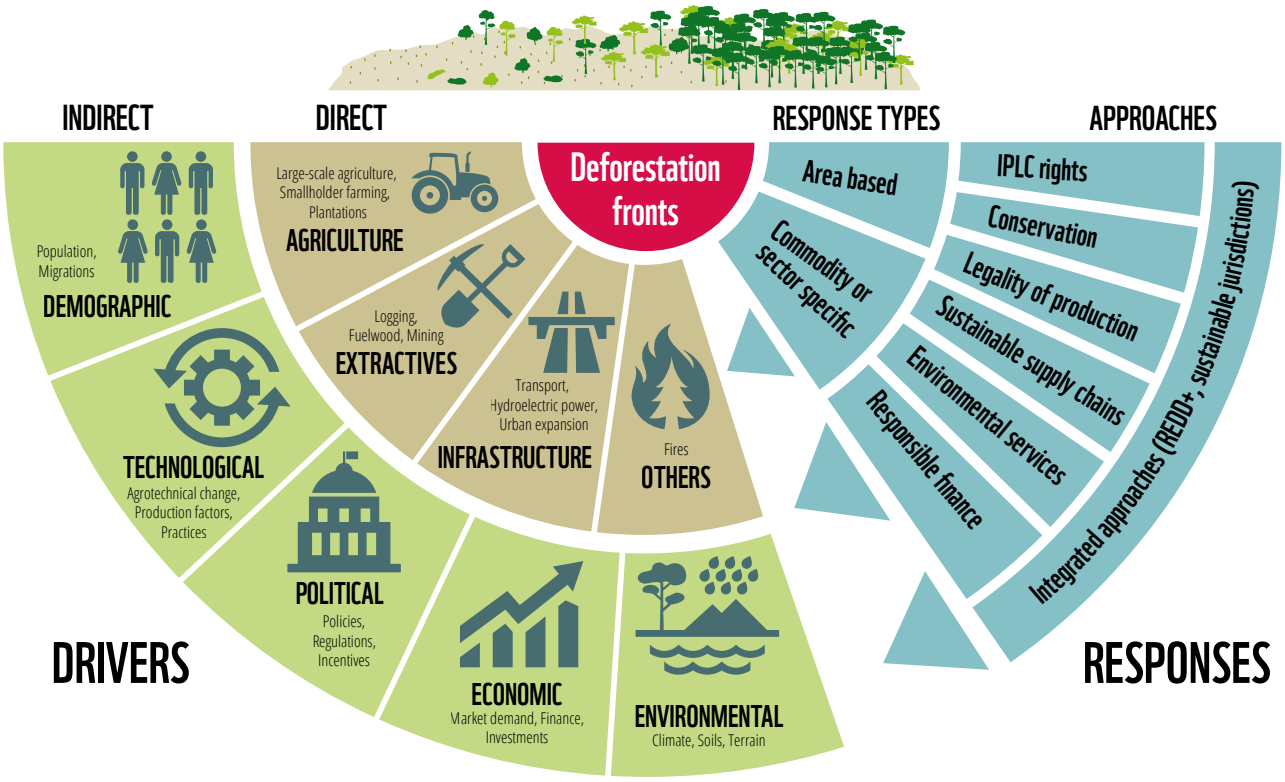
The analysis presented here focuses on the tropics and sub-tropics, which accounted for at least two-thirds of global forest cover loss from 2000 to 2018 and where forest fragmentation is significant. Nearly half of the standing forests in these 24 deforestation fronts have suffered some type of fragmentation.

Deforestation tends to oscillate over time. Recent trends indicate that deforestation will persist in these fronts unless there is collective action and more integrated approaches tailored to each front. To be more effective, the different responses to halt deforestation and forest degradation have to reinforce each other.

Rainforest in Borneo, Malaysia,
destroyed to make way for oil palm plantations.

Linking drivers and responses

The following framework shows the links between drivers of deforestation globally and the existing approaches to address them. How these approaches address drivers plays an important role in shaping the dynamics of deforestation fronts, which are at the centre of this analysis. Assessing the socio-environmental impacts of deforestation in these fronts is beyond the scope of this analysis.



Expansion of commercial agriculture (both large and small scale) and tree plantations are by far the greatest drivers of deforestation, with land speculation playing a strong role in several local contexts. Infrastructure and extractive activities, particularly the expansion of mining, are increasingly important drivers. These drivers take different shapes across locations and change over time.

Multiple approaches and responses have emerged from state and non-state actors to tackle deforestation. Some have worked better than others, yet all have limits. Acknowledging the potential and limits across approaches and responses is critical, as well as the synergies that are needed for responses to be more effective to tackle deforestation and forest degradation while avoiding negative social impacts, and achieving more inclusive and equitable outcomes.

Our findings are designed to help policy-makers, the corporate sector, civil society organizations and anyone working to halt and reverse deforestation better understand what approaches are needed to have lasting impact at scale.

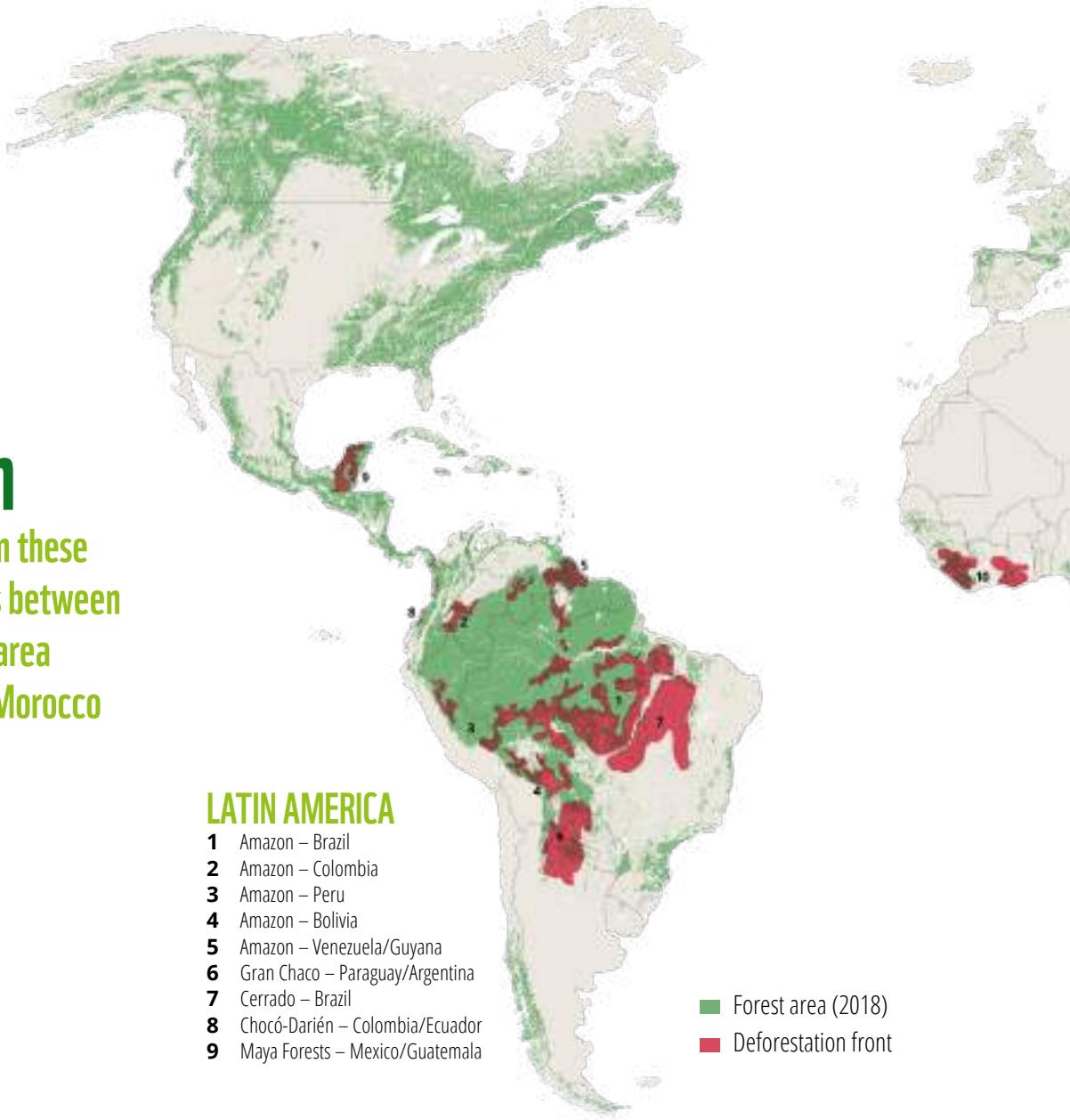
Area-based responses – such as protected & conserved areas, recognition of indigenous peoples and local communities (IPLC) tenure rights and moratoria on conversion of forestlands – can be effective in preventing the loss of threatened forests but don't help stop deforestation beyond their own boundaries and have different social implications. In turn, commodity or sector specific responses like voluntary certification, payments for environmental services (PES) and deforestation-free supply chains are important but thus far have had limited impact at scale. Additional integrated approaches are emerging motivated by result-based payments for reducing deforestation as well as jurisdictional and landscape approaches. The latter leverage the power of markets and finance but still require active state intervention at the national and sub-national levels and public-private-people partnerships, ensuring the conditions for wider participation of local stakeholders, including IPLCs.

More ambitious action is needed to build on existing responses across scales and within landscapes, while improving conditions for wider uptake of solutions that are more effective to reduce deforestation and forest degradation, with considerations of social inclusion and equity. Ultimately though, real impact will come from transforming our economies, and food and financial system and development paradigm shifts to place nature and people at the centre.

DEFORESTATION FRONTS

Over 43 million

hectares were lost in these deforestation fronts between 2004 and 2017, an area roughly the size of Morocco



Most forest loss is clustered in 24 deforestation fronts across Latin America, sub-Saharan Africa, Southeast Asia and Oceania. Several appeared in WWF's previous analysis in the 2015 *Living Forests Report*, including the Amazon, Central Africa, Mekong and Indonesia. In addition, new fronts have appeared in West Africa (e.g. Liberia, Ivory Coast, Ghana), East Africa (e.g. Madagascar) and Latin America, including the Amazon in Guyana and Venezuela and the Maya Forest in Mexico and Guatemala.

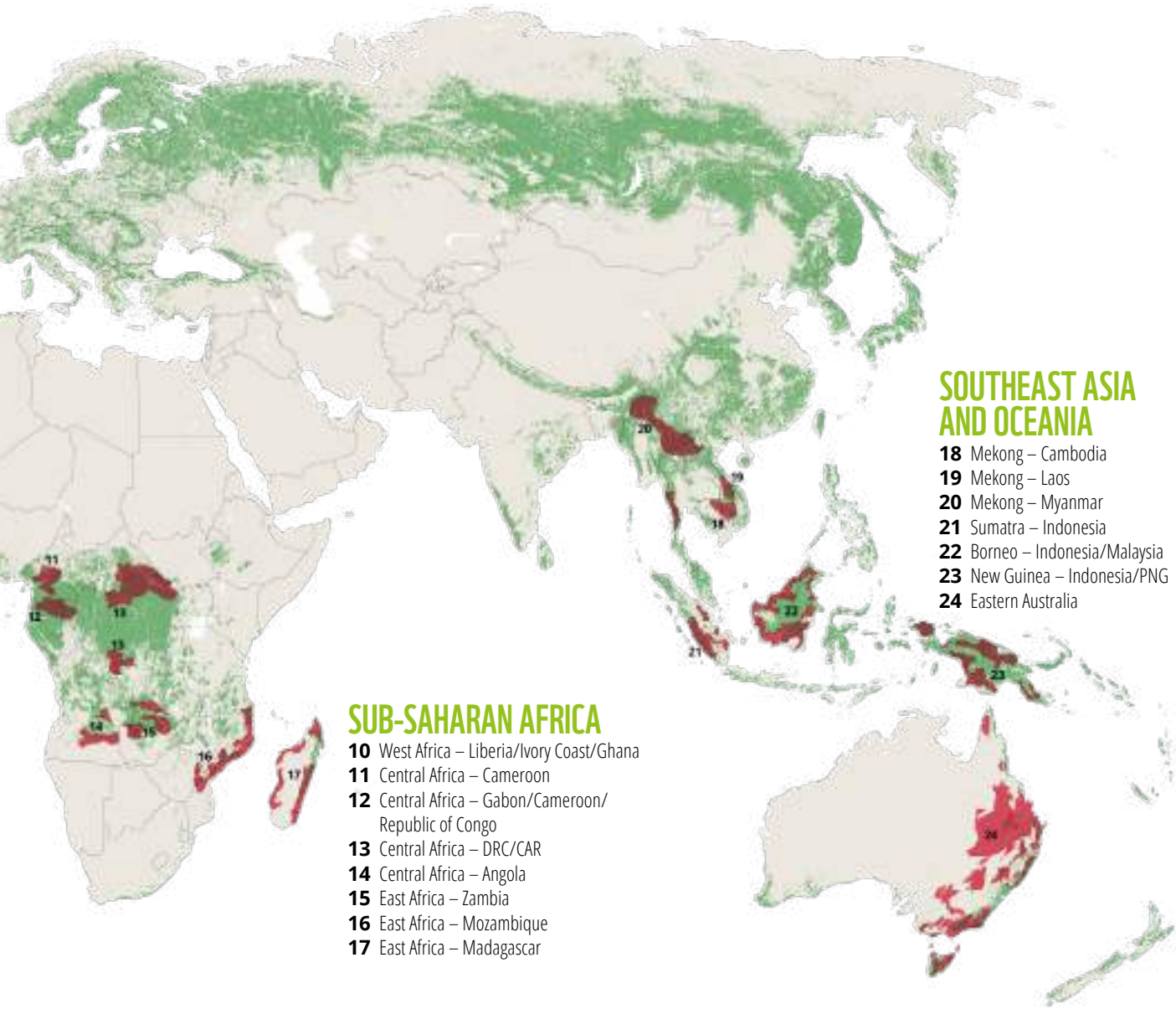
The 24 deforestation fronts cover an area of 710 million hectares. Half of this area is currently forested (377 million hectares or about a fifth of the world's total forest area in the tropics and sub-tropics), with primary or intact forests making up around two-thirds (256 million hectares). Over 10% of the forest area in the deforestation fronts, about 43 million hectares, was lost within the boundaries of these fronts between 2004 and 2017.

Nearly half of the standing forest in these fronts – around 45% – has experienced some type of fragmentation. Fragmented areas and forest edges are more prone to fire, and are more susceptible to human intervention due to higher accessibility.

Drivers of deforestation - old and new trends

We already know a good deal about the drivers of deforestation, from agriculture and plantations to infrastructure development and extractive activities. Yet the shifting influence of these drivers over time is less well understood. These drivers tend to change depending on global market and investment trends, national political shifts, and local political economies, among others.

One common thread is the steady development of roads associated with the expansion of mining and logging that is often followed by commercial agriculture. Conversion to agriculture is also linked to climatological and topographic conditions, market logistics and land speculation that tend to persist in frontier areas. A distinctive driver of deforestation



SOUTHEAST ASIA AND OCEANIA

18 Mekong – Cambodia
19 Mekong – Laos
20 Mekong – Myanmar
21 Sumatra – Indonesia
22 Borneo – Indonesia/Malaysia
23 New Guinea – Indonesia/PNG
24 Eastern Australia

SUB-SAHARAN AFRICA

10 West Africa – Liberia/Ivory Coast/Ghana
11 Central Africa – Cameroon
12 Central Africa – Gabon/Cameroon/ Republic of Congo
13 Central Africa – DRC/CAR
14 Central Africa – Angola
15 East Africa – Zambia
16 East Africa – Mozambique
17 East Africa – Madagascar

is cattle ranching and soy in Latin America – the former primarily in the Amazon and the latter in Cerrado and Chaco – and timber and oil palm plantations in Southeast Asia.

In Africa subsistence agriculture remains a key driver of forest loss, yet commercial agriculture tends to expand over time, accompanied by small-scale timber extraction for energy, though this is mainly associated with forest degradation rather than deforestation.

A new trend in several regions is the increasing number of smallholders growing commodity crops such as cacao, oil palm, maize and raising cattle – sometimes for export but often to fulfil a rapidly rising demand in domestic markets. Deforestation also expands in places where there is pressure from informal mining operations and expansion of human settlements.

Illegal large-scale logging, often to supply international timber markets, has also led to forest degradation, which is often followed by forest clearing. Large-scale logging, however, is slowly being replaced by informal smaller-scale timber operations linked to domestic and regional markets, mainly for fuelwood and construction. Timber extraction is also used to finance further forest clearing in some frontier areas.

The influence of indirect pressures underpinning these trends is less clear. Economic and global population growth leading to increased food consumption has led to an expansion of commercial agriculture. Growing demand also fuels land speculation and encroachment on public forestlands and lands under control of IPLCs. These trends are often accompanied by the expansion of illegal and/or informal economies, activities that in some cases tend to involve local and business elites.

In addition, governments tend to stimulate investment in agriculture and extractive industries, linking it to their objectives of economic growth, but often not taking fully into account the needs and perspectives of rural people including IPLCs, smallholder farmers and landless rural poor.

DRIVERS OF DEFORESTATION BY FRONT

The following maps show the 24 deforestation fronts, which were identified based on emerging deforestation hotspots analysis in the tropics and sub-tropics, identifying places where deforestation significantly increased from 2004-2017. Remaining forest is shown in green. The icons indicate the direct drivers for each of the fronts: primary causes of forest loss and/ or severe degradation are in red and secondary causes are denoted in orange.

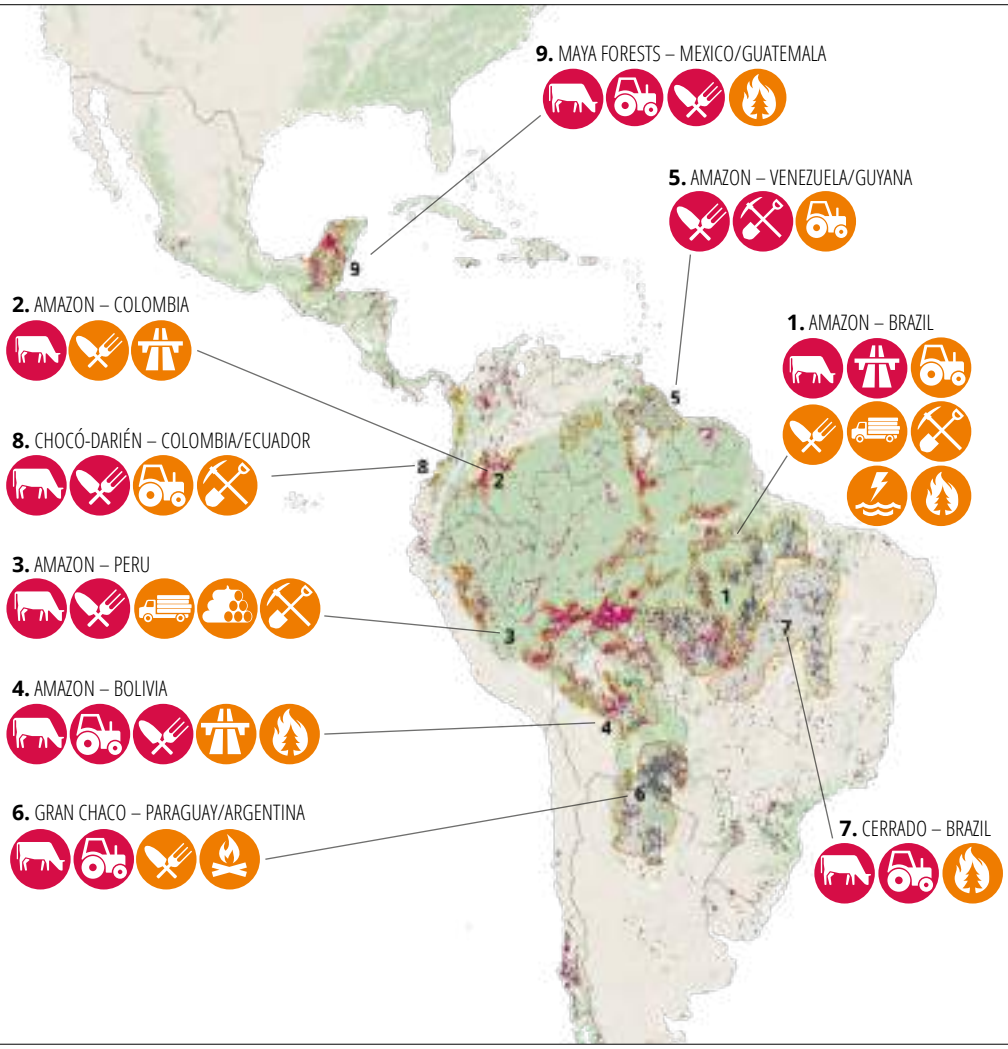
- Cattle ranching
- Large-scale agriculture
- Smallholder farming
- Tree plantations
- Large -scale logging
- Small-scale timber
- Fuelwood and charcoal
- Mining
- Transport infrastructure
- Hydroelectric power
- Urban expansion
- Fires

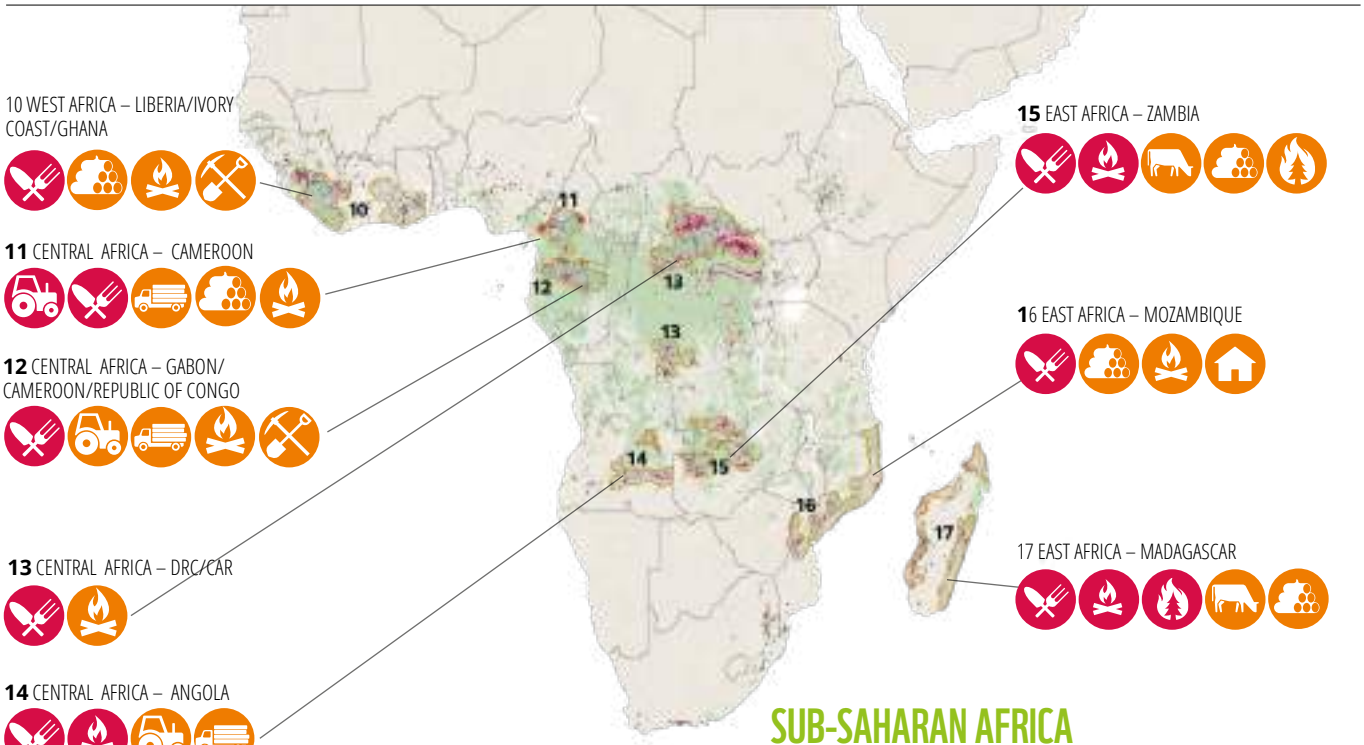
- Forest area (2018)
- Deforested since 2004
- Deforestation hotspot
- Deforestation front

For more detailed information, visit the interactive deforestation fronts dashboard here.

LATIN AMERICA

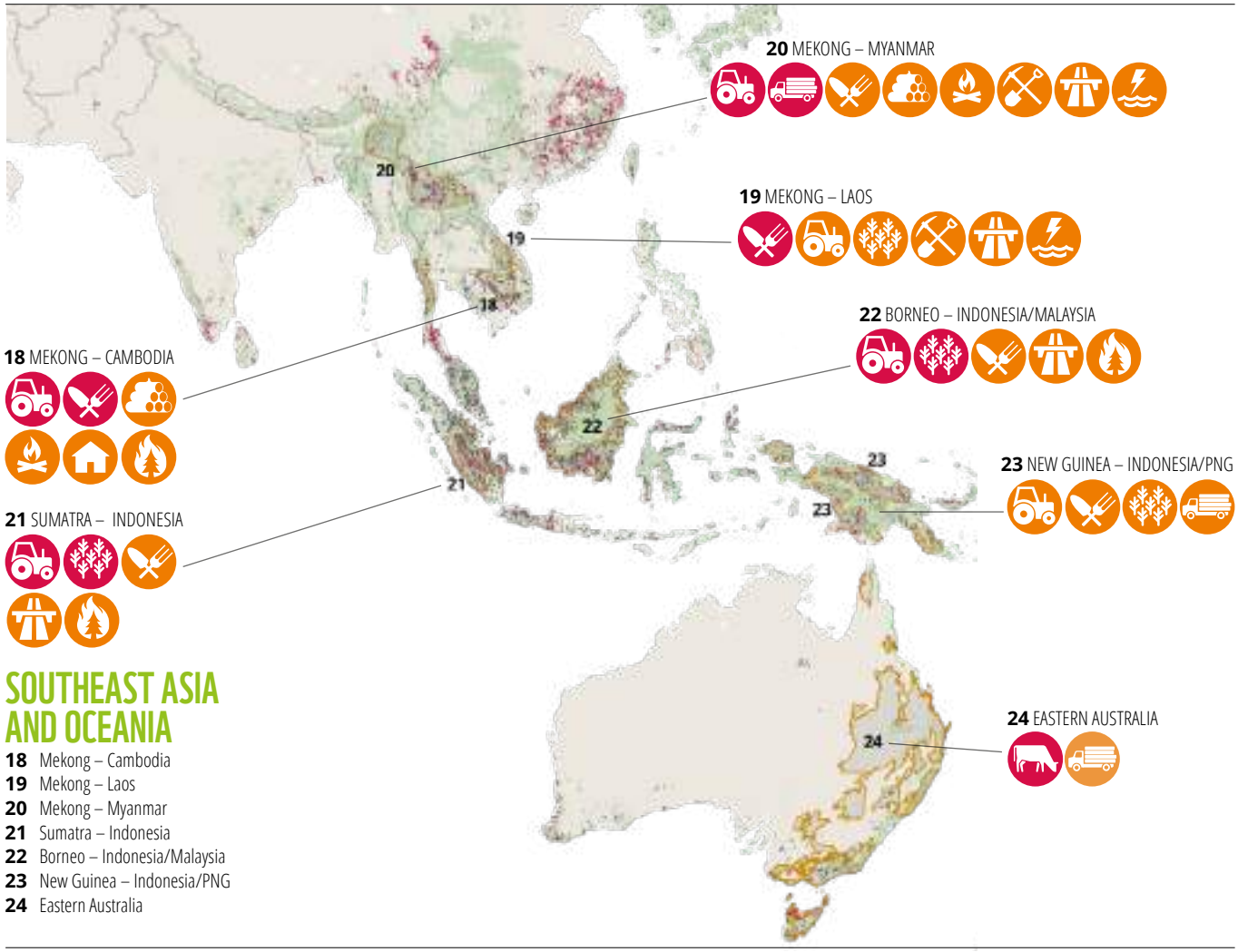
1. Amazon – Brazil
2. Amazon – Colombia
3. Amazon – Peru
4. Amazon – Bolivia
5. Amazon – Venezuela/Guyana
6. Gran Chaco – Paraguay/ Argentina
7. Cerrado – Brazil
8. Chocó-Darién – Colombia/ Ecuador
9. Maya Forests – Mexico/ Guatemala





SUB-SAHARAN AFRICA

10 West Africa – Liberia/Ivory Coast/ Ghana
11 Central Africa – Cameroon
12 Central Africa – Gabon/Cameroon/ Republic of Congo
13 Central Africa – DRC/CAR
14 Central Africa – Angola
15 East Africa – Zambia
16 East Africa – Mozambique
17 East Africa – Madagascar

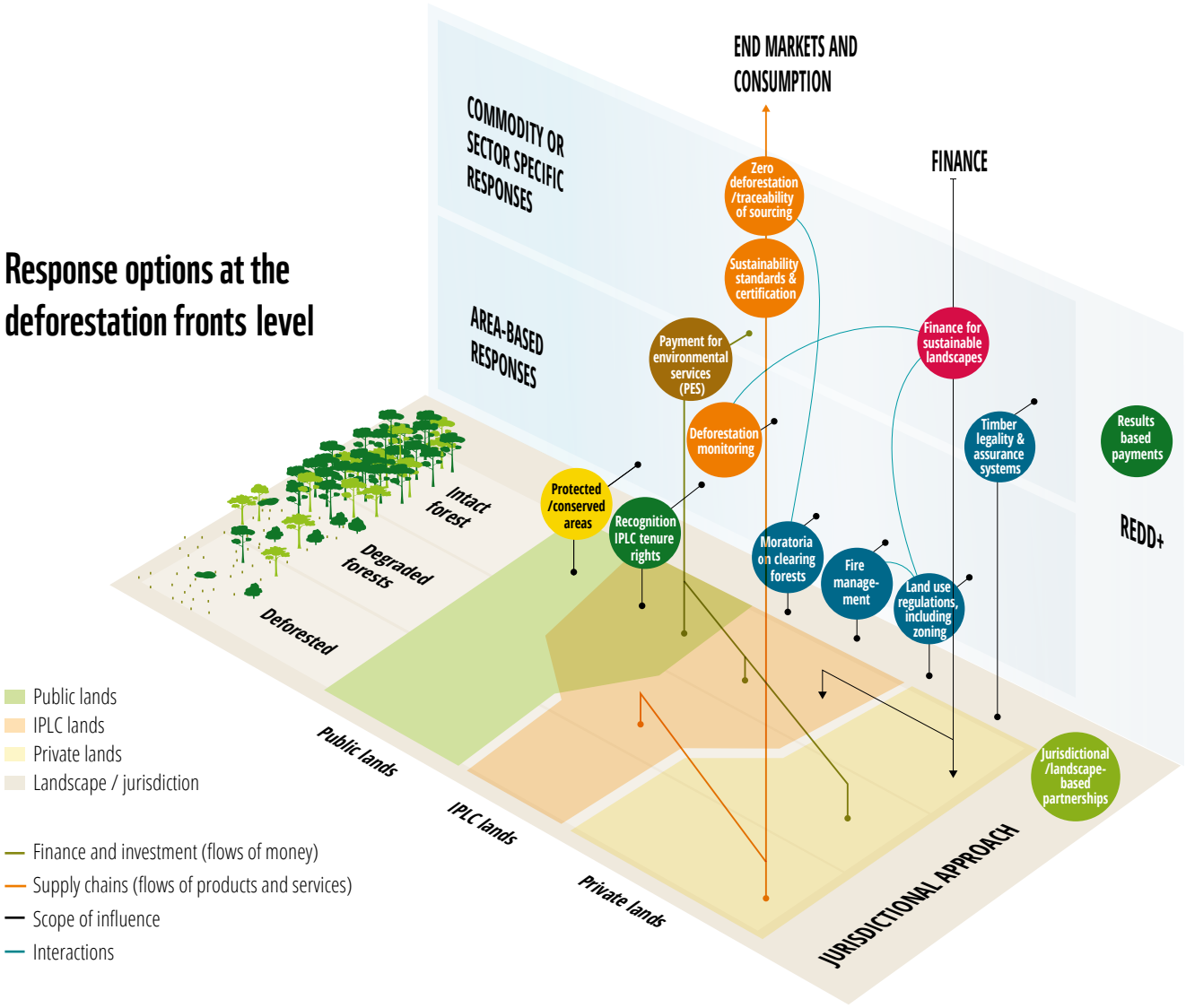


SOUTHEAST ASIA AND OCEANIA

18 Mekong – Cambodia
19 Mekong – Laos
20 Mekong – Myanmar
21 Sumatra – Indonesia
22 Borneo – Indonesia/Malaysia
23 New Guinea – Indonesia/PNG
24 Eastern Australia

RESPONSES TO DEFORESTATION: EVOLVING APPROACHES

Response options at the deforestation fronts level



Approaches to halting deforestation have evolved over time. In particular, there has been a shift from relying solely on state policies and regulations to an increased emphasis on market-based initiatives, including PES and certification schemes. Corporate commitments to zero deforestation have also been increasing, including those of financial institutions.

Approaches tend to emphasis different dimensions and goals, all of which are related to addressing deforestation and forest degradation. They have aimed at protecting the human rights of IPLCs, supporting the conservation of biodiversity-rich areas and maintenance of environmental services, as well as promoting legal production and trade, sustainable supply chains and responsible finance. Two approaches have emerged seeking to link multiple interventions. The first is REDD+, the UN-backed scheme for reducing emissions from deforestation and forest degradation. The second are jurisdictional and landscape approaches that are aimed at tackling deforestation along with achieving wider sustainable development objectives, often at sub-national or landscape scales.

The above approaches embrace different type of responses that fall under two main groups:

1. Area-based responses include the recognition of IPLCs land tenure rights, governance of those lands and territories, and sustainable economies within them. In addition, include other type of area-based strategies such as protected areas, moratoria, fire management and land use regulations.
2. Sector/commodity-specific responses include legality and assurance systems, voluntary sustainability standards and certification, zero-deforestation policies and traceability in sourcing, PES, financing for sustainable landscapes, and deforestation monitoring.

There is some overlap between these two groups of responses, since some area-based responses apply to a specific sector, while some sectoral responses focus on a particular area. Additional, yet more integrated responses include results-based payments and jurisdictional-based partnerships, both of which tend to build upon or combine various types of responses circumscribed to specific territorial boundaries.

WHAT HAVE WE LEARNED?

A number of responses have shown positive effect, with some achieving impacts at scale faster than others, but there is no certainty that these responses won't be reversed. Therefore, they need to be accompanied by conditions that ensure their permanence in the long run (e.g. by continued political support), increase their uptake and expand their scale over time (e.g. by lowering costs, improving the sharing of benefits, or redefining market access). In addition, good monitoring systems are critical to address illegality, inadequate implementation or partial compliance and leakage (the displacement of conversion from one place to another).

Area-based approaches, including protected and conserved areas, are often effective in reducing forest loss; however, they often lack management capacity and financial resources to prove effective. Recognizing indigenous peoples and community land rights, and their local management practices and governance systems have contributed to protect forests under effective local control. Moratoria to avoid deforestation within entire biomes has worked when accompanied by legal enforcement. These approaches, however, cannot avoid leakage into other areas.

Forest certification has been effective in improving forest management around the world; however, it was not aimed at halting deforestation, and its uptake was limited across those forest users engaged primarily in local, domestic, or regional market where certification is not demanded. Certification systems of other agricultural commodities are increasingly adopting zero-deforestation criteria, but have yet to have impact at scale in deforestation fronts.

Though zero-deforestation commitments by companies are a key step, most commercial enterprises struggle to drive a conservation agenda without supportive national laws and policies. When government policies coincide with private initiatives, major decreases in forest loss can follow, as was the case in the Brazilian Amazon – when the government was supportive of reducing deforestation and implemented laws to do so – and in parts of Indonesia. But there has to be continued commitment for long-term achievement of outcomes.

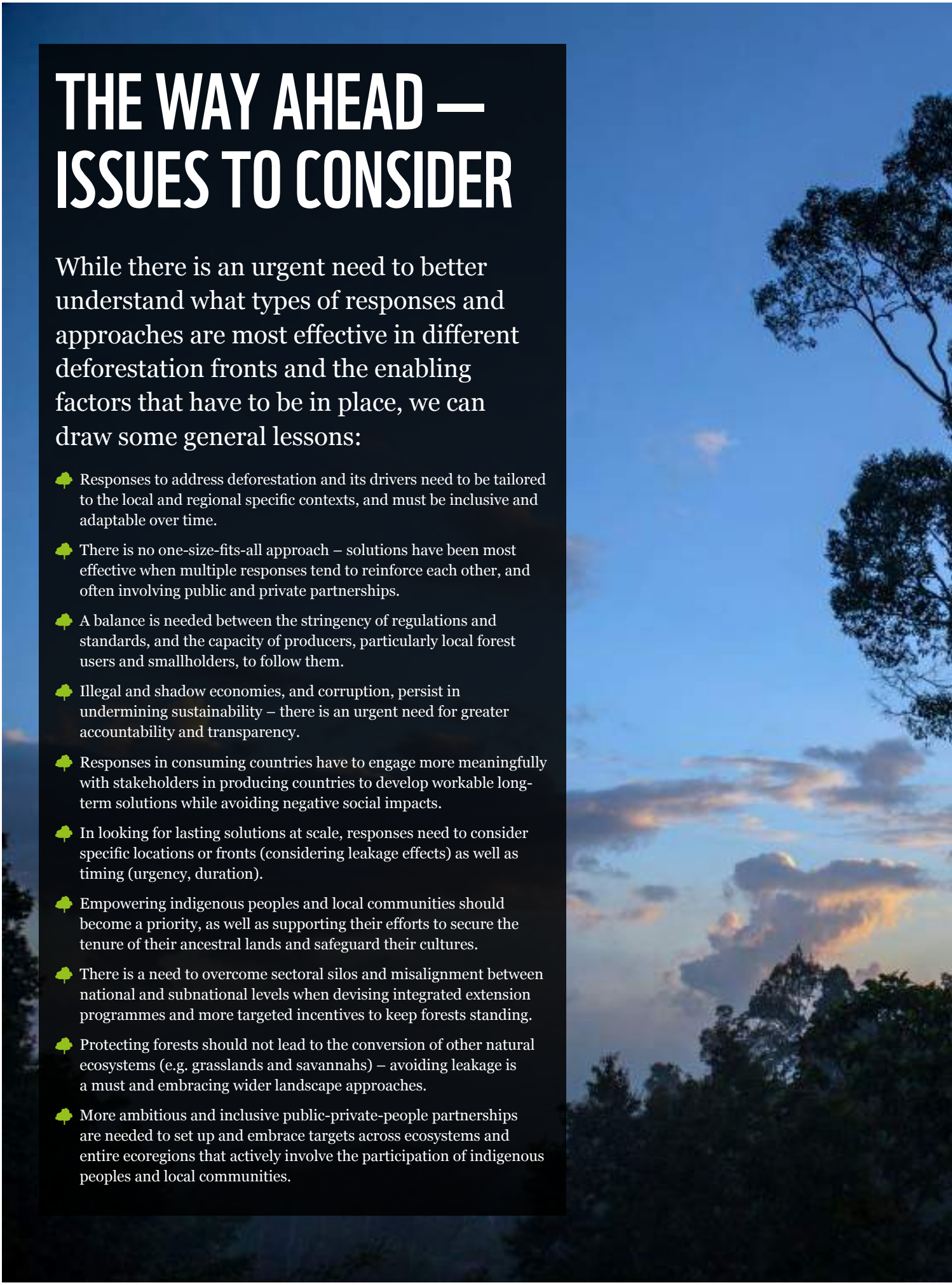
Securing provision of environmental services – mainly through payment or compensation schemes for biodiversity, carbon and water – has worked in specific places through project-based private transactions, but only on a limited scale. State-sponsored programmes reaching large numbers of farmers have overcome this limitation, but this does not always lead to additional conservation outcomes.

Initiatives such as REDD+ and jurisdictional/landscape approaches have been embraced as a way to offer integrated long-term perspectives for halting deforestation and forest degradation. REDD+ initiatives have emphasized more robust monitoring, reporting and verification in public policy, but more needs to be done to affect the political and economic forces shaping business as usual.

Responses to address deforestation and its drivers need to be inclusive and tailored to the local and regional contexts. Solutions have been most effective when multiple response options are combined.

Jurisdictional or landscape approaches promote transitions to more sustainable and inclusive low-carbon economies in a defined area, often at the subnational level. Key factors include supporting public–private partnerships, de-risking finance schemes, advancing land-use planning, clarifying tenure and supporting land conflict resolution, facilitating wider uptake of sustainability practices and clarifying responsibilities of government bodies at the jurisdictional level. This approach is promising, and more knowledge is needed on its actual effectiveness and the challenges it faces.

Finally, the Covid-19 crisis, the implications of which are not analysed in this report, may open the door for the kind of transformational changes that have been identified as necessary for some time: a changed relationship with nature, addressing over-consumption and putting greater value on health and equity rather than the current overwhelming emphasis on economic growth and financial profits. What we have learnt above all is that responses to address deforestation and its drivers need to be inclusive and tailored to the local and regional contexts. Solutions have been most effective when multiple response options are combined in ways through which they can establish reinforcing effects among each other.



THE WAY AHEAD — ISSUES TO CONSIDER

While there is an urgent need to better understand what types of responses and approaches are most effective in different deforestation fronts and the enabling factors that have to be in place, we can draw some general lessons:

- Responses to address deforestation and its drivers need to be tailored to the local and regional specific contexts, and must be inclusive and adaptable over time.
- There is no one-size-fits-all approach – solutions have been most effective when multiple responses tend to reinforce each other, and often involving public and private partnerships.
- A balance is needed between the stringency of regulations and standards, and the capacity of producers, particularly local forest users and smallholders, to follow them.
- Illegal and shadow economies, and corruption, persist in undermining sustainability – there is an urgent need for greater accountability and transparency.
- Responses in consuming countries have to engage more meaningfully with stakeholders in producing countries to develop workable long-term solutions while avoiding negative social impacts.
- In looking for lasting solutions at scale, responses need to consider specific locations or fronts (considering leakage effects) as well as timing (urgency, duration).
- Empowering indigenous peoples and local communities should become a priority, as well as supporting their efforts to secure the tenure of their ancestral lands and safeguard their cultures.
- There is a need to overcome sectoral silos and misalignment between national and subnational levels when devising integrated extension programmes and more targeted incentives to keep forests standing.
- Protecting forests should not lead to the conversion of other natural ecosystems (e.g. grasslands and savannahs) – avoiding leakage is a must and embracing wider landscape approaches.
- More ambitious and inclusive public-private-people partnerships are needed to set up and embrace targets across ecosystems and entire ecoregions that actively involve the participation of indigenous peoples and local communities.

Chris J Ratcliffe / WWF-UK

1. INTRODUCTION: OBJECTIVES AND AUDIENCE

The report has three objectives:

1. It provides arguments to support a range of ongoing national and international policy processes aimed at addressing deforestation and forest degradation, to highlight the importance of adopting more comprehensive approaches and ambitious targets for forest conservation.

2. It speaks to policy-makers, the corporate sector, civil society organizations and social organizations, identifying leverage points in efforts to halt and reverse global forest loss where efforts to introduce sustainable practices are needed, particularly in landscapes and supply chains.

3. It provides knowledge for conservation practitioners to better target interventions that are adapted to local realities to effectively halt deforestation and forest degradation.

While forests covered about **50%** of the earth's land area 8,000 years ago

Today only **30%** of land is forested

1.1 DEFORESTATION: A WICKED PROBLEM

Human pressure on forests is a persistent trend across the globe yet has changed in pace and magnitude over time [1]. Forest cover loss has led to loss of biodiversity and ecosystem services and contributed to climate change [2, 3]. While forests covered about 50% of the Earth's land area 8,000 years ago, today only 30% of land is forested [4]. Forest cover loss has human and natural causes, but the major driver is human activities that lead to a permanent conversion of forests to other land uses, or deforestation in the strict sense.

Deforestation is often linked to expanding commercial agriculture to meet increasing consumption [5, 6], along with subsistence agriculture to support the livelihoods of a large number of rural people [7, 8]. Deforestation tends to be preceded by forest fragmentation that leads to forest degradation and loss of wildlife, a long-lasting trend in many forests [3]. Forest degradation can also result from unsustainable logging and/or fires [9]. Forest degradation and deforestation both tend to reflect wider political, social and economic transitions facing societies such as urbanization, commodification, globalization, agricultural intensification and, lately, growing environmental effects linked to climate change.

Different theories have emerged to explain the causal mechanisms of forest cover change, including theories of land-use spillovers and theories of land-use transitions [10]. In addition, the "forest transition" theory is an analytical framing to explain dynamics in forest cover loss and gains [11]

Forest degradation and deforestation both tend to reflect wider political, social and economic transitions facing societies such as urbanization, commodification, globalization, agricultural intensification, and lately growing environmental effects linked to climate change.

Deforestation tends to be preceded by forest fragmentation that leads to forest degradation and defaunation, a long-lasting trend in many forests [3].

and suggests that forests within some specific administrative jurisdictions or landscapes can shift from shrinking to expanding over time [12]. Deforestation, however, is also seen as a "wicked problem" since it has multiple and evolving facets, is triggered by factors operating at different scales, and cannot be overcome with single-oriented responses [13]. For example, efforts to halt deforestation in one place may lead to growing deforestation somewhere else, something known as leakage [14].

There is a significant body of work aimed at understanding forest cover loss and deforestation dynamics, and the factors shaping them. Understanding about the responses or actions and interventions put in place by both state and non-state actors aimed at halting deforestation is also rapidly developing. The analysis of deforestation drivers ranges from global studies looking at the spatial influence of drivers [15] to other studies assessing the links between consuming and producing countries [16, 17]. These studies also focus on context-specific drivers and interactions in specific places, which have also been captured in a growing number of meta-analyses of deforestation drivers [18, 19]. The methods and sources of information have evolved and are getting more sophisticated, and while there is better understanding about deforestation drivers and trends, more knowledge is needed to understand the effectiveness of multiple responses. Nonetheless, despite knowledge about the drivers and types of responses that should be in place, deforestation continues.

Deforestation tends to oscillate over time. It has proved difficult to reduce and halt and even more difficult to reverse trends of forest loss, particularly in the tropics. In the rare cases where deforestation has been significantly reduced it has proven difficult to sustain those trends over time, which suggest that long-term efforts are needed. Progress in reducing deforestation, has often been associated with a combination of different responses, which can take place at different levels and involve collaboration between public and private actors.

1.2 A FRAMEWORK LINKING DRIVERS AND RESPONSES

Drivers and responses interact among each other. Drivers' impact on forests is mediated by the influence of responses, and responses also evolve to address the impact of shifting drivers. Figure 1.1 offers a framework—that underpins this report's structure—linking drivers and responses. Both play a role in shaping the dynamics of deforestation fronts, which is at the centre of our analysis. The framework shows that direct (proximate) drivers (i.e. agriculture, extractives, infrastructure) are influenced by indirect (underlying) drivers (i.e. demographic, technological, political, economic, environmental). These interactions result in specific pressures shaping the expansion of deforestation fronts. The drivers are counteracted by different types of responses (area-based and commodity or sector specific) embraced by different approaches (single-oriented and integrated). The specific impact of drivers and the action of responses in any deforestation front is associated with context-specific land-use decisions influenced by some mediating factors operating in each front.

Deforestation and **forest degradation** are the two key ingredients of **deforestation fronts**, which are the places with the largest concentration of forest loss or severe degradation in the world. An earlier WWF analysis of deforestation fronts in 2015 [20] used a predictive approach, suggesting that the fronts were the places of projected deforestation from 2010 to 2030. This report focuses on past deforestation during the last 18 years, while offering a more specific understanding of these different fronts.

Deforestation is the permanent conversion of forest to another land use or significant long-term reduction of tree canopy cover. This includes conversion of natural forest to tree plantations, agriculture, pasture, water reservoirs and urban areas; but excludes logging areas where the forest is managed to regenerate naturally or with the aid of silvicultural measures [20].

Forest degradation results from changes within forests that negatively affect the structure or function of the stand or site, and thereby lower the capacity of forests to supply products and/or ecosystem services [20] There are many aspects in forest degradation [21].

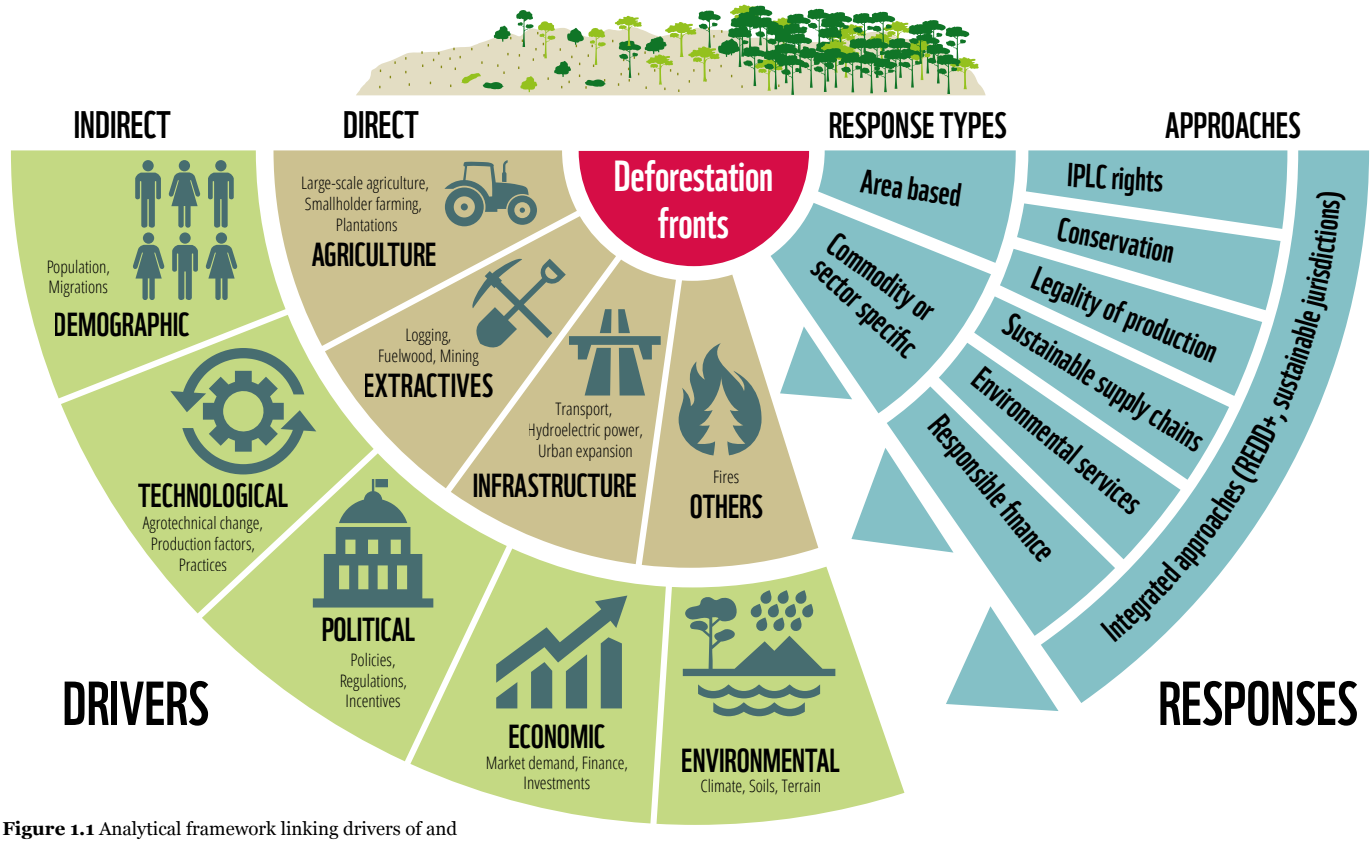


Figure 1.1 Analytical framework linking drivers of and responses to deforestation

The drivers causing deforestation and forest degradation are diverse, operate at multiple scales, and their specific influence may change over time, especially during the evolution of particular deforestation fronts that are preceded by degradation. Here we define **drivers** as all the factors natural and anthropogenic that, directly or indirectly, contribute to forest cover loss or forest degradation [22], and **pressures** are the specific manifestation of these drivers.

- **Direct or proximate drivers** are those factors that have direct physical or behavioural impact on forests leading to forest degradation or conversion of forests to other land uses. They are often associated with four broad groups of drivers, namely: agriculture and timber plantations, extractive activities, infrastructure and other factors such as fire.
- **Indirect or underlying drivers** are those factors that have a more diffuse influence on degradation and deforestation by altering and influencing direct drivers. The indirect drivers comprise demographic, technological, political, economic and environmental factors

The approaches aimed at reducing forest degradation and halting deforestation, or more widely, governing land-use decisions that influence land use change in deforestation fronts, are multiple and originate from actions involving either governments, business sector, civil society organizations, and social organizations.. At least six **single-target oriented approaches** have been implemented with effects on forest conservation and degradation, which are not exclusive. These approaches are as follows:

Securing the rights of indigenous peoples and local communities (IPLC)

Securing conservation of biodiversity-rich forest areas

Ensuring legality of production and trade

Enhancing sustainability of supply chains

Maintaining the provisioning of environmental services

Mainstreaming responsible finance.

Drawing on these, and by acknowledging their potential and limits, two more integrated approaches have emerged: (1) integrated policy frameworks under **REDD+** (Reducing emissions from deforestation and forest degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks), and (2) **jurisdictional approaches** seeking to align interests and coordinate actions among governments, businesses, local communities, and NGOs toward shared conservation, supply chain sustainability, and low-carbon development goals.

These approaches, privilege differentiated theories of change and levers of change, and embrace different types of actions and/or interventions in support of conservation or halting deforestation and forest degradation by using incentives and sanctions. We label these actions and/or interventions as responses. The responses embraced by the different approaches can be grouped in two:

- **Area-based responses,** primarily aim to conserve primary or intact forest landscapes and to avoid unsustainable forest use by defining the extent and condition of land to be dedicated to specific uses (e.g. protected and conserved areas), tenure regimes (e.g. indigenous peoples and community lands), or specific land uses or management systems (e.g. moratoria, fire management, land zoning). These can be subject of targeted support and monitoring.
- **Commodity or sector-specific responses,** rely mainly on the capacity to enforce specific economic activities, and the uptake and mainstreaming of sustainability practices in supply chains, trade and finance around specific commodity crops or sectors. These responses comprise those aimed at improving the quality of management (e.g. certification, traceability), and monetary incentives for rewarding conservation outcomes (e.g. PES, sustainable finance).

Deforestation and forest degradation have differentiated social and environmental impacts across the different fronts, which depend on the specific drivers on place, and are influenced by the type of responses adopted. Looking at the socio-environmental impacts of deforestation is beyond the scope of this analysis.

Structure of the report

This report is organized in five sections including this introduction. Section 2 identifies 24 deforestation fronts across Latin America, sub-Saharan Africa, Southeast Asia and Oceania based on a deforestation hotspots analysis for the period 2004-2017, which updates a previous deforestation fronts analysis conducted by WWF in 2015. Section 3 provides a comparative analysis of drivers and Section 4 of responses across deforestation fronts. Finally, Section 5 suggests some ways forward in support of more integrated solutions to tackle deforestation and forest degradation that build on current efforts while asking for wider transformative change. A detailed description of the methods used in the analysis is provided in the Appendix. The report also includes 24 factsheets that provide key data and describe specific drivers and responses, outcomes achieved and recommends future actions for each of the identified deforestation fronts.

2. DEFORESTATION FRONTS

KEY MESSAGES

From 2000 to 2018 two-thirds of total global forest cover loss occurred in the tropics and sub-tropics. There is a higher total annual forest cover loss in the tropics, and higher annual rates of loss in the subtropics.

We identified 24 deforestation fronts across 30 countries, comprising over half (52%) of the total deforestation in Latin America, sub-Saharan Africa, Southeast Asia and Oceania. Thus, there is also scattered deforestation outside the boundaries of these deforestation fronts.

Nine of the deforestation fronts are in Latin America, eight in Africa and seven in Asia and Oceania. In some the deforestation rate is declining, while others show a moderate or rapid increase.

The location of the deforestation fronts is broadly similar to the last WWF analysis in 2015, although several new fronts have emerged, and deforestation tends to be more widespread than acknowledged before.

Bornean elephants walk through an oil palm plantation and eat the trunks of felled old oil palm trees in Sabah, Borneo

2.1 SETTING THE SCENE

Important progress has been made in understanding global forest cover trends based on increasing availability of data, but consistent and reliable estimation of global forests and/or tree cover loss and degradation remains difficult to obtain[23]. The challenge of producing robust estimates relates not only to how forests are defined[24], but also to the methods, timeframes and sources of information that are used, as well as whether the analysis takes into account forest gains.[25-27]. Measuring forest degradation is even more challenging, since definitions vary from those that only look at the productive capacity of forests, carbon stocks or canopy cover[3] to others acknowledging that forest degradation is a multi-dimensional phenomenon[21]. We focus our analysis on deforestation fronts within and across countries, acknowledging that deforestation and forest degradation are a global problem unfolding differently across regional contexts.

Two data sources of forest cover change are often cited: the UN Food and Agriculture Organization (FAO) Global Forest Resources Assessment (FRA) and the Hansen/UMD/Google/USGS/NASA tree cover loss database used by Global Forest Watch (Hansen/GFW). Hansen/GFW indicates growing trends of forest tree loss, while FAO FRA suggests deforestation is high but has decreased over time (see Box 2.1 for a comparison).

Our analysis, given its main goal of assessing deforestation dynamics across deforestation fronts, requires a dataset that allows for comparison across deforestation fronts. We derived our deforestation fronts based on Emerging Hotspot Analysis using Terra-I datasets that detects land-cover changes in Latin America, Africa, Asia and Oceania from 2004 to 2017. We selected this dataset based on its temporal and spatial resolution and because it allows identification of vegetation loss due to anthropogenic causes (see Appendix 1 for a description of methods). In addition, to improve our current understanding of deforestation from 2000-2018 and forest cover dynamics, we produce forest cover maps for years 2000 and 2018 by looking across five different datasets:

1. ALOS PALSAR, forest and non-forests for non-boreal forests for 2007-2017[33]
2. European Space Agency (ESA) Climate Change Initiative (CCI) global land cover map for 1992-2015[34]
3. MODIS IGBP Global land cover for 2000-2015[35]
4. Hansen/GFW examining tree cover loss for 2001-2012, Landsat derived[29], with updated data from 2012 to present[36]
5. Terra-I, MODIS derived, detecting land-cover changes in Latin America, Africa, Asia and Oceania from 2004 to present[37]

A detailed description of the methods followed to conduct this analysis is presented in Appendix 2. Additional fragmentation analysis was conducted assessing the forest maps for 2000 and 2018 (see Appendix 3 for a description of methods). We estimated forest cover and deforestation dynamics across all deforestation fronts identified.

Deforestation in our analysis consists of observations (pixels) changing from forest to non-forest at any time between 2000

Box 2.1 Two contrasting perspectives of forest loss: Hansen/GFW and FAO FRA

The FAO FRA measures forest change since 1990, assessed every five years[28], while Hansen/GFW looks at tree cover loss since 2001[29]. The FRA is based on country assessments of land use including areas cleared of trees but expected to be reforested under a given management regime, while Hansen/GFW measures actual forest presence based on tree height and percent of canopy cover at 30m spatial resolution detected from remote sensing.

The latest FAO FRA 2020 indicates that the world is still losing forests, but the pace of loss has slowed[30]. According to the FRA, forest area is 4.06 billion ha in 2020 (or 31% of the total land area), and 420 million ha of forests have been lost since 1990. Average annual deforestation, according to FRA revised estimates, is still high but has decreased from 16 million ha/year in 1990-2000 to 15 million ha/year in 2000-2010, 12 million ha/year in 2010-2015 and 10 million ha/year in 2015-2020[30]. FAO estimates suggest that forest gains have increased over time – although slowing in recent years – leading to a declining net forest loss. The rate of net forest loss declined from 7.8 million ha/year in 1990–2000 to 5.2 million ha/year in 2000–2010 and 4.7 million ha/year in 2010–2020. Africa, followed by South America, had the largest annual rate of net forest loss in 2010–2020, while Asia had the highest net gain of forest area. However, many of these gains will be from plantations or secondary forests while the world is still losing natural forests.

Hansen/GFW suggests increasing tree cover loss from 2001 to 2019, but does not look at tree gains in the same period. Tree cover loss is "defined as a stand-replacement disturbance, or a change from a forest to non-forest state" and can represent deforestation (conversion of natural forests to other land uses), or factors such as mechanical harvesting, fire, disease or storm damage[29]. According to Hansen/GFW, total annual tree cover loss almost doubled from 13.6 million ha in 2001 to 25.5 million ha in 2018, reaching over 30 million ha in 2016 and 2017. Total loss was 370 million ha from 2001 to 2018, equivalent to 21.8 million ha/year. Over a third of total loss was in the tropics (35%), followed by losses in boreal (27%), temperate (20%) and sub-tropical forests (18%)[29]. Additional analysis differentiates primary humid tropical forests loss[31]. Recent updates indicate that 11.9 million ha of tree cover was lost in the tropics in 2019, of which 3.8 million ha were humid primary forests[32]. In contrast with FAO, by including factors like plantation management and natural fires, the Hansen/GFW figures estimate a greater area of natural forest loss.

to 2018. This is a conservative analysis since it accounts for forest loss only in places where at least two datasets agreed, and because it uses a spatial resolution of 250m given the original resolutions of the datasets incorporated. This resolution was also chosen on the principle that forest areas should be a minimum of 250x250m (6.25 ha) to contain the functional attributes of a forest (e.g. species distribution, ecology, ecosystem services), rather than including individual trees or small groups of trees[38]. Furthermore, it should be noted that this analysis underestimates the conversion of dry forests or woodlands, and other natural ecosystems (e.g. grasslands) that are also under large pressure[see 39].

Forest degradation is a multi-dimensional problem. Here we use forest fragmentation as one proxy for forest degradation that can easily be detected through remote sensing; while this is a critical element of forest degradation it does not capture all its aspects[40]. The changes in spatial pattern and structure by fragmentation of forest into smaller patches or "islands" damages forest functions (e.g. carbon storage, water provision, maintenance of species habitat) [41-43]. Several of these impacts are created by changes at the forest edges, which include changes in exposure to different microclimates, fire frequencies, wind speeds, and other forms of fragmentation-mediated mortality[44]. The increasing isolation of forest patches from each other or from core forest contributes to long-term changes in biodiversity, including species richness and productivity, creating fundamental and sometimes irreversible changes in forest landscapes[41].

Our analysis suggests that in the period from 2000 to 2018 about two-thirds of total deforestation took place in tropical and sub-tropical biomes, followed by boreal and temperate forests. A portion of the loss, particularly in temperate and boreal forests, will not be permanent and might refer to other types of natural forest disturbances produced by insects, fire and severe weather, as well as by felling of plantations or semi-natural forests as part of forest management. A higher annual average of total deforestation is observed in the tropics, and annual deforestation rates are higher in the sub-tropics. Annual deforestation rates are similar in South America and Africa, followed by those in Asia. Most tropical deforestation is in South America and Asia, while subtropical forest cover loss is mainly in South America and Africa. About 20% of total forest cover loss takes place in core forest, which we label "primary deforestation", and the remaining 80% took place in the edge and patched forests, which is labelled as "secondary deforestation".

The overall increase of fragmented forest area during 2000-2018 is larger than deforestation during the same period, except in subtropical forests. Worldwide, the total area of "primary degradation" (or fragmentation of core forests into forest with more edges) is more than four times that of "secondary degradation" (or the conversion of edge forests already fragmented into more fragmented classes, which are more accessible and easier to deforest)[41]. This indicates that forest fragmentation leads to a significant reduction in intact forest ecosystems and may stimulate further forest conversion to other land uses, or make those forests more vulnerable to fires.

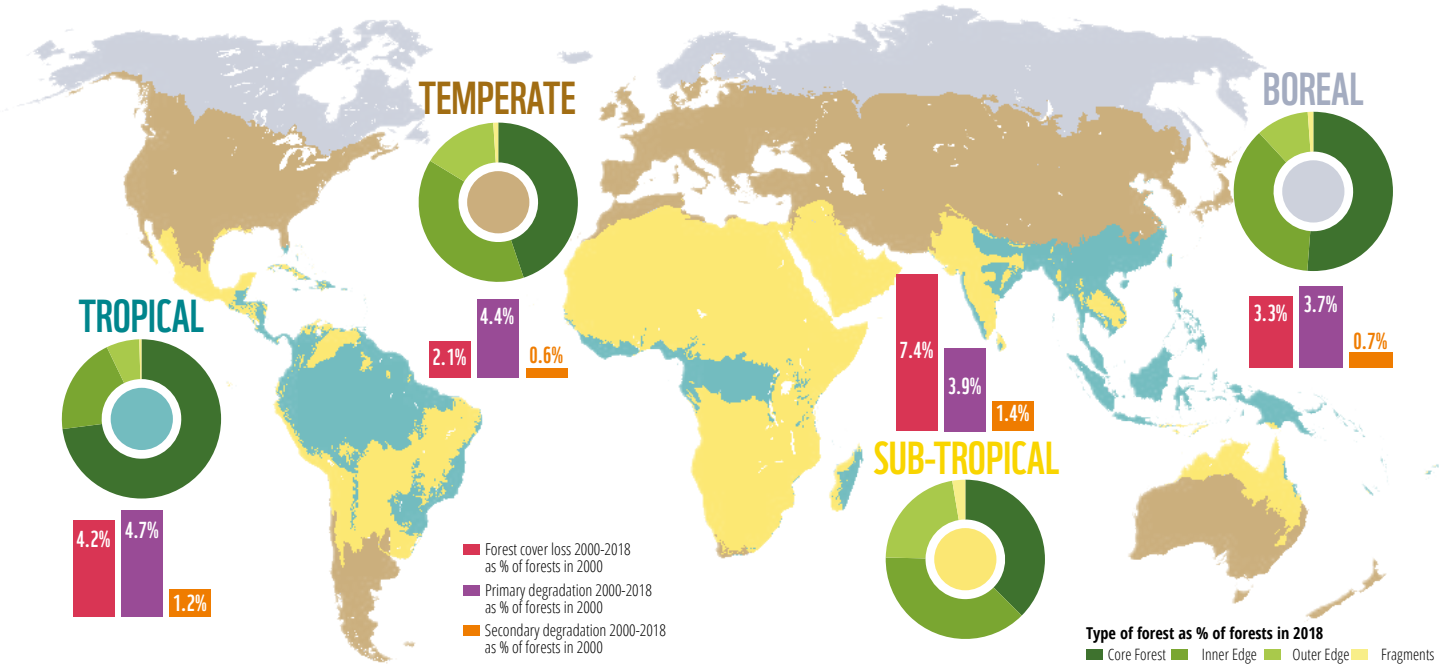


Figure 2.1 Forest cover loss and forest degradation by biome in the period 2000-2018

2.2 DEFORESTATION FRONTS

Deforestation fronts are the places at imminent risk of large-scale deforestation. A WWF (2015) report *Saving Forests at Risk*[20] identified 11 deforestation fronts suggesting that they would account for more than 80% of projected deforestation between 2010 and 2030, or up to 170 million ha. The current analysis provides new insights in these deforestation fronts dynamics by using an approach that differs in two major ways from the previous one. Firstly, it draws primarily on empirical evidence of deforestation derived from an Emerging Hotspot Analysis. Secondly, it looks at past and current forest loss due to human activities in places where there is still a significant area of remaining forests but does not include any predictive analysis. Nonetheless, since deforestation tends to happen contiguous to previously deforested areas, it is likely that deforestation will continue in these fronts.

We follow a two-step approach to revisiting the deforestation fronts analysis. First, we undertook an Emerging Hotspot Analysis, which is increasingly used in assessments of forest cover loss and deforestation, particularly at national scales, but with scalability potential to smaller or larger regions[45]. Our analysis used 10km2 hexagons within country boundaries, based on the time series of the Terra-i data[37] for Latin America, Africa, Asia and Oceania for the period from 2004 to 2017 for which validated data was available at the time of writing. We then used this analysis, complemented by a literature review and expert opinion, to draw the boundaries of 24 deforestation fronts in the locations with the largest concentration of deforestation.

We identified 24 active deforestation fronts, nine in Latin America, eight in Africa, and seven in Asia and Oceania. See Figure 2.2 for the location of these fronts, and Figure 2.3 for information on average annual deforestation rates.

These deforestation fronts comprise over half (52%) of the total deforestation that took place in Latin America, sub-Saharan Africa, Southeast Asia and Oceania, or 59% if countries where timber plantations tend to dominate are excluded (taking as reference deforestation estimates from Terra-i during the period 2004-2017). This suggests that, despite the importance of these fronts, a significant portion of deforestation is widespread and not only clustered in these identified hotspots.

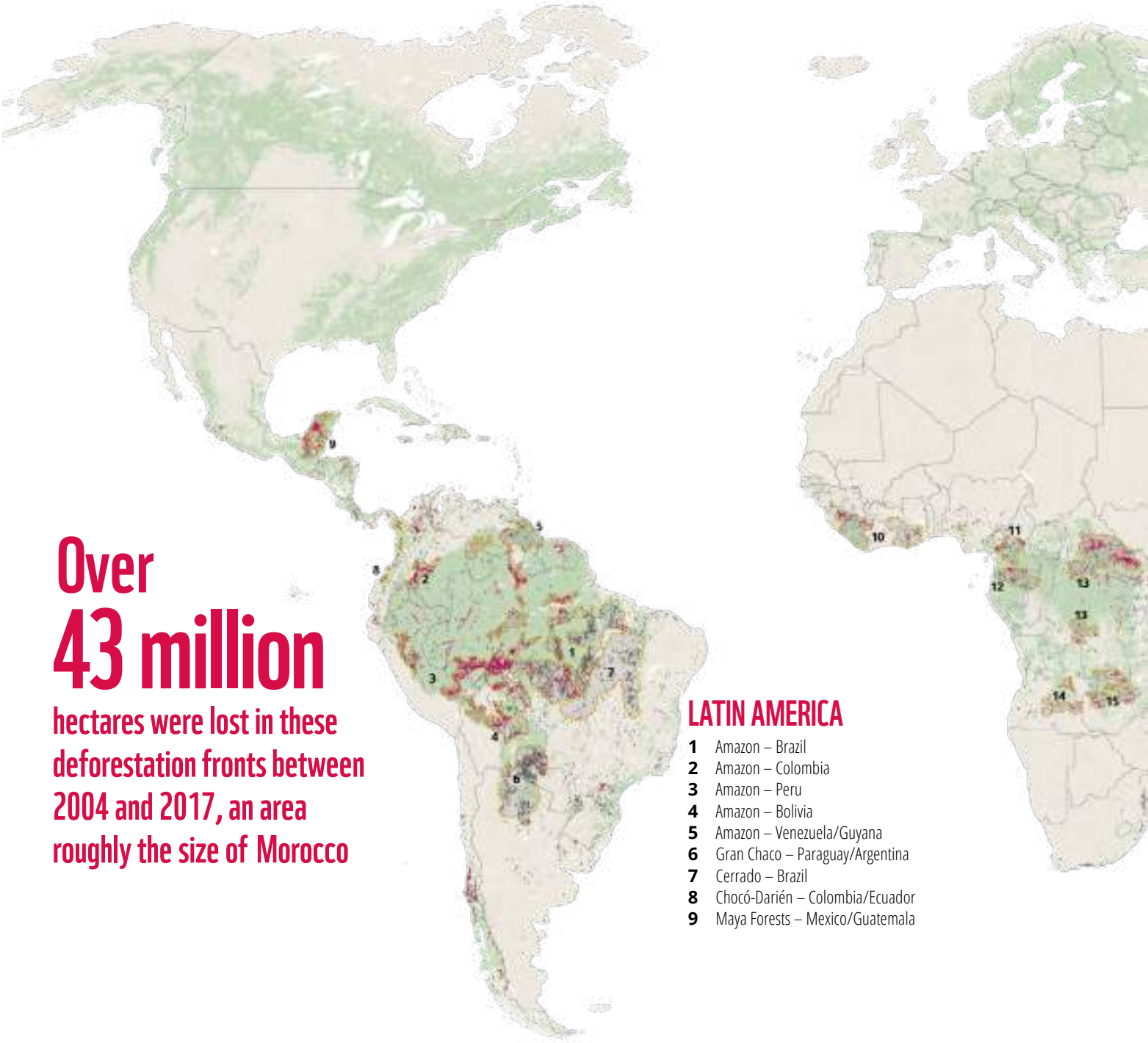
Compared with analysis undertaken in WWF's 2015 assessment, the location of several fronts is the same (e.g. Amazon, Central Africa, the lower Mekong, Indonesia), but many have kept expanding and taking over forestlands. In addition, new fronts not identified in previous analysis have appeared in West Africa (e.g. Angola), Madagascar and Latin America, including the northeast portion of the Amazon in Guyana and Venezuela and the Maya Forest in Mexico and Guatemala (see Box 2.2).

Box 2.2 Comparison of past and present deforestation fronts

WWF's 2015 *Saving Forests at Risk* report[20] identified 11 deforestation fronts, in contrast with the 24 deforestation fronts shown in Figure 2.1. The 2015 report considered fronts at the regional level. Some of these have now been subdivided into more uniform territorial units, and a few more deforestation fronts have emerged or been recognized.

- The Amazon, which was a single deforestation front in the 2015 analysis, has been subdivided into five different fronts in 1. Brazil, 2. Colombia, 3. Peru, 4. Bolivia, 5. Venezuela and Guyana.
- The Congo Basin has been subdivided into three fronts in 1. Cameroon, 2. Gabon, Cameroon and Republic of Congo, and 3. Democratic Republic of the Congo (DRC). and Central African Republic (CAR).
- The Lower Mekong has been subdivided into three fronts: 1. Cambodia, 2. Laos, and 3. Myanmar.
- East Africa has been subdivided into 1. Zambia and 2. Mozambique.
- Deforestation fronts that remain the same as in the 2015 analysis are 1. Malaysian and Indonesian Borneo, 2. Cerrado in Brazil, 3. Chocó-Darién (Colombia, Ecuador), 4. Eastern Australia, 5. Gran Chaco (Paraguay, Argentina), 6. Sumatra, Indonesia and 7. New Guinea (Papua Province, Indonesia and Papua New Guinea).
- Deforestation fronts that were not part of the 2015 analysis are those in 1. Angola, 2. West Africa, 3. Madagascar, and 4. the Maya Forest in Mexico and Guatemala.

DEFORESTATION FRONTS



Over 43 million

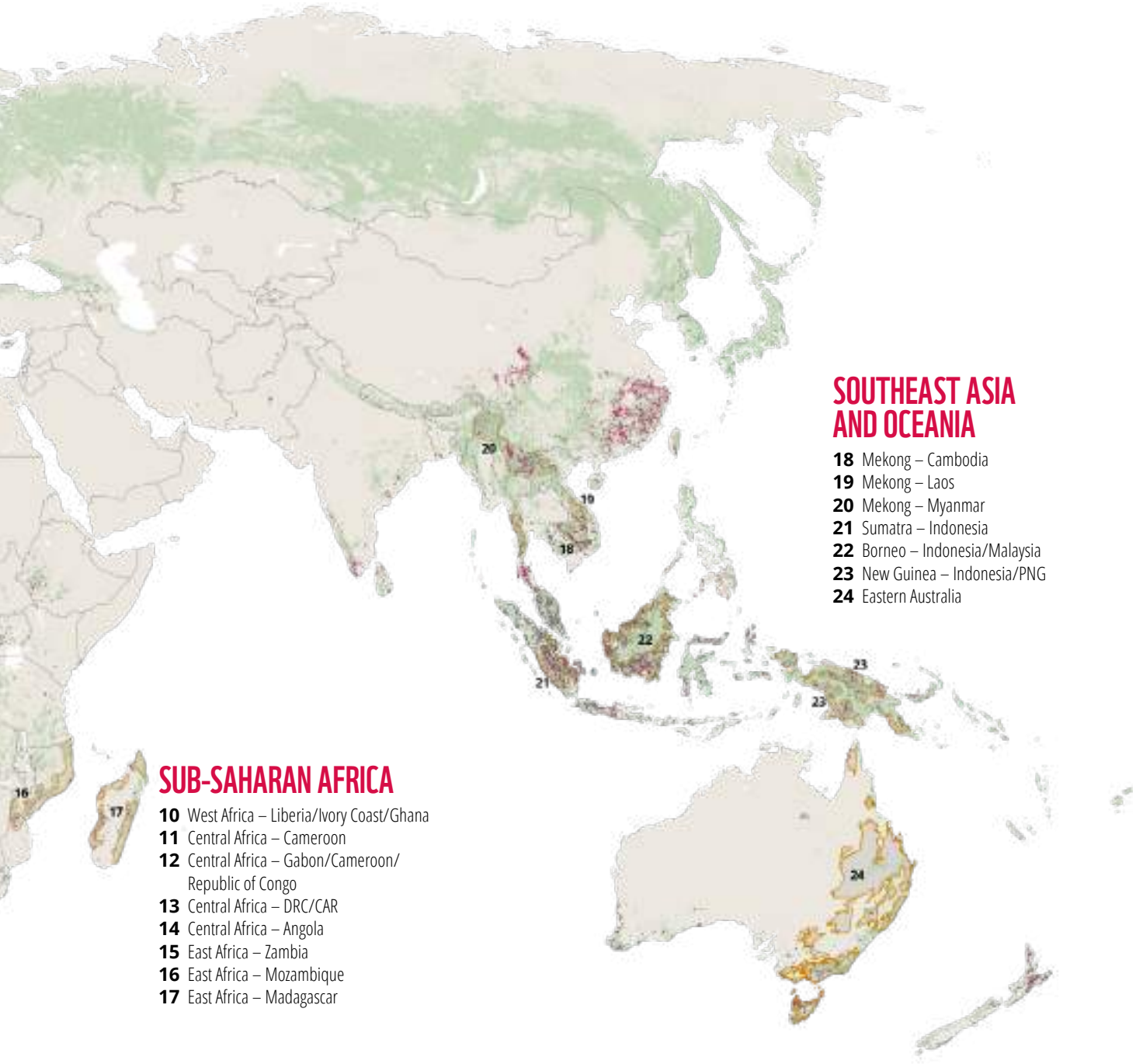
hectares were lost in these deforestation fronts between 2004 and 2017, an area roughly the size of Morocco

LATIN AMERICA

1. Amazon – Brazil
2. Amazon – Colombia
3. Amazon – Peru
4. Amazon – Bolivia
5. Amazon – Venezuela/Guyana
6. Gran Chaco – Paraguay/Argentina
7. Cerrado – Brazil
8. Chocó-Darién – Colombia/Ecuador
9. Maya Forests – Mexico/Guatemala

Figure 2.2. Deforestation fronts in Latin America, sub-Saharan Africa, Southeast Asia and Oceania

- Forest area (2018)
- Deforested since 2004
- Deforestation hotspot
- Deforestation front



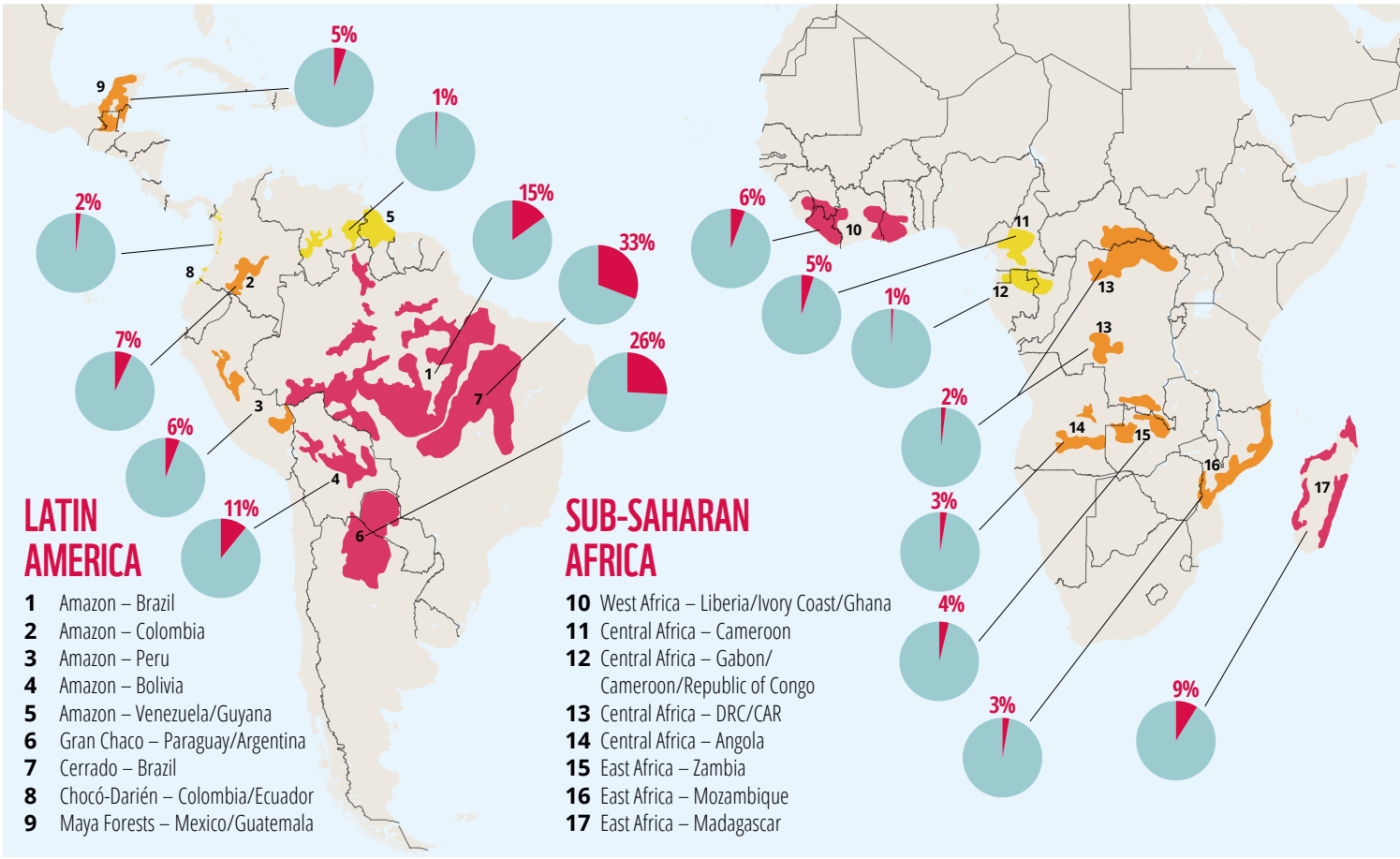
SOUTHEAST ASIA AND OCEANIA

18 Mekong – Cambodia
19 Mekong – Laos
20 Mekong – Myanmar
21 Sumatra – Indonesia
22 Borneo – Indonesia/Malaysia
23 New Guinea – Indonesia/PNG
24 Eastern Australia

SUB-SAHARAN AFRICA

10 West Africa – Liberia/Ivory Coast/Ghana
11 Central Africa – Cameroon
12 Central Africa – Gabon/Cameroon/ Republic of Congo
13 Central Africa – DRC/CAR
14 Central Africa – Angola
15 East Africa – Zambia
16 East Africa – Mozambique
17 East Africa – Madagascar

2.3 KEY FACTS ACROSS FRONTS



Deforestation continued to expand in many of the fronts identified in WWF's 2015 assessment. Deforestation trends tend to oscillate over time. The Brazilian Amazon is a case in point: according to official sources, annual deforestation dropped from a peak of 2.8 million ha in 2004 to 457,000 hectares in 2012, but has shown a growing trend since then[46] surpassing 1 million ha in 2019[47]. In contrast, in Indonesia, according to official statistics, deforestation has oscillated but the trend indicates a downward trajectory. The country's total net deforestation was over 1 million ha per year in early 2000s, it dropped below 500,000 ha per year from 2009-2011 to increase again to 1 million ha annually in 2014-15. It was estimated to be 439,000 ha in 2017-18[48, 49].

Our assessment of deforestation based on five datasets for the period 2000-2018 indicates that nine deforestation fronts underwent high rates of deforestation, including several in Latin America (Brazilian Amazon and Cerrado, Bolivian Amazon, Paraguay and Argentina), Madagascar in Africa, and Sumatra and Borneo in Southeast Asia. Ten fronts experienced medium deforestation including some countries in sub-Saharan Africa (CAR, DRC, Angola, Zambia, Mozambique), the Amazon (Colombia, Peru), Lower Mekong (Laos, Myanmar) and Eastern Australia. Five fronts faced low deforestation, including in Central Africa (e.g. Cameroon, Gabon, Republic of Congo), New Guinea and Chocó-Darién (Figure 2.3).

When looking at annual deforestation trends based on Terra-i data for 2004-2017, a moderate increase with oscillations is observed in 10 fronts (mainly those located in the western Amazon, Mesoamerica and East Africa), and a rapid increase with oscillations in 11 fronts, mainly those located in Central Africa and Lower Mekong. There was a decline of deforestation in three deforestation fronts (Brazilian Amazon, Chocó-Darién, Cameroon) during the second half of the 2000s until the early 2010s but it has increased more recently. Figure 2.4 shows key additional information on these fronts regarding type of remaining forests, annual change of deforestation, and burned areas.

The 24 deforestation fronts cover an area of 710 million ha. Half of this is currently forest (377 million ha), out of which two-thirds (256 million ha) is primary/intact forest (68% of total forest area in 2018). About 10% of the forest cover in 2000 was lost within the boundaries of these deforestation fronts between 2004 and 2017. More than a half of the standing forest is core forests (55%), and the rest (45%) has undergone some type of fragmentation. All fronts saw an increase in fragmentation in 2000-2018, but the rates were highest in Madagascar, West Africa, CAR and DRC, Mayan Forest and Sumatra.

About 73 million ha, or almost one-sixth of the total forest area in 2000, was burnt at least once in the period from 2002 to 2019. This contributes to further forest degradation that may end up in deforestation in areas facing pressure from agricultural expansion. Higher cumulative burned areas are observed in the Brazilian Amazon, Central Africa, East Africa and Eastern Australia, although fronts with dry forest vegetation and woodlands (e.g. Chaco, Cerrado, Angola, Zambia, Mozambique) have experienced a higher incidence of burning relative to their forest area in 2000.

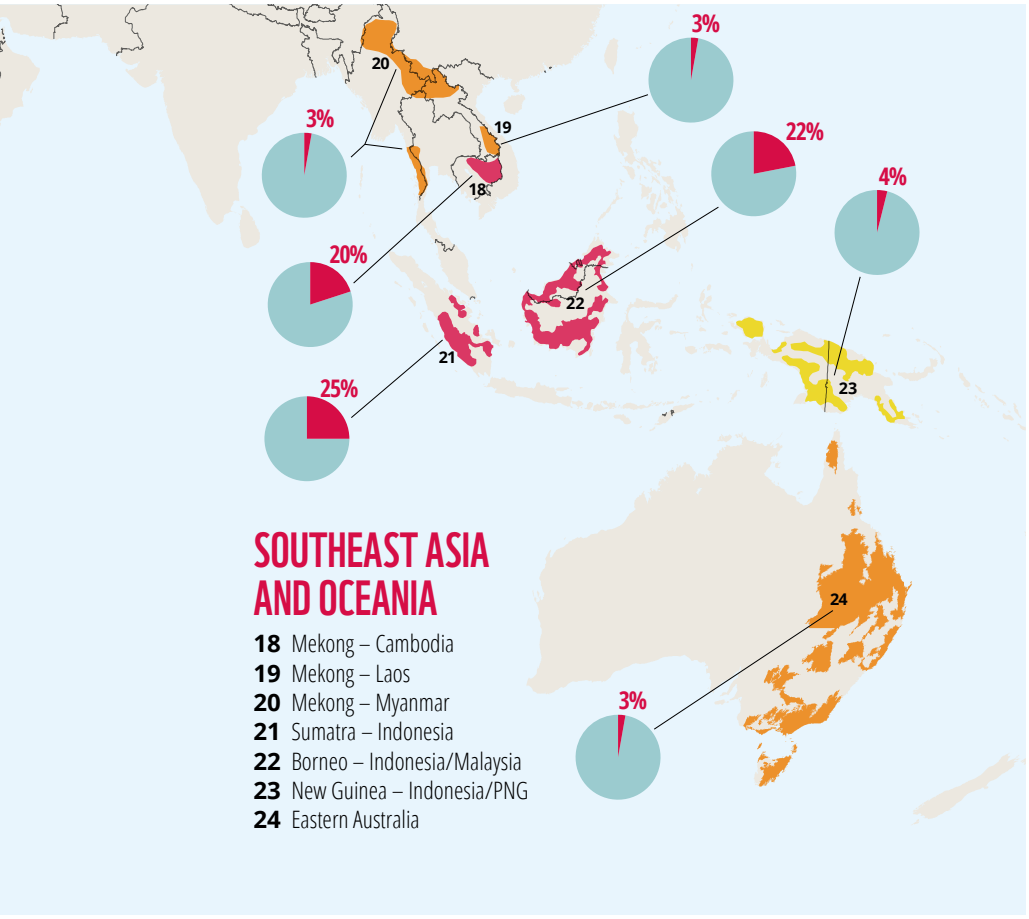


Figure 2.3 Type of deforestation fronts according to average annual deforestation rates in Latin America, sub-Saharan Africa, Southeast Asia and Oceania.

Average annual deforestation in the period 2000-2018 for the whole deforestation front

- Low <0.1%
- Medium 0.1-0.5%
- High >0.5%

Deforestation 2004-2017 as a percentage of forest area in 2000

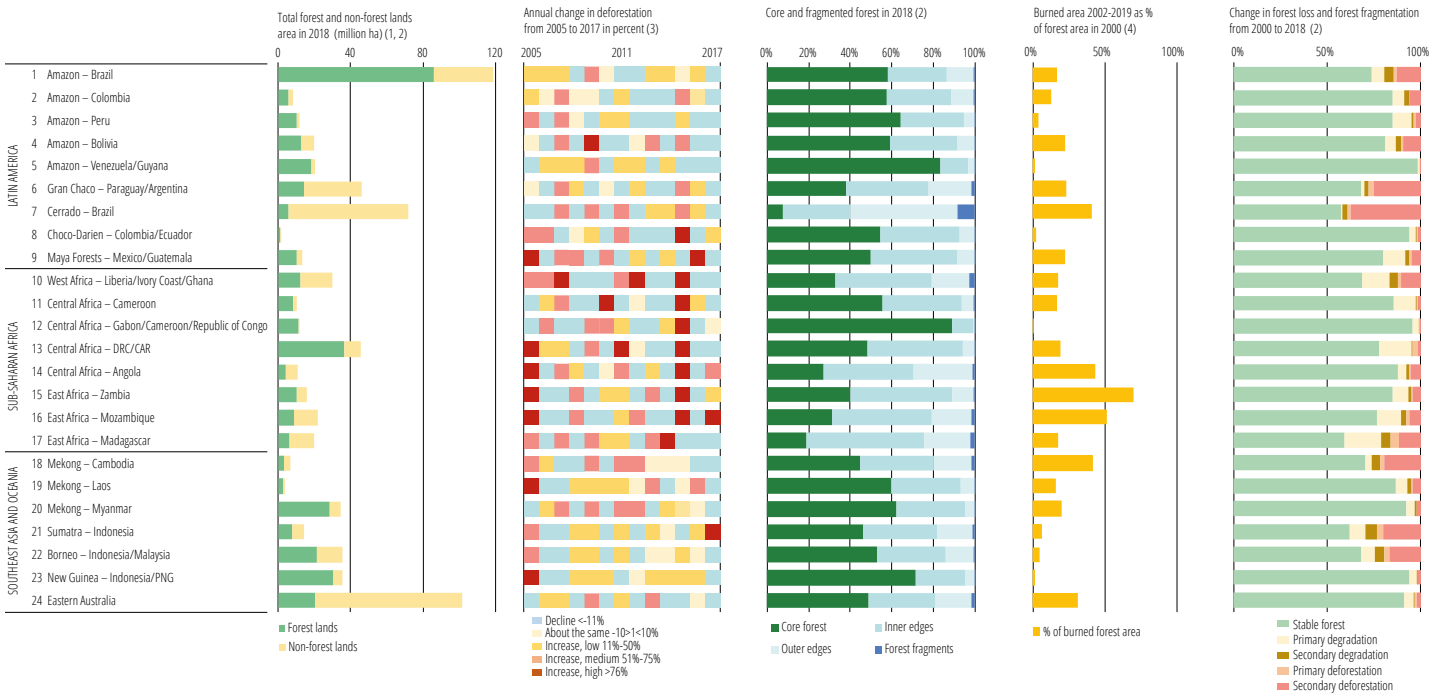


Figure 2.4 Comparison of key facts across 24 deforestation fronts in Latin America, sub-Saharan Africa, Southeast Asia and Oceania

Notes:
1. Non-forestlands in Cerrado, Eastern Africa and Eastern Australia include woodlands, grasslands and other natural ecosystems; 2. own estimates based on an assessment of five land use/land cover datasets for years 2000 and 2018, (see Appendix 2 for a description of the methods used); 3. based on estimates from Terra-i for the period 2004-2017, http://www.terra-i.org/terra-i/; 4. derived from the MODIS MCD64A1 monthly burned area product for the period Jan 2002-Dec 2019, http://lpdaac.usgs.gov/products/mcd64a1v006/

3. DRIVERS OF DEFORESTATION

KEY MESSAGES

- Drivers of deforestation are not static, and the influence of different drivers and actors tends to change over time and across regions mainly depending on political and market shifts.
- Among the direct drivers, commercial agricultural expansion continues to have the largest influence on deforestation, mainly in Latin America and Asia, while the contribution of smallholders keeps growing. In Africa small-scale agriculture remains the primary driver of deforestation.
- Logging has generally declined as a primary driver of forest degradation and loss, although it still often precedes clearing for other purposes, and both legal and illegal logging remain significant factors in some countries.
- Deforestation is most likely in places where there is a growing expansion of road networks connecting production zones to export and domestic markets. But fronts also expand where there is pressure from informal mining operations and expansion of human settlements.
- Additional pressures on forests originate from encroachment on public lands and IPLCs ancestral lands driven by speculation, sometimes linked to corruption, and taking advantage of unclear tenure rights and weak governance.
- These pressures are amplified by population growth and expansion of demand for timber, food and materials. State needs for fiscal earnings stimulate expansion of roads and agriculture, and mining and settlements in frontier lands.

3.1 DRIVERS OF DEFORESTATION — TAKING STOCK

A significant body of work is available to assess the drivers of forest loss at multiple scales from local to global, and several frameworks have been put together linking different types of drivers. This work has helped to understand the taxonomy of drivers, the multiple interactions, and their specific contributions to either stimulating or constraining deforestation. The most common understanding classifies drivers of deforestation as direct (or proximate) and indirect (or underlying)[19, 50-52]. Indirect drivers, such as population growth, increases in demand, technical changes and policy shifts, interact in multiple ways to create pressures on forests[50]. Their impacts are not clear-cut and may lead to contradictory outcomes by either stimulating or constraining deforestation[53], so their interactions and effects have to be understood across specific contexts. Indirect drivers affect the direct drivers shaping specific forest uses (e.g. logging, timber plantations) and forest conversion to agriculture or other land uses (e.g. mining), as depicted in Section 1, Figure 1.1.

A recent meta-analysis on the drivers that either trigger or stop deforestation[18] argues that deforestation is more likely to occur in places where opportunities for conversion to agriculture are higher, based on the interaction between favourable climatological and topographic conditions as well as transport and access to markets. Causal links are hard to prove, although higher populations tend to drive deforestation. In addition, deforestation has been associated with growing global food demand and shifts in diets, particularly due to an increase in meat-eating[54]. However, only part of this increased demand places pressure on tropical forests as it can be partly met by yield increases in already cleared land[17]. In addition, only a portion of supply coming from cleared tropical forests is linked to global commodity markets, since another portion fulfils the demand from growing domestic markets, also linked to urbanization.

An estimated 29–39% of deforestation-related carbon emissions in the period 2000-2014 were driven by international trade in agricultural commodities, suggesting that a large portion is still due to domestic markets[17]. Although international timber trade is significant, domestic or regional markets also make up the majority of timber consumption, often supplying wood for energy and materials for construction, again linked to the growth of cities[55].

A global non-spatially explicit analysis of proximate drivers of deforestation and forest degradation in the period 2000-2010 based on 46 countries argues that commercial agriculture is the largest driver of deforestation, followed by subsistence agriculture. In addition, timber extraction and logging drives most forest degradation, followed by fuelwood collection and charcoal production[51]. A global forest loss assessment in the period 2001-2015 attributes 27% to expansion of commodity production, 26% to forestry, 24% to shifting agriculture and 23% to wildfires. While some of this loss is permanent, including under commercial agriculture, some is only temporary – particularly forest loss driven by fires, shifting agriculture or forestry, where forests are expected to recover over long time horizons once human activity stops. Other studies show that, in the tropics, drivers of deforestation are regionally specific. An analysis of post-deforestation land uses in the period 1990-2000 indicates that, in Latin America, pasture was the most common land use (72%) followed by large-scale cropland (11%); in Africa, small-scale cropping is the main post-deforestation land use (61%) with a smaller role for pasture (15%); and in Asia, small-scale cropland (35%) was followed by tree crops (28%)[56]. These studies tend to neglect the influence in deforestation of infrastructure and extractive activities.

Our analysis adds more granularity to the existing body of research by examining the influence of indirect and direct drivers in each of the 24 deforestation fronts. In addition, we offer a comparative analysis of the specific influence of drivers across deforestation fronts, while also capturing forest dynamics in the past 15 years. The analysis undertaken here ratifies the argument that the influence of different drivers and actors tends to change over time[57] and depends on the social, political and economic characteristic of the the regional contexts, which is also explained by the role of indirect drivers.

3.2. DIRECT DRIVERS AND SHIFTING TRENDS

The most common direct pressures causing deforestation and severe forest degradation can be classified in four groups:

1. Agriculture and plantations, including cattle ranching, large-scale agriculture, smallholder (cash-income and/or subsistence) farming, and (large- and medium-scale) tree plantations.
2. Extractive activities, including logging (large- and small-scale) and mining
3. Infrastructure expansion, including transport infrastructure, hydroelectric power plants and urban growth
4. Others, such as fires.

The effects of these drivers are not always additive, since they interact in different ways and their influence is mediated by some context-specific factors. In addition, deforestation fronts are influenced by several other factors including local behaviours, values and beliefs, power relations, and governance, among others. They are also affected by a range of social and policy responses, whose effects are analysed in the next section. As a result, the magnitude and the relative influence of these different drivers changes over time. Figure 3.1 contains a simplified representation of the interactions among the different drivers with no distinction across regions.

Table 3.1 compiles the different direct drivers across the four broader categories for each of the 24 deforestation fronts, with colours showing their relative importance: primary causes of forests loss and/or severe degradation are in red, secondary causes in orange and less important causes in yellow. The direction of the arrows shows the increasing or decreasing trend of each specific driver since early 2000, based on a revision of literature and consultations with experts. A detailed description of these drivers is presented in the factsheets at the end of this report. It is important to highlight that in some cases (e.g. Brazilian Amazon, Bolivia, West Africa, Eastern Australia) only a select number of drivers are included in the corresponding factsheets. In addition, Table 3.1 differentiates large-scale logging and small-scale timber extraction, distinction that is not always made explicit in the factsheets (e.g. Peru, Bolivia, Maya Forests, Cameroon, Angola, Cambodia, Laos, Myanmar).

In the **Amazon region**—including Brazil, Colombia, Peru and Bolivia—pressures on forests originate from road expansion, yet the greater effect is likely linked to the development of local roads including logging roads. Some large-scale hydroelectric dams have been established and others are planned, along with development corridors for crop commodity production zones to reach external markets since global demand has increased its influence in shaping agricultural expansion in the region. Pasture expansion for cattle ranching is still the main driver leading to forest conversion, and while it tends to be decreasing in the Brazilian Amazon, it is still expanding in the other Amazon countries. Pasture expansion is in part due to attempts to justify land ownership for speculative rather than productive purposes. Large-scale agriculture also leads to deforestation in places with suitable soils; it tends to occupy already converted lands in places with appropriate market logistics, but it has also led to displacement of ranching into active forest frontiers, and indirectly fuels land speculation. Timber extraction, mainly small-scale illegal logging, tended to decrease in the Brazilian and Bolivian Amazon, but increased in Colombia and Peru. The effects of mining, which is widespread in the region, are more localized and have been greater as a result of informal gold mining in the Peruvian Amazon. Fires tend to follow forest conversion since they are used to remove already clear-cut trees and fallen vegetation, yet some fires also triggered forest conversion in the Brazilian and Bolivian Amazon.

The other regions in Latin America share some attributes but differ in many others. The **Cerrado** and **Gran Chaco** have faced a rapid and extensive expansion of soy production, largely driven by large- and medium-size farmers accompanied by expansion of logistic and storage and crushing facilities in response to a growing global market. Agricultural expansion linked to growing external markets for feed also triggered a very dynamic land market, including speculation and transaction brokered by "land companies". Deforestation drivers in the Mesoamerican **Maya Forest** have also changed. If cattle ranching and traditional smallholder agriculture were major drivers in the past, commercial farming (especially large-scale) plays an increasingly important role. In addition, the shift from collective (sometimes customary) to more individual land tenure regimes has been associated with land purchases by large-scale producers and greater deforestation.

In **Africa** throughout the deforestation fronts, small-scale agriculture remains the primary driver of deforestation. Pressure from large-scale agriculture varies, from minor and possibly even declining in West Africa to playing an increasingly significant role in the Miombo forests of Zambia, Mozambique and Angola. Commercial agriculture is also increasing in the Congo Basin; it is already significant in Cameroon but remains less so in other Congo Basin countries. Fuelwood and charcoal, associated with expanding urban markets, are key drivers but mainly cause degradation rather than complete loss. Fire is also found in all the countries in the Miombo, where fire is traditionally used for the management of Miombo woodlands, yet it may lead to forest degradation. Logging occurs widely but was only considered significant in Cameroon and Angola, though small-scale logging and chainsaw milling is a factor particularly in Central African countries. Transport infrastructure, although projected to be highly significant in the future, is still generally only judged to be a minor cause of forest loss.

The **Lower Mekong** region has experienced steady economic growth and integration of regional and global commodity markets over the last two decades. This has spurred rapid expansion of cash crops including sugarcane, cassava and maize, as well as rubber, oil palm, nut trees and coffee. Both large-scale and smallholder farming are

Table 3.1 Analysis of drivers for 24 deforestation fronts

Deforestation front		Agriculture and plantations				Extractive activities				Infrastructure expansion			Other
Amazon	Brazil	↗	→	→		↘	↘		→	↗	↗		↗
	Colombia	↗		↗			↗		↘	↗			
	Peru	↗	→	↗		↗	↗		↗	↗			
	Bolivia	↗	↗	↗		→	↘		↗	↗	↗		↗
	Venezuela/Guyana	→	→	→		→			↗				
Gran Chaco	Paraguay/Argentina	↗	↗	→			→	→					
Cerrado	Brazil	→	→					→	↗				→
Chocó-Darién	Colombia/Ecuador	↗	↗	↗					↗	↗		→	
Maya Forests	Mexico/Guatemala	↗	↗	↗		↘	→	→				↗	→
West Africa	Liberia/Ivory Coast/ Ghana		↘	↗			→	→	↗	↗			
Central Africa	Cameroon	→	↗	↗		↗	↗	→	↗	→		→	
	Gabon/Cameroon/ Republic of Congo		↗	↗		→		↗	→	↗		↗	
	DRC/CAR		↗	↗		→	→	→	↗	↗			
	Angola		↗	↗	→	↗	→	→	→	↗		↗	↗
East Africa	Zambia	↗		↗			↗	↗	↗	↗			↗
	Mozambique		→	→			→	→				→	→
	Madagascar	→		→			→	→	→	→			→
Mekong	Cambodia		↗	↗	↗	↘	↗	↗	→	↗	→	↗	→
	Laos		↗	↗	↗	↘	↗	↗	→	↗	→		
	Myanmar		↗	↘		↗	→	↗	↗	↗	↗		
Indonesia	Sumatra		↘	↗	↘		↘		→	↗		→	↗
Borneo	Indonesia/Malaysia		↘	↗	↘		↘		→	↗		→	↗
New Guinea	Indonesia/PNG		↗	↗	↗	↗			→	↗			→
Eastern Australia		↗	↗		↗	↗			→	→		→	↗

Relative influence

- Primary cause of forest loss and/or severe degradation
- Important secondary cause of forest loss and/or severe degradation
- Less important cause of forest loss and/or severe degradation

Trends

- Increase ↗
- Decrease ↘
- Stable →

prevalent. However, because of the scarcity of large areas of "empty" land, large-scale economic land concessions for agricultural production are becoming less common. Often local farmers are encouraged by middlemen or contracted by agri-businesses to grow in-demand crops on their land, which are then sold to buyers from all over the region (notably Viet Nam, Thailand, China). Economic growth has also fuelled demand for energy (hydropower), transportation infrastructure and mining, which are secondary drivers of deforestation through the region. As more rural communities are integrated into global markets, traditional agriculture such as shifting cultivation is being replaced by permanent smallholder farms. Due in part to depletion of high-quality timber and in part to stricter enforcement of laws and regulations, the role of logging as a driver of deforestation and severe forest degradation has decreased in recent years. However, demand for high-value species in countries such as China and Viet Nam continues to drive wood extraction in Myanmar, Laos and Cambodia, where large areas of primary forests remain. In some cases, such demand is found to be the motivation for companies to acquire agricultural concessions as legal conversion is being used to circumvent logging bans.

In **Sumatra** and **Borneo** in Southeast Asia, oil palm and pulpwood plantations have been the major drivers of deforestation. A portion of concession land granted to palm oil companies has not been developed and has become a stranded asset for those exposed to larger reputational and financial risks when converting forest to plantations. There is a gap between wood supply from pulpwood plantations and existing and planned pulp milling capacity, which may lead to continued pressures on natural forests. Over time, an increasing number of smallholders have become engaged in commercial crop production. Illegal oil palm plantations, often conducted by smallholders and absentee landholders, have become common in Sumatra and Borneo. Illegal logging in retired logging concessions or protected areas has decreased but still occurs, and localized illegal logging at smaller scales is difficult to stamp out. There are several large-scale mining operations, along with small-scale gold mining, but these operations tend to have a localized impact on forests although they may trigger some indirect pressure by attracting people to frontier areas. Finally, fires are often used in areas after the lands are deforested, but their effects tend to oscillate depending on climatic conditions; fire outbreaks are difficult to control in dry years such as in 2015 and 2019. Along with other policy actions, in the Malaysian part of Borneo, the state governments of Sabah and Sarawak have instituted land-use regulatory frameworks emphasizing the goals to maintain 50% and 57% respectively of total landmass under forest cover.

In **Oceania** there are contrasting trends between New Guinea and Australia. In both countries of New Guinea (Papua province in Indonesia, and Papua New Guinea), subsistence agriculture is still the single most important cause of deforestation, although larger-scale commercial agriculture is also expanding and some smallholders are switching to produce cash crops. Logging remains very important, particularly in Papua New Guinea which has become the world's largest exporter of tropical timber and includes much illegal logging, although timber extraction is primarily a cause of forest degradation rather than complete loss. Pulpwood plantations play a significant role and growing road development often opens opportunities for further deforestation. In eastern Australia, by far the most significant driver is cattle ranching, with other forms of large-scale agriculture declining slightly. Fires are increasing and were particularly devastating in 2020 but are not generally associated with long-term conversion of forests to other uses and were not included within the timeline of our analysis. Logging remains significant in some places.

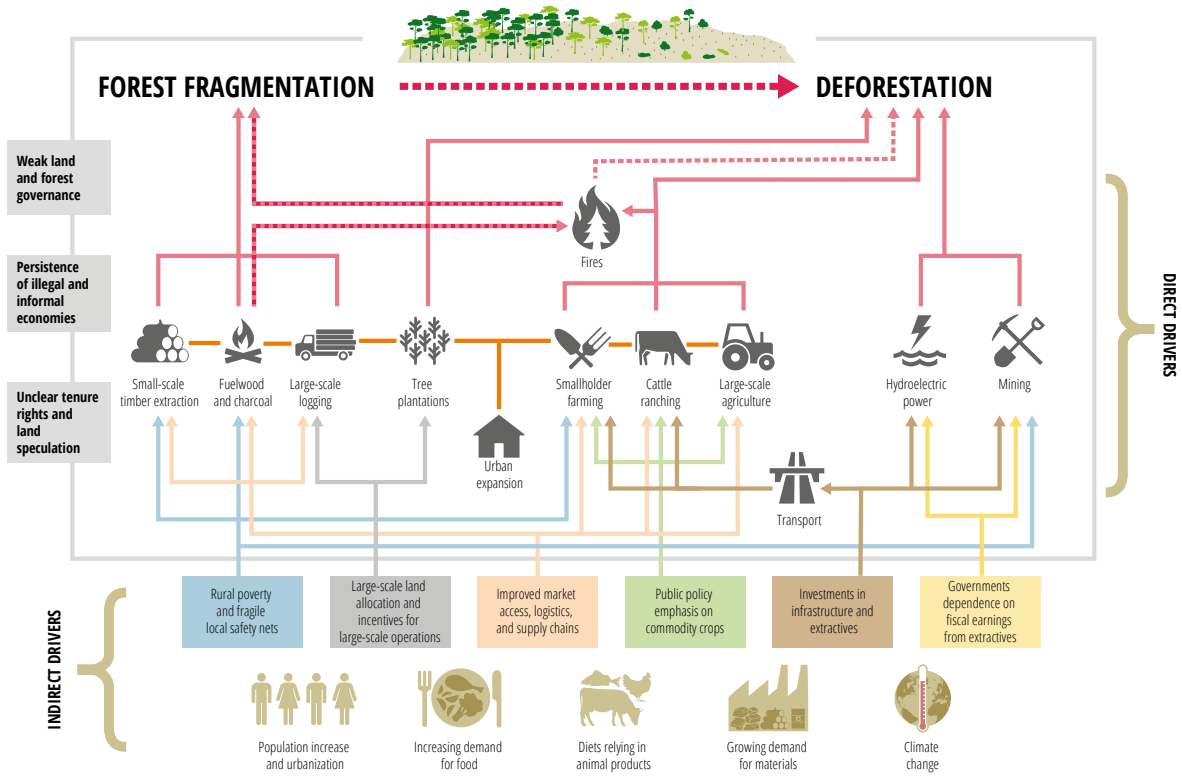


Figure 3.1. Main interactions among drivers of deforestation and forest fragmentation

3.3 INDIRECT DRIVERS PUTTING PRESSURE ON DEFORESTATION FRONTS

The factsheets for each deforestation front included in this report also capture the different underlying drivers, providing insights on their characteristics, intensity and influence across regions. With the risk of oversimplifying, since these pressures unfold differently across regions, below we synthesize the main indirect drivers influencing the dynamics of deforestation fronts since early 2000.

Population increases and growing domestic demand. Growing population in cities, which is faster in some contexts in Asia and Africa, leads to additional pressure on land for food, energy and materials[58]. Growing urbanization stimulates commercial agriculture for food supply, and timber extraction to supply a growing construction sector. Urban population growth also expands demand for energy, which in countries in Central Africa (e.g. Cameroon, DRC, CAR) and East Africa (e.g. Zambia and Mozambique) originates from traditional sources such as fuelwood and charcoal[59]. In addition, population increase in rural areas leads to further occupation of lands for agriculture[60]. This is likely one of the most important drivers of deforestation in some countries in Central Africa (e.g. DRC and CAR) and West Africa (e.g. Ghana), but it also places pressure on forestlands in some frontier contexts in the Amazon in Peru, Bolivia, Colombia and Brazil.

Increasing consumption levels and associated dietary shifts. Demand for food places continued pressure on land, particularly in the tropics and subtropics[61]. A heavy reliance of food systems on a narrow range of crops and livestock[62] has led to a rapid increase in the demand of a few commodity crops for food and feed (e.g. wheat, rice, maize, soy, oil palm, meat)[63], which tends to place pressure on expanding agricultural lands. The decline in cropland in temperate areas, which in part is associated with growing yields, has triggered a sharp increase in cropland area in tropical countries, including pasture, which has expanded mainly in Latin America[56]. Tropical croplands increased by more than 100 million ha during the 1980s and 1990s, including 47 million ha of pasture in Latin America[5]. About 55% of that expansion was at the expense of intact forests, and another 28% came from disturbed forests[5]. This effect was not only facilitated by the globalization of agricultural markets, but also the expansion of domestic demand in tropical countries, whose food systems also rely on oils, meats and refined carbohydrates[64].

The role of meat and dairy products. Animal products have dominated agricultural land-use change over the last half-century[65]. Global per capita meat consumption has almost doubled since the 1960s and is for instance projected to increase by 4-6 times more in sub-Saharan Africa by 2050[66]. Meat production requires about five times more land to produce the nutritional value of its plant-based equivalents[67]. If livestock is kept indoors, relying on feed grown elsewhere, land requirements increase even more[1]. Currently, 36% of calories from the world's crops are used for

animal feed, with only 12% of those feed calories contributing to the human diet[68]. Beef is by far the most inefficient form of livestock produce commonly available[69]. When land used for grazing and feed crops is combined, livestock production accounts for around 70% of agricultural land[70]. While aimed at supplying domestic markets, beef production in the Amazon continues to be the main driver of deforestation; which involving different types of farmers from large-scale cattle ranchers to diversified smallholders, it is often linked to low-production extensive systems[71].

Land contestation and encroachment of public and inidgenous peoples and community lands. Weak land tenure rights result in land contestation that often works against indigenous peoples and local communities, in many cases with severe negative impacts on livelihoods and cultural losses, such as in cases in East Africa, Indonesia and the Mekong; land conflict has also been triggered by policies favouring land concessions to large-scale agriculture[72]. In contrast, there has been a widespread process of land rights recognition in the Amazon[73], where indigenous peoples have control of large portions of land[74], which has slowed but not stopped land grabbing of indigenous and traditional community lands. In addition, slow progress in the identification of public forests tends to be accompanied with active processes of encroachment of public forestlands, particularly in the tropics. In the Amazon, forestlands are still converted to pasture as the most effective and cheapest way to justify land ownership. In addition, forest clearing for pasture or grazing, or any other agricultural land use, leads to increased land market value, which tends to stimulate speculative processes of land acquisition, which are observed across deforestation fronts in the Amazon, Mexico and Guatemala, and Australia. There are cases in Indonesia, Mozambique and Cameroon where processes of land appropriation tend to involve local elites that make use of their political influence.

Persistence of informal, illegal economies in frontier areas. Informal economies are widespread in frontier areas, which in some cases are unregulated and operate outside of the law[75]. A portion are illegal activities that contravene formal regulations, often related to land use and timber management, in some cases due to local people's inability to comply with regulatory frameworks[76], but in others due to the action of local mafias[77]. While illegal logging has shrunk in many contexts, as in the Amazon and Indonesia[78], it is still triggered when opportunities arise linked to oscillating international and regional demand as in Central Africa[55]. A few illicit economies have also expanded in frontier areas, notably in Colombia, Peru and Bolivia related to coca production[79]. In some cases, the establishment of processing facilities tends to stimulate illegal local supply such as palm oil in Indonesia that directly fuel expansion of oil palm plantations in public forests[80]. Illegal practices also comprise illegal land appropriation, illegal land conversion, illegal mining and money laundering used to expand agricultural activities.

Box 3.1 Land grabbing and land speculation in the Brazilian Amazon and Cerrado

Edegar de Oliveira Rosa, WWF-Brazil

Cattle production is the main activity that follows deforestation in the Amazon and cattle and soy play this role in the Cerrado. Yet underpinning deforestation and conversion of native vegetation in Brazil, and many other places in the tropics, is the financial outcome from the increasing value of the converted land through land speculation and land grabbing. The increment in the land value is associated with the production potential of the land, which increases with improved access to infrastructure and services. There is also a desire to hold land as a low-risk counter-cyclical asset (similar to gold). Therefore, the financial gains that can be obtained through the land markets, legal or illegal, constitute an important factor for converting forests and other ecosystems to other land uses. Curbing land grabbing and speculation requires not only effective land enforcement, but also other measures linked to the development of new infrastructure and logistics that support improved use of already cleared lands and the upgrade of low production farming systems.

There are 287 million ha of state-owned forest in the Amazon, mainly as protected areas, indigenous territories and concessions for forest management. About 70 million ha are still undesignated. Land grabbers target state-owned lands, which accounted for 27% of the deforestation in 2019[102], affecting many indigenous people and traditional communities living in these areas and scaling up social conflict. Currently, there is a bill in the Brazilian Congress (MP 910/2019), proposed by the federal government, that if approved as it is would allow undesignated lands to be legally titled even if illegally deforested prior to 2018. Such changes in the legislation, proposed from time to time, heat up the illegal market of land grabbing in the Amazon. Similar situations affect protected areas, where land speculators convert natural vegetation expecting a change in the limits of the protected areas, or the degazettement of the entire unit.

The Cerrado has no significant area of state-owned undesignated land and land-use regulations permit more conversion of natural ecosystems to agriculture. The total area under protection is only 8% (compared to 50% in the Amazon). This context attracted investors looking for real estate assets, and the emergence of so called "land companies" specialized in brokering land transactions. This in turn has attracted international investors looking to profit from buying pristine Cerrado lands to produce soy and cattle, and benefit from a large increase in the land value. Due to unclear tenure documents and to the fact that many of these areas are occupied by traditional communities and indigenous people, land grabbing tends to happen based on fake titles, which also leads to conflict with these communities. Recent reports on the activities of these land companies are improving awareness of investors, some of whom are embracing non-conversion commitments and looking to run their activities in already cleared areas (based on a cut-off date).

Focus on commodity crops for rural development. Several fronts have faced an increase of large-scale crop plantations aimed at supplying agricultural commodities to international markets including soy in the Cerrado[81], and palm oil in Indonesia (Sumatra and Borneo)[80, 82] and increasingly in New Guinea[83] and Peru[84], among other countries[85]. Some of these commodities involve significant smallholder participation, such as cocoa in Central and West Africa[86], and increasingly palm oil production in Indonesia and Malaysia[82, 87]. Growing expansion of plantation agriculture is strongly linked to infrastructure development, including not only expansion of road infrastructure, but also processing capacities (e.g. soy crushing plants, palm oil mills), and marketing logistics and services[61]. Agricultural policies, in a context of globalized markets, have often privileged the development of commercial agricultural targeting global markets, as a way to modernize the agricultural sector and sustain its contribution to economic growth.

Extractive industries as a way to increase fiscal earnings. Several countries have made use of "neo-extractivist" government policies to generate fiscal earnings in order to support social policies and infrastructure development, including in the Amazon, notably Bolivia and Peru[88], in Africa (DRC, Cameroon and Angola) and in Indonesia. These policies tend to favour allocation of mining, gas and oil concessions over other uses and tenure rights in frontier areas, including protected areas. In addition, these perspectives are permissive of informal gold mining, as in Peru, Colombia, Guyana and Indonesia. In sub-Saharan Africa, expansion of mining has been triggered by Chinese investments and demand, which have stimulated large-scale operations (such as in Congo Basin), but also informal mining[89]. A different type of extractivism entails large-scale logging operations or small-scale chainsaw milling when undertaken unsustainably, often in public forests or lands under contested tenure rights.

Expansion of investments in infrastructure. Large-scale investments in infrastructure (roads and hydroelectric dams) accompanied by urbanization are common in Latin America, Mekong and Indonesia, and are increasing in Africa. The latter are associated with the wider Belt and Road Initiative aimed at stimulating production and trade and is linked to the development of extractive activities[90]; the initiative is expected to pose significant risk to biodiversity[91]. Road expansion in forestlands is facilitated by large-scale public investments, often financed by regional development banks, which are accompanied by private investments in processing and storage facilities (e.g. slaughterhouses, soy crushing plants, palm oil and pulp and paper mills). Roads are expanding at an unprecedented rate, both in total length and spatial extent[92, 93]. In addition, local roads are expanding into the fringes of forestlands and in some cases penetrating into protected areas, stimulating the expansion of human settlements[94]. This is the case in the Amazon[95], Central Africa, Mekong and Indonesia[96].

Rural poverty and reliance on forests as social safety nets. Access to forest goods often fulfils basic needs and provides social safety nets for poor local populations and smallholders[97]. Yet growing social needs lead to increased pressure on forests for fuelwood and for land for shifting agriculture, particularly when smallholders and local villagers are in need of cash income to deal with external shocks in the absence of off-farm labour opportunities. This tends to be the case in Central Africa (e.g. CAR, DRC, Cameroon) and East Africa (e.g. Zambia, Madagascar). Smallholders engage in high-value tree crop production (e.g. cacao in West Africa, oil palm in Indonesia) but while this may alleviate rural poverty, it can result in adverse environmental effects. Growing reliance on cash economies due to a lack of local public social services or social cash-transfer programs may erode existing family and community safety nets for the rural poor and increase dependence on cash income, thus increasing the vulnerability of local populations to external market shocks.

Lack of policy alignment, weak governance, and corruption. Significant efforts have been spent in improving the regulatory frameworks for land and forest management, monitoring and environmental control. The main issue is still the lack of alignment between the legal frameworks that support long-term environmental sustainability, and the financial and economic incentive systems aimed at achieving short-term economic growth[98]. This is notably the case in the Brazilian Amazon, Indonesia and DRC. In addition, environmental control is not supported by the necessary public budgets, and corruption prevails as evidenced in several cases across the Amazon, Central Africa, the lower Mekong and Indonesia. The emergence of private governance has complemented public policy enforcement, and upward convergence of state regulatory frameworks and voluntary standard systems[99, 100]. Nonetheless, these attempts are often accompanied by a lack of accountability and transparency, and in some cases have contributed to an effect of shifting the blame between state and corporate actors, and between the latter and local stakeholders[101].

Indirect drivers by their nature are larger and more diffuse, have greater momentum and are more difficult to tackle than many of the direct drivers of forest degradation and loss. Those trying to achieve sustainable development – be they local communities, indigenous peoples, conservation or human rights NGOs, responsible companies or even national and local governments – often feel powerless to do much to address these underlying issues. The focus of practical action is therefore usually on trying to control the direct drivers. However, the extent to which many of the direct drivers can be addressed at the scale needed is severely hampered unless the indirect drivers are also tackled at the same time. This paradox lies at the heart of much conservation work. Population increase and booming levels of consumption – particularly of meat products – together help drive land conversion for agriculture, huge illegal economies undermine efforts to achieve sustainability through improvements to the legal trade, and so on. Conservation organizations are often forced into short-term responses to address particular emergencies. While this is inevitable, and often necessary, it is important to keep a longer term perspective in mind. In the next section, the focus shifts from drivers to responses, and we examine some of the responses put in place across deforestation fronts to halt and reverse deforestation.


© Daniel Martínez / WWF-Peru

4. RESPONSES TO DEFORESTATION

KEY MESSAGES

Responses to deforestation have evolved from a narrow focus on national laws and policies to a wide range of statutory and voluntary actions involving many different stakeholders.

Six single-target oriented approaches and two integrated approaches, which are not exclusive, have been implemented. These approaches have focused on 13 responses, both area-based and commodity or sector specific.

Area-based responses have contributed to halting deforestation in localized places under threat but have not avoided leakage. Commodity or sector-specific responses still struggle to reach impacts at scale mainly due to limited uptake by upstream players.

None of these responses perfectly addresses deforestation and progress has been most successful when two or more are used in combination. Combinations of responses within deforestation fronts and across scales have potential to achieve positive results.

Main challenges arise from the need to tailor responses to the context and to avoid leakage and unintended results. A balance needs to be found between stringency and inclusivity. Illegal and shadow economies persist in undermining sustainability.

4.1 FRAMING THE ANALYSIS: MULTIPLE RESPONSES

Multiple responses have emerged to tackle deforestation and forest degradation, which have evolved over time in their aims, theories of change and operational frameworks. These responses consist of a large number of policies, institutional and social actions and initiatives embraced by state and non-state actors including private sector, civil society organizations, social organizations, and multistakeholder processes. In the past, these responses were primarily linked to state-driven efforts to change regulatory frameworks and enforcement systems. Since then, there has been a proliferation of approaches and initiatives relying on market-based mechanisms and supply-chain interventions, as well as involving multi-stakeholder processes at several different scales. Another approach has emphasized right-based approaches with a focus on recognizing the rights of IPLCs to their ancestral lands and territories, their governance systems, and sustainable economies within them.

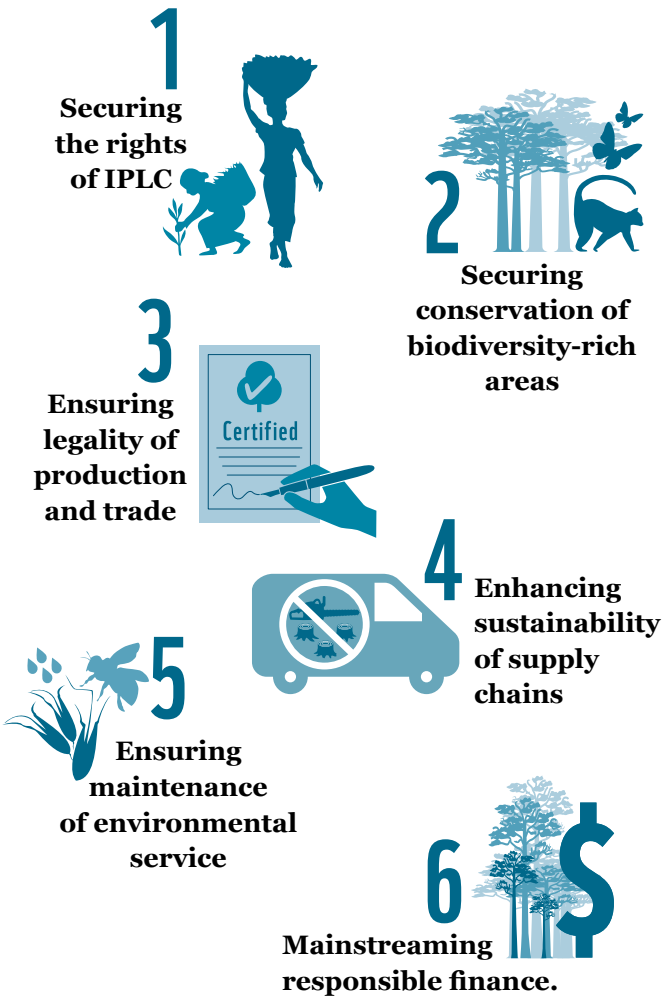
Beyond enhancing legality and law enforcement, there has been a proliferation of market-based initiatives, such as payments for environmental/ecosystem services (PES) to ensure the delivery of environmental outcomes, and certification to advance sustainable land and forest management. These are seen as mechanisms with potential to contain deforestation expansion as well[100, 103]. The business sector, chiefly downstream consumer goods companies[104], has increasingly embraced supply chain-based initiatives translated into zero deforestation commitments, supported by consensus-based guidance on commitments setting and implementation (e.g. the Accountability Framework initiative). These commitments have been accompanied by approaches to support sustainable supply at the jurisdictional level, to stimulate public and private partnerships while increasingly relying on responsible investment and sustainable development initiatives[105].

The most ambitious global experiment to tackle deforestation has been REDD+, the mechanism to reduce emissions from deforestation and forest degradation, and foster conservation, sustainable management of forests and enhancement of forest carbon stocks in the context of intergovernmental climate negotiations. Key developments include the UNFCCC Warsaw Framework for REDD+ (2013), various options for financing through results-based payments and results-based finance, and emission reductions credits through the mechanism established by article 6 of the Paris Agreement (2015). The complex process of negotiation and divergent visions about how to mobilize finance for REDD+ have so far undermined hopes that it would evolve into an effective instrument to reduce forest-related carbon emissions as originally expected[106]. However, many countries have included forest-related actions under their nationally determined contributions (NDCs)[107], and are in the process to increase their level of ambition. In addition, several private efforts are aligning with NDCs to achieve their carbon emission targets[108], and there are hopes that meaningful partnerships will evolve at the sub-national level through jurisdictional approaches involving all relevant local actors, including smallholders and IPLCs[109].

By following the framework provided in our introduction, linking deforestation drivers and responses, Table 4.1 offers a description of eight approaches (six single-target oriented and two integrated approaches) embraced in one way or another by state and non-state actors across the 24 deforestation fronts aimed at supporting forest conservation, and avoiding deforestation and forest degradation.

The six single-target oriented approaches focusing on:

1. Securing the rights of indigenous peoples and local communities (IPLC)
2. Securing conservation of biodiversity-rich areas
3. Ensuring legality of production and trade
4. Enhancing sustainability of supply chains
5. Ensuring maintenance of environmental service
6. Mainstreaming responsible finance.



Building on these single-target oriented approaches, two integrated approaches have evolved:

1. Results-based payments under integrated REDD+ policy frameworks
2. Jurisdictional and landscape approaches

These approaches embrace 13 different responses grouped as area-based and sector/commodity specific (Figure 4.1). These responses combine carrots (rewards) and sticks (sanctions) in different ways under initiatives driven by governments, corporate actors and/or civil society organizations.

Results-based payments under integrated REDD+ policy frameworks

Jurisdictional and landscape approaches

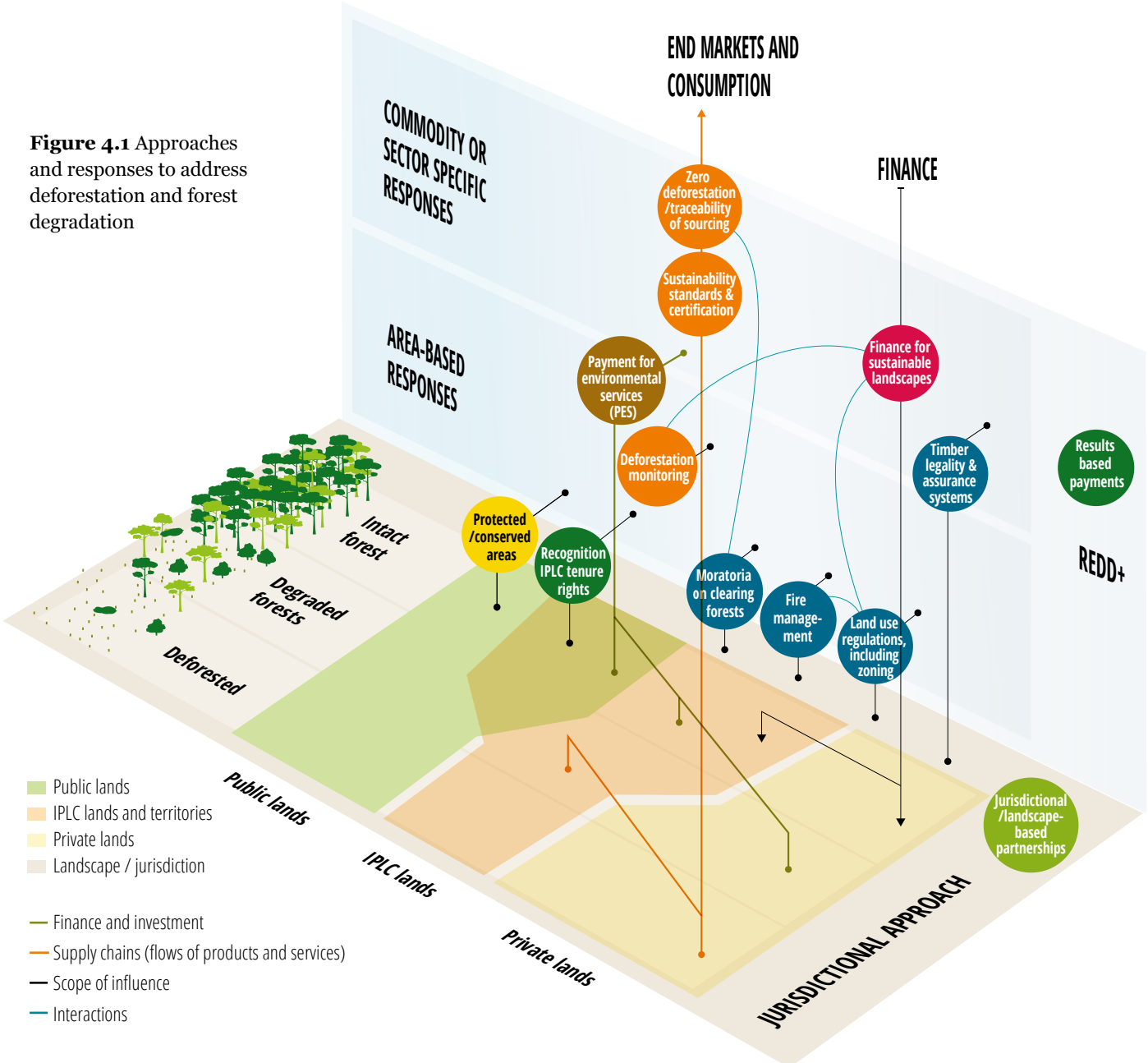


Figure 4.1 Approaches and responses to address deforestation and forest degradation

Table 4.1 Main approaches to support conservation and reduce deforestation

	Single-target oriented approaches				
	Securing the rights of indigenous peoples and local communities	**Securing conservation of biodiversity-rich forest areas**	**Ensuring legality of production and trade**	**Enhancing sustainability of supply chains**	
Operational scope	Area-based (indigenous peoples and local community lands and territories)	Area-based (high value biodiversity and conservation areas)	Comprising mainly land use, and production and trade of agricultural and forestry products	Commodity specific (e.g. palm oil, cocoa, beef, timber)	
Impact pathway	Ensuring indigenous peoples and local communities' social and economic rights	Avoiding encroachment and conversion of forestlands	Enforcing compliance with regulatory frameworks	Uptake of sustainability practices, and segregation of supply sources	
Main goal	Recognize the rights of indigenous peoples and local communities, and their customary systems of authority and forms of government and natural resources management, and provide the means including secure tenure and participation in decision-making for the realization of their human rights	Reduce the expansion of non-forest land uses over forestlands, and maintaining other ecosystem services	Ensure compliance with legal and regulatory frameworks to advance sustainable development goals	Segregate the supply complying with sustainability standards, and exclude non-performing suppliers	
Levers of change	• Demarcated forests • Clarified tenure rights	• Demarcated protected areas and OECMs • Closed agricultural frontiers • Rewards for provision of environmental services	• Improved productivity • Agricultural intensification • Corruption and illegality • Transparency	• Segregation of suppliers • Transparency of sourcing • Rewarding good performers • Preferential markets	
Type of responses	• Recognition of indigenous peoples and local communities' tenure rights	• Protected and conserved areas (includes OECMs and ICCAs)	• Moratoria on clearing forests • Fire management • Land-use and forest regulations including zoning and logging and export bans • Timber legality and assurance systems	• Sustainability standards and certification • Zero deforestation / traceability of supply sourcing	
			• Deforestation monitoring at the national or supply-chain level, and tailored monito		
Originator	Social movements, indigenous peoples' social organizations	State, environmental NGOs, governments, industry	Governments at the national or sub-national level	End-buyers, consumer goods companies, environmental NGOs, multi-stakeholder processes	
Primary target	Indigenous territories and community lands	Public lands with high biodiversity value, indigenous territories, some private lands	All producers, although small-scale farmers may be exempted in some cases	Consumer goods companies, large-scale corporations, traders	
Secondary target	Other community lands	Plantations and private lands	Intermediaries, traders and financial institutions	Upstream suppliers	

Acronyms:
ES Environmental services.
ICCA Indigenous and community conserved areas.
NGO Non-governmental organization.
OECM Other effective area-based conservation measures.
PES Payment for environmental/ecosystem services.
REDD Reducing emissions from deforestation and forest degradation.

The six single-target approaches are not exclusive, and their response options often interact. In particular, protected areas and indigenous peoples and local communities' lands and territories may overlap, and there are many efforts to support conservation within IPLC lands. In addition, synergies occur between conservation and sustainable supply chain responses through engaging the private sector to advance deforestation-free supply chains. Furthermore, approaches to advance sustainable finance interact with options to advance sustainable supply of forest-risk commodities (e.g. soy, palm oil, beef, cocoa) in the context of jurisdictional and/or landscape approaches. Monitoring of deforestation is a cross-cutting response linked to ensuring legal compliance, achieving deforestation-free targets and compliance with PES contracts. Finally, under the integrated approaches, delivery of results-based payments for REDD+ depends on a combination of response options by state and non-state actors, particularly at the national level. Jurisdictional partnerships may implement diverse response options to advance low-carbon development strategies while enhancing jurisdictional sustainability, often at the sub-national level.

Given their different scope, and conditions associated with their uptake and scaling up, the potential of the different responses to address the drivers of deforestation and forest degradation and ameliorate their negative social and

			Integrated approaches	
	Ensuring maintenance of environmental services (ES)	**Mainstreaming responsible finance**	**Achieving results-based payments under REDD+**	**Stimulating transitions to more sustainable jurisdictions/landscapes**
	Provision of ES (e.g. carbon sequestration and storage, watershed and biodiversity protection)	Deployment of finance to sustainable agriculture and forestry	Payments in exchange for reduction of carbon emissions and enhancement of carbon stocks	Stimulating public and private partnerships towards adoption of low-carbon development options in jurisdictions or landscapes
	Development of market transactions to pay for the delivery of ES	Mainstreaming responsible finance and investment practices	Governments at the national and/ or sub-national level adopt effective measures to achieve REDD+ agreed targets	Partnerships that combine public and private efforts to advance uptake and scaling up of sustainability practices and response options
	Compensate those who enhance carbon sequestration and storage, and protect watersheds and biodiversity	De-risk finance that supports transitions to deforestation-free and sustainable production	Reduce forest emissions and enhance carbon stocks in forests while contributing to national sustainable development	Align interests and coordinate actions among stakeholders towards shared conservation, supply chain sustainability and inclusive development goals
	• Monetization of carbon • Carbon markets • Additional cash income for farmers	• Finance conditionalities • Financial and reputational risk • Full-cost accounting	• Providing monetary incentives for protecting forests and avoiding deforestation • Mobilizing finance for cost-effective climate solutions	• Partnerships that share costs and minimize risks • Collaborative action around common objectives for conservation and development at the jurisdictional level
	• PES (monetary payments, compensations, and/or rewards)	• Finance for sustainable landscapes (includes impact investing, de-risking private finance)	• Results-based payments (includes a combination of all other response options)	• Jurisdictional or landscape-based partnerships (may foster the implementation of all other response options)
oring for assessing compliance in PES contracts			• Deforestation monitoring at the national and or subnational level	
	Environmental NGOS, local and national governments, some companies	Environmental NGOs, multilateral banks	Intergovernmental negotiation under the UNFCCC	Environmental NGOs, coalitions of sub-national governments, business partnerships
	National and sub-national governments	International banks, investors	National and sub-national governments, state agencies	Governments, private sector, farmers, indigenous communities
	Project developers, project beneficiaries	Project developers, finance aggregators	IPLCs, farmers, companies	Traders, banks, investors

environmental effects tends to differ. We build here on the emerging scholarly work for assessing the effectiveness of the different response options implemented to halt deforestation[110]. We look separately at the responses as they have been implemented in the deforestation fronts, and review the emerging scholarly work assessing their effectiveness. State-driven responses, notably protected areas and recognition of customary tenure rights and community-based management, have received greater attention[111, 112], along with moratoria on forest clearing as part of renewed state attempts to tackle deforestation[113-115]. Market-based measures, notably PES[116] and forest certification[117], have also received attention, as well as zero-deforestation/conversion commitments[118-120]. The analysis of REDD+ has mainly focused on policy processes shaping design[121] and results from pilot projects[122]. Jurisdictional initiatives are receiving growing attention, yet still with more emphasis on conditions explaining progress[123].

Systems change responses are gaining attention for their potential to effect transformative change – including shifts in diets and consumption patterns, and development paradigms that more explicitly acknowledge nature's contributions to people[124]. Systems change responses may be more impactful, but their effects across deforestation fronts will likely differ.

4.2 DEVELOPMENTS IN RESPONSES ACROSS FRONTS

Different responses have been adopted across the deforestation fronts, as described in the factsheets for each front. Table 4.2 summarizes these responses and classifies them into two major groups – *area-based responses* and *commodity or sector-specific responses*, as described in Section 1. A more detailed explanation of some selected responses is provided in the factsheets for each deforestation front at the end of this document. In addition, those factsheets include responses that are specific to each deforestation fronts, and thus are not captured in Table 4.2.

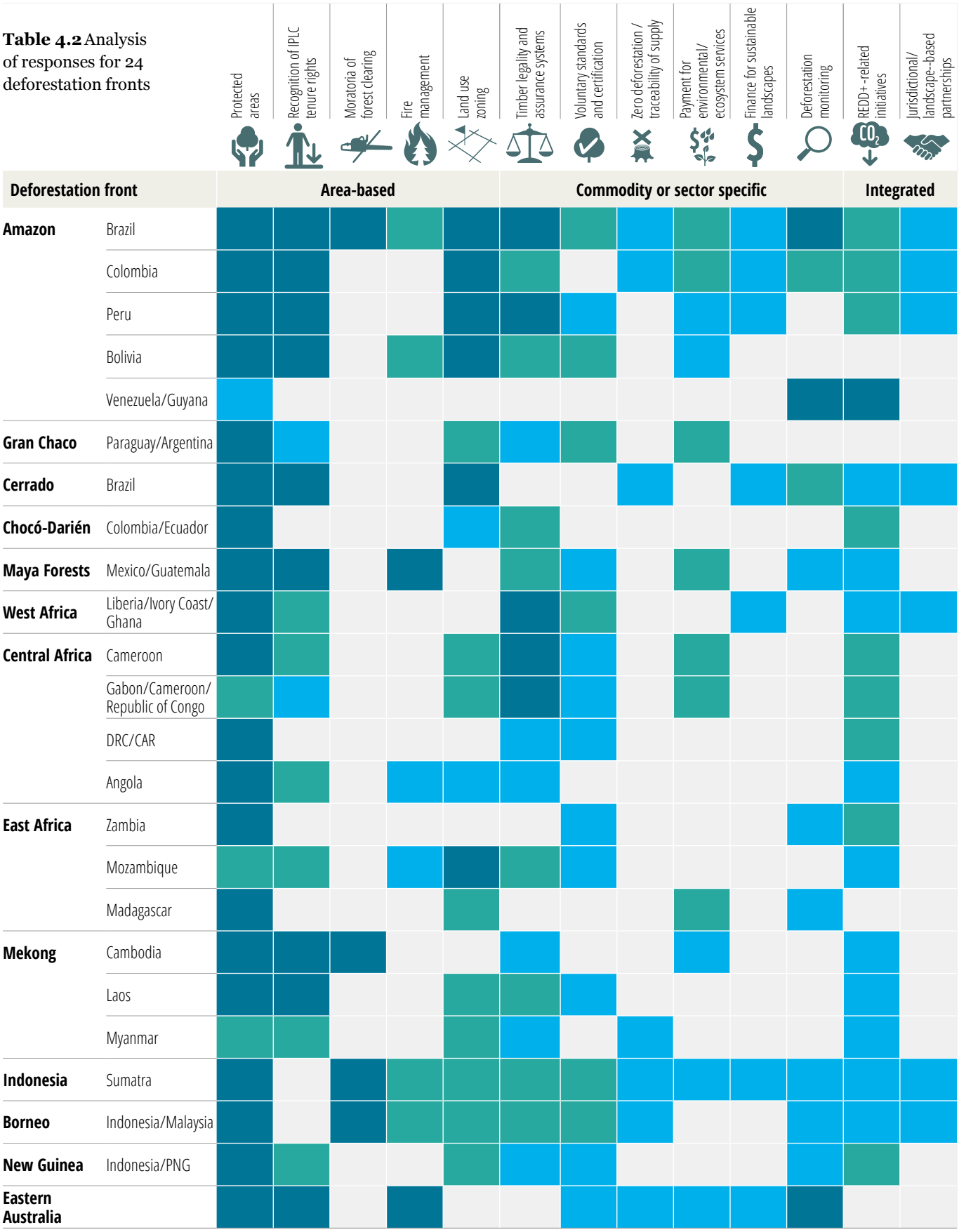
Protected areas remain the most widely applied response to deforestation given their effect on halting external human interventions and avoiding conversion[111]. There is still much room for improvement in spatial distribution and management of protected areas. The area covered by terrestrial protected areas globally has started to plateau, at 15% of land area, or 20% of forest area[125], with substantial regional variations across deforestation fronts, ranging from less than 5% (New Guinea, Liberia) to over 50% (Venezuela). Qualitatively, protected areas have seen improvements in terms of increased connectivity and attention to management effectiveness. The percentage of protected connected land has increased globally from 6.5% in 2010 to 7.7% in 2018[126], while the number of protected areas undergoing management effectiveness assessments nearly doubled[127]. Asia is the only exception to this global trend, where protected area connectivity has decreased.

Recognition of IPLC tenure rights, linked to community-based forest management, is receiving greater attention as a promising conservation strategy[112]. Approximately one-quarter of global forests, or 1 billion hectares, are estimated to be managed by indigenous peoples and local communities[74]. Since the 2000s, countries have increasingly recognized and formalized IPLC tenure rights to forestland and/or forest resources, with 15% of forest area now legally owned, managed or used by IPLCs, an increase of nearly 40% from 2002 to 2017[128]. In recent years, there has been renewed interest in securing IPLC rights to land, forest resources and promoting actions to more equitable benefit sharing as a strategy to slow down forest loss and climate change, while delivering greater socioeconomic benefits locally[129, 130]. Across deforestation fronts, IPLC tenure rights have already been widely recognized in the Amazon, and the trend is increasing in Southeast Asia, Australia and West Africa, but more is needed for governments to acknowledge existing IPLC tenure claims. In addition, in some contexts, there is a lack of institutional mechanisms to avoid encroachment of recognized IPLC lands and territories. But tenure rights alone are not necessarily enough to ensure sustainable use; several other conditions also have to be in place such as effective local enforcement and monitoring, and collective action to pursue land management and share benefits[131]. In the tropics, mainly in Latin America and Asia, the recognition of IPLC rights has been accompanied by the development of community and social forestry, also as a way to protect their lands and territories[132].

Actions for fire management and prevention have been unevenly applied across countries and have been more about fire control than wildfire prevention. Some longstanding fire management efforts have been developed in Australia, since the tropical savannahs of northern Australia are among the most fire-prone regions in the world. But despite these efforts, fires have expanded, particularly into intact and non-fire-adapted rainforests[133]. Fires have been traditionally used in the Amazon and Indonesia as part of traditional shifting cultivation practices, but today are also increasingly used as a cheap way to convert lands either for cattle ranching in the Brazilian Amazon[134], or industrial plantations in Indonesia[135]. Additionally, a portion of the observed fires are also uncontrolled fires. In the tropics, extreme El Niño Southern Oscillation (ENSO) events have driven increase in fires[136], testing the capacity of governments, civil society and producers to prevent, control and eradicate them. Forest fires are likely to increase due to longer and more extreme dry seasons as a result of climate change[137]. The recurrence of fires in 2019 has significantly affected large areas in the Brazilian Amazon, Bolivian lowlands, Indonesia, Chaco and Australia, leading to growing efforts and increasing budget pressures for firefighting.

Land-use and spatial zoning was widely adopted by some countries for conservation and development planning at different levels, but has received less attention over time. Land-use zoning was mainly adopted in the Amazon (e.g. Bolivia, Brazil, Peru) and Southeast Asia (e.g. Indonesia) under different labels. For example, extensive efforts were undertaken in Bolivia to embrace land-use plans at the sub-national level as part of the formal planning process, yet these were abandoned during the last government administration[138]. Economic and territorial zoning was also undertaken at the state level in Brazil[139]. These efforts, however, while involving long-term stakeholder negotiations, were often not accompanied by incentive mechanisms or proper enforcement. Further debates on transitions to low-carbon development, particularly in the context of jurisdictional approaches to REDD+, have tried to revitalize this type of conservation planning[140]. There are still only a few of these attempts that have effectively linked territorial planning to reward incentive systems, yet doing so constitutes a key ingredient of sustainable landscape approaches, which are also gaining increasing traction. There are dangers that spatial land-use planning often relies primarily on external expert opinions to optimize solutions at a landscape level, yet in practice these have to be negotiated by local stakeholders[141].

Table 4.2 Analysis of responses for 24 deforestation fronts



Scale of response

- Significant deployment at wider scale
- Actively used and expanding
- Project-specific, small-scale and experimental

Timber legality and assurance systems, driven by importing markets, have begun to tackle illegal logging and improve the transparency of timber supply chains at national scale. One example is the European Union Forest Law Enforcement, Governance and Trade (EU FLEGT) Action Plan, issued to implement the EU Timber Regulation (EUTR). This has brought substantial and much-needed resources and political attention to improving forest governance through efforts to define and monitor legal timber extraction and trade formulated in voluntary partnership agreements (VPAs) with forest countries[142]. The EU's efforts in negotiating VPAs focused mainly on Central Africa (5), West Africa (2) and Southeast Asia (6), and Honduras and Guyana in Latin America. An evaluation of EU FLEGT conducted in 2016 suggested that additional efforts were needed to ensure its effective and efficient application, and that the programme needed to address new challenges regarding deforestation and forest conversion[143]. Indonesia in 2016 was the first country to sign a VPA based on its own timber legality assurance system, known as SVLK. Other major timber importing countries have enacted similar legislation prohibiting the import of illegal timber, including the US 2008 amendment of the Lacey Act and Australia's Illegal Logging Prohibition Act. In the Amazon, countries including Brazil, Bolivia and Peru have developed national timber legality assurance systems outside of FLEGT. Governments and companies are also using wood identification technologies such as wood anatomy, DNA and stable isotope testing and DART mass spectrometry to verify wood species and provenance. These technologies can help to pinpoint potentially illegal wood products at timber checkpoints, in ports and in company supply chains.

The adoption of voluntary sustainability standards and certification schemes is growing but scale remains limited. Voluntary certification has been used as a conservation strategy for decades, starting with the timber sector[144]. The Forest Stewardship Council (FSC) runs one of the oldest commodity certification schemes, but the expansion of forest certification has plateaued in recent years and uptake has been limited across deforestation fronts due to, among other factors, lack of market demand, premium price points and high cost of conformance. At the same time, the voluntary market-based approach has expanded to other agricultural commodity sectors with high deforestation footprints in the tropics, such as beef, soy, palm oil, coffee[145] and cacao[146, 147]. There has been steady growth in certified area and volume for soybean[148], oil palm[149], coffee[150] and cacao[151] in countries experiencing high deforestation.

15% of forest area globally is now legally owned, managed or used by IPLCs, an increase of nearly 40% from 2002 to 2017[128]

The percentage of protected connected land has increased globally from 6.5% in 2010 to 7.7% in 2018[126], while the number of protected areas undergoing management effectiveness assessments nearly doubled.

However, many of the initiatives are relatively new and consequently the scale of their contributions, as well as the uptake by small-scale producers, remains relatively small in comparison with commodity volumes traded in the markets.

A diverse set of supply chain-based initiatives has emerged to move towards zero deforestation. The urgency of stopping deforestation to mitigate climate change and biodiversity loss has prompted a groundswell of business initiatives in the form of codes of conduct and public pledges to zero deforestation in supply chains[104, 118]. These supply chain-based initiatives tend to be viewed as 'stepping stones' toward full conformance with sustainability standards: targets tend to be issue-specific and auditing requirements less stringent[152]. More than 480 companies had made 850 commitments as of 2019[48], with beef, soy, palm oil, pulp and paper, and natural rubber sectors being the main focus, underscoring the popularity of the approach[119]. However, effective implementation is lagging, in part due to lack of clarity about how such commitments can be achieved in an inclusive, equitable and credible manner, something that the Accountability Framwork Inititive (AFI) is aimed to contribute to[153]. More importantly, companies embracing commitments tend to be those closer to consumer pressure and that face higher reputational and financial risks[154]. Conversely, companies higher up the value chains have generally not endorsed deforestation-free commitments[120], since these upstream producers (companies or smallholder farmers) may face higher production costs without necessarily receiving direct market benefits.

The recognition that a handful of agricultural commodities have a disproportionate impact on tropical deforestation[155] has led to sector-wide efforts to halt commodity-driven deforestation. Banning purchases linked to particular sourcing areas became a popular strategy. Brazil's Soy Moratorium was the first voluntary industry-wide agreement, where major

soy traders agreed not to purchase soy grown on lands deforested after July 2006 in the Brazilian Amazon[115]. Similar approaches were adopted by the cattle sector in 2009 but under a much more fragmented supply chain[156]. State-mandated moratoria have been implemented in Indonesia and Cambodia. The government of Indonesia issued a moratorium on new conversion permits in primary forests and peatlands in 2011 and subsequently made the ban permanent[157], as well as issuing a palm oil moratorium suspending new oil palm concession licences for three years in 2018[158]. In Cambodia, timber concessions for selective logging were suspended[159] and a moratorium on new economic land concessions for commercial agricultural expansion was enacted in 2012[160].

PES has been adopted as a market-based mechanism to reduce deforestation by rewarding the provision of forest-related environmental services. Several projects have been set up in the Amazon (Brazil, Bolivia, Colombia, Peru), in Argentina in the Chaco region, and in some countries in Southeast Asia, notably Viet Nam and Indonesia. In Brazil, there have been multiple PES projects, several in the Amazon[161]. In Colombia, incentives were introduced to support the improvement of extensive cattle ranching systems through uptake of agrosilvicultural practices[162]; these were associated with enhanced watershed management in Bolivia[163]. Several PES experiments were conducted in Indonesia, with a focus on water and carbon[164]. In a few cases, PES has been adopted at wider scales with government involvement. For example, in Argentina, a programme was devised at the subnational level to support sustainable forest management, and to pursue activities such as tourism and agroforestry[165]. In Brazil, programmes have been introduced at state level in Amazonas and Acre, along with a national programme, Bolsa Verde[166]. Peru has implemented a National Forest Conservation Programme with a PES approach[167], and a PES law was recently issued in the context of the Peace Agreements in Colombia[168]. In Mexico in 2003, the National Forestry Commission (CONAFOR) introduced a large-scale programme encouraging forest conservation by making payments to owners of ecologically valuable land[169].

There has been a proliferation of REDD+ pilot projects and national frameworks have been developed and implemented, but momentum has slowed due to a lack of results-based payments. Initiatives fostering REDD+ include the Forest Carbon Partnership Facility, the UN-REDD+ Programme, the pilot REDD+ results-based payment of the Green Climate Fund, and bilateral programmes of Norway and Germany. The Paris Agreement (Article 6.2) opened new ways for mobilizing public, private, bilateral and multilateral finance through a transfer-based finance approach . Projects have been implemented across forest-rich countries in the Amazon (e.g. Brazil, Colombia, Peru), Central Africa (e.g. Cameroon, DRC, Gabon), West Africa (e.g. Liberia, Ghana), Mekong (e.g. Cambodia, Myanmar) and Indonesia. Many of these projects involved readiness activities such as adopting monitoring, reporting and verification (MRV) systems and enhancing deforestation monitoring systems (e.g. Colombia)

Recognition of IPLC tenure rights, linked to community-based forest management, is receiving greater attention as a promising conservation strategy[112]. Approximately one-quarter of global forests, or 1 billion hectares, are estimated to be managed by indigenous peoples and local communities[74].

or improving existing ones (e.g. Brazil to include the Cerrado region). Momentum was lost due to the lack of cash flows to forest-rich countries for reducing carbon emissions, but some have been sustained by conditional payments under bilateral agreements, including between Norway and Brazil (US$1 billion, 2007)[170], Indonesia (US$1 billion, 2010)[171] Gabon (US$150 million, 2019)[172] and Guyana (US$250 million, 2010)[173]. Many other countries across the tropics and subtropics have signed an Emission Reductions Payment Agreement (ERPA) with the Forest Carbon Partnership Facility Carbon Fund[174]. In addition, many countries have integrated their REDD+ strategies in their NDCs under the Paris Agreement[175].

A growing interest in upscaling solutions has triggered landscape projects embracing one or several dimensions of sustainability. Landscape projects are diverse. Some offer assistance to support wider uptake of sustainability practices, such as those implemented in Ghana on sustainable cocoa production as part of wider partnerships between traders, producer organizations and state agencies[176]. This is also the case in some green development projects implemented at the provincial level in Indonesia, particularly around sustainable palm oil production[177]. Other projects are mobilizing finance, often blended finance through targeted financial schemes, to support the transition to more sustainable commodity supply, while de-risking investments for private funds[178]. Through sustainable jurisdictional approaches, some environmental NGOs are supporting long-term partnerships between the corporate sector and state agencies to put in place sustainability roadmaps for specific jurisdictions[123]. Increasingly, initiatives at the jurisdictional level to halt deforestation are also including efforts to support forest landscape restoration.

4.3 REVIEW OF THE EFFECTIVENESS OF SELECT RESPONSES

Our knowledge on the effectiveness of responses is still limited and often refers only to some of the more widely adopted strategies, such as protected areas, indigenous peoples and community forest management, certification and PES. Main shortcomings identified in the current analysis are linked to the poor design of assessments, the difficulty to simultaneously capture their conservation and economic outcomes, as well as changes of outcomes over time, since they are not static[179]. Recent interventions have received less scrutiny, particularly those that deal with more complex value chain and territorial arrangements and policy mixes[180]. Below we summarize some of the main findings in the literature regarding both area-based and sector/commodity-specific responses, complemented with an expert assessment conducted in each of the 24 deforestation fronts.

Protected areas can be an effective measure for conservation[181] with on average positive impacts on local people's wellbeing[182], yet their coverage is limited[183] and subject to changing government policies and protected area downgrading, downsizing and degazettement (PADDD**)**. The effectiveness of protected areas in reducing forest loss varies across regions, with Southeast Asia experiencing the highest losses[184]. Some of the differences in deforestation outcomes can be explained by the locations and types of protected areas[185]. Large and relatively remote protected areas in the Congo and Amazon basins have low deforestation rates, while in Southeast Asia, Central America and West Africa, many protected areas confer little or no protection from human activities that lead to forest loss[186]. Lack of resources and management capacity to enforce protected areas[187] and limited alternative economic strategies that could discourage encroachment, hunting or timber extraction[188] are among the main underlying reasons why some perform poorly. Furthermore, protected areas' performance is also precarious because they are constantly under pressure from competing interests to develop or exploit natural landscapes[189], as demonstrated by the change in Brazilian government's views in favour of supporting agribusiness and extractive industries in the Amazon[190].

Box 4.1 A case exploring the determinants of protected area effectiveness

Protected areas scored consistently high in our analysis of responses and have been effective in parts of Africa in maintaining forest cover. In some countries they are now virtually the only places where native forests remain, for example in Rwanda[191] and Ghana[192]. Protected areas are not perfect conservation tools. Forest loss and degradation still occur in many and some apparently successful protected areas are probably maintained for now more by their remoteness from development than by effective management. Forest protected areas in West Africa have been identified as under particular pressure[193]. Other protected areas, while maintaining vegetation cover, have lost many of their constituent species to bushmeat hunting and the wildlife trade[194], leading to the "empty forests" phenomenon[195].

These problems should, however, not be overstated: many African protected areas continue to maintain both forests and species[196], in spite of heavy pressures. A regional review found that only 6.8% of East African protected areas had been converted to farmland since gazettement[197]. A major review of the effectiveness of African protected areas in retaining forest found that parks generally had less forest loss within their boundaries than outside, sometimes dramatically so, with success closely linked to management effectiveness. Smaller protected areas and, counterintuitively more inaccessible protected areas were more likely to suffer losses[198]. A meta-study in Africa's national parks found that socio-cultural issues were the prime factor in determining success and failure, particularly related to the establishment of the protected area and the participation and attitudes of local communities[199]. Security of land tenure is an important factor in securing forests[200], although there is also evidence of disproportionate loss of forests in community-managed lands in Tanzania[201] and continuing decline of biodiversity in locally managed forests[202]. There are thus no magical solutions here but a mixture of effective management and good community relations seem to be critical factors in protected area success.

There is growing evidence that supporting forest management by IPLCs may contribute to containing deforestation while supporting local livelihoods[203, 204]. While protected areas are generally effective, pan-tropical analysis indicates that strict protection may not indeed be the best conservation measure everywhere (for reasons mentioned above). Indigenous peoples and local communities can be especially effective as forest stewards in places where weak forest governance and law enforcement capacity cripple the government's ability to safeguard public lands, yet in many cases indigenous peoples and local communities tend to face with greater pressures from other actors interested in getting access to extract the natural resources of their lands and territories. The studies on the effectiveness of indigenous and community conserved areas tend to agree on their positive contributions. One pan-tropical study research finds multi-use protected areas where indigenous peoples local communities have access to forest resources may be even more effective than strictly protected areas in suppressing fire across Latin America and Asia, with indigenous lands reducing deforestation pressure even further[205]. Another review found that community conserved areas fell short of the effectiveness of protected areas, but showed a marked improvement over open-access areas[206]. An in-depth study of six community forestry initiatives in Indonesia found marked differences in the sustainability of management in different areas[207]. It is important to ensure that the enabling conditions are in place for communities to effectively manage lands, including protection of tenure rights and capacity of community members to manage production forestry as well as financial feasibility of local initiatives, particularly the ones related to timber extraction. In this line, initial support from governments and other partners for start-up capital, subsidized access to training and technical assistance, and navigating complex bureaucratic systems are key elementsto improve commercial forest management.[208].

Box 4.2 Smallholders in the global commodity marketplace – exploring sustainable community-based natural resource management in the Mekong

The growing global appetite for agricultural and forest commodities is changing the livelihood choices faced by millions of smallholders around the tropics. Nowhere is this change more visible than in the lower Mekong, owing to its high rural population density and proximity to large consumer markets and processing hubs. Marked-oriented commodity production – such as rubber, oil palm, coffee, sugarcane, biofuel feedstock and fast-growing tree species – is steadily replacing subsistence agriculture as the dominant economic activity for farmers and communities across rural landscapes. There is no readymade solution to effectively address the deforestation pressure coming from small-scale commodity production. Secure land tenure is found to be effective as a forest protection measure on average[200], but insufficient on its own to prevent conversion due to land speculation[209] and high pressure from competing land uses[210]. In the lower Mekong countries, governments have implemented policies to allocate land to poor households and instituted legal frameworks for community-based forest management. While these policies are well intended, they can also create barriers for communities and smallholders to gain material benefits from managing their land and resources sustainably, for example, by making it prohibitively expensive for small-scale tree growers to sell their wood legally[142].

The day-to-day challenges that many of the small-scale producers face – from legal compliance[211] to finance and market access[212] – also limit their engagement with voluntary standards and certification systems, as the costs of conformance are often perceived to be higher than the benefits. The growing role of communities and smallholders in global commodity value chains presents a new threat, as well as an opportunity, in tackling deforestation. In the lower Mekong, the integration of macro and micro-level interventions to align policy and market incentives has shown potential to reduce forest loss from community-managed production forests.

For over a decade, WWF has been working in Bolikhamxai province in central Laos to support a nature-based development model in line with communities' traditional ways of living. The project has sought to align government land-use planning policy with bottom-up village forest management, while incorporating certification to ensure the quality of forest management and community governance and building a non-timber forest product (rattan) value chain. This helped reduce forest loss in four participating villages by 13% between 2010 and 2018[213].

Smallholders and communities – like all economic agents – face trade-offs and respond to incentives. Spatial planning for land use at landscape level could help better allocate land for economic development and for conservation. Market and policy measures at local, national and global levels need to work together to ensure that they are conduits to sustainable community production.

Market-based initiatives, notably certification, have been widely scrutinized and the results show ambiguous outcomes in reducing forest cover loss – in some cases, certification resulted in lower forest cover loss, but in others it had no measurable impact. Overall, certification in coffee and palm oil may have reduced rates of tree-cover loss in certified farms in some specific settings, yet there is no evidence on whether voluntary standards have wider effects on deforestation outside the boundaries of certified areas[214] Explanations for the heterogeneity of impacts ranges from poor data quality and disparities in research design[117] to the different trade-offs that standard systems face within the local contexts of implementation[215]. In recent years, there have been studies using rigorous statistical methods to compare forest cover change in FSC-certified and non-certified concessions in Central Kalimantan, Indonesia[216], Mexico[217], Peruvian Amazon[218] and Cameroon[219]. Only in Kalimantan was FSC certification found to have large effects on reducing forest loss. The low intensity of logging practices in the tropics (except for Indonesia) and the correlation of FSC with more active management (Cameroon, Peru) partially explain the limited effects observed. When researchers unpack the standards to examine individual management practice, positive effects are often found. For example, a study on forest management plans and FSC certification in the Congo Basin argues that in the period between 2000 and 2010, deforestation was 74% lower in concessions with a management plan compared to those without. This was associated with actions regulating access to concessions, such as closing logging roads, to limit hunting and illegal timber harvesting[220].

Beyond certification, **wider corporate commitments to zero deforestation have not yet achieved the expected outcomes**. Constraints include limited uptake by suppliers in the upstream value chain, market segmentation that allows for supply to be channelled to buyers with no commitments and difficulties for traceability of smallholders, as well as the need to align with the public sector[119] and improve coordination among all the value chain stakeholders[221]. For example, the agreement in the cattle sector in Brazil has contributed to slowing deforestation[156], but its impact was limited due to its focus on direct suppliers; this indirectly led to leakage and laundering due to the lack of control of indirect suppliers[222] (see Box 4.3).

In comparison, **legal actions to impose land moratoria, combined with business sector commitments, have proven more successful**. The Soy Moratorium has halted the expansion of soy's footprint in the Amazon biome[115], despite some concerns that it may have displaced pressures to the Cerrado (See Box 4.3). In addition, some consider the moratorium on oil palm expansion in primary forests and peatlands in Indonesia effective in reducing primary forest loss and peatland conversion[113, 114], although loopholes have been pointed out by some environmental NGOs[223]. In Cambodia, the moratorium on new economic land concessions initially increased deforestation in the short run as companies rushed to clear forests to secure concession rights before the ban came into effect[160], but is generally considered a step in the right direction.

The last decade has brought an expansion of timber legality in tropical timber producing and importing countries. **It is difficult to empirically measure the effects of trade regulations**, such as the EUTR and Lacey Act, on tropical deforestation because of several challenges. Illegal timber may be laundered into legal supply chains[224], implementation of the legislation varies, and stricter legality requirements in one importing market may divert

Box 4.3 Market-based agreements to halt deforestation in the Brazilian Amazon

Soy Moratorium

Between 2001 and 2006, soy planted area expanded by one million ha in the Brazilian Amazon. The Soy Moratorium, which limited soy-driven deforestation in the Amazon biome, was agreed in 2006. In the two years preceding the agreement, 30% of soy expansion occurred through deforestation rather than by replacement of pasture or other previously cleared lands[115]. By 2014, deforestation for soy had decreased to about 1% of expansion in the Amazon biome[115]. However, some critics argue that this apparent success is due to the availability of land already converted to pasture, and that soybean expansion on pasturelands tended to displace cattle into new forests. An additional criticism is that the Soy Moratorium may have led to a leakage effect into the Cerrado, where natural conversion to soy has continued[228]. An analysis of the likely impacts associated with expanding the Soy Moratorium from the Brazilian Amazon to the Cerrado suggests that it would prevent the conversion of 3.6 million ha of native vegetation by 2050[229].

Cattle agreements

Multiple policies have aimed to govern uncontrolled expansion of extensive cattle ranching linked to land encroachment and land speculation, while also supporting intensification of production systems[71, 230]. The most significant are the zero-deforestation cattle agreements signed by meatpacking companies with the state of Para in 2009, and extended to three other states (Mato Grosso, Rondônia and Amazonas) in 2013. The cattle agreements have contributed to reducing deforestation, but some properties not included in the cattle agreements continue to supply beef originating from lands affected by deforestation[231]. A study in Para found that slaughterhouses covered by the agreement did try to avoid purchasing from properties with deforestation, which was not the case before[156]. However, a major difficulty has been to control indirect suppliers, and "cattle laundering" has become a widely adopted practice[232]. Recent analysis confirms that indirect suppliers contribute more to deforestation, which is more likely to occur in remote areas where oversight is lower, as is the risk of ranchers of being penalized for clearing[231].

illegal timber to more lenient markets (including domestic markets). The European Commission has acknowledged the weakness of the EUTR in addressing deforestation and forest degradation[143], and in 2019 signalled its intention of "Stepping up EU Action to Protect and Restore the World's Forests"[225]. An evaluation of the EUTR pointed out a number of shortcomings, including disproportionately light fines and penalties, limited capacity of customs agencies and low transparency[226]. Under the US Lacey Act, only three companies have ever been investigated for violation while it is estimated that a large amount of illegal timber continues to flow into the US market. In terms of displacement, there is a trend of Asian markets replacing the EU and the US as top timber export destinations[227]. Nonetheless, where these trade regulations do make a difference it is by sending a market signal to wood processing hubs such as China, Viet Nam and Malaysia to improve timber legality in their respective jurisdictions.

Incentive-based mechanisms such as PES approaches have strong potential but have not always delivered the expected outcomes. The main views on PES suggest that they depend on the interplay between context, design and implementation[116]. PES projects across deforestation fronts vary significantly in design and implementation. Systematic analysis on PES initiatives has raised doubts about how much they have contributed to additional, permanent deforestation reduction, since conditionality requirements are often lacking during implementation of these initiatives[116]. Some pre-conditions that have to be in place for PES initiatives to work relate to information, economics, culture and institutions. Land stewardship with "the right to exclude third parties" has been highlighted as important[233], which argues in favour of securing tenure rights for IPLCs. More serious consideration needs to be given to what preconditions need to be met if incentives for landowners are to become an effective mechanism for conservation[234].

Building on PES, REDD+ was conceived to provide compensation to farmers and forest users, yet pilot projects have shown very diverse outcomes in reducing deforestation and delivering positive impacts for farmers. The lack of a global agreement has inhibited the potential of REDD+ to reduce forest-related carbon emissions as originally expected[235]. Pilot projects have included many types of actions, from supporting protected areas, to direct incentives (such as PES) to forest dwellers, supporting farmer uptake of best production practices, and enhancing enabling conditions such as recognition of local tenure rights[180]. A review of 45 articles looking at the outcomes of REDD+ interventions on the ground argues that these projects achieved moderately encouraging results on carbon/land-use outcomes, but insignificant results on local people's wellbeing[122]. Yet it is still hard to draw definitive conclusions since many of these studies lacked a counterfactual scenario to measure REDD+ impacts and did not adequately balance carbon versus non-carbon outcomes. Beyond these pilot projects, a major issue that remains in country-level REDD+ programmes is what type of combined interventions have the potential to lead to better outcomes for both carbon emissions or removals, and co-benefits translated into local economic benefits. Some argue that while REDD+ has supported sustainable land-based investments, it struggles to compete with business-as-usual incentives to convert forests, and has still not created the institutional conditions nor mobilized enough finance to unlock its potential to trigger transformative actions on a large scale[236].

Various landscape approaches combine supply-chain and territorial-based interventions, relying on public and private partnerships to deliver their outcomes, yet there is still little work to assess these outcomes in practice and many initiatives are still at the initial stages. Available preliminary analysis has identified some gaps, which differ depending on the main purpose of the landscape projects. For example, sustainable landscape finance projects in Brazil and Peru show a mismatch between the investors looking for social and environmental outcomes beyond financial gains and the supply side of sustainable land-use investments on the ground[178]. Other initiatives to enhance sustainable supply at the landscape level have emerged outside formal state systems, as in Indonesia, yet face challenges to get integrated more formally into existing executive systems; thus their impact is mediated by complex decision-making processes and wider policy frameworks[237]. Different versions of these landscape-type of initiatives, involving public and private stakeholders at the sub-national level, are being reconceptualized under jurisdictional approaches[105]. A recent review suggests there has been little examination of sub-national governments' authority to make policy decisions to slow deforestation; they often lack decision-making power on land ownership, permits for extractives and protected areas[238].

While not captured in our analysis of deforestation fronts, **proposals have emerged on the demand side** that are primarily related to three types of efforts. The first relates to the need for regulations in consuming countries to reduce the footprint of their consumption by supporting deforestation-free supply chains, which has been built into the EU Communication (July 2019) on Stepping up EU Action to Protect and Restore the World's Forests. The second is advancing more responsible finance through financial institutions integrating environmental, social and governance (ESG) criteria into their lending operations. Examples include financial regulators from emerging market countries (e.g. China, Indonesia, Peru and Brazil) cooperating in the Sustainable Banking Network, and on the other side, a group of financial regulators, mostly from European countries, collaborating in the Network for Greening the Financial System (see Box 4.4). The third relates to improving the visibility and ambitions of nature-based solutions in NDCs, which includes reducing emissions from deforestation and forest degradation as part of a wider range of interventions[239]. The latter are evolving agendas that are not necessarily connected to each other, some of which have not yet translated into actions in the deforestation fronts.

Box 4.4 The role of finance in stopping deforestation
By Jan Willem van Gelder, PROFUNDO

The finance sector plays a crucial role in (avoiding) deforestation. To operate and expand, agricultural, forestry, mining and energy companies seek capital from a variety of financial institutions: commercial banks, investment banks, (multilateral) development banks, asset managers, private equity funds, pension funds, insurance companies and others. As the provided capital is essential for the operations and – especially – expansion plans of these companies, their financiers potentially have strong leverage: they can dissuade these companies away from deforestation-linked activities towards a more sustainable development path.

How can financiers use their leverage?

What financiers need to do to use their leverage to avoid deforestation has crystallized in recent years. First, they should develop responsible investment and credit policies, which set clear sustainability criteria on the companies and projects they are prepared to finance. Second, they need to train staff to understand the issues, collect data on potential investee companies and screen these companies rigorously against the policy criteria. Third, they can use a range of instruments to implement their policies: exclusion of worst offenders, complemented by engagement – during shareholder meetings and behind closed doors – with other companies to help them change their practices, resulting in agreements on action plans and clauses in loan contracts. Finally, they should monitor progress, publish their results, exert pressure on their peers and call financial regulators and other government agencies to action.

It is expected that when a critical mass of relevant financial institutions takes such steps, the companies operating in forest-risk sectors will feel the pressure from their shareholders and creditors to change their practices, investment plans and procurement policies. As it is crucial for these companies to maintain a good relationship with their investors and creditors to continue to keep access to sources of capital. Expanding this pressure could become an effective way forward in the absence of other alternative sources of finance.

Do we see progress? Is the system changing?

Momentum in the financial sector is growing to take a more active, leading role in the necessary transformation of the global economy towards a more sustainable development path. The forerunners, collaborating in initiatives such as the Principles for Responsible Investment (PRI) and the Principles for Responsible Banking (PRB), are taking action, and opportunities to press laggards in the finance sector are increasing as well. Peer pressure plays a key role here, as financial institutions often need to cooperate in lending and underwriting syndicates, and financial institutions do not want to lose customers to banks with lower standards.

Financial regulators have recently started to encourage financial institutions to integrate ESG criteria in their financing and investment decisions, thereby creating a level playing field. Financial regulators from emerging markets such as China, Indonesia, Peru and Brazil, cooperating in the Sustainable Banking Network, have taken steps in this direction. Another group of financial regulators, mostly from European countries, collaborate in the Network for Greening the Financial System; though aimed initially at finance for climate change challenges, this has expanded to address biodiversity loss as well. Combined, these trends show an acceleration in the uptake of responsible investment and credit practices in the finance sector, which will undoubtedly pressure companies operating in forest-risk sectors to refrain from further deforestation.

Natural Cerrado vegetation surrounded by soy crop. Cerrado, Brazil.

4.4 WHY, DESPITE A MULTITUDE OF RESPONSES, DOES DEFORESTATION CONTINUE?

Despite significant international and corporate commitments and declarations, deforestation and forest degradation is still increasing, or at best, not experiencing the level of reductions necessary. This demonstrates that the actions implemented to oppose it are not enough. Our report outlines in detail the specific pressures and responses available in each deforestation front, where halting deforestation will require significantly more effort. While international policy and corporate frameworks help to organize these response options, they must be able to mobilize concrete actions and achieve impact within the landscapes experiencing the diverse and persistent drivers of deforestation.

The eight approaches and 13 responses introduced in sub-section 4.1, and analysed above, interact in complex ways, which makes it difficult to isolate their specific role in halting deforestation and forest degradation. Table 4.3 offers a synthesis of the main strengths and weaknesses of the different approaches as informed by the review of responses implemented in the 24 deforestation fronts, and insights from our additional literature review. Due to their different impact pathways, levers of change and targets, no single approach alone can address the indirect and direct causes of deforestation. Enhanced integrated approaches are needed, yet with growing consideration of the local political economies and market and institutional configurations in each of the different fronts with particular attention to the specific needs and interests of local stakeholders.

Table 4.3 Strengths, weaknesses and ways forward across approaches to halt deforestation

	SINGLE-TARGET ORIENTED APPROACHES	
	Securing the rights of indigenous people and local communities	**Securing conservation of biodiversity-rich forest areas**
Strengths	• Reinforces local values and local management practices, and institutions • Supports a growing engagement of indigenous peoples and local community voices in national and global level policy for enabling conditions • Enables the self-strengthening of local governance systems and sustainable economies	• Clear definitions of boundaries and land-use functions that reduce land contestation (with some exceptions)
Weaknesses	• Risks of elite capture • Success depends on pre-existing authority and local accountability systems • Limited options for enhancing livelihoods • Attitudes and priorities may change over time	• No control of external pressures outside protected or OECMs • Dependence on regular external flow of resources • Susceptible to government policy changes
Undesired effects	• Not foreseen undesired effects, although some risks of IPLCs not able to resist external pressures may exist depending on existing local capacitiesand increasing threats to indigenous peoples and environmental human rights defenders fighting to preserve their rights	• May limit access to sources of livelihood for local populations with customary rights in lands classified for protection
Ways forward	Expand the recognition of local tenure rights to IPLCs • Facilitate the means for effective natural resource management in IPLC lands • Provide legal and institutional means for avoiding encroachment and conflict resolution • Work with communities to maximize sustainable management options	• Actively embrace OECMs under wider inclusive conservation approaches to expand area-based conservation while supporting local livelihoods • Identify and allocate secure funding sources for the effective management of protected areas and OECMs

				INTEGRATED APPROACHES	
Ensuring legality of production and trade	**Enhancing sustainability of supply chains**	**Ensuring maintenance of environmental services (ES)**	**Mainstreaming responsible finance**	**Achieving results-based payments under REDD+**	**Stimulating transitions to more sustainable jurisdictions/ landscapes**
• Defines the rules of the game with combination of incentives and sanctions, and systems in place to ensure compliance	• Monitoring and auditing systems, and traceability to ensure the credibility of sustainable supply • Systems can be used as a platform to combine with other incentives • Starting to be used in a limited way by some governments to better control certain sectors	• Contributes to creating enabling institutional conditions and MRV systems	• Large influence in consumer goods companies, retailers and traders upstream in value chains	• Formalized agreement and approval of a voluntary mechanism under Art• 6 of Paris Agreement	• Fosters meaningful partnerships among public and private actors around common goals at a scale that matters
• Heavy focus on procedural compliance rather than outcomes • Lack of harmonization between national and sub-national regulatory frameworks • Difficult to adapt regulations to support adaptive governance	• Low uptake of good practices • Voluntary standards not designed to have impact outside of certified units • Limited additionality since adoption tends to be pursued by those already performing well • Difficult to trace smallholders	• Lack of stable financial flows at scale to reverse business-as-usual incentives, unless public funds are used • Transaction costs associated with ES market development • For carbon, limited regulations setting up cap-and-trade schemes	• High penetration in market segments better complying with sustainable practices • Low penetration in micro-finance, widely used for smallholders • Limited influence in informal economies	• Difficult coordination to get ready for obtaining results-based payments • Lack of enough financing to motivate actions at scale • Long-term process for moving from experimental and pilot initiatives to market-based transactions under Paris Agreement	• Disparate perspectives across actors requires political negotiation around long-term goals • Progress in some jurisdictions may trigger pressures on forests in other jurisdictions, thus leading to leakage
• May exclude or work against producers or local populations unable to comply with regulations, thus reproducing situations of illegality or informality	• Leakage into markets with low environmental concerns • Value chain segmentation • Exclusion of non-performing smallholders	• Deforestation may reduce demand for labour from poor households • PES may increase the value of land, which may lead to displacement of poorer households	• May lead to increased costs of finance for non-complying producers, thus limiting their opportunities to take up more sustainable practices	• Risks of unequal benefit sharing among disparate actors with differentiated responsibilities	• Unbalanced sharing of costs and benefits from collaborative interventions • May lead to more powerful actors imposing their views without active social participation
• Improve coordination between national and sub-national levels • Adopt systems and mechanisms for governing through goals, and defining goals in participatory ways • More meaningful partnerships with the private sector under jurisdictional approaches	• Tailored incentives for suppliers, including smallholders, to upgrade their production practices across supply chains and jurisdictions • Include specific zero deforestation/zero conversion criteria in voluntary standards • Embrace a landscape approach while reducing costs for uptake of voluntary standards • Stimulate wider adoption of accountability frameworks • Layer various incentives	• More explicit consideration of nature-based solutions that contribute to mitigation and adaptation while protecting intact/ primary forests, management and restoration options • Set aside public and private funds and financial schemes that compensate for ES provision	• Accelerate the uptake of responsible investment and credit practices in the finance sector • Advance tailored financial schemes at the landscape level for scaling up sustainability • Refine sustainable finance taxonomies in the land sector • Better capture and share audit data especially pertaining to outcomes and impacts	• Clarify political visions for long-term climate financing under REDD+ mechanisms • Assess the REDD+ pilot results-based payments for ensuring continuity of successful measures • Factor payments for REDD+ action in the national budgets • Improve capacities to implement and monitor progress of forest-related actions committed under NDCs	• Link corporate commitments to jurisdictions with active jurisdictional partnerships • Expand commitments to widen the jurisdictional scale of actions • Advance the monitoring of progress, and foster learning across jurisdictions with active partnerships

Below, we summarize the main findings from our analysis of how effective different approaches, and their corresponding responses, have been in halting deforestation and forest degradation.

- **Securing the rights of indigenous peoples and local communities** has been effective. However, tenure rights alone are not enough for IPLCs to realize the economic and social benefits of their rights. Empowering IPLCs, and their capacities to self-strengthen and manage their lands and territories, and to build the partnerships needed to deliver sustained positive impacts over time should be a priority. In addition, many IPLCs require legal and institutional support to maintain and protect their acquired rights against external threats.

- **Securing conservation in biodiversity-rich forest** through area-based responses (e.g. protected areas) has proven effective in reducing threats to forests, yet cannot avoid leakage into other areas. Conservation areas require compliance monitoring and enforcement of stipulated rules, as well as regular financial flows to ensure effective management. Linking with IPLCs under negotiated agreements has potential to expand conservation areas as OECMs.

- **Ensuring legality and enforcement** has often been limited to monitoring legal compliance rather than penalizing illegal actors. Significant efforts have been spent on defining legal procedures to enforce land-use and forest management regulations. Effective enforcement requires long-term political will and resources for continued monitoring. Moratoria have a short-term impact, yet to be sustained need involvement of the business sector.

- **Enhancing sustainability of supply chains** has mobilized efforts of downstream corporations, but with little commitment from upstream suppliers. Certification has been used to advance sustainability practices, yet it has had limited uptake due to costs and limited response of end consumers. Additional efforts to achieve zero deforestation/zero conversion have sought to improve traceability across third-party suppliers. However, traceability comprising entire supply chains has proven difficult, mainly in cases involving smallholder suppliers who connect to markets through informal networks.
- **Ensuring maintenance of environmental services** through payments or compensation schemes for biodiversity, carbon and water, while effective in localized project-based interventions, have been unable to achieve impacts at scale. More ambitious state-sponsored programmes have set up larger-scale funds for reaching a significant number of farmers, yet in some cases those programmes have not achieved additional conservation results.

- **Mainstreaming responsible finance** is progressively leading to international banks incorporating zero-deforestation targets into responsible investment and credit policies. Guidelines on responsible finance are being adopted by some regulatory agencies in forest-rich countries. In addition, several schemes for de-risking finance have been put in place to support farmers to improve their practices, leading to increasing yields while reducing pressures on forests.

None of these are perfect on their own and progress has been most successful when different approaches are combined. As mentioned, REDD+ and jurisdictional/landscape approaches may offer integrated long-term perspectives for halting deforestation and forest degradation.

- **REDD+ results-based payments and results-based finance** have emphasized public policy enhancement for reducing carbon emissions with more robust MRV systems, but it has proven to be difficult under current frameworks to affect the political powers and economic forces shaping business-as-usual land use. Revised NDCs could include more ambitious targets for reducing deforestation and forest degradation.

- **Jurisdictional-based partnerships** have emphasized transitions to more sustainable and inclusive low-carbon economies at the sub-national level. Important components include meaningful public and private partnerships, de-risking finance schemes, and wider uptake of sustainability practices with clearer responsibilities for government bodies at the jurisdictional level. This approach is promising but more knowledge is needed on its actual effectiveness and challenges.

4.5 MAIN CHALLENGES AHEAD

- **Not all conservation strategies for halting deforestation work everywhere.** The effectiveness of individual responses depends on the local context, including enabling conditions, baseline practices, types of deforestation pressures and trade-offs faced by local actors. As a result, many forest conservation strategies face challenges with scaling up. There is a need to tailor interventions to local contexts, and to embrace the values and interests of local stakeholders.

- **Misalignment of responses across approaches.** Some responses encouraging more sustainable management of resources may be offset by market signals or investment policies that incentivize more of the same. Alignment among the different approaches is needed to produce reinforcing effects. For example, incentives in supply chains have to be aligned to area-based interventions.

- **Disconnected interventions tend to reinforce silo approaches.** Interventions tend to focus on one or other driver, even when these are linked (e.g., commodities, infrastructure, mining, finance), and forest-based interventions are pursued independently from other relevant interventions in the landscapes, for example on wildlife or freshwater.

- **Conflicting views and interests across actors.** Different actors, with competing perspectives and interacting on non-level playing fields, tend to embrace different approaches. In addition, the lack of coordination between national and sub-national levels also tends to negatively influence progress. Building common visions and goals is important – external interventions from NGOs or financial institutions may play an important catalytic role.

- **Growing stringency tends to clash with inclusivity.** Standard systems and public and private policies tend to get more stringent in response to the demands of end-users, but this may conflict with social inclusivity if costs for producers increase. Solutions for upscaling the uptake of good practices need mechanisms for transferring benefits to upstream suppliers.

- **Persistent shadow economies and corrupt behaviours.** The lack of mechanisms to curtail shadow economies and corrupt behaviours works against efforts to address deforestation and forest degradation. In addition, land speculation has proved to be strongly related to the expectation of future profits from the expansion of agricultural frontiers. These social behaviours are difficult to dismantle since may benefit local and national elites.

- **Policy inflation and capacity building needs.** The proliferation of approaches with no clear connections between them generates a massive need for capacity building, particularly in low-income forest-rich countries. Capacity building is critical for effective policy implementation, monitoring and reporting, as well as learning from the success or failures of measures and developing adaptive management.

- **Continued poverty drives unsustainable resource use.** Liquidating forest assets, such as felling timber for sale or clearing forest to increase the area for agriculture, is often a route out of extreme poverty, even if it has knock-on effects for wider society. Until fundamental social inequities are addressed, progress in forest conservation will remain fragile.

The limits of existing approaches call for greater integration and innovation in responses that are better tailored to specific contexts. This entails policies and initiatives targeting specific forest contexts (e.g. remote core forest areas, frontier forests, and forest-agriculture mosaics)[240] with the right mix of incentives and regulations[57], and trying to encompass wider jurisdictional approaches. Enhancing alignment between state and non-state actors in specific territories has potential to address critical constraints[118].

Even this, however, is unlikely to be enough, and more comprehensive solutions with long-lasting effects are needed. New perspectives on transformative change are calling for system-wide responses to tackle the indirect drivers of deforestation[241]. These types of responses are still emerging. Notably, calls have been made to promote changes towards more sustainable and efficient food systems accompanied by shifts to healthier diets[242]. This could be supported by actions to transform the financial system (multilateral, public and private)[243] to divert resources away from conventional agriculture and other activities that drive deforestation and habitat loss, and towards sustainable production and positive environmental outcomes. Another more general perspective calls for changes in development paradigms to reduce overconsumption, and shifts in values and social norms to embrace the conservation of nature as part of wider societal attempts to sustain biodiversity, avoid the impacts of climate change, and restore the health of our planet.

5. AN AGENDA FOR ACTION

There have been many attempts to reduce forest loss since the early 1980s. All have strengths and weaknesses. While none has fully succeeded in halting deforestation and forest degradation, losses would have been even greater without them – some ecosystems would have entirely disappeared and species would have become extinct.

- 1980s: primary emphasis on lobbying for state actions through legislation and protected area creation
- 1990s: increased attention on working with the private sector through codes of conduct, certification and other voluntary measures
- 2000s: recognition of the importance of bottom-up approaches, working with local and indigenous communities, and directly with consumers
- 2010s: renewed attention on international processes such as the Convention on Biological Diversity (CBD; Aichi targets) and UN Framework Convention on Climate Change (UNFCCC), and private and public voluntary commitments and pledges to advance zero deforestation
- 2020: focus on the development of jurisdictional partnerships, and other integrated approaches and solutions to scaling up sustainable consumption and production, with an emphasis on food systems and responsible finance.

Responses usually address *direct* pressures; it has been more challenging to tackle the larger *indirect* pressures, such as poverty, corruption, over-consumption and economic growth at the expense of forests. The Covid-19 pandemic may provide an opportunity for the kind of radical, transformative changes that are essential, though only if all stakeholders fully understand the value of safeguarding nature and forests.

This is a time to think big but also to not lose sight of the importance of consolidating the more modest progress made to date. Bringing together what has been learned over the last 40 years into a coherent, integrated approach needs to be the priority.

TYPES OF RESPONSES

Our analysis shows there is no single approach that can help halt deforestation globally. Solutions need to be context-specific, take into account the complexities of the deforestation front and involve multiple stakeholders. All changes require inputs from many levels of society.

The following section highlights some changes that are needed most urgently, noting that this list is not comprehensive and much more action is needed at the consumer level – for example a shift in diets and reduction in food waste.

IMMEDIATE: Changes to start working towards now

Primarily with communities: recognizing values and taking back control

1. **Addressing tenure issues for indigenous peoples and local communities (IPLCs)**: *aiming to secure tenure rights of IPLCs on their lands and territories.* There is much evidence that suggests IPLCs often retain forest cover and good forest condition in areas under their management. Identifying the links between local management and sustainability, supporting these through policies and where necessary finance, and building wider coalitions are key steps.

- ***Immediate action***: expand the recognition, demarcation, and titling of IPLCs lands and territories, including their efforts to strengthen their traditional knowledge and governance systems that will expand the areas of forests under legally secured control of IPLCs.
- ***Immediate action:*** support IPLCs in defending their recognized land and territories from encroachment, and their voices against the violation of their human rights.

2. **Investigating other effective area-based conservation mechanisms (OECMs) and territories and areas conserved by indigenous peoples and local communities (ICCAs)**: *looking at non-traditional ways of securing forests.* Working with communities through field programmes and development initiatives offers opportunities to expand non-traditional ways of protecting natural and semi-natural forests and other valuable ecosystems.

- ***Immediate action***: identify suitable places for OECMs and ICCAs in key deforestation fronts and focus field programmes on working with IPLCs to bring these into conservation systems.

3. **A wider focus on ecosystem services:** *building support for retaining forests to provide water, food, erosion control and other ecosystem services.* There is strong evidence that proper recognition and valuation of ecosystem services can help build local support for retention of natural ecosystems.

    - ***Immediate action***: build on experience gained in existing payment for environmental services (PES) and REDD+ schemes to introduce similar programmes throughout the deforestation fronts.

Primarily with companies: moving to sustainability at a landscape scale

4. **Moratoria that takes a whole landscape, all ecosystems and global approach**: *ensuring that commitments in one place do not undermine conservation elsewhere*. Moratoria can be counter-productive if they simply shift conversion elsewhere. An integrated approach must look at conservation priorities in all ecosystems.

   - ***Immediate action***: agree and introduce moratoria for all commodities and ecosystems in remaining natural forests, grasslands and savannahs.
   - ***Immediate action***: employ traceability to ensure avoidance of products from illegal conversion or extraction.

5. **Scaling up sustainable consumption and production** *from site to landscape, from one commodity to many commodities, from green consumers to all consumers and into public and private finance*. This involves corporate commitments and government legislation, including due diligence. The EU Green Deal commits to imports and value chains that avoid deforestation and degradation. Site-level commodity certification needs to develop more broadly into commitments and credible verification for all significant uses. Jurisdictional approaches and landscape standards can be used, and public procurement policies help build sustainable systems. Improving access for smallholders is a critical step for several certification schemes.

   - ***Immediate action***: support landscape and jurisdictional plans for sustainable production that avoids further conversion of natural forest.
   - ***Immediate action***: invest in sustainable agricultural production at landscape and jurisdictional level with a special focus on supporting smallholders.

Primarily with civil society: a role for everyone in preventing deforestation

6. **Reducing pressures on forests through civil society action**: *helping to encourage wider societal shifts towards lower consumption, sustainable diets and consumer choice*. Environmentally-conscious consumers have been responsible for driving change in many countries, through letter-writing campaigns, petitions, boycotts, direct support for sustainable products, among others. As awareness of environmental issues grows, citizens everywhere can play their part in combating deforestation.

   - ***Immediate action:*** protect nature where you live – plant the right trees in the right places.
   - ***Immediate action:*** avoid products linked to deforestation – know what you consume and eat and look for labels that show where your products come from.
   - ***Immediate action:*** use your voice – ask for policies that protect and restore forests, and for actions that protect the human and economic rights of IPLCs.

Primarily with governments: integrating forest conservation into every level of government

7. **New approaches to area-based conservation**: *using a range of tools to ensure the majority of remaining natural ecosystems remain intact*. Many governments resist more protected areas, which are often ineffective or wrongly located. But the need for more protection is widely recognized, as is the importance of embracing more inclusive conservation linking socio-cultural perspectives and conservation actions.. The designation of OECMs opens new opportunities for conservation and finding common ground with multiple stakeholders.

   - ***Immediate action***: take active steps to increase connectivity and management effectiveness in the existing protected area network.
   - ***Immediate action***: investigate with governments opportunities for OECMs as a means of extending the area under conservation.
   - ***Immediate action***: embrace actions emphasizing cultural connectivity as well as biological connectivity in IPLC lands and territories.

8. **Ensuring effective legislation, monitoring and traceability throughout the value chain**: *to allow consumer companies to guarantee product sustainability*. Consumer countries can help address deforestation by blocking export options for products resulting from recent conversion. The particular challenges of addressing illegality should not be understated, with increased emphasis on enforcement policies. Producer countries are also recognizing the need to tackle lost revenues and lost ecosystem services due to deforestation.

   - ***Immediate action***: introduce, strengthen and better enforce due diligence legislation in both consumer and producer countries, and in those countries that are both significant producers and consumers.
   - ***Immediate action***: increase efforts to implement and enforce measures against the illegal timber trade.
   - ***Immediate action***: in consumer countries, introduce and support strong policies and legislation to ensure imports and procurement of commodities are deforestation- and conversion-free.
   - ***Immediate action***: in consumer countries, provide and scale up support to producer governments and landscapes for a transition towards sustainable, deforestation-free agricultural production, with a focus on smallholders.
   - ***Immediate action****:* in producer countries, support sustainable, deforestation-free agricultural practices and better land-use planning to identify appropriate areas for agricultural production outside forests and other ecosystems.

9. **Integrate nature-based solutions more effectively with climate action**: *to unite mitigation of climate change with biodiversity conservation and ecosystem services*. Governments need better integration of nature-based solutions into nationally determined contributions (NDCs) under the UNFCCC. More climate finance should be allocated to forest conservation, which currently receives less than 1.5%. Voluntary carbon markets are growing through company commitments and investor action. Strong messaging from governments and the public that climate neutrality is an expected part of business will be needed to ensure that ecosystem markets continue to grow.

   - ***Immediate action***: increase proportion of climate finance allocated to forest conservation.
   - ***Immediate action***: include quantified deforestation, conservation and restoration targets in NDCs and align with national biodiversity strategies and action plans (NBSAPs).

10. **Support sub-national and multistakeholder action**: *bringing sub-national governments centre stage*. National government inaction is being countered at sub-national level through initiatives such as the Under 2 Coalition, Governor's Climate and Forest Task Force and Rio Blanco Declaration to cut deforestation by 80%. Sub-national governments often control planning, taxation, budgeting and roads but not usually mining, policing or land tenure. In the deforestation fronts, sub-national governments have the most opportunities in Brazil, Indonesia and Malaysia, and least in Angola, Madagascar, CAR and Gabon. Effective cooperation with sub-national governments should be a key component of global responses.

    - ***Immediate action***: increase and channel public finance to support sub-national government actions that in particular support alternative, deforestation- and conversion-free economic development pathways.
    - ***Immediate action***: support landscape and jurisdictional plans that connect multistakeholder spatial plans with adequate incentives and policy power for implementation.

Primarily with the global community: setting ambitious goals for a sustainable planet.

11. **Making targets count**: *using new and existing global targets to drive forward conservation commitments*. New targets from the CBD in early 2021 should focus on retaining existing natural forests and other native ecosystems, in both extent and intactness. But this process is driven by political whims; failure should not cause despair. There are already many targets, through the UNFCCC, the Convention to Combat Desertification (UNCCD), the Sustainable Development Goals (including many social targets), the UN Forum on Forests (UNFF), and voluntary initiatives like the New York Declaration on Forests (NYDF) and the Bonn Challenge, which, if properly implemented, would address the problems outlined here. Science-based targets are an avenue to engage corporate actors. A recent groundswell of interest in climate and environmental issues from youth groups, religions and industry could also help drive forest-friendly commitments.

    - ***Immediate action***: advocate for a strong target on retention of natural/primary forests under the new CBD Global Biodiversity Framework, along with strong forest indicators and concrete policies or sectoral actions that address the drivers of deforestation, including commodity production and climate change.
    - ***Immediate action***: integrate forest conservation more closely into existing global targets such as land degradation neutrality under the CBD, the Sustainable Development Goals (SDGs) and the UNFCCC.

MEDIUM TERM: Changes that need to start now but have a longer time-horizon

1. **A coordinated global response**: *integrating multiple international, national, commercial and civil society initiatives and partnerships around a single global vision*. Calls for a UN forest convention have been resisted; the UN Forum on Forests has little influence (contributions are "voluntary" and adequate finance not available) and the FAO focuses on monitoring and sustainable management. Some commentators call for a "Marshall Plan" for forests, ideally from the UN, possibly jointly from the FAO and the three Rio conventions (CBD, UNFCCC and UNCCD) [29]. Cooperative action by several governments is an option, along the model pioneered by the Ministerial Conference for the Protection of Forests in Europe (now Forests Europe). Any such response needs to include all stakeholders.

2. **Actively restoring forests**: *using the UN Decade on Ecosystem Restoration and the Bonn Challenge as vehicles to rebuild forest cover and quality in areas of the greatest loss*. While forest restoration seldom reclaims exactly what has been lost, it can regain significant ecological integrity, ecosystem services and much biodiversity. Ramping up ambition to rebuild as well as conserve is an important element in any strategy.

3. **Developing fire-control strategies suitable for emerging conditions**: *taking action to address the increasing risk and severity of forest fires*. Around the world, new climate extremes mean traditional control mechanisms are no longer working. A global action-research programme is urgently needed to address the challenge, including fire prevention, management, planning and resource implications. IPLCs should be considered key actors and supported to strengthen their capacities for monitoring, preventing and controlling fires in their lands and territories.

4. **Building a post-COVID approach to nature**: *that prioritizes climate change mitigation and management of ecosystem services and biodiversity*. Research has shown that the risk of novel diseases emerging is higher in tropical forest regions that are experiencing land-use change, like many of the deforestation fronts. Post-COVID recovery programmes and stimulus packages should be aligned with the SDGs and actions to protect and restore forests. The health benefits of ecosystems must be integrated into political decision-making following the "One Health Approach".

APPENDIX 1: DERIVING DEFORESTATION FRONTS FROM HOTSPOT ANALYSIS

An Emerging Hotspot Analysis was used to derive deforestation fronts using the ArcGIS Emerging Hot Spot Analysis tool. This analysis was undertaken in 10km2 hexagons, within country boundaries, based on remote sensing data series from Terra-i data[37] for Latin America, Africa, Asia and Oceania for the period from 2004 to 2017 for which validated data was available. We selected Terra-i deforestation data as a result of several criteria: 1) temporal resolution (16-day) which allows for a more detailed Emerging Hotspot Analysis than annual datasets; 2) spatial resolution of 250m is more relevant to detecting forest loss than changes in individual tree cover or canopies; and 3) the Terra-i algorithm uses neural network machine learning to identify vegetation loss due to anthropogenic causes.

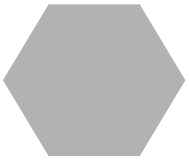
Emerging Hotspot Analysis

The goal of this analysis was to assess the presence of deforestation fronts: areas where deforestation is significantly increasing and is threatening remaining forests. We selected the Emerging Hotspot Analysis to assess spatio-temporal trends of deforestation across the (sub-)tropics[45].

Spatial unit

We selected hexagons as the spatial unit for the analysis for several reasons. They have a low perimeter-to-area ratio, straightforward neighbour relationships, and reduced distortion due to curvature of the Earth. For the hexagon size we decided on a unit of 1,000 ha, which based on the resolution of the deforestation data (250m) meant that we could aggregate several deforestation events inside units over time. Hexagons that are close to or equal to the size of a deforestation event would mean there could only be one event before the forest unit is gone, limiting statistical analysis.

We processed over 13 million hexagons, and limited the analysis to only hexagons with at least 15% forest cover remaining (from the all-evidence forest map). This prevented including hotspots in agricultural areas or where all forest has been converted.

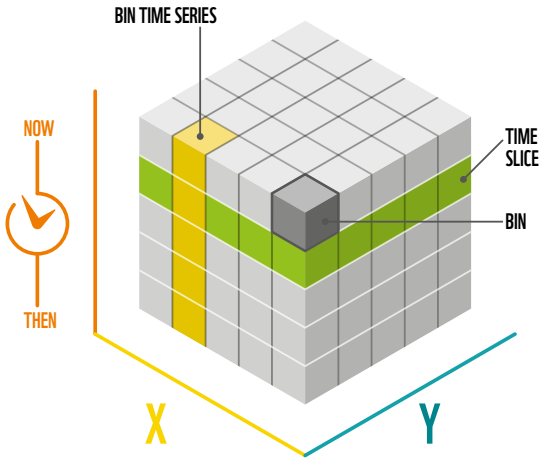


Hexagon Geometries:

Edge length: 1,961.887m

Perimeter: 11,771.324m

Area: 1,000 ha (10km2)



Outputs

This analysis uses the Getis-Ord and Mann-Kendall statistics to identify spatial clusters of deforestation which have a non-parametric significant trend across a time series. The spatial clusters are defined by the spatial unit and a temporal neighbourhood parameter. We use a neighbourhood parameter of 5km to include spatial neighbours in the hotspots assessment and time slices for each country described below. Deforestation events are summarized by a spatial unit (hexagons described below). The results comprise a trends assessment, which defines increasing or decreasing deforestation in the units determined at three confidence intervals (90%, 95% and 99%), and a spatio-temporal analysis classifying areas into eight unique hot or cold spot categories.

Our analysis identified seven hotspot categories (new, consecutive, intensifying, persistent, diminishing, sporadic, historical), which we combined into four classes of spatio-temporal trends to represent four major trajectories of changing deforestation:

Hotspot type	Definition
New	A location with a statistically significant increase in deforestation hotspots including the final time steps
Persistent	Statistically significant or uninterrupted hotspot with no upward or downward trend in clustering intensity
Sporadic	On-again then off-again hotspot
Old	At least 90% of the intervals show statistically significant hotspots, but these do not include the latter time steps.

Hexagons by region

Africa and Madagascar	Asia	Europe and Russia	North America	South America	Oceania	Total
3,050,613	3,139,885	2,378,654	2,125,240	1,847,028	919,216	**13,460,636**

Data

For the evaluation of spatio-temporal trends of tropical deforestation we selected the Terra-i deforestation dataset to define the temporal deforestation patterns. Terra-i is a freely available monitoring system derived from the analysis of MODIS (NVDI) and TRMM (rainfall) data which are used to assess forest cover changes due to anthropogenic interventions at a 250m resolution. It was first developed for Latin American countries in 2012, and then expanded to pan-tropical countries around the world. Terra-i generates maps of vegetation loss every 16 days, from January 2004 until the present. This relatively high temporal resolution of twice-monthly observations allows for a more detailed emerging hotspots analysis, increasing the number of time steps or bins available for assessing spatio-temporal patterns than annual datasets. Next, the spatial resolution of 250m is more relevant for detecting forest loss than changes in individual tree cover or canopies and is better adapted to process trends on large scales. Finally, the added value of the Terra-i algorithm is that it employs additional neural network machine learning to identify vegetation loss that is due to anthropogenic causes as opposed to natural events or other causes. Our dataset comprised all Terra-i deforestation events observed between 2004 and 2017.

Temporal unit

The temporal unit or time slice was selected for each country according to the distribution of data. The deforestation data comprised 16-day periods between 2004 and 2017 for a total of 312 potential observation time periods. These were aggregated to time bins to overcome any seasonality in the detection of deforestation events (due to clouds). The temporal unit is combined with the spatial parameter (i.e. 5km) to create the space-time bins for hotspot analysis. For dense time series or countries with a lot of deforestation events (i.e. Brazil) a smaller time slice was used (i.e. three months, n=54) with a neighbourhood interval of eight months, meaning that the previous year and next year together were combined to assess statistical trends relative to the global variables. The rule we employed was that the time slice x neighbourhood interval was equal to 24 months, or two years, in order to look at general trends over the entire time period and prevent the hotspots analysis from being biased to short time intervals of a few months.

Deriving deforestation fronts from hotspot analysis

Locations with the highest incidence of deforestation were selected in the tropical and subtropical biomes in each country – since some countries may comprise more than one biome – with more than 355,000 ha covered by deforestation hotspot hexagons (Figure A.1). A total of 54 biomes by country were included. The tropical and subtropical Brazilian northeast was considered a single region, as well as tropical West Africa and subtropical West Africa. An exceptions was Australia where the temperate biome was retained because of deforestation dynamics identified in national assessments that we wanted to explore further. Southern tropical China shows a comparatively large number of hexagons classified as deforestation hotspots yet was not included in further analysis given the more complex dynamics of forest conversion and regeneration taking place in this region[244, 245].

Following the hotspot analysis, a visual interpretation of the spatial clustering of deforestation hotspots in the selected biomes by country was conducted in order to delineate the boundaries of deforestation fronts, which comprise all countries in which deforestation hotspots were detected. Deforestation fronts are places that contain an important area of remaining forests where there is a relatively larger spatial concentration or clustering of deforestation hotspots (measured in 10km2 hexagons). As a result of this exercise, based on the Terra-i data, 30 countries were retained in the analysis.

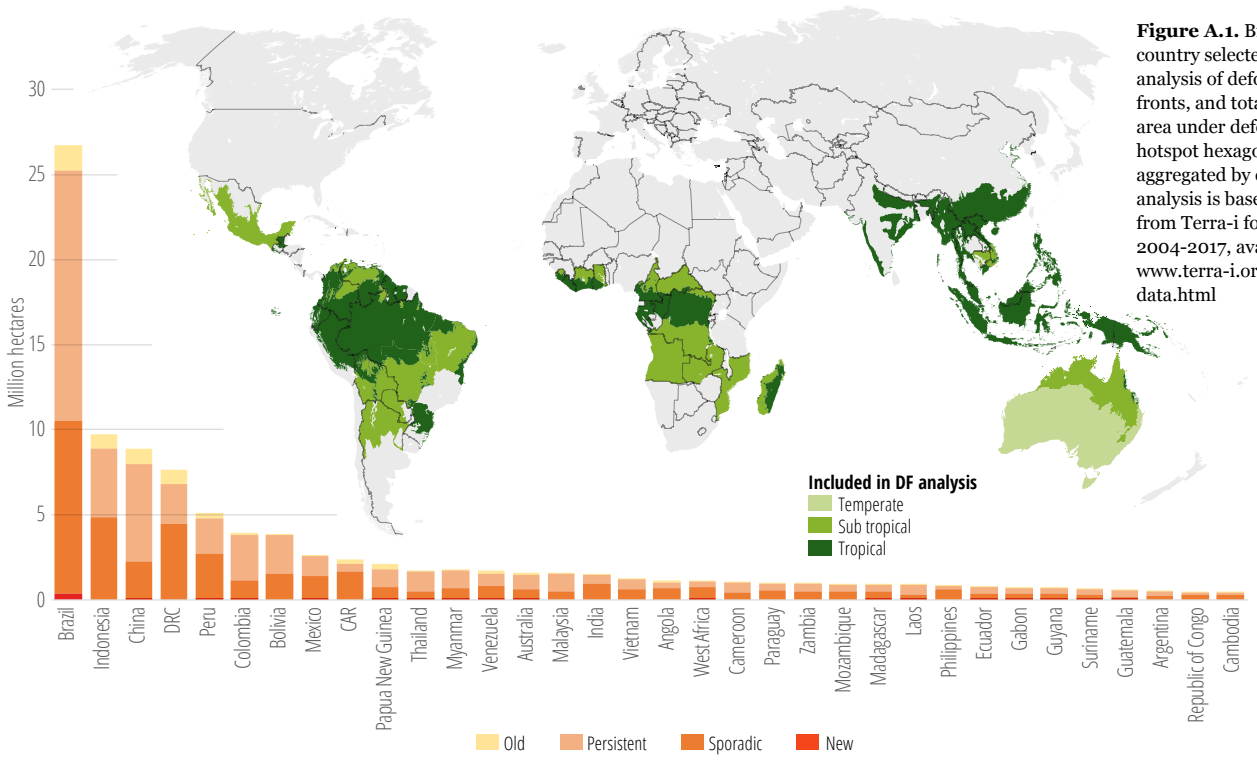


Figure A.1. Biomes by country selected for the analysis of deforestation fronts, and total land area under deforestation hotspot hexagons aggregated by country. Our analysis is based on data from Terra-i for the period 2004-2017, available at www.terra-i.org/terra-i/data.html

APPENDIX 2: METHOD TO DERIVE FOREST COVER MAPS

An all-available data approach

The products used for the analysis of forest cover loss and forest fragmentation consist of a global total forest loss map during the period 2000-2017, and a global present forest map for 2018. The global forest cover map of 2000 was derived by adding the global present forest map and the global deforested area map during the period from 2000 to 2017. Instead of deriving the forest loss areas by subtracting the forest cover maps of the two different periods of time considered (2000 and 2018), the present forest cover map and the map of deforested areas were used to derive the forest cover map in 2000 (see Map A.1). Thereby, the forest cover map of 2000 is equal to the addition of the present (2018) forest cover map and the forest loss areas from 2000 to 2017 (Figure A.2). The rationales are that 1. the main purpose of this study is to determine forest cover loss; and 2. due to the advancement of technology, the forest detection closer to the present is more accurate than that in the past.

Multiple available remote sensing datasets were assessed in order to establish the likely extent of forests as of 2018. After analysing the quality of various remote sensing products, it became evident that in order to obtain a global assessment of forest cover loss, no single approach/data source would work everywhere. This is because each available dataset adopts different definitions of forest, uses different thresholds of tree canopy cover to define forest, and comprises different timeframes. Those discrepancies lead to different estimates of forest cover[24]. In addition, each remote sensing product has its own limitations in terms of area of coverage and timeframes of analysis. In order to address these limitations, an all-available data approach was used as a way to undertake the forest loss assessment by having all the datasets compensating one another[246]. Using this approach, each dataset can complement the other datasets, thus contributing to achieve higher accuracy in classification[247].

Analyses were carried out based on data availability taking into consideration the need to separate data into different regions. A majority vote based on the consensus theoretic classification method[248] was developed to inform the condition of each location in terms of current forest presence. The higher the score, the higher the level of consensus among analytical approaches. For each map from the five different datasets employed, a minimum score was established to produce the maps of forest/non-forest, total forest loss areas, present (2018) forest cover, and 2000 forest cover. Because data quality and availability differ depending on the region, possible maximum and minimum score values differed accordingly. The final global maps were created by combining the binary maps of the boreal and non-boreal regions. A 30m resolution global surface water map[249] was applied to mask out areas classified as seasonal or permanent water between 2000 and 2018.

Resolution: A 250m x 250m (6.25ha) spatial resolution was selected for this analysis. This considered the global scope of this analysis, and the fact that multiple high-quality datasets used were derived from MODIS data. Additionally, a 6.25 ha area is large enough to attribute to it the functional characteristics of a forest (e.g. climate, ecology, ecosystem services) since the tree crown size in tropical forests can range between 5m to 25m[250]. Others have also considered that a spatial resolution from 250m to 1km is an appropriate resolution for detecting land-use/land-cover change[38]. For data with spatial resolution less than 250m, such as the GFC and JAXA ALOS Forest/Non-Forest maps (see below), the spatial resolutions of the deforestation maps were aggregated to 250m using the majority rule.

Canopy threshold: when using data depicting percent tree cover, a threshold value of 25% was adopted. This was used to compromise data calibrated for tropical forests and the values relevant for tropical dry forests while attempting to avoid inclusion of too many shrublands. The minimum percent tree canopy cover usually ranges between 10% and 30%[251]. Different countries adopt different minimum percent thresholds. The difference in the threshold has led to discrepancies in forest area estimates especially in boreal forests and taiga, flooded grasslands and savannahs, and tropical and subtropical dry broadleaf forests[24]. For countries that are mostly arid or semi-arid, such as Kenya, adopting a 10% threshold would result in a 28.1% forest cover for the country, but in humid tropical countries, such as Ecuador, adopting such threshold will result in more than 90% forest cover for the whole country[252]. The lowest threshold used is in Iran, where forest is defined as an area with more than 1% tree canopy cover, while the highest are Malawi and Zimbabwe, where forest is defined as an area with more than 80% tree canopy cover[253]. The tree canopy threshold used by Hansen et al (2013) was 30%[29].

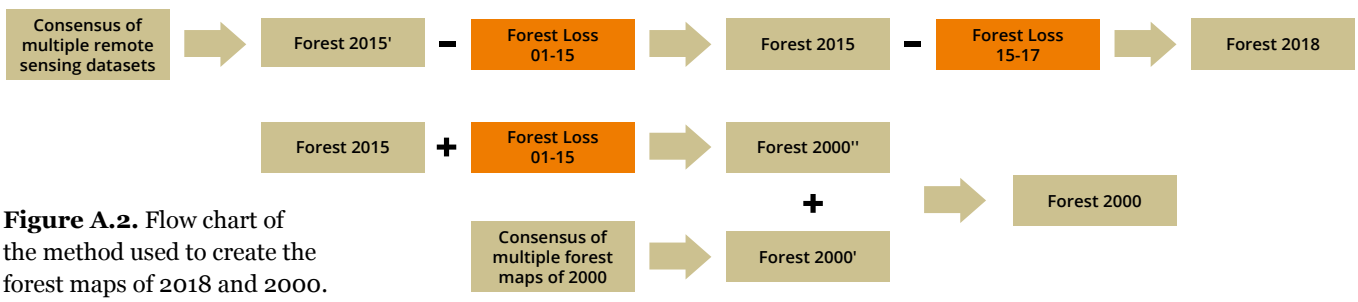
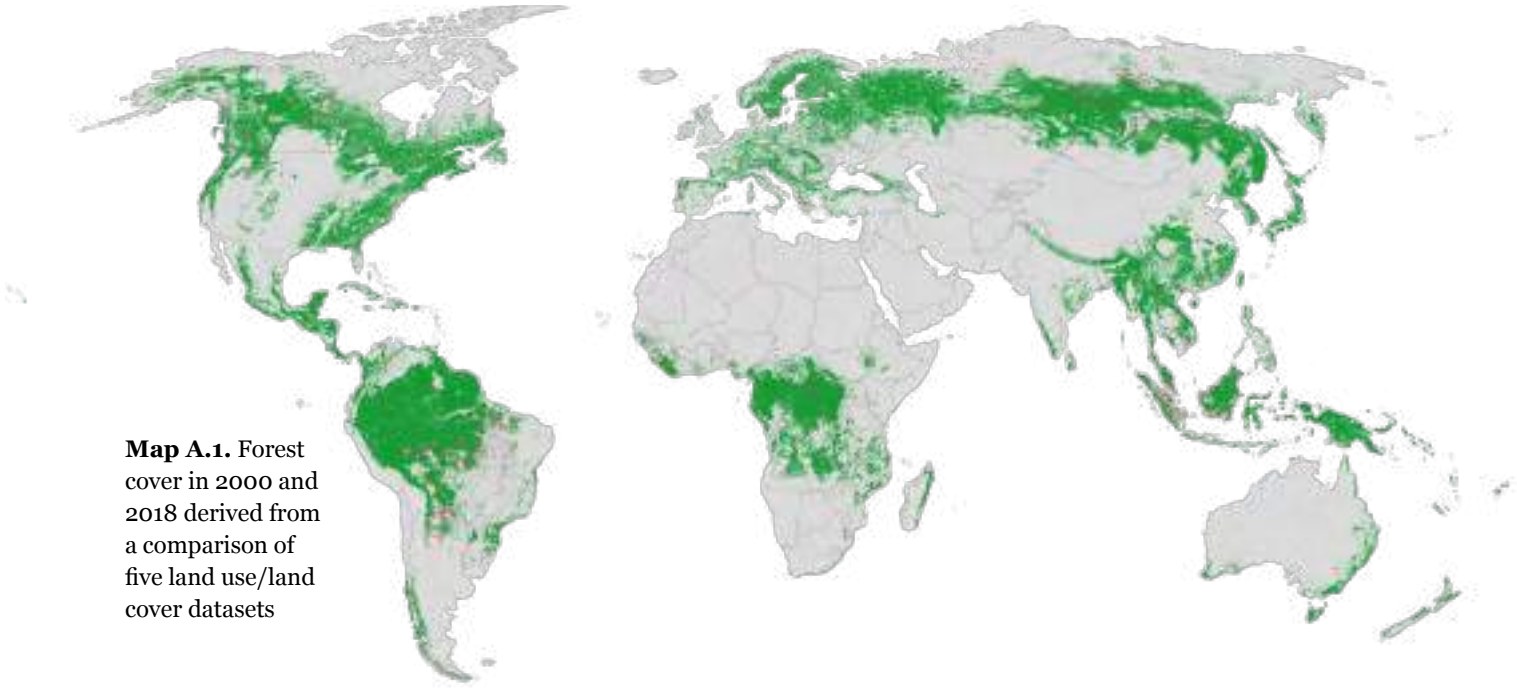


Figure A.2. Flow chart of the method used to create the forest maps of 2018 and 2000.



Map A.1. Forest cover in 2000 and 2018 derived from a comparison of five land use/land cover datasets

Estimating global forest cover loss

The analysis to estimate forest cover loss for the period 2000 to 2017 was divided into two steps: the first to map deforestation from 2000-2015, and the second to update the map until 2018. The rationale for selecting 2015 is merely because most datasets are available for the period from 2000 to 2015. The final product obtained is presented in Map A.1.

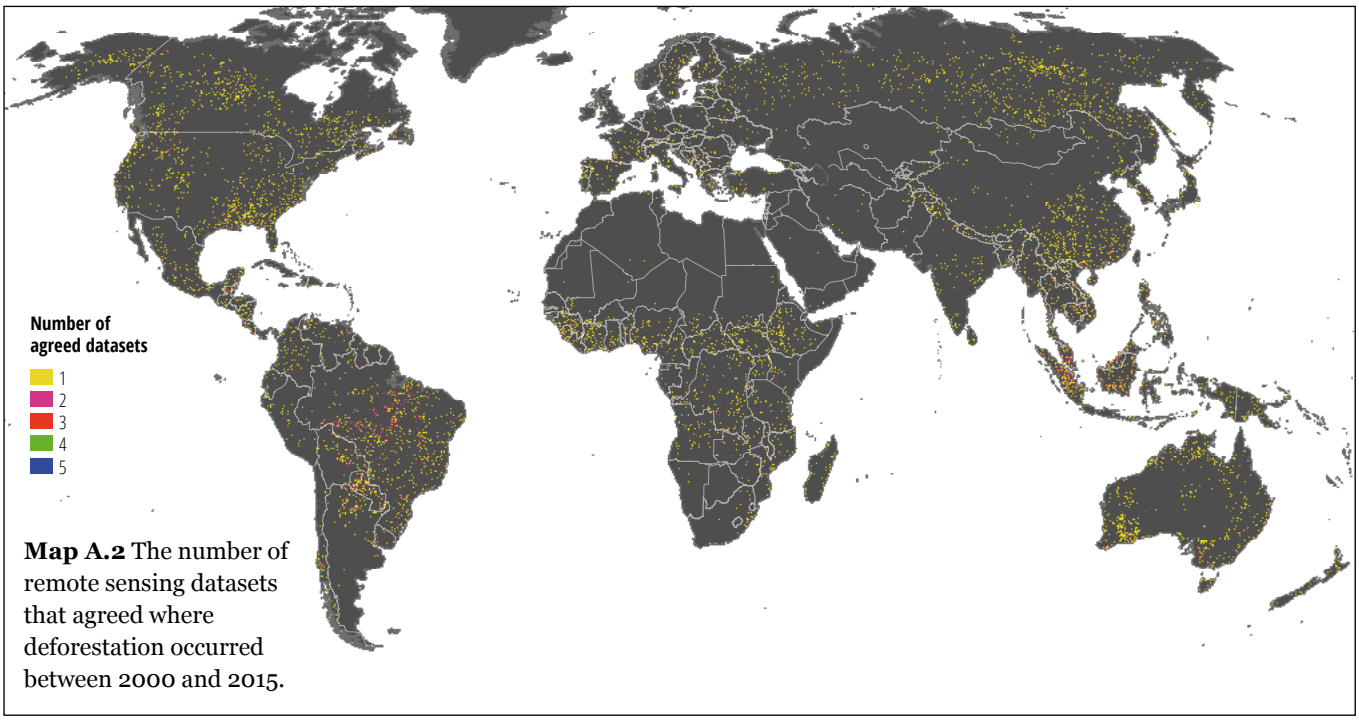
Forest cover loss between 2000 and 2015

Forest cover data comprises two types of data: 1) purposely built deforestation data, and 2) time series of land cover maps where the mapped class was the change from forest to non-forest, which is defined as forest cover loss in this study. The purposely built tree cover loss data was produced by Global Forest Change (GFC)[29] and deforestation data from Terra-i datasets[37]. These two are considered more accurate assessments than data derived from forest map comparisons. The time series of land cover maps includes the MODIS IGBP[254], JAXA ALOS Forest/Non-Forest[33], and ESA CCI[34]. The JAXA ALOS Forest/Non-Forest data was used only in the non-boreal region (areas that are south of 50 degrees north), where the backscatter effect of snow is minimal and the data performs the best[33]. The definition of forest was the same as the one adopted by the used datasets. Table A.1 provides the links to the definition of forest used in the forest/non-forest maps. Land cover datasets are used in this study, as opposed to the FAO, which incorporates land use information in its definition of forest.

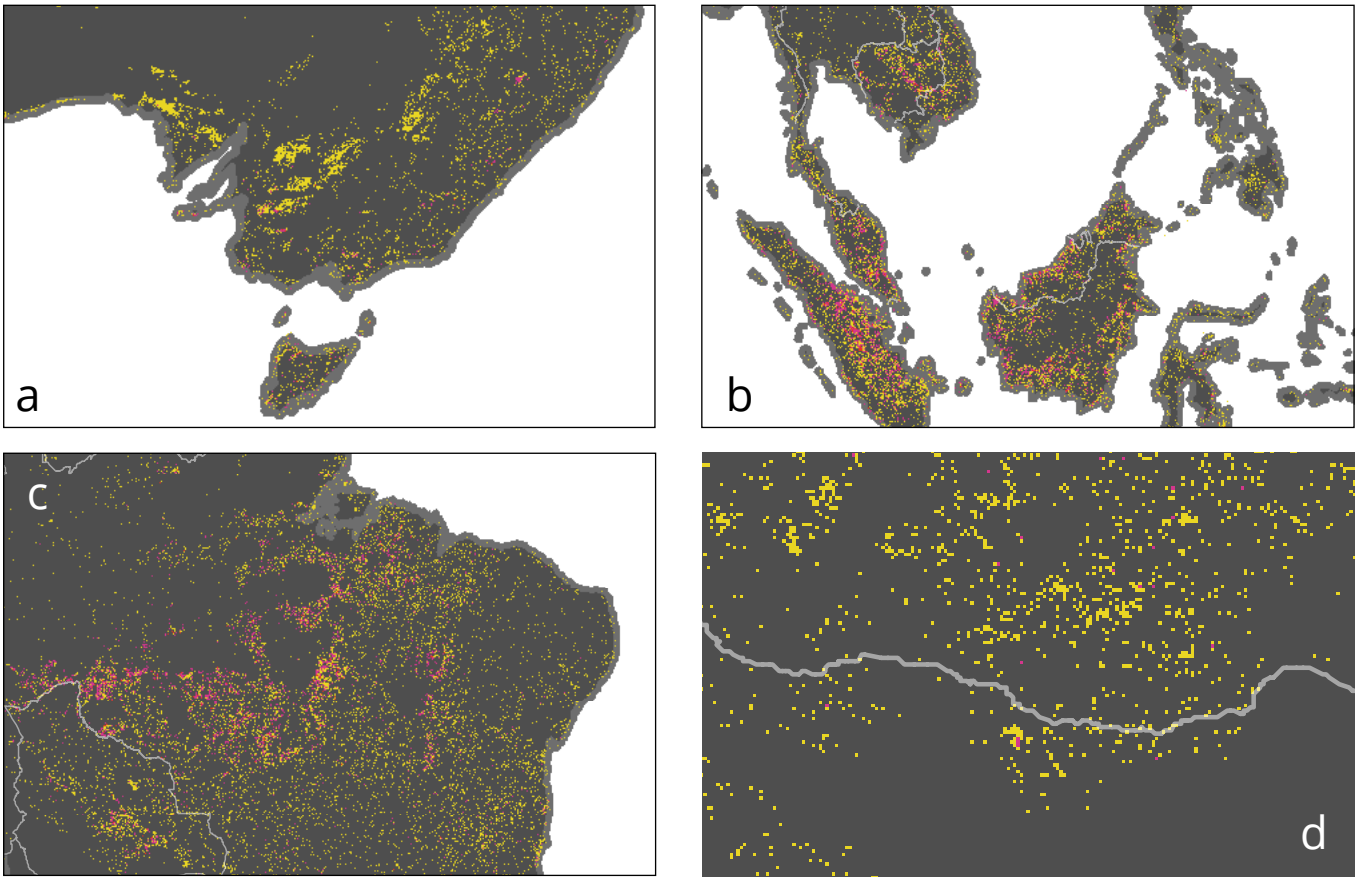
Any pixel mapped as showing changes from forest to non-forest or forest loss between 2000 and 2015 received a score of 1 for all datasets. A total score map was created with the tally of all data for each location (Maps A.2 and A.3). A binary map of deforested areas was created by selecting pixels mapped as transitioning from forest to non-forest or as deforested (depending on the source data) by more than two datasets. In other words, pixels with a tally score >=2 were selected. As shown in the maps, most of the deforested area only has one dataset agreed. Since our estimate of the deforested area is based on areas where at least two remote-sensing datasets agreed on deforestation, and some of those datasets include implicit definition of land use, that leads to an estimate of deforested area lower than any of the estimates using only one dataset. Moreover, the spatial resolution of our estimate is at 250m (6.25ha), thus forest cover losses less than 3.1ha within a 250m pixel are not included.

Table A.1. Datasets used to calculate the total forest loss areas from 2000 to 2017

Dataset	Area	Spatial resolution	Period	Temporal resolution	Source	Rationale
JAXA ALOS F/NF	non-boreal	25m	2007-2017	6 years	Shimada et al (2014)[33]	Free of backscattering effect of snow
ESA CCI Land Cover	Global	300m	1992-2015	Annual	European Space Agency (2019)[34]	Global land cover map with good accuracy. Land covers classified with "tree cover" were considered as "forest"
MODIS IGBP	Global	500m	2000-2015	Annual	Sulla-Menashe and Friedl (2018)[254]	Global land cover map with good accuracy. Land cover classes with more than 30% tree cover were classified as "forest"
Global Forest Change	Global	30m	2000-2018	Annual	Hansen et al. (2013)[29]	Landsat wall-to-wall annual maps of forest loss. Maps that indicate areas of tree cover loss were considered as "deforested".
Terra-I	Tropical	250m	2004-2017	Annual	Reymondin et al. (2012)[37]	Maps that indicate deforestation due to anthropogenic causes.



Map A.2 The number of remote sensing datasets that agreed where deforestation occurred between 2000 and 2015.



Map A.3 The number of remote sensing datasets that indicate deforestation area at 250m resolution between 2000 and 2015, in southeastern Australia (a); part of southeastern Asia (b); northeastern Brazil (c); and Russia-Mongolia region (d). These zoom-in figures show that a lot of deforested areas had no agreement for more than one dataset. The deforested areas in Mongolia, according to the local experts, were mostly due to fire and the lands are not converted to other land uses.

The calculation for the binary deforestation map for Africa was different. Instead of using a majority rule, since the GFC is the main dataset estimating deforestation in Africa, deforestation pixels were selected where GFC data indicates a forest loss or other pixels where at least two other datasets agreed. In the African case, therefore, the forest loss pixels indicated by GFC were given larger weight over the other datasets. The forest loss was drastically underestimated in Africa by most of the datasets, except for the GFC forest loss data. GFC is the only dataset that did not show any underestimation of deforestation in Africa likely because the GFC conducted calibration and validation in all the biomes, including those in Africa[29].

Forest cover loss from 2015 to 2017

While there were five datasets available to determine deforestation from 2000 to 2015, only three datasets were available from 2015 to 2017, namely JAXA ALOS, GFC and Terra-I (see Table A.1). As for the deforested area estimate for 2000-2015, areas where at least two datasets agreed deforestation occurred were included in the binary deforestation area map. The total deforested area from 2000 to 2017 is, therefore, the combined deforested areas between these two periods (Map A.4).

ALOS PALSAR data: ALOS PALSAR Forest/Non-forest maps produced by JAXA[33] were available for 2007-2010, and 2015-2017. Given discrepancies in Forest/Non-Forest classification among the ALOS-PALSAR maps time series for some locations, a decision tree permutation (see Table A.2) was used to determine the forest/non-forest class as the results of forest loss between 2015 and 2017.

Estimating forest maps for years 2000, 2015 and 2018

Forest map, year 2015

The largest number of either forest or land cover datasets is available for 2015. Four datasets were used to elaborate a 2015 forest map. Areas where at least three of the datasets used agreed in forest classification (Table A.3) were included. The data considered included:

- 2015 MODIS MOD44B Version 6 Vegetation Continuous Field (VCF) dataset[255]: A threshold at canopy cover of at least 25% was used to produce a binary map.
- Since the ALOS data was not used in the boreal region, to classify the forest cover in that region, areas with at least two datasets agreed as forest were selected.

Map A.4 Binary map indicates where at least two remote sensing datasets agreed on where deforestation has occurred between 2000 and 2018 (except Africa). The resolution of the map is at 250m (6.25 ha).

Table A.2 Determining the forest (F) or non-forest (NF) class after year 2017 based on the forest/non-forest classification maps between 2015 and 2017 of ALOS.

ALOS Based Classification			
2015	2016	2017	2015-2017 assigned Class
F	F	F	F
F	NF	F	F
NF	F	F	F
F	F	NF	NF
F	NF	NF	NF
NF	F	NF	NF
NF	NF	F	NF
NF	NF	NF	NF

Estimating forest maps for years 2000, 2015 and 2018

Table A.3. Datasets used in the analysis to estimate forest cover in 2015

Dataset	Area	Resolution	Period	Source	Rationale
ALOS F/NF	non-boreal	25m	2015	Shimada et al (2014)[33]	Free of backscattering effect of snow
ESA CCI Land Cover	Global	300m	2015	European Space Agency (2019)[34]	Global land cover map with good accuracy. Land covers classified with "tree cover" were considered as "forest".
MODIS VCF	Global	250m	2015	DiMiceli et al (2017)[255]	Wall-to-wall coverage of global percentage tree cover. Pixels with more than or equal to 25% tree cover were classified as "forest".
MODIS IGBP	Global	500m	2015	Sulla-Menashe and Friedl (2018)[254]	Global land cover map with good accuracy. Land cover classes with more than 30% tree cover were classified as "forest"

Forest map, year 2018

The present (2018) forest cover map was produced by updating the 2015 map. This was done by subtracting the deforestation data produced for the 2015-2017 period. The total deforested areas from 2000 to 2017 were masked out from the present (2018) forest map. Figure A.3 illustrates the flow chart followed:

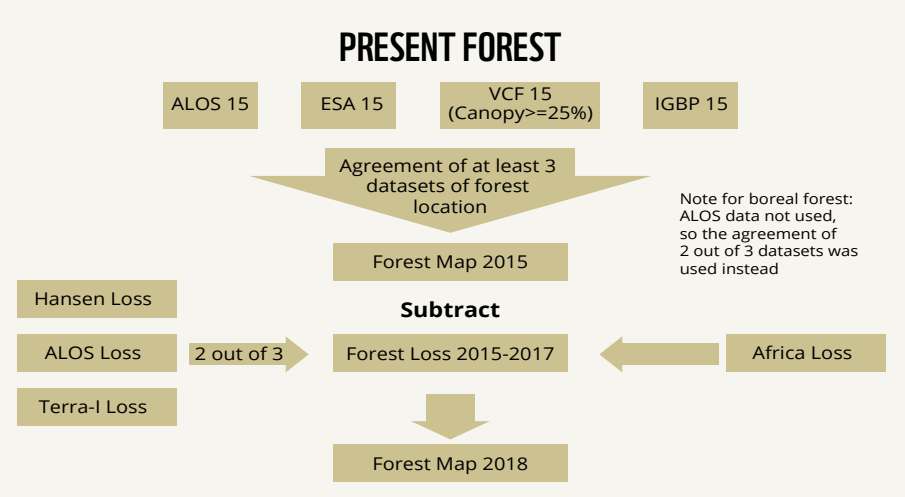


Figure A.3. Methods and datasets used to calculate the present (2018) forest cover map

Forest map, year 2000

The global forest map of the year 2000 was obtained by adding the total deforested area from 2001 to 2017 and the global present forest map. Mapping deforestation is different from producing a forest cover map. A key aspect to highlight is the fact the 2001-2015 forest cover loss analysis is the cornerstone of all the datasets. As explained above, the main reason for this is because this is a forest cover loss/deforestation analysis and not a forest cover analysis. The availability of datasets for more recent years increases the certainty of our forest lost estimates, and the present forest cover map.

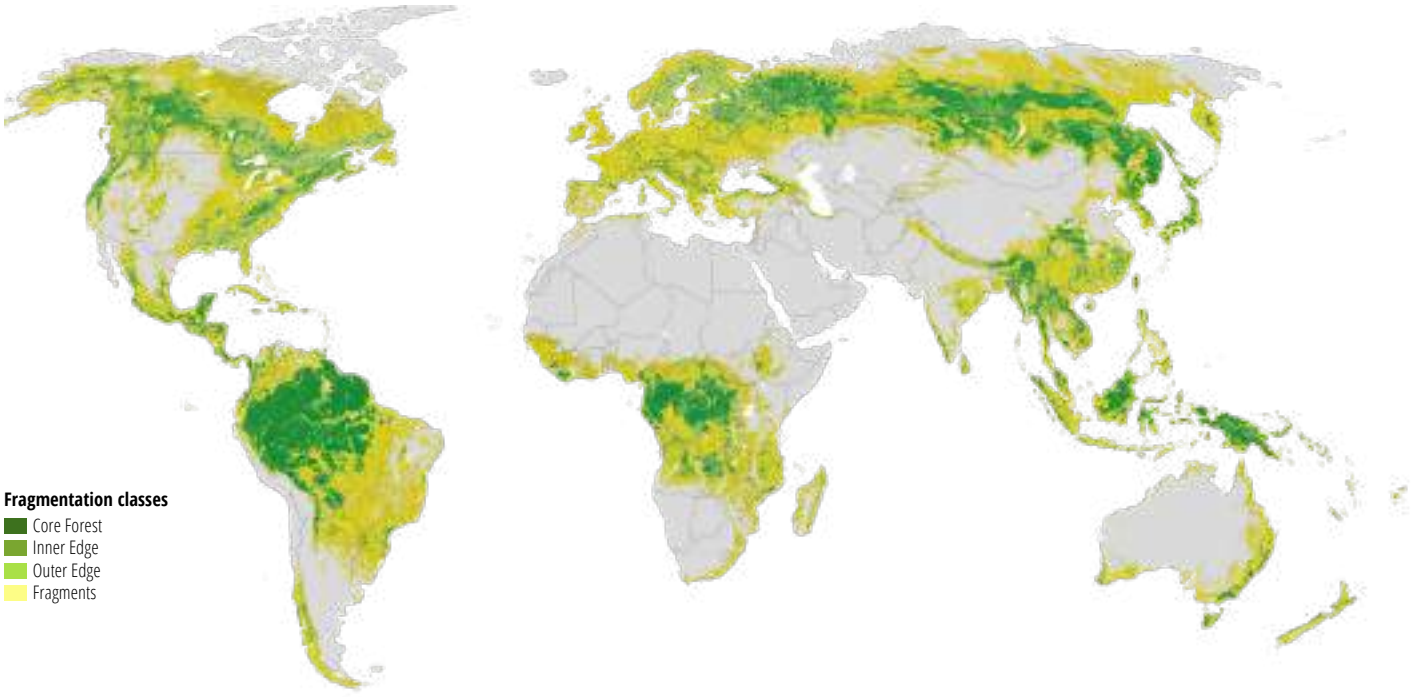
APPENDIX 3: METHOD TO DETERMINE FOREST FRAGMENTATION

Fragmentation is assessed on a binary forest/non-forest map using MSPA (Morphological Spatial Pattern Analysis) based on Vogt et al. (2007)[256]. This produces a four-class map with varying levels of degradation, as described in Shapiro et al. (2016)[41]. The fragmentation class map is created for a forest map according to the following categories, using an edge width of 300m (Table A.4):

Table A.4. Fragmentation classes

Class	Description	Level of Degradation
Core Forest	Interior forest pixels surrounded by forest	Low
Inner Edge	Forest unit on edge of interior non-forest (opening)	
Outer Edge	Forest units bordering large non-forest areas	
Fragment	Forest units too small to contain core forest	High

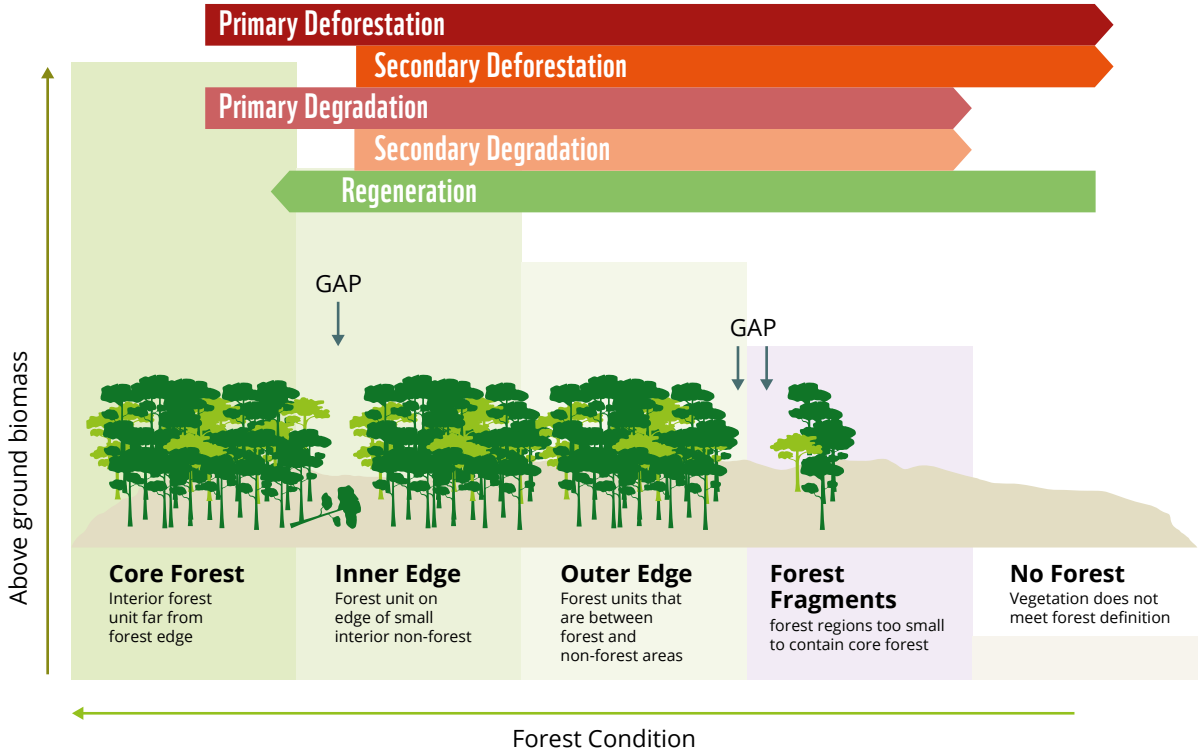
Map A.5 shows the fragmentation map using the classes defined in Table A.4.

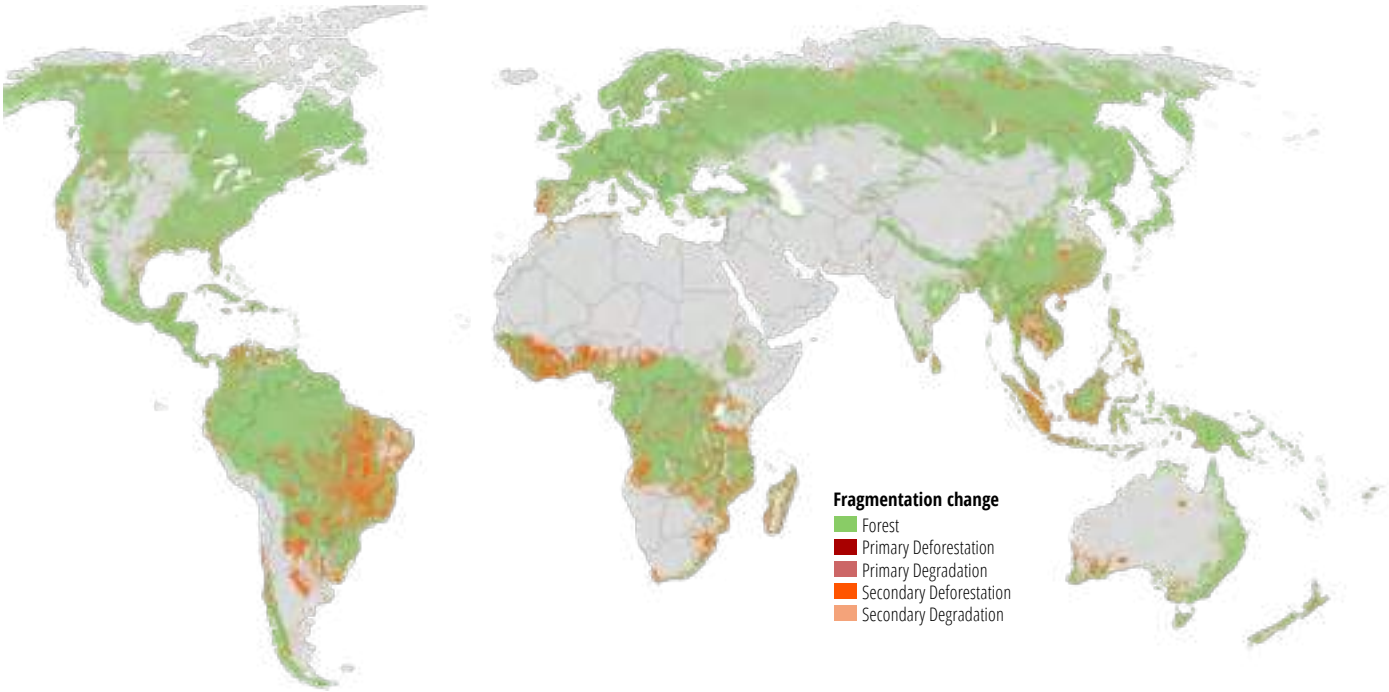


Map A.5 Current forest fragmentation circa 2018 considering core forests, inner edges, outer edges and fragments.

We define degradation via a reduction of above-ground biomass at forest edges through a process of fragmentation. We mapped fragmentation classes for both all-evidence forest cover maps from 2000 and 2018 (see Appendix 2), and determine which classes stay the same or transition to a different class. The transitions are reclassified into their defined trajectories as shown below. All processes were performed in Google Earth Engine.

The resulting map is classified according to its stable state if it does not change (i.e. core, inner edge, outer edge or patch) or a trajectory (primary or secondary deforestation or degradation) if the fragmentation class has changed between years (see Map A.6). This allows us to assess primary and secondary deforestation and degradation, as well as intact core forest, or stable edge categories worldwide.





Map A.6 Present forest and total deforestation (primary and secondary) and degradation (primary and secondary). Based on all-available data estimates. The categories build on Shapiro et al (2016).[41].

Mountain gorillas at Virunga National Park,
Democratic Republic of Congo.

REFERENCES

1. Lambin, E.F., Geist, H.J., and Lepers, E. 2003. Dynamics of Land-Use and Land-Cover Change in Tropical Regions. *Annual Review of Environment and Resources* 28(1): 205-241.
2. FAO. 2018. *The State of the World's Forests 2018 - Forest pathways to sustainable development*. FAO, Rome, Italy.
3. IPCC. 2019. *IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse gas fluxes in Terrestrial Ecosystems*. https://www.ipcc.ch/site/assets/uploads/2019/08/Edited-SPM_Approved_Microsite_FINAL.pdf.
4. Ball, J.B. 2001. *Global forest resources: history and dynamics*. In: J. Evans (ed), *The Forests Handbook, 3-22*. Blackwell Science, Oxford, UK.
5. Gibbs, H.K., Ruesch, A.S., Achard, F., Clayton, M.K., Holmgren, P., Ramankutty, N., and Foley, J.A. 2010. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *Proceedings of the National Academy of Sciences of the United States of America* 107(38): 16732-16737.
6. Alexander, P., Brown, C., Arneth, A., Finnigan, J., Moran, D., and Rounsevell, M.D.A. 2017. Losses, inefficiencies and waste in the global food system. *Agricultural Systems* 153: 190-200.
7. Babigumira, R., Angelsen, A., Buis, M., Bauch, S., Sunderland, T., and Wunder, S. 2014. Forest Clearing in Rural Livelihoods: Household-Level Global-Comparative Evidence. *World Development* 64: S67-S79.
8. Sunderlin, W., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., Santoso, L., and Wunder, S. 2005. Livelihoods, forests, and conservation in developing countries: an overview. *World development* 33(9): 1383-1402.
9. Rudel, T., Coomes, O., Moran, E., Frédéric, A., Angelsen, A., Xu, J., and Lambin, E. 2005. Forest Transitions: Towards a Global Understanding of Land Use Change. *Global Environmental Change* 15: 23-31.
10. Meyfroidt, P., Roy Chowdhury, R., de Bremond, A., Ellis, E.C., Erb, K.H., Filatova, T., . . . Verburg, P.H. 2018. Middle-range theories of land system change. *Global Environmental Change* 53: 52-67.
11. Mather, A.S. 1992. The Forest Transition. *Area* 24(4): 367-379.
12. Meyfroidt, P. and Lambin, E.F. 2011. Global Forest Transition: Prospects for an End to Deforestation. *Annual Review of Environment and Resources* 36(1): 343-371.
13. Pacheco, P. 2015. One wicked problem, three major challenges, available from: https://forestsnews.cifor.org/33868/zero-deforestation-special-one-wicked-problem-three-major-challenges?fnl=en.
14. Meyfroidt, P., Lambin, E.F., Erb, K.-H., and Hertel, T.W. 2013. Globalization of land use: distant drivers of land change and geographic displacement of land use. *Current Opinion in Environmental Sustainability* 5(5): 438-444.
15. Curtis, P.G., Slay, C.M., Harris, N.L., Tyukavina, A., and Hansen, M.C. 2018. Classifying drivers of global forest loss. *Science* 361(6407): 1108-1111.
16. European Commission. 2013. *The impact of EU consumption on deforestation: Comprehensive analysis of the impact of EU consumption on deforestation* Vito, CICERO, IIASA, IUCN NL. http://pure.iiasa.ac.at/id/eprint/14868/1/1.%20Report%20analysis%20of%20impact.pdf.
17. Pendrill, F., Persson, U.M., Godar, J., Kastner, T., Moran, D., Schmidt, S., and Wood, R. 2019. Agricultural and forestry trade drives large share of tropical deforestation emissions. *Global Environmental Change* 56: 1-10.
18. Busch, J. and Ferretti-Gallon, K. 2017. What Drives Deforestation and What Stops It? A Meta-Analysis. *Review of Environmental Economics and Policy* 11(1): 3-23.
19. Angelsen, A. and Kaimowitz, D. 1999. Rethinking the causes of deforestation : lessons from economic models. *The World Bank research observer* 14(1): 73-98.
20. WWF. 2015. *Living Forests Report: Chapter 5 Saving forests at risk. Living Planet Report*. World Wildlife Fund.
21. Dudley, N., Schlaepfer, R., Jackson, W., Jeanrenaud, J.-P., and Stolton, S. 2012. *Forest Quality: Assessing Forests at a Landscape Scale*. Routledge, London.
22. IPBES. 2019. *Glossary, Global assessment report on biodiversity and ecosystem services*. United Nations, UNEP, UNESCO, FAO, UNDP, BES, Paris, France.
23. Grainger, A. 2008. Difficulties in tracking the long-term global trend in tropical forest area 105(2): 818-823.
24. Sexton, J.O., Noojipady, P., Song, X.-P., Feng, M., Song, D.-X., Kim, D.-H., . . . Townshend, J.R. 2016. Conservation policy and the measurement of forests. *Nature Climate Change* 6(2): 192-196.
25. Pearce, D. 2018. Conflicting Data: How Fast Is the World Losing its Forests? [last accessed: October 9, 2019 December 31, 2019], available from: https://e360.yale.edu/features/conflicting-data-how-fast-is-the-worlds-losing-its-forests
26. Holmgren, P. 2017. One number to rull them all. [last accessed: January 2 2019], available from: https://forestsnews.cifor.org/49146/one-number-to-rule-them-all?fnl=en.
27. Butler, R.A. 2019. Tropical deforestation tables. [last accessed: May 12, 2019 December 31, 2019], available from: https://rainforests.mongabay.com/deforestation_alpha.html.
28. FAO. 2016. *Global Forest Resources Assessment 2015*. Food and Agriculture Organization of the United Nations, Rome, Italy. 125pp.
29. Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., . . . Townshend, J.R.G. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science* 342(6160): 850-853.
30. FAO. 2020. *Global Forest Resources Assessment 2020 – Key findings*. FAO, Rome.
31. Turubanova, S., Potapov, P.V., Tyukavina, A., and Hansen, M.C. 2018. Ongoing primary forest loss in Brazil, Democratic Republic of the Congo, and Indonesia. *Environmental Research Letters* 13(7): 074028.
32. Weisse, M. and Goldman, E.D. 2020. We Lost a Football Pitch of Primary Rainforest Every 6 Seconds in 2019. [last accessed: June 5, 2020], available from: https://www.wri.org/blog/2020/06/global-tree-cover-loss-data-2019.
33. Shimada, M., Itoh, T., Motooka, T., Watanabe, M., Shiraishi, T., Thapa, R., and Lucas, R. 2014. New global forest/non-forest maps from ALOS PALSAR data (2007–2010). *Remote Sensing of Environment* 155: 13-31.
34. ESA. 2019. Global land cover 1992-2015. European Space Agency (ESA), Climate Change Initiative (CCI), available from: http://maps.elie.ucl.ac.be/CCI/viewer/.
35. Friedl, M.A., Sulla-Menashe, D., Tan, B., Schneider, A., Ramankutty, N., Sibley, A., and Huang, X. 2010. MODIS Collection 5 global land cover: Algorithm refinements and characterization of new datasets. *Remote Sensing of Environment* 114(1): 168-182.
36. University of Maryland. 2019. Global Forest Change 2000-2018, available from: http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.6.html.
37. Reymondin, L., Jarvis, A., Perez-Uribe, A., Touval, J., Karolina Argote, Coca, A., . . . Mulligan, M. 2012. *A methodology for near real-time monitoring of habitat change at continental scales using MODIS-NDVI and TRMM*. CIAT, TNC, heig-vd, King's College of London, Cali, Colombia. http://www.terra-i.org/dam/jcr:508a0e27-3c91-4022-93dd-81cf3fe31f42/Terra-i%20Method.pdf.
38. Chambers, J.Q., Asner, G.P., Morton, D.C., Anderson, L.O., Saatchi, S.S., Espírito-Santo, F.D.B., . . . Souza, C. 2007. Regional ecosystem structure and function: ecological insights from remote sensing of tropical forests. *Trends in ecology & evolution* 22(8): 414-423.
39. Osborne, C.P., Charles-Dominique, T., Stevens, N., Bond, W.J., Midgley, G., and Lehmann, C.E.R. 2018. Human impacts on African savannahs are mediated by plant functional traits. *New Phytologist* 220: 10-24.
40. Sasaki, N. and Putz, F.E. 2009. Critical need for new definitions of "forest" and "forest degradation" in global climate change agreements. *Conservation Letters* 2(5): 226-232.
41. Shapiro, A.C., Aguilar-Amuchastegui, N., Hostert, P., and Bastin, J.-F. 2016. Using fragmentation to assess degradation of forest edges in Democratic Republic of Congo. *Carbon Balance and Management* 11(1): 11.
42. Haddad, N.M., Brudvig, L.A., Clobert, J., Davies, K.F., Gonzalez, A., Holt, R.D., . . . Townshend, J.R. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. *Science advances* 1(2): e1500052-e1500052.
43. Betts, M.G., Wolf, C., Pfeifer, M., Banks-Leite, C., Arroyo-Rodríguez, V., Ribeiro, D.B., . . . Ewers, R.M. 2019. Extinction filters mediate the global effects of habitat fragmentation on animals. *Science* 366(6470): 1236-1239.
44. Brinck, K., Fischer, R., Groeneveld, J., Lehmann, S., Dantas De Paula, M., Pütz, S., . . . Huth, A. 2017. High resolution analysis of tropical forest fragmentation and its impact on the global carbon cycle. *Nature Communications* 8(1): 14855.
45. Harris, N.L., Goldman, E., Gabris, C., Nordling, J., Minnemeyer, S., Ansari, S., . . . Potapov, P. 2017. Using spatial statistics to identify emerging hot spots of forest loss. *Environmental Research Letters* 12(2): 024012.
46. Instituto Nacional de Pesquisas Espaciais [INPE]. 2020. TerraBrasilis. Ministério de Ciência e Tecnologia, São José dos Campos, Brazil, available from: http://terrabrasilis.dpi.inpe.br/downloads/.
47. MapBiomas. 2020. *Annual Deforestation Report of Brazil 2019*. https://s3.amazonaws.com/alerta.mapbiomas.org/relatrios/MBI-deforestation-report-2019-en-final5.pdf.
48. KLHK. 2019. *Deforestasi Indonesia Tahun 2017-2018*. Kementerian Lingkungan Hidup dan Kehutanan, Jakarta, Indonesia.

49. NYDF Assessment Partners. 2019. *Protecting and Restoring Forests: A Story of Large Commitments yet Limited Progress. New York Declaration on Forests Five-Year Assessment Report*. Climate Focus (coordinator and editor). https://forestdeclaration.org/.
50. Geist, H. and Lambin, E. 2001. *What drives tropical deforestation? A meta-analysis of proximate and underlying causes of deforestation based on subnational case study evidence*. LUCC International Project Office. 136pp.
51. Hosonuma, N., Herold, M., Sy, V.D., Fries, R.S.D., Brockhaus, M., Verchot, L., . . . Romijn, E. 2012. An assessment of deforestation and forest degradation drivers in developing countries. *Environmental Research Letters* 7(4): 044009.
52. Kissinger, G., Herold, M., and Sy, V.D. 2012. *Drivers of deforestation and forest degradation: A Synthesis Report for REDD+ Policymakers*. Lexeme Consulting, Vancouver Canada.
53. Kaimowitz, D. and Angelsen, A. 1999. *The World Bank and non-forest sector policies that affect forests*. CIFOR, Bogor, Indonesia.
54. Boucher, D., Elias, P., Lininger, K., May-Tobin, C., Roquemore, S., and Saxon, E. 2011. *The root of the problem: What's driving tropical deforestation today?* Union of Concerned Scientists, Cambridge, MA. https://www.illegal-logging.info/sites/files/chlogging/uploads/UCSRootoftheProblemDriversofDeforestationFullReport.pdf.
55. Eba'a Atyi, R., Lescuyer, G., Cerutti, P.O., Tsanga, R., Essiane Mendoula, E., and Collins, F. 2016. *Domestic markets, cross-border trade and the role of the informal sector in Cote d'Ivoire, Cameroon and the Democratic Republic of Congo*. CIFOR report for ITTO, Yaoundé, Cameroon. 79pp.
56. De Sy, V., Herold, M., Achard, F., Avitabile, V., Baccini, A., Carter, S., . . . Verchot, L. 2019. Tropical deforestation drivers and associated carbon emission factors derived from remote sensing data. *Environmental Research Letters* 14(9): 094022.
57. Seymour, F. and Harris, N.L. 2019. Reducing tropical deforestation. *Science* 365(6455): 756-757.
58. Satterthwaite, D., McGranahan, G., and Tacoli, C. 2010. Urbanization and its implications for food and farming. *Philosophical Transactions of the Royal Society B: Biological Sciences* 365(1554): 2809-2820.
59. Ahrends, A., Burgess, N.D., Milledge, S.A.H., Bulling, M.T., Fisher, B., Smart, J.C.R., . . . Lewis, S.L. 2010. Predictable waves of sequential forest degradation and biodiversity loss spreading from an African city. *Proceedings of the National Academy of Sciences* 107(33): 14556-14561.
60. Haller, A. 2014. The "sowing of concrete": Peri-urban smallholder perceptions of rural–urban land change in the Central Peruvian Andes. *Land Use Policy* 38: 239-247.
61. Byerlee, D. 2018. *Agriculture, Globalization, and the Demand for Land in the Tropics*. The World Bank, Washington DC, USA.
62. Khoury, C.K., Bjorkman, A.D., Dempewolf, H., Ramirez-Villegas, J., Guarino, L., Jarvis, A., . . . Struik, P.C. 2014. Increasing homogeneity in global food supplies and the implications for food security 111(11): 4001-4006.
63. FAO. 2018. FAOSTAT. Food and Agriculture Organization of the United Nations, Rome, Italy, available from: http://faostat3.fao.org/download/Q/QC/E.
64. HLPE. 2017. *Sustainable Forestry for Food Security and Nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security*. Rome.
65. Alexander, P., Rounsevell, M.D.A., Dislich, C., Dodson, J.R., Engström, K., and Moran, D. 2015. Drivers for global agricultural land use change: The nexus of diet, population, yield and bioenergy. *Global Environmental Change* 35: 138-147.
66. Herrero, M., Havlik, P., McIntire, J., Palazzo, A., and Valin, H. 2014. *African Livestock Futures: Realizing the Potential of Livestock for Food Security, Poverty Reduction and the Environment in Sub-Saharan Africa*. Office of the Special Representative of the UN Secretary General for Food Security and Nutrition and the United Nations System Influenza Coordination (UNSIC), Geneva, Switzerland.
67. UNEP. 2009. *Towards sustainable production and use of resources: Assessing biofuels*. United Nations Environment Programme, Division of Technology Industry and Economics, Paris, France.
68. Cassidy, E.S., West, P.C., Gerber, J.S., and Foley, J.A. 2013. Redefining agricultural yields: from tonnes to people nourished per hectare. *Environmental Research Letters* 8(3): 034015.
69. Eshel, G., Shepon, A., Makov, T., and Milo, R. 2014. Land, irrigation water, greenhouse gas, and reactive nitrogen burdens of meat, eggs, and dairy production in the United States. *Proceedings of the National Academy of Sciences* 111(33): 11996-12001.
70. FAO. 2006. *Livestock's Long Shadow: Environmental issues and options*. FAO, Rome, Italy. http://www.fao.org/3/a0701e/a0701e.pdf.
71. Pacheco, P. and Poccard-Chapuis, R. 2012. The complex evolution of cattle ranching development amid market integration and policy shifts in the Brazilian Amazon. *Annals of the Association of American Geographers* 102(6): 1366-1390.
72. German, L. 2014. Multi-Sited Governance of Large-Scale Land Acquisitions: Mapping and Evaluating the Terrain. *Review of Policy Research* 31(3): 218-252.
73. RAISG. 2018. Pressures on and threats to protect areas and indigenous territories in Amazonia. [last accessed: January 6, 2020], available from: https://www.amazoniasocioambiental.org/en/publication/pressures-on-and-threats-to-protect-areas-and-indigenous-territories-in-amazonia-2/.
74. Garnett, S.T., Burgess, N.D., Fa, J.E., Fernández-Llamazares, Á., Molnár, Z., Robinson, C.J., . . . Leiper, I. 2018. A spatial overview of the global importance of Indigenous lands for conservation. *Nature Sustainability* 1(7): 369-374.
75. Pacheco, P., Barry, D., Cronkleton, P., and Larson, A. 2008. *The role of informal institutions in the use of forest resources in Latin America*. CIFOR, Bogor.
76. Pokorny, B. and de Jong, W. 2015. Smallholders and forest landscape transitions: locally devised development strategies of the tropical Americas. *International Forestry Review* 17: 1-19.
77. Human Rights Watch. 2019. Rainforest Mafias: How Violence and Impunity Fuel Deforestation in Brazil's Amazon, available from: https://www.hrw.org/report/2019/09/17/rainforest-mafias/how-violence-and-impunity-fuel-deforestation-brazils-amazon.
78. Hoare, A. 2015. *Tackling Illegal Logging and the Related Trade: What Progress and Where Next?* . Chatham House, London, UK.
79. Davalos, L.M., Sanchez, K.M., and Armenteras, D. 2016. Deforestation and Coca Cultivation Rooted in Twentieth-Century Development Projects. *Bioscience* 66(11): 974-982.
80. Pacheco, P., Gnych, S., Dermawan, A., Komarudin, H., and Okarda, B. 2017. *The palm oil global value chain: Implications for economic growth and social and environmental sustainability*. CIFOR, Bogor, Indonesia.
81. Pacheco, P. 2012. *Soybean and oil palm expansion in South America: a review of main trends and implications*. 28pp. https://www.cifor.org/knowledge/publication/3776/.
82. Cramb, R. and McCarthy, J.F. 2016. *The Oil Palm Complex: Smallholders, Agribusiness and the State in Indonesia and Malaysia*. NUS Press, Singapore. 512pp.
83. Nelson, P., Gabriel, J., Filer, C., Banabas, M., Sayer, J., Curry, G., . . . Venter, O. 2013. Oil Palm and Deforestation in Papua New Guinea. *Conservation Letters* 7.
84. Dammert, J.L. 2018. *El crecimiento de la palma aceitera en la Amazonía peruana y su impacto en los bosques*. IWGIA, Grupo Internacional de Trabajo sobre Asuntos Indígenas, Lima, Peru.
85. Potter, L. 2015. *Managing oil palm landscapes: A seven-country survey of the modern palm oil industry in Southeast Asia, Latin America and West Africa*. CIFOR, Bogor, Indonesia.
86. Wessel, M. and Quist-Wessel, P.M.F. 2015. Cocoa production in West Africa, a review and analysis of recent developments. *NJAS - Wageningen Journal of Life Sciences* 74-75: 1-7.
87. Jelsma, I., Schoneveld, G.C., Zoomers, A., and van Westen, A.C.M. 2017. Unpacking Indonesia's independent oil palm smallholders: An actor-disaggregated approach to identifying environmental and social performance challenges. *Land Use Policy* 69(Supplement C): 281-297.
88. Burchardt, H.-J. and Dietz, K. 2014. (Neo-)extractivism – a new challenge for development theory from Latin America. *Third World Quarterly* 35(3): 468-486.
89. Putzel, L., Assembe-Mvondo, S., Ndong, L.B.B., Banioguila, R.P., Cerutti, P., Tieguhong, J.C., . . . Mala, W. 2011. *Chinese Trade and Investment in the Forests of the Congo Basin*. Center for International Forestry Research, Bogor, Indonesia.
90. Zhang, W., Alon, I., and Lattemann, C. 2018. *China's Belt and Road Initiative: Changing the Rules of Globalization*. Palgrave Macmillan, Switzerland.
91. Hughes, A.C. 2019. Understanding and minimizing environmental impacts of the Belt and Road Initiative. *Conservation Biology* 33(4): 883-894.
92. Laurance, W.F. and Arrea, I.B. 2017. Roads to riches or ruin? 358(6362): 442-444.
93. Laurance, W.F., Sloan, S., Weng, L., and Sayer, J.A. 2015. Estimating the Environmental Costs of Africa's Massive "Development Corridors". *Current Biology* 25(24): 3202-3208.
94. Kleinschroth, F. and Healey, J.R. 2017. Impacts of logging roads on tropical forests. *Biotropica* 49(5): 620-635.
95. Barber, C.P., Cochrane, M.A., Souza, C.M., and Laurance, W.F. 2014. Roads, deforestation, and the mitigating effect of protected areas in the Amazon. *Biological Conservation* 177: 203-209.

96. Sloan, S., Alamgir, M., Campbell, M.J., Setyawati, T., and Laurance, W.F. 2019. Development Corridors and Remnant-Forest Conservation in Sumatra, Indonesia. *Tropical Conservation Science* 12: 1940082919889509.
97. Wunder, S. 2005. *Poverty alleviation and tropical forests: what scope for synergies?* In: J. Sayer (ed), *Forestry and development*. Earthscan, London.
98. Mwangi, E. and Wardell, A. 2012. Multi-level governance of forests. *International Journal of the Commons* 6(2): 79-103.
99. van der Heijden, J. 2012. Voluntary environmental governance arrangements. *Environmental Politics* 21(3): 486-509.
100. Abbott, K.W. and Snidal, D. 2009. *The governance triangle: Regulatory standards institutions and the shadow of the state*. In: W. Mattli and Woods, N. (eds), *The Politics of Global Regulation*, pp 44-88. Princeton University Press.
101. Mithöfer, D., van Noordwijk, M., Leimona, B., and Cerutti, P.O. 2017. Certify and shift blame, or resolve issues? Environmentally and socially responsible global trade and production of timber and tree crops. *International Journal of Biodiversity Science, Ecosystem Services & Management* 13(1): 72-85.
102. IPAM. 2019. Amazon deforestation rate in 2019 puts Brazil at stake in the climate debate. [last accessed: April 20, 2020], available from: https://ipam.org.br/amazon-deforestation-rate-in-2019-puts-brazil-at-stake-in-the-climate-debate/.
103. Cashore, B. 2002. Legitimacy and the Privatization of Environmental Governance: How Non–State Market–Driven (NSMD) Governance Systems Gain Rule–Making Authority. *Governance* 15(4): 503-529.
104. Lambin, E.F., Gibbs, H.K., Heilmayr, R., Carlson, K.M., Fleck, L.C., Garrett, R.D., . . . Walker, N.F. 2018. The role of supply-chain initiatives in reducing deforestation. *Nature Climate Change* 8(2): 109-116.
105. Fishman, A., Oliveira, E., and Gamble, L. 2017. *Tackling Deforestation Through A Jurisdictional Approach: Lessons From The Field*. World Wildlife Fund (WWF), Wahsington, DC.
106. Angelsen, A., Martius, C., Sy, V.d., Duchelle, A.E., Larson, A.M., and T.T., P. *Transforming REDD+: Lessons and new directions*. CIFOR, Bogor, Indonesia.
107. Lee, D. and Sanz, M.J. 2017. *UNFCCC Accounting for Forests: What's in and what's out of NDCs and REDD+*. CLUA. http://www.climateandlandusealliance.org/wp-content/uploads/2017/07/Policy_brief-NDCs-and-REDD.pdf.
108. Streck, C. and Zwick, S. 2019. Shades of REDD+: Understanding the History and Future of Forest Finance, available from: https://www.ecosystemmarketplace.com/articles/shades-of-redd-plus/.
109. Stickler, C., Duchelle, A., Ardila, J.P., Nepstad, D., David, O., Chan, C., . . . Warren, M. 2018. *The state of jurisdictional sustainability: Synthesis for practitioners and policy makers*. EII, CIFOR, GCF, San Francisco, CA. https://earthinnovation.org/wp-content/uploads/2018/09/Stickler_et_al_2018_StateJS_Synthesis_small.pdf.
110. Agrawal, A., Hajjar, R., Liao, C., Rasmussen, L.V., and Watkins, C. 2018. Editorial overview: Forest governance interventions for sustainability through information, incentives, and institutions. *Current Opinion in Environmental Sustainability* 32: A1-A7.
111. Miller, D.C. and Nakamura, K.S. 2018. Protected areas and the sustainable governance of forest resources. *Current Opinion in Environmental Sustainability* 32: 96-103.
112. Hajjar, R. and Oldekop, J.A. 2018. Research frontiers in community forest management. *Current Opinion in Environmental Sustainability* 32: 119-125.
113. Busch, J., Ferretti-Gallon, K., Engelmann, J., Wright, M., Austin, K.G., Stolle, F., . . . Baccini, A. 2015. Reductions in emissions from deforestation from Indonesia's moratorium on new oil palm, timber, and logging concessions. *Proceedings of the National Academy of Sciences* 112(5): 1328-1333.
114. Chen, B., Kennedy, C.M., and Xu, B. 2019. Effective moratoria on land acquisitions reduce tropical deforestation: evidence from Indonesia. *Environmental Research Letters* 14(4): 044009.
115. Gibbs, H.K., Rausch, L., Munger, J., Schelly, I., Morton, D.C., Noojipady, P., . . . Walker, N.F. 2015. Brazil's Soy Moratorium. *Science* 347(6220): 377-378.
116. Wunder, S., Brouwer, R., Engel, S., Ezzine-de-Blas, D., Muradian, R., Pascual, U., and Pinto, R. 2018. From principles to practice in paying for nature's services. *Nature Sustainability* 1(3): 145-150.
117. van der Ven, H. and Cashore, B. 2018. Forest certification: the challenge of measuring impacts. *Current Opinion in Environmental Sustainability* 32: 104-111.
118. Newton, P. and Benzeev, R. 2018. The role of zero-deforestation commitments in protecting and enhancing rural livelihoods. *Current Opinion in Environmental Sustainability* 32: 126-133.
119. Pacheco, P., Bakhtary, H., Camargo, M., Donofrio, S., Drigo, I., and Mithöfer, D. 2018. *The private sector: Can zero deforestation commitments save tropical forests?* In: A.e. al. (ed), *Transforming REDD+: Lessons and new directions*, pp 161-174. CIFOR, Bogor, Indonesia.
120. Taylor, R. and Streck, C. 2018. *The elusive impact of the deforestation-free supply chain movement*. World Resources Institute, Climate Focus, Washington, DC.
121. Brockhaus, M., Di Gregorio, M., and Mardiah, S. 2014. Governing the design of national REDD+: An analysis of the power of agency. *Forest Policy and Economics* 49: 23-33.
122. Duchelle, A.E., Simonet, G., Sunderlin, W.D., and Wunder, S. 2018. What is REDD+ achieving on the ground? *Current Opinion in Environmental Sustainability* 32: 134-140.
123. Boyd, W., Stickler, C., Duchelle, A.E., Seymour, F., Nepstad, D., Bahar, N.H.A., and Rodriguez-Ward, D. 2018. *Jurisdictional approaches to REDD+ and low emissions development: Progress and prospects*. World Resources Institute, Climate Focus, Washington, DC.
124. IPBES. 2019. *Summary for policymakers of the global assessment report on biodiversity and ecosystem services*. United Nations, UNEP, UNESCO, FAO, UNDP, BES, Paris, France.
125. Planet, P. 2020. Discover the world's protected areas. [last accessed: April 15, 2020], available from: https://www.protectedplanet.net/.
126. Saura, S., Bertzky, B., Bastin, L., Battistella, L., Mandrici, A., and Dubois, G. 2019. Global trends in protected area connectivity from 2010 to 2018. *Biological Conservation* 238: 108183.
127. Coad, L., Leverington, F., Knights, K., Geldmann, J., Eassom, A., Kapos, V., . . . Hockings, M. 2015. Measuring impact of protected area management interventions: current and future use of the Global Database of Protected Area Management Effectiveness. *Philosophical Transactions of the Royal Society B: Biological Sciences* 370(1681): 20140281.
128. RRI. 2018. *At a Crossroads: Consequential trends in recognition of community-based forest tenure reform from 2002-2017*. Rights and Resources Initiative (RRI), Washington, DC. https://rightsandresources.org/wp-content/uploads/2018/11/At-A-Crossroads_RRI_Nov-2018.pdf.
129. RRI. 2018. *A Global Baseline of Carbon Storage in Collective Lands: Indigenous and Local Community Contributions to Climate Change Mitigation*. Rights and Resources Initiative, Washington DC.
130. Fa, J.E., Watson, J.E., Leiper, I., Potapov, P., Evans, T.D., Burgess, N.D., . . . Garnett, S.T. 2020. Importance of Indigenous Peoples' lands for the conservation of Intact Forest Landscapes. *Frontiers in Ecology and the Environment* 18(3): 135-140.
131. Baynes, J., Herbohn, J., Smith, C., Fisher, R., and Bray, D. 2015. Key factors which influence the success of community forestry in developing countries. *Global Environmental Change* 35: 226-238.
132. Larson, A.M., Barry, D., Dahal, G.R., and Colfer, C. 2010. *Forests for people: Community rights and forest tenure reform*. Earthscan, London, UK.
133. Baldwin, C. and Ross, H. 2019. Our warming climate and fire's role in the Australian landscape. *Australasian Journal of Environmental Management* 26(4): 305-310.
134. Barlow, J., Berenguer, E., Carmenta, R., and França, F. 2020. Clarifying Amazonia's burning crisis. *Global Change Biology* 26(2): 319-321.
135. Purnomo, H., Shantiko, B., Sitorus, S., Gunawan, H., Achdiawan, R., Kartodihardjo, H., and Dewayani, A.A. 2017. Fire economy and actor network of forest and land fires in Indonesia. *Forest Policy and Economics* 78: 21-31.
136. Chen, Y., Morton, D.C., Andela, N., van der Werf, G.R., Giglio, L., and Randerson, J.T. 2017. A pan-tropical cascade of fire driven by El Niño/Southern Oscillation. *Nature Climate Change* 7(12): 906-911.
137. Andela, N., Morton, D.C., Giglio, L., Paugam, R., Chen, Y., Hantson, S., . . . Randerson, J.T. 2019. The Global Fire Atlas of individual fire size, duration, speed and direction. *Earth System Science Data* 11(2): 529-552.
138. Müller, R., Pacheco, P., and Montero, J.C. 2014. *The context of deforestation and forest degradation in Bolivia: Drivers, agents and institutions*. CIFOR, Bogor, Indonesia.
139. Santos, M.R.R.d. and Ranieri, V.E.L. 2013. Critérios para análise do zoneamento ambiental como instrumento de planejamento e ordenamento territorial. *Ambiente & Sociedade* 16: 43-60.
140. FAO. 2017. *Land use planning for REDD+*Rome, Italy. http://www.fao.org/3/CA0827EN/ca0827en.pdf.
141. Sayer, J., Sunderland, T., Ghazoul, J., Pfund, J.-L., Sheil, D., Meijaard, E., . . . Buck, L.E. 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses 110(21): 8349-8356.
142. Lewin, A., Mo, K., Scheyvens, H., and Gabai, S. 2019. Forest Certification: More Than a Market-Based Tool, Experiences from the Asia Pacific Region. *Sustainability* 11(9): 2600.

143. EU. 2016. *Evaluation of the EU Flegt Action Plan (Forest Law Enforcement Governance and Trade) 2004 - 2014: Final Report ; Volume 1 (Main Report)*. European Commission, Brussels, Belgium.

144. Ehrenberg-Azcarate, F. and Pena-Claros, M. 2020. Twenty years of forest management certification in the tropics: Major trends through time and among continents. *Forest Policy and Economics* 111: 10.

145. Maguire-Rajpaul, V.A., Rajpaul, V.M., McDermott, C.L., and Pinto, L.F.G. 2020. Coffee certification in Brazil: compliance with social standards and its implications for social equity. *Environment Development and Sustainability* 22(3): 2015-2044.

146. Milder, J.C., Arbuthnot, M., Blackman, A., Brooks, S.E., Giovannucci, D., Gross, L., . . . Zrust, M. 2015. An agenda for assessing and improving conservation impacts of sustainability standards in tropical agriculture. *Conservation Biology* 29(2): 309-320.

147. Lernoud, J., Potts, J., Sampson, G., Garibay, S., Lynch, M., Voora, V., . . . Wozniak, J. 2017. *The State of Sustainable Markets – Statistics and Emerging Trends 2017*. ITC, Geneva. http://www.intracen.org/uploadedFiles/intracenorg/Content/Publications/State-of-Sustainable-Market-2017_web.pdf

148. Round Table on Responsible Soy Association. 2019. *RTRS Headlines 2019*. http://www.responsiblesoy.org/wp-content/uploads/2020/01/RTRS-highlights-2019_ENG_.pdf

149. Roundtable on Sustainable Palm Oil. 2019. *RSPO Impact Update 2019*. https://rspo.org/impact

150. Takahashi, R. and Todo, Y. 2017. Coffee Certification and Forest Quality: Evidence from a Wild Coffee Forest in Ethiopia. *World Development* 92: 158-166.

151. Ansah, E.O., Kaplowitz, M.D., Lupi, F., and Kerr, J. 2020. Smallholder participation and procedural compliance with sustainable cocoa certification programs. *Agroecology and Sustainable Food Systems* 44(1): 54-87.

152. Garrett, R., Rueda, X., Levy, S., Bermudez Blanco, J.F., and Shah, S. 2018. *Measuring impacts of supply chain initiatives for conservation: focus on forest-risk food commodities*. Meridian Institute, Washington, DC. https://www.evidensia.eco/resources/273/measuring-impacts-of-supply-chain-initiatives-for-conservation-focus-on-forest-risk-food-commodities/

153. Rogerson, S. 2019. Forest 500 annual report 2018 - the countdown to 2020.

154. Gnych, S.M., Limberg, G., and Paoli, G. 2015. *Risky business: Motivating uptake and implementation of sustainability standards in the Indonesian palm oil sector*. CIFOR, Bogor, Indonesia. http://www.cifor.org/publications/pdf_files/OccPapers/OP-139.pdf.

155. Union of Concerned Scientists. 2016. *What's Driving Deforestation?* . https://www.ucsusa.org/resources/whats-driving-deforestation

156. Gibbs, H.K., Munger, J., L'Roe, J., Barreto, P., Pereira, R., Christie, M., . . . Walker, N.F. 2016. Did Ranchers and Slaughterhouses Respond to Zero-Deforestation Agreements in the Brazilian Amazon? *Conservation Letters* 9(1): 32–42.

157. Jong, H.N. 2019. Indonesia forest-clearing ban is made permanent, but labeled 'propaganda'. [last accessed: April 5, 2020], available from: https://news.mongabay.com/2019/08/indonesia-forest-clearing-ban-is-made-permanent-but-labeled-propaganda/

158. Cabinet Secretariat of the Republic of Indonesia. 2018. President Jokowi Imposes Moratorium on New Palm Oil Plantations. https://setkab.go.id/en/president-jokowi-imposes-moratorium-on-new-palm-oil-plantations/.

159. Forest Trends. 2015. *Conversion Timber, Forest Monitoring, and Land-Use Governance in Cambodia*. https://www.forest-trends.org/wp-content/uploads/2015/07/Cambodia-Concessions-Report-small-size.pdf.

160. Oldenburg, C. and Neef, A. 2014. Reversing Land Grabs or Aggravating Tenure Insecurity? Competing Perspectives on Economic Land Concessions and Land Titling in Cambodia. *Law and Development Review* 7(1) 49-77.

161. Coudel, E., Ferreira, J., Amazonas, M., Eloy, L., Hercowitz, M., Mattos, L., . . . Toni, F. 2015. *The rise of PES in Brazil: from pilot projects to public policies*. pp 450-472.

162. Pagiola, S., Honey-Roses, J., and Freire-Gonzalez, J. 2016. Evaluation of the Permanence of Land Use Change Induced by Payments for Environmental Services in Quindio, Colombia. *Plos One* 11(3): 18.

163. Pynegar, E.L., Jones, J.P.G., Gibbons, J.M., and Asquith, N.M. 2018. The effectiveness of Payments for Ecosystem Services at delivering improvements in water quality: lessons for experiments at the landscape scale. *Peerj* 6: 29.

164. Suich, H., Lugina, M., Muttaqin, M.Z., Alviya, I., and Sari, G.K. 2017. Payments for ecosystem services in Indonesia. *Oryx* 51(3): 489-497.

165. Alcaniz, I. and Gutierrez, R.A. 2020. Between the Global Commodity Boom and Subnational State Capacities: Payment for Environmental Services to Fight Deforestation in Argentina. *Global Environmental Politics* 20(1): 38-59.

166. Pagiola, S., Carrascosa von Glehn, H., and Taffarello, D. 2013. *Experiências de Pagamentos por Serviços Ambientais no Brasil*. Secretaria de Estado do Meio Ambiente, São Paulo.

167. Giudice, R., Börner, J., Wunder, S., and Cisneros, E. 2019. Selection biases and spillovers from collective conservation incentives in the Peruvian Amazon. *Environmental Research Letters* 14(4): 045004.

168. Moros, L., Corbera, E., Velez, M.A., and Flechas, D. 2020. Pragmatic conservation: Discourses of payments for ecosystem services in Colombia. *Geoforum* 108: 169-183.

169. Alix-Garcia, J.M., Sims, K.R.E., Orozco-Olvera, V.H., Costica, L.E., Fernández Medina, J.D., and Romo Monroy, S. 2018. Payments for environmental services supported social capital while increasing land management. *Proceedings of the National Academy of Sciences* 115(27): 7016-7021.

170. Branford, S. and Borges, T. 2019. Norway freezes support for Amazon Fund; EU/Brazil trade deal at risk? [last accessed: April 15, 2020], available from: https://news.mongabay.com/2019/08/norway-freezes-support-for-amazon-fund-eu-brazil-trade-deal-at-risk/.

171. Jong, H.N. 2019. Indonesia to get first payment from Norway under $1b REDD+ scheme. [last accessed: April 12, 2020], available from: https://news.mongabay.com/2019/02/indonesia-to-get-first-payment-from-norway-under-1b-redd-scheme/.

172. Mongabay. 2019. Gabon could earn up to $150 million for forest conservation. [last accessed: April 13, 2020], available from: https://news.mongabay.com/2019/09/gabon-could-earn-up-to-150-million-for-forest-conservation/.

173. The World Bank. 2010. Guyana REDD+ Investment Fund (GRIF) Established. [last accessed: April 15, 2020], available from: https://www.worldbank.org/en/news/press-release/2010/10/09/guyana-redd-investment-fund-grif-established0.

174. FCPF. 2020. FCPF Country Participants. [last accessed: April 10, 2020], available from: https://www.forestcarbonpartnership.org/countries.

175. Pham, T.T., Moeliono, M., Angelsen, A., Brockhaus, M., Gallo, P., Hoang, T.L., . . . Bocanegra, K. 2018. *Strategic alignment: Integrating REDD+ in NDCs and national climate policies*. In: A. Angelsen, Martius, C., Sy, V.d., Duchelle, A.E., Larson, A.M., and T.T., P. (eds), *Transforming REDD+: Lessons and new directions*, pp 69-80. CIFOR,, Bogor, Indonesia.

176. Carodenuto, S. 2019. Governance of zero deforestation cocoa in West Africa: New forms of public-private interaction. *Environmental Policy and Governance* 29(1): 55-66.

177. Bronkhorst, E., Cavallo, E., van Dorth tot Medler, M.-M., Klinghammer, S., Smit, H.H., Gijsenbergh, A., and van der Laan, C. 2017. *Current practices and innovations in smallholder palm oil finance in Indonesia and Malaysia: Long-term financing solutions to promote sustainable supply chains*. *Occasional Paper 177*. CIFOR., Bogor, Indonesia.

178. Rode, J., Pinzon, A., Stabile, M.C.C., Pirker, J., Bauch, S., Iribarrem, A., . . . Wittmer, H. 2019. Why 'blended finance' could help transitions to sustainable landscapes: Lessons from the Unlocking Forest Finance project. *Ecosystem Services* 37: 10.

179. Burivalova, Z., Allnutt, T.F., Rademacher, D., Schlemm, A., Wilcove, D.S., and Butler, R.A. 2019. What works in tropical forest conservation, and what does not: Effectiveness of four strategies in terms of environmental, social, and economic outcomes. *Conservation Science and Practice* 1(6): e28.

180. Pirard, R., Wunder, S., Duchelle, A.E., Puri, J., Asfaw, S., Bulusu, M., . . . Vedoveto, M. 2019. *Effectiveness of forest conservation interventions: An evidence gap map*. Green Climate Fund, Songdo, South Korea. https://ieu.greenclimate.fund/documents/977793/985626/Learning_paper-Effectiveness_of_forestry_conservation_interventions-Evidence_gap_map.pdf.

181. Gillingham, P.K., Bradbury, R.B., Roy, D.B., Anderson, B.J., Baxter, J.M., Bourn, N.A.D., . . . Thomas, C.D. 2015. The effectiveness of protected areas in the conservation of species with changing geographical ranges. *Biological Journal of the Linnean Society* 115(3): 707-717.

182. Naidoo, R., Gerkey, D., Hole, D., Pfaff, A., Ellis, A.M., Golden, C.D., . . . Fisher, B. 2019. Evaluating the impacts of protected areas on human well-being across the developing world. *Science Advances* 5(4): eaav3006.

183. Mokany, K., Ferrier, S., Harwood, T.D., Ware, C., Di Marco, M., Grantham, H.S., . . . Watson, J.E.M. 2020. Reconciling global priorities for conserving biodiversity habitat. *Proceedings of the National Academy of Sciences* 117(18): 9906-9911.

184. Geldmann, J., Barnes, M., Coad, L., Craigie, I.D., Hockings, M., and Burgess, N.D. 2013. Effectiveness of terrestrial protected areas in reducing habitat loss and population declines. *Biological Conservation* 161: 230-238.

185. Nolte, C., Agrawal, A., Silvius, K.M., and Soares-Filho, B.S. 2013. Governance regime and location influence avoided deforestation success of protected areas in the Brazilian Amazon. *Proceedings of the National Academy of Sciences* 110(13): 4956-4961.

186. Spracklen, B.D., Kalamandeen, M., Galbraith, D., Gloor, E., and Spracklen, D.V. 2015. A Global Analysis of Deforestation in Moist Tropical Forest Protected Areas. *PLOS ONE* 10(12): e0143886.

187. Blackman, A., Pfaff, A., and Robalino, J. 2015. Paper park performance: Mexico's natural protected areas in the 1990s. *Global Environmental Change* 31: 50-61.

188. Laurance, W.F., Useche, D.C., Rendeiro, J., Kalka, M., Bradshaw, C.J.A., Sloan, S.P., . . . Zamzani, F. 2012. Averting biodiversity collapse in tropical forest protected areas. *Nature* 489(7415): 290-+.

189. Golden Kroner, R.E., Qin, S., Cook, C.N., Krithivasan, R., Pack, S.M., Bonilla, O.D., . . . Mascia, M.B. 2019. The uncertain future of protected lands and waters. *Science* 364(6443): 881-886.

190. Carvalho, W.D., Mustin, K., Hilário, R.R., Vasconcelos, I.M., Eilers, V., and Fearnside, P.M. 2019. Deforestation control in the Brazilian Amazon: A conservation struggle being lost as agreements and regulations are subverted and bypassed. *Perspectives in Ecology and Conservation* 17(3): 122-130.

191. Akinyemi, F.O. 2017. Land change in the central Albertine rift: Insights from analysis and mapping of land use-land cover change in north-western Rwanda. *Applied Geography* 87: 127-138.

192. Adom, D., Umachandran, K., Asante, D., Ziarati, P., and Sawicka, B. 2019. The Concept, State, Roles and Management of Protected Areas in Ghana: A Review. *Acta agriculturae Slovenica* 3: 68-76.

193. Tranquilli, S., Abedi-Lartey, M., Abernethy, K., Amsini, F., Asamoah, A., Balangtaa, C., . . . Sommer, V. 2014. Protected Areas in Tropical Africa: Assessing Threats and Conservation Activities. *PLOS ONE* 9(12): e114154.

194. Western, D., Russell, S., and Cuthill, I. 2009. The Status of Wildlife in Protected Areas Compared to Non-Protected Areas of Kenya. *PLOS ONE* 4(7): e6140.

195. Redford, K.H. 1992. The Empty Forest. *BioScience* 42(6): 412-422.

196. Beaudrot, L., Ahumada, J.A., O'Brien, T., Alvarez-Loayza, P., Boekee, K., Campos-Arceiz, A., . . . Andelman, S.J. 2016. Standardized Assessment of Biodiversity Trends in Tropical Forest Protected Areas: The End Is Not in Sight. *PLOS Biology* 14(1): e1002357.

197. Riggio, J., Jacobson, A.P., Hijmans, R.J., and Caro, T. 2019. How effective are the protected areas of East Africa? *Global Ecology and Conservation* 17: e00573.

198. Bowker, J.N., De Vos, A., Ament, J.M., and Cumming, G.S. 2017. Effectiveness of Africa's tropical protected areas for maintaining forest cover. *Conservation Biology* 31(3): 559-569.

199. Muhumuza, M. and Balkwill, K. 2013. Factors effecting the success of conserving biodiversity in national parks: A review of case studies from Africa. International. *Journal of Biodiversity* 2013: 798101.

200. Robinson, B.E., Holland, M.B., and Naughton-Treves, L. 2014. Does secure land tenure save forests? A meta-analysis of the relationship between land tenure and tropical deforestation. *Global Environmental Change* 29(29: 281-293).

201. FAO. 2019. *Status of community-based forestry and forest tenure in the United Republic of Tanzania*. Rome.

202. Sayer, J., Margules, C., and Boedhihartono, A.K. 2017. Will Biodiversity Be Conserved in Locally-Managed Forests? *Land* 6(1): 6.

203. Porter-Bolland, L., Ellis, E.A., Guariguata, M.R., Ruiz-Mallén, I., Negrete-Yankelevich, S., and Reyes-García, V. 2012. Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management* 268: 6-17.

204. Blackman, A. and Veit, P. 2018. Titled Amazon Indigenous Communities Cut Forest Carbon Emissions. *Ecological Economics* 153: 56-67.

205. Nelson, A. and Chomitz, K.M. 2011. Effectiveness of Strict vs. Multiple Use Protected Areas in Reducing Tropical Forest Fires: A Global Analysis Using Matching Methods. *Plos One* 6(8).

206. Shahabuddin, G. and Rao, M. 2010. Do community-conserved areas effectively conserve biological diversity? Global insights and the Indian context. *Biological Conservation* 143: 2926-2936.

207. Boedhihartono, A.K. 2017. Can Community Forests Be Compatible With Biodiversity Conservation in Indonesia? *Land* 6(1): 21.

208. Humphries, S., Holmes, T., de Andrade, D.F.C., McGrath, D., and Dantas, J.B. 2020. Searching for win-win forest outcomes: Learning-by-doing, financial viability, and income growth for a community-based forest management cooperative in the Brazilian Amazon. *World Development* 125: 13.

209. Poffenberger, M. 2009. Cambodia's forests and climate change: Mitigating drivers of deforestation. *Natural Resources Forum* 33(4): 285-296.

210. Chanthalath, X., Yong, L., Beckline, M., and Inthilath, S. 2017. Assessing the Socioecological Perspectives of Eucalyptus Cultivation and Plantation Expansion in Laos. *Open Access Library Journal* 4: 1-15.

211. Gritten, D., Lewis, S.R., Breukink, G., Mo, K., Thuy, D.T.T., and Delattre, E. 2019. Assessing Forest Governance in the Countries of the Greater Mekong Subregion. *Forests* 10(1): 47.

212. ISEAL Alliance. 2018. Understanding Certified Small Producers' Needs: Interviews with certified producers to understand their needs and how sustainability standards can innovate to meet them, available from: https://www.isealalliance.org/sites/default/files/resource/2020-03/Producer-Needs-Report_2018_ISEAL.pdf.

213. Mo, K., Zenobi, S., and Oliver, J. 2020. *Community forest management, FSC certification, and avoided deforestation – A case study from Khamkeut District of Bolikhamxay Province, Laos PDR (internal evaluation) (unpublished)*. WWF.

214. Komives, K., Arton, A., Baker, E., Kennedy, E., Longo, C., Pfaff, A., . . . Newsom, D. 2018. *Conservation impacts of voluntary sustainability standards: How has our understanding changed since the 2012 publication of 'Toward sustainability: The roles and limitations of certification'?* Meridian Institute, Washington, DC. https://www.evidensia.eco/resources/181/conservation-impacts-of-voluntary-sustainability-standards-how-has-our-understanding-changed-since-the-2012-publication-of-toward-sustainability-the-roles-and-limitations-of-certification/.

215. Garret, R. and Pfaff, A. 2019. *When And Why Supply-Chain Sustainability Initiatives "Work: Linking initiatives' effectiveness to their characteristics and contexts*. Meridian Institute, Washington, DC.

216. Miteva, D.A., Loucks, C.J., and Pattanayak, S.K. 2015. Social and Environmental Impacts of Forest Management Certification in Indonesia. *PLOS ONE* 10(7): e0129675.

217. Blackman, A., Goff, L., and Rivera Planter, M. 2018. Does eco-certification stem tropical deforestation? Forest Stewardship Council certification in Mexico. *Journal of Environmental Economics and Management* 89: 306-333.

218. Rico, J., Panlasigui, S., Loucks, C.J., Swenson, J., and Pfaff., A. 2017. *Logging Concessions, Certification &Protected Areas in the Peruvian Amazon: forest impacts from combinations of development rights & land-use restrictions*. FAERE.

219. Panlasigui, S., Rico-Straffon, J., Pfaff, A., Swenson, J., and Loucks, C. 2018. Impacts of certification, uncertified concessions, and protected areas on forest loss in Cameroon, 2000 to 2013. *Biological Conservation* 227(September 2017): 160-166.

220. Tritsch, I., Mertens, B., Velly, G., Meyfroidt, P., Sannier, C., Makak, j., and Houngbedji, K. 2019. *Do forest management plans and FSC certification reduce deforestation in the Congo Basin ?* AFD Research, Montpellier, France.

221. Camargo, M.C., Hogarth, N.J., Pacheco, P., Nhantumbo, I., and Kanninen, M. 2019. Greening the Dark Side of Chocolate: A Qualitative Assessment to Inform Sustainable Supply Chains. *Environmental Conservation* 46(1): 9-16.

222. Alix-Garcia, J. and Gibbs, H. 2017. Forest conservation effects of Brazil's zero deforestation cattle agreements undermined by leakage. *Global Environmental Change* 47: 201-217.

223. EIA. 2019. 2019. Indonesia's moratorium on clearing forests and peatlands now permanent – but excludes vast areas. [last accessed: April 15, 2020], available from: https://eia-international.org/news/indonesias-moratorium-on-clearing-forests-and-peatlands-now-permanent-but-excludes-vast-areas/

224. EIA. 2019. *Toxic trade: Forest crime in Gabon and the Republic of Congo and contamination of the US market*Washington, DC. https://content.eia-global.org/posts/documents/000/000/830/original/Toxic_Trade_EIA-web.pdf?1553480150.

225. European Commission. 2019. EU Communication (2019) on Stepping up EU Action to Protect and Restore the World's Forests. [last accessed: May 30, 2020], available from: https://ec.europa.eu/environment/forests/eu_comm_2019.htm.

226. WWF Sweden. 2019. *WWF Enforcement Review of the EU Timber Regulation (EUTR): EU Synthesis Report*Brussels, Belgium. https://d3bzkjkd62gi12.cloudfront.net/downloads/wwf_eutr_implementation_eu_synthesis_report_2019.pdf.

227. ITTO. 2018. *Review and Assessment of the World Timber Situation: 2017-2018*Yokohama, Japan. https://www.itto.int/annual_review/.

228. Branford, S. and Torres, M., *Amazon Soy Moratorium: defeating deforestation or greenwash diversion?* 2017: Mongabay. p. https://news.mongabay.com/2017/03/amazon-soy-moratorium-defeating-deforestation-or-greenwash-diversion/.

229. Soterroni, A.C., Ramos, F.M., Mosnier, A., Fargione, J., Andrade, P.R., Baumgarten, L., . . . Polasky, S. 2019. Expanding the Soy Moratorium to Brazil's Cerrado. *Science Advances* 5(7): eaav7336.

230. Walker, R., Browder, J., Arima, E., Simmons, C., Pereira, R., Caldas, M., . . . Zen, S.d. 2009. Ranching and the new global range: Amazônia in the 21st century. *Geoforum* 40(5): 732–45.

231. Skidmore, M., Moffette, F., Rausch, L., and Gibbs, H.K. 2020. *Characterizing compliance in cattle supply chains: What factors encourage deforestation-free production in the Brazilian Amazon?* Dept. of Geography and Nelson Institute for Environmental Studies, Gibbs Land Use and Environment Lab (GLUE), University of Wisconsin-Madison, Madison, Wisconsin. https://743a3c3a-9890-45b8-a645-7c0b50c92edb.filesusr.com/ugd/5e1a0d_845ee14d2a6a4658ac6935b39aa49870.pdf.

232. Krauss, C., Yaffe-Bellany, D., and Simões, M., *Why Amazon Fires Keep Raging 10 Years After a Deal to End Them*, in *The New York Times*. 2019: October 18, 2019.

233. Wunder, S. 2009. *Can payments for environmental services reduce deforestation and forest degradation?* In: A. Angelsen and Brockhaus, M. (eds), *Realising REDD+: National Strategy and Policy Options*, pp 213–221. CIFOR, Bogor, Indonesia.

234. Wunder, S., Duchelle, A.E., Sassi, C.d., Sills, E.O., Simonet, G., and Sunderlin, W.D. 2020. REDD+ in Theory and Practice: How Lessons From Local Projects Can Inform Jurisdictional Approaches. *Frontiers in Forests and Global Change* 3(11).

235. Angelsen, A., Martius, C., De Sy, V., Duchelle, A., Larson, A., and Pham, T. 2018. *Transforming REDD+: Lessons and new directions*. CIFOR, Bogor, Indonesia.

236. Lima, M.G.B., Visseren-Hamakers, I.J., Brana-Varela, J., and Gupta, A. 2017. A reality check on the landscape approach to REDD plus : Lessons from Latin America. *Forest Policy and Economics* 78: 10-20.

237. Luttrell, C., Komarudin, H., Zrust, M., Pacheco, P., Limberg, G., Nurfatriani, F., . . . Antika, F. 2018. *Implementing sustainability commitments for palm oil in Indonesia: governance arrangements of sustainability initiatives involving public and private actors*. CIFOR, Bogor, Indonesia.

238. Busch, J. and Amarjargal, O. 2020. Authority of Second-Tier Governments to Reduce Deforestation in 30 Tropical Countries. *Frontiers in Forests and Global Change* 3(1).

239. Beasley, E., Murray, L.S., Funk, J., Lujan, B., Kasprzyk, K., and Burns, D. 2019. *Guide to including nature in National Determined Contributions: A checklist of information and accounting approaches for natural climate solution*. Nature4Climate. https://www.conservation.org/docs/default-source/publication-pdfs/guide-to-including-nature-in-ndcs.pdf.

240. Angelsen, A. and Rudel, T.K. 2013. Designing and Implementing Effective REDD + Policies: A Forest Transition Approach. *Review of Environmental Economics and Policy* 7(1): 91-113.

241. Díaz, S., Settele, J., Brondízio, E.S., Ngo, H.T., Agard, J., Arneth, A., . . . Zayas, C.N. 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science* 366(6471): eaax3100.

242. Willett, W., Rockström, J., Loken, B., Springmann, M., Lang, T., Vermeulen, S., . . . Murray, C.J.L. 2019. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet* 393(10170): 447-492.

243. Laski, J. 2019. Aligning Finance and Sustainability: The Role of the Principles for Responsible Banking. [last accessed: April 15, 2020], available from: https://www.sustainalytics.com/sustainable-finance/2019/11/26/sustainable-lending-principles-for-responsible-banking-aligning-finance-and-sustainability/.

244. Nüchel, J. and Svenning, J.-C. 2017. Recent tree cover increases in eastern China linked to low, declining human pressure, steep topography, and climatic conditions favoring tree growth. *PLOS ONE* 12(6): e0177552.

245. Chen, C., Park, T., Wang, X., Piao, S., Xu, B., Chaturvedi, R.K., . . . Myneni, R.B. 2019. China and India lead in greening of the world through land-use management. *Nature Sustainability* 2(2): 122-129.

246. Reiche, J., Lucas, R., Mitchell, A.L., Verbesselt, J., Hoekman, D.H., Haarpaintner, J., . . . Herold, M. 2016. Combining satellite data for better tropical forest monitoring. *Nature Climate Change* 6(2): 120-122.

247. Benediktsson, J., Sveinsson, J., and Swain, P. 1997. Hybrid Consensus Theoretic Classification. *Geoscience and Remote Sensing, IEEE Transactions on* 35: 833-843.

248. Benediktsson, J.A. and Swain, P.H. 1992. Consensus theoretic classification methods. *IEEE Transactions on Systems, Man, and Cybernetics* 22(4): 688-704.

249. Pekel, J.-F., Cottam, A., Gorelick, N., and Belward, A.S. 2016. High-resolution mapping of global surface water and its long-term changes. *Nature* 540(7633): 418-422.

250. Ferraz, A., Saatchi, S., Mallet, C., and Meyer, V. 2016. Lidar detection of individual tree size in tropical forests. *Remote Sensing of Environment* 183: 318–333.

251. UNFCCC. 2002. *Report of the Conference of the Parties on its Seventh Session, Held in Marrakech from 29October-10 November 2001. Addendum Part Two : Action Taken by the Conference of the Parties VolumeII (FCCC/CP/2001/13/Add.* United Nations Framework Convention on Climate Change Secretariat, Bonn, Germany.

252. Verchot, L.V., Zomer, R., Van Straaten, O., and Muys, B. 2007. Implications of country-level decisions on the specification of crown cover in the definition of forests for land area eligible for afforestation and reforestation activities in the CDM. *Climate Change* 81(3-4): 415-430.

253. Lund, H.G. 2002. When Is a Forest Not a Forest? *Journal of Forestry* 100(8): 21-28.

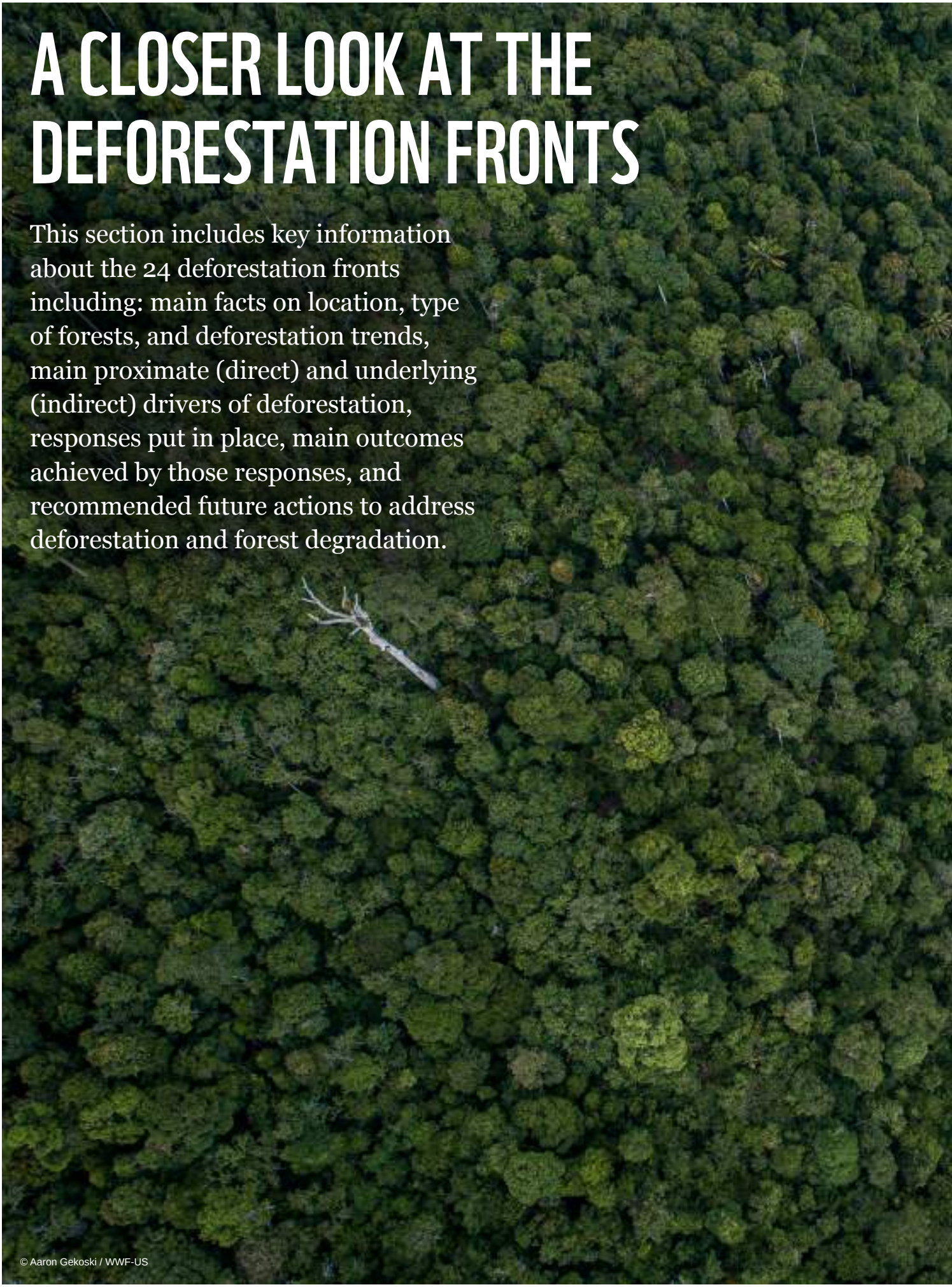
254. Sulla-Menashe, D. and Friedl, M.A. 2018. *User guide to collection 6 MODIS land cover (MCD12Q1 and MCD12C1) product*. USGS: , Reston, VA, USA. 1-18pp.

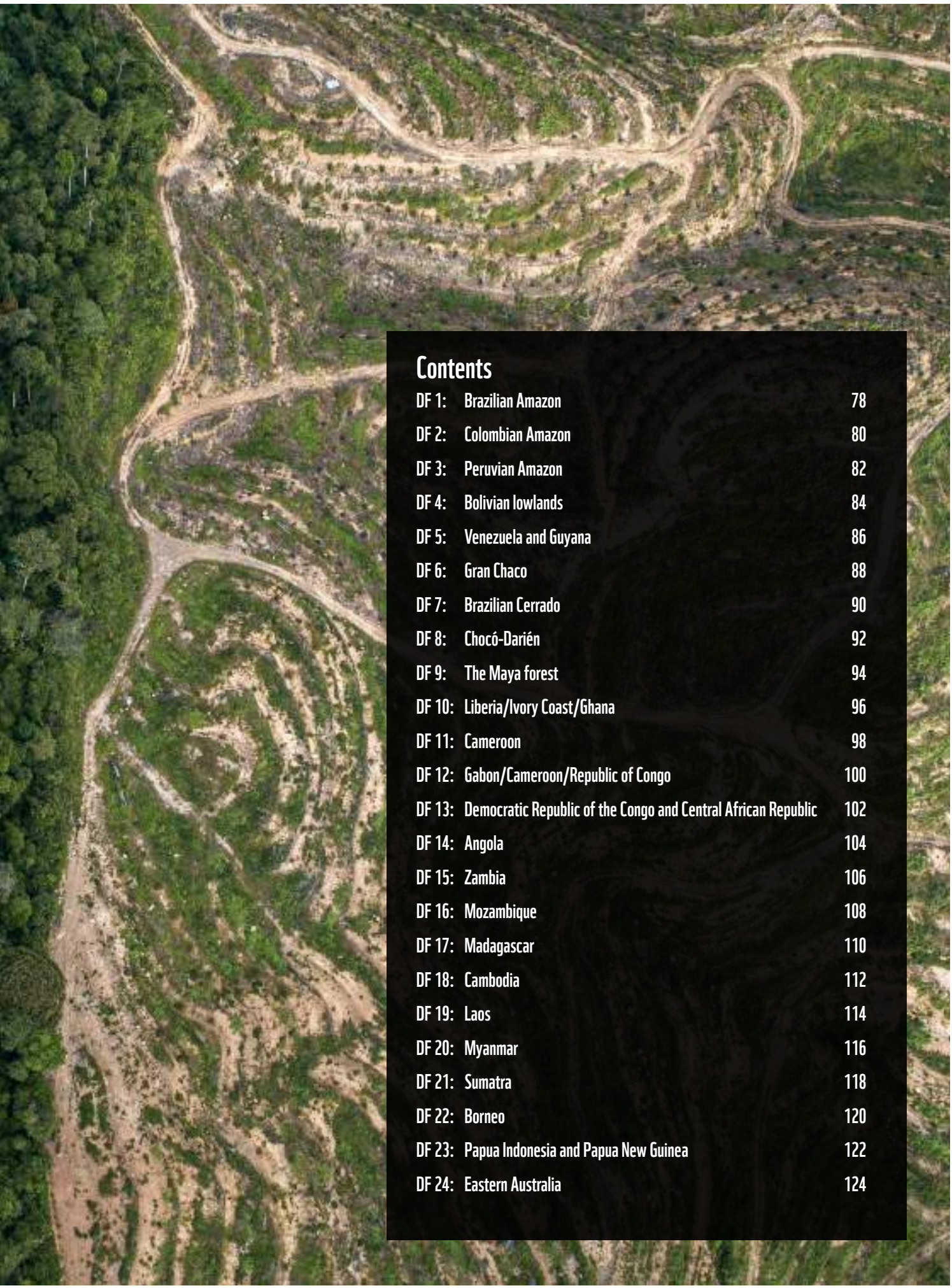
255. DiMiceli, C., Carroll, M., Sohlberg, R., Kim, D., Kelly, M., and Townshend, J., *MOD44B MODIS/Terra Vegetation Continuous Fields Yearly L3 Global 250m SIN Grid V006*. . 2017.

256. Vogt, P., Riitters, K.H., Estreguil, C., Kozak, J., Wade, T.J., Wickham, and J.D. 2007. Mapping spatial patterns with morphological image processing. Landscape Ecol 22:171–177. doi: 10.1007/s10980-006-9013-2.

A CLOSER LOOK AT THE DEFORESTATION FRONTS

This section includes key information about the 24 deforestation fronts including: main facts on location, type of forests, and deforestation trends, main proximate (direct) and underlying (indirect) drivers of deforestation, responses put in place, main outcomes achieved by those responses, and recommended future actions to address deforestation and forest degradation.





Contents

DF 1:	Brazilian Amazon	78
DF 2:	Colombian Amazon	80
DF 3:	Peruvian Amazon	82
DF 4:	Bolivian lowlands	84
DF 5:	Venezuela and Guyana	86
DF 6:	Gran Chaco	88
DF 7:	Brazilian Cerrado	90
DF 8:	Chocó-Darién	92
DF 9:	The Maya forest	94
DF 10:	Liberia/Ivory Coast/Ghana	96
DF 11:	Cameroon	98
DF 12:	Gabon/Cameroon/Republic of Congo	100
DF 13:	Democratic Republic of the Congo and Central African Republic	102
DF 14:	Angola	104
DF 15:	Zambia	106
DF 16:	Mozambique	108
DF 17:	Madagascar	110
DF 18:	Cambodia	112
DF 19:	Laos	114
DF 20:	Myanmar	116
DF 21:	Sumatra	118
DF 22:	Borneo	120
DF 23:	Papua Indonesia and Papua New Guinea	122
DF 24:	Eastern Australia	124

BRAZILIAN AMAZON

The Brazilian Amazon is one of the largest areas of tropical forests at 395 million ha[1], and provides significant environmental services, including carbon sequestration and some of the world's richest biodiversity[2]. The southern and eastern portions of the Amazon have faced high pressures in the last four decades. The biome is close to reaching a tipping point, at which the forest will no longer be able to sustain processes such as water recycling, that keep it alive[2], and the most affected portions will suffer diminished rainfall and prolonged dry seasons[3].

Drivers of deforestation

Cattle ranching	Expanding predominantly under extensive and low-production systems, in some cases linked to land speculation that leads to establishment of pasture to justify land ownership[5, 6].
Roads expansion	Mainly through the paving of main transport corridors[7]. Also, the growing network of unofficial roads[8] facilitates logging operations followed by active land occupation[9].
Large-scale agriculture	Commercial agricultural crops tend to expand by taking over pasture lands, but may contribute to deforestation through displacement of ranching for beef production[13, 14].
Smallholder farming	Linked to the expansion of subsistence and cash crops (e.g. cocoa), and combined with the adoption of cattle ranching in smallholder systems, including agrarian reform settlements[10].
Large-scale logging	While commercial logging has dropped over time, illegal activities have continued, linked to small-scale logging but also promoted by organized criminal networks[11, 12].
Mining operations	Large-scale mining has limited direct impacts on deforestation, but may generate waste and affect local livelihoods[15]. Illegal gold mining also threatens indigenous lands[16].
Hydroelectric power	Hydroelectric dams play a significant role in deforestation, not just from the area flooded but by the settlement that they attract – a recent example is the Belo Monte Dam[17]. The Bolsonaro administration has signalled its intention to expand dams in the Amazon basin.
Fires	Used for clearing primary forests and preparing the area for agriculture[18], though fires occur also on already cleared land[19] and can get out of control, invading standing forests[20].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Underlying causes are insecure tenure and land speculation that is also associated with land grabbing or encroachment of public lands, protected areas and indigenous lands[21]. In addition, large-scale investments in infrastructure and hydroelectrical dams and expansion of logistics for supporting agribusiness development have also prompted land occupation and growing pressure on forestlands[15]. More recently, relaxed environmental controls[22, 23] and the national government's support of agribusiness and extractive industries in the Amazon have countered previous governments' perspectives on forest conservation in the Amazon[24], suggesting that it is no longer a federal government priority.

Countries, region	Brazil, Amazon
Forest type	Humid tropical forests
Total area	118.7Mha
Forest area in 2018	85.9Mha (72.3% of total deforestation front area)
Forest loss 2004-2017	15.5Mha (15.4% of forest area in 2000)
Location of deforestation	Mainly in the south and east[4]
Total forest core area in 2018	49.8Mha (58.0% of forests in 2018)
Fragmented forests 2000-2018	11.4Mha (11.4% of forest area in 2000)
Accumulated burned area, 2002-2019	14.2Mha (14.1% of forest area in 2000)
Deforestation trend	Downward trends from 2004 to 2012; upward trends since 2013 but still at a relatively lower rate[4] compared to early 2000s
Future trends	Increase in deforestation during 2018 and 2019 suggests that deforestation in the Amazon will follow an upward trend

Responses

Protected areas	Active establishment of a mosaic of protected areas and conservation units (103M ha) intended to protect biodiversity and contain the agricultural frontier expansion[1, 25].
Recognition of IPLCs	Extended recognition of indigenous territories and other traditional tenure rights (115M ha)[1], constituting an important strategy to support local livelihoods and protect forests.
Moratoria	Soy Moratorium (2006) to halt the expansion of soy into forestlands[26], and a cattle agreement (2009) to avoid sourcing beef from deforestation-risk areas[27].
Land-use zoning	Land-use regulations – including a rural environmental registry and reform of the Forest Code – and credit constraints to halt conversion and restore legal forest reserves[28].
Deforestation monitoring	Brazil has developed one of the most reliable systems for monitoring deforestation in the Amazon (INPE)[4], along with an independent system of deforestation alerts (SAD)[29].
Timber legality	Growing investments in enforcement and monitoring of illegal forest clearing[30, 31], but some loopholes in the system still allow for the laundering of illegal timber[24]. More recently, there has been a significant weakening of enforcement operations.
REDD+ projects	Several REDD+ projects were established in the Amazon. The Amazon Fund (2008) was created to finance conservation, monitoring and sustainable use projects[32].
Traceability of supply	Main soy traders are tracing their sources of supply to comply with the Soy Moratorium, as are meat-packing groups, but some loopholes persist[24].

Deployment at wider scale
Actively used and expanding
Project-specific, experimental

Main outcomes

The establishment of protected areas and recognition of indigenous rights have proven effective in containing deforestation, securing carbon stocks and protecting biodiversity[33]. The Soy Moratorium helped halt the expansion of soy in the Amazon biome[26], yet the cattle agreement has been unable to control indirect suppliers and "cattle laundering" has become a widely adopted practice[34]. Persisting deforestation has been associated with land speculation and encroachment of public lands[35]. In the recent past, a gradual weakening of law enforcement has stimulated a growth of illegal activities.

Recommended future actions

- Eliminate land grabbing and land speculation.
- Reduce deforestation on private properties by facilitating payments for environmental services (PES) combined with market initiatives for sustainable sourcing.
- Incentivize increased productivity through targeted investments.
- Provide technical assistance to enhance smallholders' performance[36].

References

1. RAISG. 2015. *Deforestation in the Amazonia (1970-2013).* 48pp. www.amazoniasocioambiental.org
2. Nobre, C., Abramovay, R., Azevedo, T., Barlow, B., Berenguer, E., Brando, P., ... Young, C.E. 2019. *Scientific Framework to Save the Amazon.*
3. Sampaio, G., Nobre, C., Costa, M.H., Satyamurty, P., Soares-Filho, B.S., and Cardoso, M. 2007. Regional climate change over eastern Amazonia caused by pasture and soybean cropland expansion. *Geophysical Research Letters* 34(17).
4. Instituto Nacional de Pesquisas Espaciais [INPE]. 2020. TerraBrasilis. Ministério de Ciência e Tecnologia, São José dos Campos, Brazil. Available from: terrabrasilis.dpi.inpe.br/downloads
5. Seymour, F. and Harris, N.L. 2019. Reducing tropical deforestation. *Science* 365(6455): 756-757.
6. Barreto, P., Pereira, R., Brandão, A., and Baima, S. 2017. *Os frigoríficos vão ajudar a zerar o desmatamento da Amazônia?* Imazon, Belem, Brazil.
7. Killeen, T. 2007. *A Perfect Storm in the Amazon Wilderness: Development and Conservation in the Context of the Initiative for the Integration of the Regional Infrastructure of South America (IIRSA).* Center for Applied Biodiversity Science (CABS), Conservation International, Arlington, VA, USA.
8. Barber, C.P., Cochrane, M.A., Souza, C.M., and Laurance, W.F. 2014. Roads, deforestation, and the mitigating effect of protected areas in the Amazon. *Biological Conservation* 177: 203-209.
9. Perz, S., Brilhante, S., Brown, F., Caldas, M., Ikeda, S., Mendoza, E., ... Walker, R. 2008. Road building, land use and climate change: prospects for environmental governance in the Amazon. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 363(1498): 1889-1895.
10. Schneider, M. and Peres, C.A. 2015. Environmental Costs of Government-Sponsored Agrarian Settlements in Brazilian Amazonia. *PLOS ONE* 10(8): e0134016.
11. Solinge, T.B.v. 2014. Researching illegal logging and deforestation. *International Journal for Crime, Justice and Social Democracy* 3(2).
12. Human Rights Watch. 2019. Rainforest Mafias: How Violence and Impunity Fuel Deforestation in Brazil's Amazon. Available from: www.hrw.org/report/2019/09/17/rainforest-mafias/how-violence-and-impunity-fuel-deforestation-brazils-amazon
13. Gollnow, F., Hissa, L.d.B.V., Rufin, P., and Lakes, T. 2018. Property-level direct and indirect deforestation for soybean production in the Amazon region of Mato Grosso, Brazil. *Land Use Policy* 78: 377-385.
14. Arima, E.Y., Richards, P., Walker, R., and Caldas, M.M. 2011. Statistical confirmation of indirect land use change in the Brazilian Amazon. *Environmental Research Letters* 6(2): 024010.
15. Tófoli, R.M., Dias, R.M., Zaia Alves, G.H., Hoeinghaus, D.J., Gomes, L.C., Baumgartner, M.T., and Agostinho, A.A. 2017. Gold at what cost? Another megaproject threatens biodiversity in the Amazon. *Perspectives in Ecology and Conservation* 15(2): 129-131.
16. Diele-Viegas, L.M. and Rocha, C.F.D. 2020. Why releasing mining on Amazonian indigenous lands and the advance of agrobusiness is extremely harmful for the mitigation of world's climate change? Comment on Pereira et al. (*Environmental Science & Policy* 100 (2019) 8-12). *Environmental Science & Policy* 103: 30-31.
17. Faiola, A., Lopes, M., and Mooney, C. 2019. The price of 'progress' in the Amazon. Available from: www.washingtonpost.com/world/2019/06/28/how-building-boom-brazilian-amazon-could-accelerate-its-deforestation
18. Nepstad, D. 2019. Amazon fires: What we know and what we can do. Earth Innovation Institute blog. Available from: earthinnovation.org/2019/08/amazon-fires-what-we-know-and-what-we-can-do
19. Symonds, A. 2019. Amazon rainforest fires: Here's what's really happening. *New York Times*, 23 August. Available from: www.nytimes.com/2019/08/23/world/americas/amazon-fire-brazil-bolsonaro.html.
20. Barlow, J., Berenguer, E., Carmenta, R., and França, F. 2020. Clarifying Amazonia's burning crisis. *Global Change Biology* 26(2): 319-321.
21. Richards, P.D., Walker, R.T., and Arima, E.Y. 2014. Spatially complex land change: The indirect effect of Brazil's agricultural sector on land use in Amazonia. *Global Environmental Change* 29: 1-9.
22. Abessa, D., Fama, A., and Buruaem, L. 2019. The systematic dismantling of Brazilian environmental laws risks losses on all fronts. *Nature Ecology & Evolution* 3(4): 510-511.
23. de Area Leão Pereira, E.J., Silveira Ferreira, P.J., de Santana Ribeiro, L.C., Sabadini Carvalho, T., and de Barros Pereira, H.B. 2019. Policy in Brazil (2016–2019) threatens conservation of the Amazon rainforest. *Environmental Science & Policy* 100: 8-12.
24. Carvalho, W.D., Mustin, K., Hilário, R.R., Vasconcelos, I.M., Eilers, V., and Fearnside, P.M. 2019. Deforestation control in the Brazilian Amazon: A conservation struggle being lost as agreements and regulations are subverted and bypassed. *Perspectives in Ecology and Conservation* 17(3): 122-130.
25. RAISG. 2018. Presiones y amenazas sobre las areas naturales protegidas y los territories indigenas de la Amazonia 2018. Available from: https://www.amazoniasocioambiental.org/en/download/pressures-on-and-threats-to-protect-areas-and-indigenous-territories-in-amazonia-2018/
26. Gibbs, H.K., Rausch, L., Munger, J., Schelly, I., Morton, D.C., Noojipady, P., ... Walker, N.F. 2015. Brazil's Soy Moratorium. *Science* 347(6220): 377-378.
27. Gibbs, H.K., Munger, J., L'Roe, J., Barreto, P., Pereira, R., Christie, M., ... Walker, N.F. 2016. Did ranchers and slaughterhouses respond to zero-deforestation agreements in the Brazilian Amazon? *Conservation Letters* 9(1): 32–42.
28. Soares-Filho, B., Rajão, R., Macedo, M., Carneiro, A., Costa, W., Coe, M., ... Alencar, A. 2014. Cracking Brazil's Forest Code. *Science* 344(6182): 363-364.
29. World Bank. 1978. *Economic Memorandum.* Latin America and the Caribbean Regional Office, Washington, DC, USA.
30. Nepstad, D., Soares, B.S., Merry, F., Lima, A., Moutinho, P., Carter, J., ... Stella, O. 2009. The end of deforestation in the Brazilian Amazon. *Science* 326(5958): 1350-1351.
31. Nepstad, D., McGrath, D., Stickler, C., Alencar, A., Azevedo, A., Swette, B., ... Hess, L. 2014. Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains. *Science* 344(6188): 1118-1123.
32. Garcia, J.J.G., Ree, M.v.d., Boas, R.V., and Gramkow, C. 2019. *Mid-term evaluation report on the effectiveness of the Amazon Fund 2008-2018.* Economic Commission for Latin America and the Caribbean (ECLAC). www.amazonfund.gov.br/export/sites/default/en/.galleries/documentos/monitoring-evaluation/Mid-Term-Evaluation-Report-Effectiveness-Amazon-Fund.pdf
33. Crisostomo, A.C., Alencar, A., Mesquita, I., Silva, I.C., Dourado, M.F., Moutinho, P., ... Piontekowski, V. 2015. *Terras Indígenas na Amazônia Brasileira: do orçamento à mitigação da mudança climática.* IPAM, Agência Alemã de Cooperação Internacional – GIZ, Fundação Nacional do Índio – FUNAI, Brasilia, Brazil. https://ipam.org.br/wp-content/uploads/2015/12/terras_ind%C3%ADgenas_na_amaz%C3%B4nia_brasileira_-1.pdf
34. Krauss, C., Yaffe-Bellany, D., and Simões, M. 2019. Why Amazon fires keep raging 10 years after a deal to end them. *New York Times*, 18 October.
35. Miranda, J., Börner, J., Kalkuhl, M., and Soares-Filho, B. 2019. Land speculation and conservation policy leakage in Brazil. *Environmental Research Letters* 14(4): 045006.
36. Stabile, M.C.C., Guimarães, A.L., Silva, D.S., Ribeiro, V., Macedo, M.N., Coe, M.T., ... Alencar, A. 2019. Solving Brazil's land use puzzle: Increasing production and slowing Amazon deforestation. *Land Use Policy*: 104362.

COLOMBIAN AMAZON

The Colombian Amazon comprises about two-thirds of the forests in Colombia, containing important biodiversity and water resources. Main pressures to the region originate from colonization programmes established in the Andes-Amazon foothills (piedemonte), which expanded along the Caquetá, Putumayo, Caguán and Orteguaza rivers and main roads that opened over time. Spontaneous occupation by smallholders followed, triggered by opportunities for timber extraction and land for farming, including coca cultivation. Cattle ranching associated with a speculative process of land occupation has also contributed to active frontier expansion and deforestation. In addition, armed conflict has been a key influence on land-use occupation and decision-making in Colombia.

Drivers of deforestation

Cattle ranching	Cattle herds of about 5 million heads (18% of the total cattle herd in the country) are located in the Amazon region, with a higher concentration in Meta and Guaviare[3]. Cattle ranching expands through low-production extensive systems associated with land speculation and concentration[4, 5].
Smallholder farming	Mainly linked to the expansion of coca cultivation, which increased from the mid-2010s but shrank in 2018. About 27% of coca production is located in the arc of deforestation (Meta, Guaviare, Caquetá and Putumayo)[6]. New areas tend to be established in small patches non-contiguous with previously cleared areas[7].
Road expansion	Deforestation used to occur mainly along rivers[8], but more recently about 76% of deforestation took place in areas closer to roads[2]. More recent deforestation was associated with the expansion of the *"Marginal de la Selva"* road that connects the deforestation expansion areas of southern Meta and northwestern Guaviare[7, 9].
Timber extraction	Timber extraction places pressures on forests, following the opening of local roads[7]. There are no consistent estimates about the magnitude of timber extraction in the Amazon, particularly informal extraction, but it may be increasing as frontiers expand.
Mining operations	Linked to mainly alluvial gold mining that attracts people from outside and within the region, in particular along the Caquetá, Orteguaza and Vaupés rivers[7]. Gold mining tends to oscillate depending on the market dynamics, and has decreased since 2017[10].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

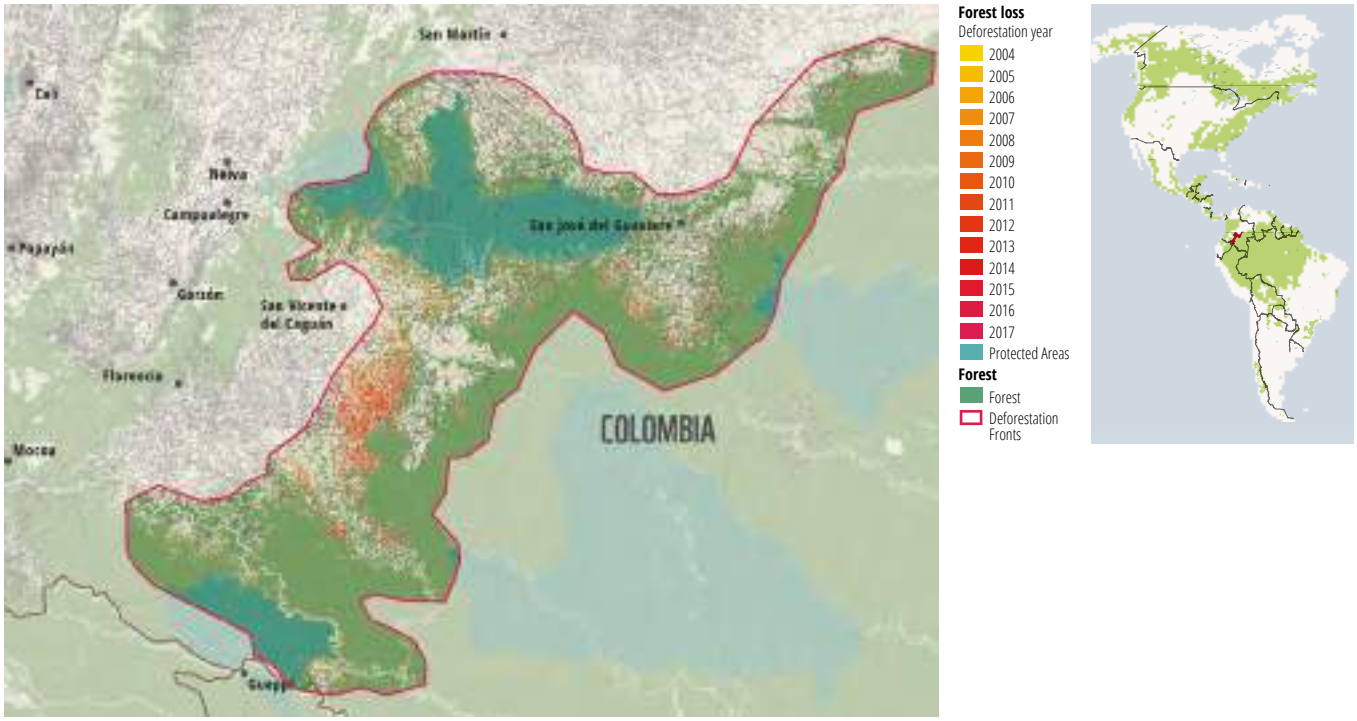
Global demand for commodities produced in the region, such as gold and coca, tends to stimulate production, as does domestic demand for beef and investments in the expansion of secondary roads. These factors are accompanied by the expansion of informal and illicit economies, and the lack of more aggressive policies and budgets to support environmental protection and contain deforestation[7]. The armed conflict had different impacts on forests in different places, depending on local conditions[11-13] – deforestation in conflict zones increased after the 2016 peace process[14].

Countries, region	Colombia, Amazon
Forest type	Humid tropical forests
Total area	8.2Mha
Forest area in 2018	5.8Mha (70.4% of total deforestation front area)
Forest loss 2004-2017	0.4Mha (6.8% of forest area in 2000)
Location of deforestation	Deforestation has moved from Putumayo to the southern portion of Meta, along the "deforestation arc", comprising also Caquetá and Guaviare[1]
Total forest core area in 2018	3.3Mha (57.8% of forests in 2018)
Fragmented forests 2000-2018	0.5Mha (8.6% of forest area in 2000)
Accumulated burned area, 2002-2019	0.8Mha (12.4% of forest area in 2000)
Deforestation trend	Increasing mainly in the two last years, according to national sources[2]
Future trends	Deforestation may continue at current rates

Responses

Protected areas	There are 18 protected areas in the Colombian Amazon comprising 9.4Mha[15], and no major pressure was observed in these protected areas, which are still distant from the frontier areas[7]. The "Heritage Colombia" programme has been established to support the management of protected areas[16].
Recognition of IPLCs	Some 206 indigenous reserves (*resguardos indígenas*) were recognized in the Amazon over 26Mha[15]. Only 9.3% of total deforestation took place within indigenous lands in 2018[1].
Land-use zoning	A law for territorial zoning was issued in 2011, which included a goal to zone the forestry reserves in the Amazon region, and specified the competences of different levels of government, granting more responsibilities to subnational governments[17].
Payments for ecosystem services	Payment for ecosystem services (PES) mechanisms, including the Forestry Incentive (*Certificado de Incentivo Forestal*), issued in 1994, originally targeted reforestation actions but has also embraced conservation targets since 1997[18].
REDD+ projects	Under the REDD+ programme, the government formulated a strategy to control deforestation and support forest management (EICDGB)[19]. US$366 million was secured from donors (Norway, Germany, UK) to reduce deforestation to 150,000 ha by 2022 and less than 100,000 by 2025[20]. These resources will be managed by the recently set up "Sustainable fund ".
Timber legality	There is a long-standing pact aimed at legal timber in Colombia (PIML), and since 2007 the government of Colombia has negotiated the implementation of FLEGT with the EU[19].
Deforestation monitoring	A system to monitor forest cover and carbon (SMBYC) under the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM) includes remote sensing data analysis, and developing community participatory processes[21].
Conservation agreements	As part of the EICDGB, several supply chain-based zero-deforestation agreements and conservation agreements with communities are planned[19]. Conservation agreements with farmers and communities in the Caquetá and Guaviare are being implemented[2].

Deployment at wider scale
Actively used and expanding
Project-specific, experimental



Main outcomes

The government has embraced different responses to halt deforestation targeting not only the Amazon but also other regions. The most important is the EICDGB strategy to control deforestation and support forest management. This has attracted some external finance under a results-based mechanism to avoid carbon emissions, and has led to the establishment of a fund to support actions on the ground along with conservation agreements in value chains. However, several challenges must be addressed to prove the effectiveness of this strategy: these include the outcomes from the peace agreements on deforestation[14, 22], vigorous informal and illegal economies, pasture expansion triggered by speculative land concentration[7] and policy signals favouring agricultural development.

Recommended future actions

- Strengthen monitoring and control systems for deforestation.
- Enhance transparency in land registration and tenure rights.
- End encroachment of protected areas and indigenous territories.
- Embrace more actively actions to close the agricultural frontier.
- Facilitate incentives to local farmers to comply with territorial planning while improving their production practices and building alternative livelihoods.
- Support indigenous people to manage their forests according to their cultural values.
- Support new conservation agreements linked to the peace process to enhance local governance of land and forest resources, while increasing benefits for local people.

References

1. IDEAM. 2019. Resultados monitoreo de la deforestación 2018. Available from: pidamazonia.com/content/resultados-monitoreo-de-la-deforestaci%C3%B3n-2018
2. IDEAM. 2020. Reporte de Cambio de la Superficie Cubierta por Bosque Natural. Available from: smbyc.ideam.gov.co/MonitoreoBC-WEB/pub/reporteGeoproceso.jsp?id_reporte=7315
3. ICA. 2019. *Censo Pecuario año 2019*. Instituto Colombiano Agropecuario, Bogota, Colombia. www.ica.gov.co/areas/pecuaria/servicios/epidemiologia-veterinaria/censos-2016/censo-2018.
4. SINCHI. 2016. *Monitoreo de los bosques y otras coberturas de la Amazonia Colombiana a escala 1:100.000. Cambios multitemporales en el período 2012 al 2014 y coberturas del año 2014*. Bogota,Colombia. siatac.co/web
5. Armenteras, D., Cabrera, E., Rodriguez, N., and Retana, J. 2013. National and regional determinants of tropical deforestation in Colombia. *Regional Environmental Change* 13(6): 1181-1193.
6. UNODC-SIMCI. 2019. *Monitoreo de territorios afectados por cultivos ilícitos 2018*. Oficina de las Naciones Unidas contra la Droga y el Delito (UNODC)-Sistema Integrado de Monitoreo de Cultivos Ilícitos (SIMCI), Bogota, Colombia. www.odc.gov.co/Portals/1/publicaciones/images/oferta/censos/MON%20D%20CULT%20baja%202018%2002%20AGO%2020-35_BAJA.pdf
7. González, J., Cubillos, A., Chadid, M., Cubillos, A., Arias, M., Zúñiga, E., ... Berrío, V. 2017. *Caracterización de las principales causas y agentes de deforestación a nivel nacional período 2005-2015*. Instituto de Hidrología, Meteorología y Estudios Ambientales – IDEAM. Ministerio de Ambiente y Desarrollo Sostenible. Programa ONU-REDD, Bogotá, Colombia. www.fao.org/3/I9618ES/i9618es.pdf
8. Armenteras, D., Rudas, G., Rodriguez, N., Sua, S., and Romero, M. 2006. Patterns and causes of deforestation in the Colombian Amazon. *Ecological Indicators* 6(2): 353-368.
9. Volckhausen, T. 2017. Marginal de la Selva: In search of Deforestation Road. *The City Paper*, 18 July. Available from: thecitypaperbogota.com/features/marginal-de-la-selva-in-search-of-deforestation-road/17657
10. SIMCO-UPME. 2020. Oro: Produccion desde 2012. Available from: www1.upme.gov.co/simco/Cifras-Sectoriales/Paginas/oro.aspx.
11. Castro-Nunez, A., Mertz, O., Buritica, A., Sosa, C.C., and Lee, S.T. 2017. Land related grievances shape tropical forest-cover in areas affected by armed-conflict. *Applied Geography* 85: 39-50.
12. Hoffmann, C., Marquez, J.R.G., and Krueger, T. 2018. A local perspective on drivers and measures to slow deforestation in the Andean-Amazonian foothills of Colombia. *Land Use Policy* 77: 379-391.
13. Landholm, D.M., Pradhan, P., and Kropp, J.P. 2019. Diverging forest land use dynamics induced by armed conflict across the tropics. *Global Environmental Change – Human and Policy Dimensions* 56: 86-94.
14. Prem, M., Saavedra, S., and Vargas, J.F. 2020. End-of-conflict deforestation: Evidence from Colombia's peace agreement. *World Development* 129: 104852.
15. RAISG. 2015. *Deforestation in the Amazonia (1970-2013)*. 48pp. www.amazoniasocioambiental.org
16. WWF. 2019. Heritage Colombia: at the Climate Summit. Available from: www.wwf.org.co/?uNewsID=353670
17. Observatorio Regional de Planificacion para el Desarrollo. 2019. Ley orgánica de ordenamiento territorial – Ley 1454 de 2011. Available from: observatorioplanificacion.cepal.org/es/marcos-regulatorios/ley-organica-de-ordenamiento-territorial-de-colombia
18. FINAGRO. 2020. Certificado de Incentivo Forestal. Available from: www.finagro.com.co/productos-y-servicios/incentivo-forestal
19. MADS. 2017. *Estrategia Integral de Control a la Deforestación y Gestión de los Bosques (EICDGB)*. Ministerio de Ambiente y Desarrollo Sostenible, Bogotá, Colombia. redd.unfccc.int/files/eicdgb_bosques_territorios_de_vida_web.pdf
20. Cardona, A.J.P. 2020. Colombia: así se invertirán los 366 millones de dólares que donarán Noruega, Alemania y el Reino Unido. Available from: es.mongabay.com/2020/01/cooperacion-en-medio-ambiente-366-millones-dolares-colombia
21. IDEAM. 2020. Sistema de Monitoreo de Bosques y Carbono (SMBYC). Available from: smbyc.ideam.gov.co/MonitoreoBC-WEB/reg/indexLogOn.jsp
22. Negret, P.J., Sonter, L., Watson, J.E.M., Possingham, H.P., Jones, K.R., Suarez, C., ... Maron, M. 2019. Emerging evidence that armed conflict and coca cultivation influence deforestation patterns. *Biological Conservation* 239.

PERUVIAN AMAZON

The Peruvian Amazon's large areas of primary forest support a rich biodiversity and the livelihoods of numerous indigenous groups and local communities. In the past, large number of smallholders from the highlands have moved to the region and have developed active local economies linked to commercial crops. A large informal economy has also developed in the region involving illegal logging and small-scale illegal gold mining activities.

Drivers of deforestation

Smallholder farming	Associated with the growth of small-scale coffee and cacao plantations, along with coca cultivation[2, 3] which are expanding northwards[4]. In Ucayali, some indigenous lands have been encroached on by smallholder colonists from traditional coca production zones[4].
Cattle ranching	The Ucayali/Huanuco region in the central Peruvian Amazon has faced pressure from cattle ranching[5]. Much of this expansion takes place outside areas defined for agricultural use[6].
Mining operations	Small-scale illegal gold mining in rivers and floodplains in Madre de Dios attracts people to forest zones, places pressure on protected areas[7] and leads to deforestation[2, 8]. It also contributes to mercury contamination from terrestrial to aquatic environments[9].
Commercial logging	About eight major market circuits supply timber to the main urban markets in Peru. Around two-thirds of the total comes from informal sources, involving a significant number of smallholders, small-scale chainsaw operators and intermediaries[10].
Large-scale agriculture	In Ucayali and Loreto/San Martin, a handful of projects for expanding large-scale oil palm plantations placed pressure on indigenous communities lacking tenure rights and took advantage of informal land markets. Other projects did not materialize as expected[11].
Roads expansion	The opening and expansion of local and secondary roads, often associated with illegal logging operations, indirectly contributes to livestock activity and smallholders expansion[12]. Project road expansion (e.g. a road in the buffer zones of Manu National Park and Amarakaeri Communal Reserve) is expected to produce uncontrolled colonization and deforestation[13].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

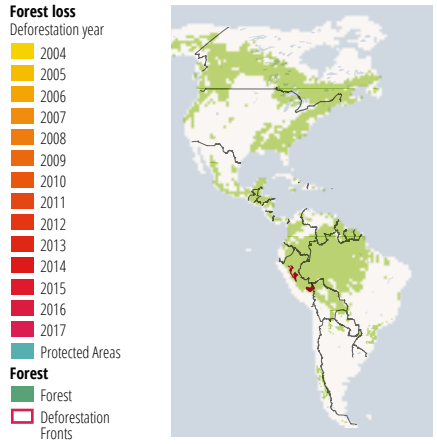
Underlying causes are mainly linked to a process of land occupation that has been triggered by the expansion of relatively large informal economies. These are connected to speculative land markets, as well as illegal logging, small-scale gold mining and illicit coca cultivation. Local regional elites have also stimulated extractive and industrial expansion in the Peruvian Amazon[4]. The government, however, has issued legislation to address illegal activities and support forest conservation, and there are several initiatives to support alternative economic activities for local communities[2].

Countries, region	Peru, Amazon
Forest type	Tropical forests
Total area	11.8Mha
Forest area in 2018	10.2Mha (86.1% of total deforestation front area)
Forest loss 2004-2017	0.6Mha (5.9% of forest area in 2000)
Location of deforestation	Localized in Ucayali/Huanuco, San Martin and Madre de Dios[1]
Total forest core area in 2018	6.5Mha (64.4% of forests in 2018)
Fragmented forests 2000-2018	1.2Mha (11.4% of forest area in 2000)
Accumulated burned area, 2002-2019	0.4Mha (3.4% of forest area in 2000)
Deforestation trend	Increasing, with oscillations during the last decade
Future trends	Deforestation to continue expanding

Responses

Protected areas	About 20Mha have been designed as protected areas, a significant proportion covering forestlands[14]. A new initiative, "National Parks: Peru's Natural Legacy", was signed in 2019 involving the national government and donors to mobilize financial support for managing these protected areas[15].
Recognition of IPLCs	Recognition of indigenous tenure rights has increased over time. By 2016, 12Mha were titled, and 5.8Mha were pending. In addition, 2.8Mha were set aside as reserves to protect semi-nomadic groups and another 2.2Mha as communal reserves comprising various communities[16].
Land-use zoning	Subnational governments hold decision-making power over natural resources through a law on territorial planning[17]. Several regions have finalized their ecological zoning plans including Ucayali and San Martin (the latter has also approved the zoning of forest reserves).
Timber legality	Organismo de Supervisión de los Recursos Forestales y de Fauna Silvestre (OSINFOR) is the state agency in charge of monitoring and controlling timber extraction in the Peruvian Amazon, while Servicio Nacional Forestal y de Fauna Silvestre (SERFOR) is in charge of granting permits. However, the limited mandate of OSINFOR, and the lack of support of regional governments, makes this a difficult task[18].
REDD+ projects	Peru participated in REDD+ readiness initiatives (CPF, UN-REDD) and received funds from several donors, including US$50M from the Forest Investment Program. Norway pledged US$300M for REDD+ performance-based payments in 2014[19].
Voluntary standards	About 7.4Mha in the Peruvian Amazon were allocated to forest concessions but a portion of those concessions are inactive[10]. Only 0.7Mha are under FSC certification[20].
Payments for ecosystem services	The Programa Bosques, created in 2010 and implemented by the Ministry of Environment (MINAM), aims to conserve 54Mha by compensating indigenous communities with titles (around US$3.20 per ha/year), and includes capacity building, monitoring and financial reporting[21].
Sustainable landscape finance	A project on "unlocking forest finance" was implemented to promote sustainable supply in San Martin, supported by the International Climate Initiative (IKI) (2013-18), in agreement with the Regional Environmental Authority, and Agrobanco to develop a green agricultural credit line[22].

Deployment at wider scale
Actively used and expanding
Project-specific, experimental



Main outcomes

Protected areas have proven effective in halting deforestation but there is pressure from illegal logging. Forest concessions also face that pressure, and no significant differences in deforestation rates have been observed between certified and non-certified concessions[23]. Regional governments have not always been able to put in place the mechanisms to enforce their land use plans[2]. While active financial and institutional support has been deployed under REDD+ readiness programmes, Measurement, Reporting and Verification (MRV) has been only partially adopted[24]. The current government administration is investing additional efforts to alleviate the negative effects of gold mining[25].

Recommended future actions

- Advance recognition of tenure rights in forest areas, and support formalization of smallholders' tenure rights supporting them to improve their farming systems and develop alternative livelihoods.
- Improve national and sub-national monitoring systems and financial and technical means to improve farmers' compliance with land-use plans.
- Provide the institutional conditions for small-scale and informal chainsaw loggers to undertake sustainable forest management.
- Continue efforts to formalize and regulate illegal gold mining.

References

1. MINAM. 2019. Bosque y perdida de bosques. Available from: geobosques.minam.gob.pe/geobosque/view/perdida.php
2. Piotrowski, M. 2019. *Nearing the tipping point: Drivers of Deforestation in the Amazon Region*. Inter-American Dialogue, Washington DC. www.thedialogue.org/wp-content/uploads/2019/05/Nearing-the-Tipping-Point-for-website.pdf
3. Davalos, L.M., Sanchez, K.M., and Armenteras, D. 2016. Deforestation and coca cultivation rooted in twentieth-century development projects. *Bioscience* 66(11): 974-982.
4. Chirif, A. 2018. *Deforestación en tiempos de cambio climático*. IWGIA, Grupo Internacional de Trabajo sobre Asuntos Indígenas, Lima, Peru. 228pp.
5. Finer, M., Mamani, N., García, R., and Novoa, S. 2018. Deforestation Hotspots in the Peruvian Amazon, 2017. Available from: maaproject.org/2018/hotspots-peru2017
6. Hance, J. 2016. Cattle driving big forest loss in Peru's 'under-appreciated' Amazon. Available from: news.mongabay.com/2016/07/cattle-driving-big-forest-loss-in-perus-under-appreciated-amazon
7. Asner, G.P. and Tupayachi, R. 2017. Accelerated losses of protected forests from gold mining in the Peruvian Amazon. *Environmental Research Letters* 12(9): 8.
8. Espejo, J.C., Messinger, M., Roman-Danobeytia, F., Ascorra, C., Fernandez, L.E., and Silman, M. 2018. Deforestation and forest degradation due to gold mining in the Peruvian Amazon: A 34-year perspective. *Remote Sensing* 10(12): 17.
9. Diringer, S.E., Berky, A.J., Marani, M., Ortiz, E.J., Karatum, O., Plata, D.L., ... Hsu-Kim, H. 2020. Deforestation due to artisanal and small-scale gold mining exacerbates soil and mercury mobilization in Madre de Dios, Peru. *Environmental Science & Technology* 54(1): 286-296.
10. Mejía, E., Cano, W., de Jong, W., Pacheco, P., Tapia, S., and Morocho, J. 2015. *Actores, aprovechamiento de madera y mercados en la Amazonía peruana*. CIFOR, Bogor, Indonesia.
11. Dammert, J.L. 2018. *El crecimiento de la palma aceitera en la Amazonía peruana y su impacto en los bosques*. IWGIA, Grupo Internacional de Trabajo sobre Asuntos Indígenas, Lima, Peru.
12. Briceno, N.B.R., Castillo, E.B., Quintana, J.L.M., Cruz, S.M.O., and Lopez, R.S. 2019. Deforestation in the Peruvian Amazon: indexes of land cover/land use (LC/LU) changes based on GIS. *Boletin De La Asociacion De Geografos Espanoles* (81): 34.
13. Gallice, G.R., Larrea-Gallegos, G., and Vazquez-Rowe, I. 2019. The threat of road expansion in the Peruvian Amazon. *Oryx* 53(2): 284-292.
14. RAISG. 2015. *Deforestation in the Amazonia (1970-2013)*. 48pp. www.amazoniasocioambiental.org
15. WWF. 2019. Protecting the Peruvian Amazon. Available from: www.worldwildlife.org/stories/protecting-the-peruvian-amazon
16. Monterroso, I., Cronkleton, P., Pinedo, D., and Larson, A. 2017. *Reclaiming collective rights: Land and forest tenure reforms in Peru (1960–2016)*. CIFOR, Bogor, Indonesia. www.cifor.org/publications/pdf_files/WPapers/WP224Monterroso.pdf
17. Gustafsson, M.-T. 2017. The struggles surrounding ecological and economic zoning in Peru. *Third World Quarterly* 38(5): 1146-1163.
18. Furones, L. 2019. Peru's forest inspection agency OSINFOR regains its indepdendence, but what next? *Global Witness*, 8 May. Available from: www.globalwitness.org/en/blog/perus-forest-inspection-agency-osinfor-regains-its-independence-but-what-next
19. Menton, M., Gonzales, J., and Kowler, L.F. 2014. *REDD+ in Peru: The national context*. In: E.O. Sills, et al. (eds). *REDD+ on the ground: A case book of subnational initiatives across the globe*. CIFOR, Bogor, Indonesia.
20. FSC. 2020. FSC Facts & Figures. Available from: fsc.org/en/page/facts-figures [accessed 5 March 2020]
21. Rosa da Conceição, H., Börner, J., and Wunder, S. 2015. Why were upscaled incentive programs for forest conservation adopted? Comparing policy choices in Brazil, Ecuador, and Peru. *Ecosystem Services* 16: 243-252.
22. Rode, J., Pinzon, A., Stabile, M.C.C., Pirker, J., Bauch, S., Iribarrem, A., ... Wittmer, H. 2019. Why 'blended finance' could help transitions to sustainable landscapes: Lessons from the Unlocking Forest Finance project. *Ecosystem Services* 37: 10.
23. Anderson, C.M., Asner, G.P., and Lambin, E.F. 2019. Lack of association between deforestation and either sustainability commitments or fines in private concessions in the Peruvian Amazon. *Forest Policy and Economics* 104: 1-8.
24. Ochieng, R.M., Arts, B., Brockhaus, M., and Visseren-Hamakers, I.J. 2018. Institutionalization of REDD plus MRV in Indonesia, Peru, and Tanzania: progress and implications. *Ecology and Society* 23(2): 13.
25. Catanoso, J. 2019. Gov't takedown of illegal gold mining in Peru shows promise, but at a cost. *Mongabay*, 9 August. Available from: news.mongabay.com/2019/08/govt-takedown-of-illegal-gold-mining-in-peru-shows-promise-but-at-a-cost

BOLIVIAN LOWLANDS

The Bolivian lowlands comprise a diverse mosaic of tenure systems, land uses and actors. These range from indigenous people and local communities (IPLCs) to agribusiness and traditional cattle ranchers, along with smallholders increasingly engaged in commercial agriculture. The expansion of agriculture and cattle ranching in frontier areas, also promoted by government policies, is placing increasing pressures on forests.

Drivers of deforestation

Cattle ranching	A large portion of deforestation has been driven by mid- to large-scale extensive cattle ranching in the deciduous forests of the Chiquitania region, often taking over public lands[3].
Smallholder farming	Expansion of smallholder farming producing commercial crops, linked to a governmental process of land allocation to smallholders or occupation of public forestlands and forest reserves stimulated by a legal and regulatory framework that is more supportive of small-scale deforestation[3, 4].
Large-scale agriculture	Large-scale agriculture for grain production (e.g. soy, sunflower, rice) has been a major driver of deforestation in the new frontier areas in northwestern and southern Santa Cruz[3, 5]. Part of this expansion is triggered by the expansion of Mennonite settlements in the new fronts.
Road expansion	Public investments in transport corridors in northern La Paz, northeastern Santa Cruz and southern Beni, and transboundary highways have facilitated land occupation[6].
Fires	There is a long-lasting occurrence of fires in lowland Bolivia, yet fire outbreaks in 2019 were more severe, with more than a third (2Mha) affecting forestlands[7]. Fires, however, lead more to forest degradation and were associated with forest conversion.
Commercial logging	Logging has persisted, particularly in the forest fringes in northern La Paz and Pando, leading to further degradation of primary forests[8]. Timber extraction has shrunk dramatically as a result of growing imports of cheaper wood products.

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

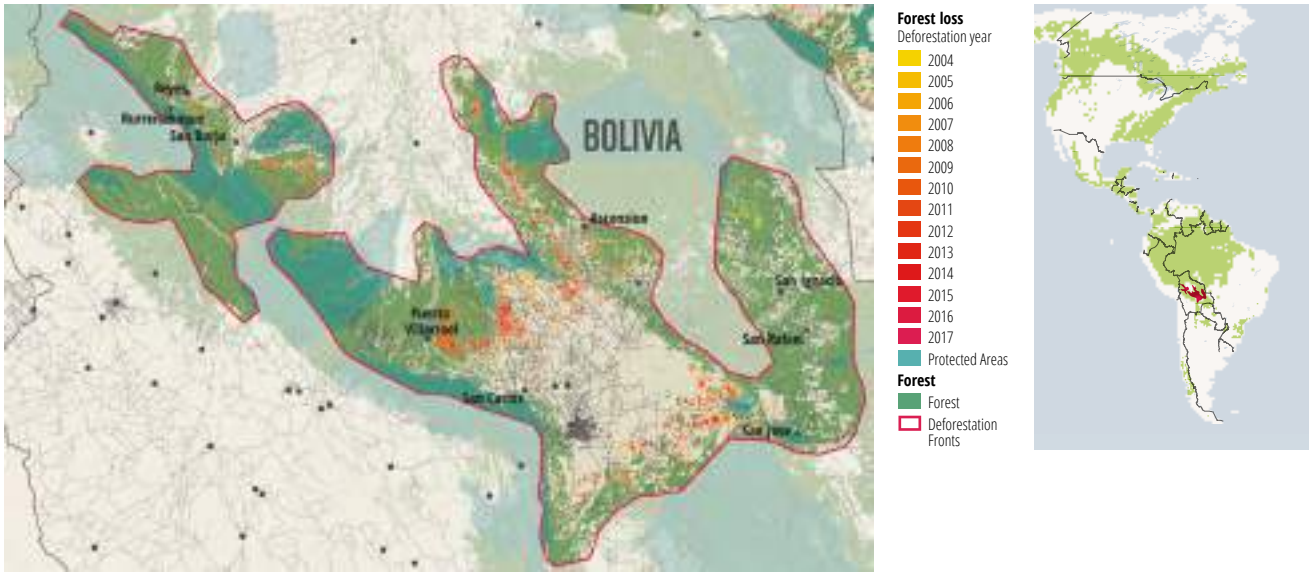
Primarily associated with "neo-extractivist" government policies[9]. The national government has encouraged agricultural expansion for grain production and biofuels as a driver for economic growth, and the expansion of smallholders into non-occupied public forestlands[10] due to migration from the western to the eastern part of the country. In addition, growing investments in infrastructure and road construction, due to growing fiscal earnings originating from gas exports as well as government borrowing, have also stimulated occupation of lowland forests. The government has approved several regulations prompting deforestation, such as Law 337 of Support to Food Production and Forest Restitution (2013), Law 741 authorizing forest clearing for smallholders up to 20ha (2015) and Law 1090 promoting production of biofuel (2019). These laws were complemented with other regulations relaxing environmental constraints on land use.

Countries, region	Bolivia, Amazon
Forest type	Tropical and deciduous forests
Total area	19.9Mha
Forest area in 2018	12.8Mha (64.2% of total deforestation front area)
Forest loss 2004-2017	1.5Mha (10.6% of forest area in 2000)
Location of deforestation	Mainly in northern and eastern Santa Cruz and Chiquitania region[1, 2]
Total forest core area in 2018	7.5Mha (59.0% of forests in 2018)
Fragmented forests 2000-2018	1.2M ha (8.3% of forest area in 2000)
Accumulated burned area, 2002-2019	3.2Mha (22.5% of forest area in 2000)
Deforestation trend	Increasing; deforestation decreased after a peak in 2010, but has resurged since 2016
Future trends	Deforestation to continue expanding

Responses

Protected areas	About 21Mha have been designated as protected areas, a significant proportion covering forestlands[1], yet oil and gas exploration activities have been allowed in some protected areas[11]. Some expansion of protected areas has taken place in recent years at the departmental and municipal level.
Recognition of IPLCs	About 19Mha have been granted to IPLCs, 5Mha of which are inside protected areas[1]. These areas have different degrees of protection[12].
Land-use zoning	All departments in the lowlands (i.e. Santa Cruz, Beni, Pando) have land-use zoning plans, yet there is a lack of economic incentives and enforcement to ensure compliance[3]. The departmental government in Beni has revised land-use plans removing constraints for agriculture expansion, and the forestry agency has relaxed some of the land-use regulations.
Voluntary standards	A large portion of forest concessions were certified under FSC[13]. No progress has been made in the adoption of sustainable practices on large-scale farms, with some few exceptions[14].
Timber legality	The government has developed a national system of monitoring and verification of timber legality, but it has been accompanied by a discretionary policy of granting forest permits[15]. Lack of enforcement by government entities, corruption and traffic of permits are widespread.

Deployment at wider scale
Actively used and expanding
Project-specific, experimental



Main outcomes

A system of protected areas accompanied by land-use plans at the department level and the recognition of tenure rights for indigenous people have helped contain the expansion of the agricultural frontier[12, 16]. However, pressures from new smallholder settlements, road infrastructure and growing connection to markets continue to drive deforestation and forest degradation[17]. Despite its conservationist rhetoric of "living in harmony with Mother Earth", the government has stimulated quite aggressively agribusiness and biofuel production as well as the expansion of human settlements, while the lack of control of genetically modified crops has allowed grain production to expand into new areas[10, 18]. This has been in part reflected in the fire outbreaks in the Chiquitania during the 2019 fire season[7].

Recommended future actions

- Revise the process of forestland allocation in the lowlands, particularly in areas identified as public forestlands, and develop actions to contain encroachment into protected areas and forest reserves.
- Account for the environmental impacts of new investments in infrastructure development, including roads and hydroelectric dams.
- Intensify agricultural activities in already occupied lands and restore productivity, along with promoting habitat corridors in frontier areas.
- Provide compensation for local communities to protect their forests while building alternative livelihoods in areas that still maintain an important amount of primary forests.
- Reverse the erosion of the national system of protected areas and provide more financial and human resources.
- Support capacities of indigenous people to manage their territories.

References

1. RAISG. 2015. *Deforestation in the Amazonia (1970-2013)*. 48pp. www.amazoniasocioambiental.org
2. Sabogal, C. 2018. *Informe Regional sobre la Situacion de los Bosques en la Region Amazonica*. OTCA, GIZA, Ministry of Foreign Affairs Netherlands, Brasilia, Brazil. www.otca-oficial.info/assets/documents/20181203/5d6be8f9271304c91c0812cd60309a9f.pdf
3. Müller, R., Pacheco, P., and Montero, J.C. 2014. *The context of deforestation and forest degradation in Bolivia: Drivers, agents and institutions*. CIFOR, Bogor, Indonesia.
4. Méndez, C. and Mercado, I. 2019. Disaster strikes in Bolivia as fires lay waste to unique forests. *Mongabay,* 6 September. Available from: news.mongabay.com/2019/09/disaster-strikes-in-bolivia-as-fires-devastate-unique-forests
5. Kalamandeen, M., Gloor, E., Mitchard, E., Quincey, D., Ziv, G., Spracklen, D., ... Galbraith, D. 2018. Pervasive rise of small-scale deforestation in Amazonia. *Scientific Reports* 8(1): 1600.
6. Baraloto, C., Alverga, P., Quispe, S.B., Barnes, G., Chura, N.B., da Silva, I.B., ... Perz, S. 2015. Effects of road infrastructure on forest value across a tri-national Amazonian frontier. *Biological Conservation* 191: 674-681.
7. FAN. 2019. *Reporte de incendios forestales a nivel nacional 25 de septiembre de 2019*. Fundacion Amigos de la Naturaleza, Santa Cruz, Bolivia. incendios.fan-bo.org/Satrifo/reportes/IncendiosNal-FAN-25092019.pdf?fbclid=IwAR2yvllEIivVnKgc9CN10IjGAt8geUnTeDuI2BUzv96qj_vbqpzkMhs_pJo
8. Cano, W., Van de Rijt, A., de Jong, W., and Pacheco, P. 2015. *Aprovechamiento y mercados de la madera en el norte amazónico de Bolivia*. CIFOR, Bogor, Indonesia.
9. McKay, B.M. 2017. Agrarian extractivism in Bolivia. *World Development* 97: 199-211.
10. Romero-Muñoz, A., Jansen, M., Nuñez, A.M., Toledo, M., Almonacid, R.V., and Kuemmerle, T. 2019. Fires scorching Bolivia's Chiquitano forest. *Science* 366(6469): 1082-1082.
11. Jiménez, G. 2013. *Territorios Indígenas y Áreas Protegidas en la mira. La ampliación de la frontera de industrias extractivas (Petropress 31, 6.13)*. CEDIB, La Paz, Bolivia. cedib.org/wp-content/uploads/2013/08/territorios_indigenas-y-areas-protegidas-en-la-mira.pdf
12. Blackman, A. and Veit, P. 2018. Titled Amazon Indigenous communities cut forest carbon emissions. *Ecological Economics* 153: 56-67.
13. Pacheco, P., de Jong, W., and Johnson, J. 2010. The evolution of the timber sector in lowland Bolivia: Examining the influence of three disparate policy approaches. *Forest Policy and Economics* 12(4): 271-276.
14. Jacobi, J. and Llanque, A. 2018. "When we stand up, they have to negotiate with us": Power relations in and between an agroindustrial and an Indigenous food system in Bolivia. *Sustainability* 10(11): 4001.
15. Pacheco, P., Mejia, E., Cano, W., and de Jong, W. 2016. Smallholder forestry in the western Amazon: Outcomes from forest reforms and emerging policy perspectives. *Forests* 7(9): 18.
16. Hanauer, M.M. and Canavire-Bacarreza, G. 2015. Implications of heterogeneous impacts of protected areas on deforestation and poverty. *Philosophical Transactions of the Royal Society B-Biological Sciences* 370(1681): 10.
17. Perez, C.J. and Smith, C.A. 2019. Indigenous knowledge systems and conservation of settled territories in the Bolivian Amazon. *Sustainability* 11(21): 41.
18. Tejada, G., Dalla-Nora, E., Cordoba, D., Lafortezza, R., Ovando, A., Assis, T., and Aguiar, Ana P. 2016. Deforestation scenarios for the Bolivian lowlands. *Environmental Research* 144: 49-63.

VENEZUELA AND GUYANA

The region still holds large forest areas; about 60% of Venezuela is covered by natural forest, and 90% of Guyana is forested[1]; 84% of the whole deforestation front is covered by natural forests. Deforestation is lower compared to other fronts, and main pressures originate from mining and smallholder farming. Guyana has been active in adopting measures in the context of REDD+ to protect its forests and as such has maintained low annualized deforestation rate, averaging 0.053% since 2018 [2].

Drivers of deforestation

Mining	Deforestation related to gold mining has been an increasing driver of deforestation in both Venezuela and Guyana, especially around 2012[3,4]. In Guyana, mining is estimated to account for up to 84% of deforestation[5]. Infrastructure and road-building related to mining are also important[6].
Smallholder farming	Small-scale shifting agriculture has been a persistent and large driver of deforestation in Venezuela, responsible for the majority of deforestation every year from 2001 to 2015. In Guyana, small-scale agriculture is also a primary driver of deforestation[1].
Large-scale agriculture	Large-scale commodity crop agriculture has been a persistent but minor driver of deforestation, responsible for approximately a quarter of deforestation in Venezuela from 2001 to 2015[1], and a far smaller proportion in Guyana[1].
Cattle ranching	Small-scale shifting agriculture in Venezuela is often accompanied by some livestock activities and thus is paired with agriculture as a driver of deforestation[7].
Commercial Logging	Forestry is a consistent but very minor driver of deforestation in Venezuela, responsible for just a small percentage of overall deforestation in recent years[1].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

In Guyana, market forces, such as increasing gold prices followed by the expansion of other markets in the country, are likely responsible for the rise and subsequent recent decrease in deforestation.

Countries, region	Venezuela and Guyana, Amazon
Forest type	Tropical moist forest primarily
Total area	20.6Mha
Forest area in 2018	18.5Mha (89.7% of total deforestation front area)
Forest loss 2004-2017	0.2Mha (1.3% of forest area in 2000)
Location of deforestation	Southern Venezuela and northern Guyana
Total forest core area in 2018	15.4Mha (83.3% of forests in 2018)
Fragmented forests 2000-2018	0.2Mha (1.2% of forest area in 2000)
Accumulated burned area, 2002-2019	0.2Mha (1.1% of forest area in 2000)
Deforestation trend	Increasing, with oscillations
Future trends	Recent political instability in Venezuela may impact deforestation

Responses

Deforestation monitoring	As part of its REDD+ efforts, Guyana has developed and instituted an intensive, nationwide forest monitoring system[4].
REDD+	Guyana has been an early and active REDD+ participant, including through a major agreement with Norway[4].
Protected areas	Venezuela has a relatively large share of its land in protected areas, but in one study these protected areas were found to be not as effective in limiting deforestation as they have been in other countries[8].

Deployment at wider scale
Actively used and expanding
Project-specific, experimental

Main outcomes

The most prominent driver of deforestation, particularly in Guyana, continues to be mining, though mining activity has decreased in recent years[9]. Future trends are likely to depend on changes in the underlying market drivers that influence mining.

Recommended future actions

- Continue deforestation monitoring associated with REDD+, which has been significant as a response to deforestation, especially in Guyana.
- Ensure protected areas are managed effectively.
- Incorporate methodologies and technologies which allow for more real-time, predictive monitoring to address deforestation proactively and to support better land-use planning.
- Ensure expansion of protected areas to meet CBD target and continue to maintain so that protected areas are managed effectively.
- Ensure decisive action on the increasing deforestation from gold mining, which can have lasting negative impacts on Guyana's REDD+ efforts.

References

1. WRI. 2020. WRI. Global Forest Watch Dashboard. Available from: www.globalforestwatch.org/dashboards [accessed: April 15, 2020].
2. Guyana Forestry Commission. 2018.
3. Alvarez-Berríos, N.L. and Mitchell Aide, T. 2015. Global demand for gold is another threat for tropical forests. *Environmental Research Letters* 10(1): 014006.
4. Kalamandeen, M., Gloor, E., Mitchard, E., Quincey, D., Ziv, G., Spracklen, D., ... Galbraith, D. 2018. Pervasive rise of small-scale deforestation in Amazonia. *Scientific Reports* 8(1): 1600.
5. Laing, T. 2019. Small man goes where the large fears to tread: Mining in Guyana: 1990-2018. *Resources Policy* 63: 101426.
6. Commission, G.F. 2015. *Guyana REDD+ Monitoring Reporting & Verification System (MRVS)*. The Guyana Forestry Commission, Indufor, Guyana. forestry.gov.gy/wp-content/uploads/2015/09/MRVS-Interim-Measures-Report-Year-4-V3.pdf
7. Pacheco, C.E., Aguado, M.I., and Mollicone, D. 2014. Identification and characterization of deforestation hot spots in Venezuela using MODIS satellite images. *Acta Amazonica* 44: 185-196.
8. Spracklen, B.D., Kalamandeen, M., Galbraith, D., Gloor, E., and Spracklen, D.V. 2015. A global analysis of deforestation in moist tropical forest protected areas. *PLOS ONE* 10(12): e0143886.
9. Sharples, C. 2018. Guyana deforestation rate hits 7-year low, officials say. *Mongabay*, 19 October. Available from: news.mongabay.com/2018/10/guyana-deforestation-rate-hits-7-year-low-officials-say

GRAN CHACO

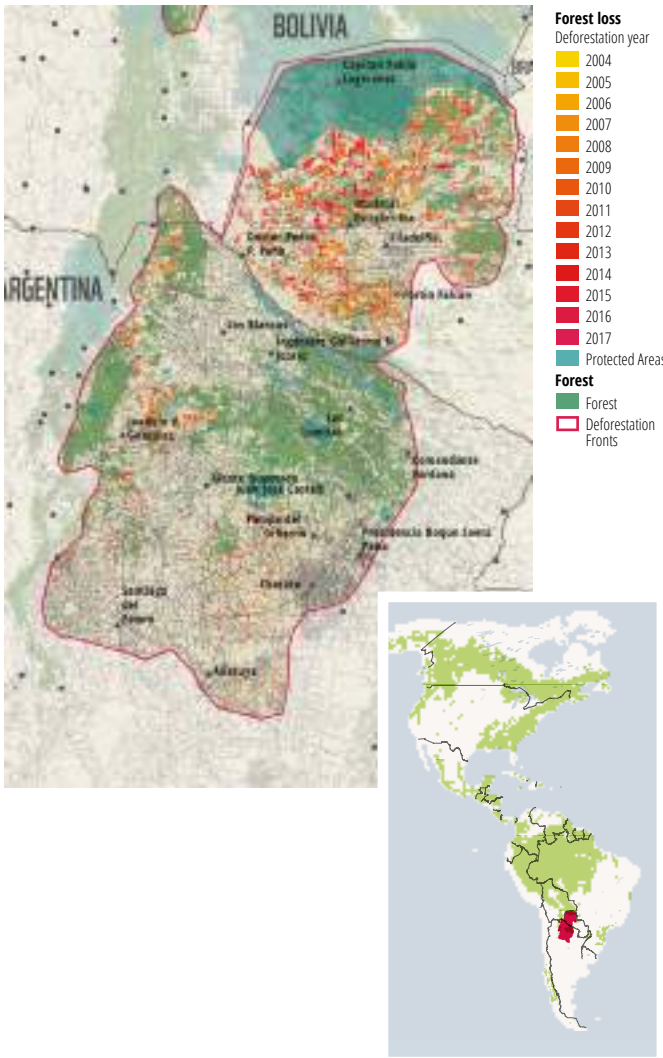
The Gran Chaco has one of the highest rates of deforestation in the world, driven particularly by genetically modified soy production and large-scale cattle ranching. Most efforts to control the rate of loss have so far been unsuccessful, although deforestation rates are slowing in some areas.

Countries, region	Argentina (60%), Paraguay (28%), Bolivia (11%) and Brazil
Forest type	Dry arid and semi-arid forest (78.8Mha), humid and flooded savannahs (29.0Mha)
Total area	46.3Mha
Forest area in 2018	14.5Mha (31.3% of total deforestation front area)
Forest loss 2004-2017	5.2Mha (26.1% of forest area in 2000)
Location of deforestation	Broad belt sweeping from the east
Total forest core area in 2018	5.5M ha (37.9% of forests in 2018)
Fragmented forests 2000-2018	0.8M ha (4.0% of forest area in 2000)
Accumulated burned area, 2002-2019	4.6Mha (23.1% of forest area in 2000)
Deforestation trend	Once the world's highest[1], but has decreased since 2009 in Argentina[2]. For three years, Paraguay has had higher annual losses[3]
Future trends	Possibly decreasing under new regulations

Drivers of deforestation

Large-scale agriculture	Large- and medium-scale mechanized agriculture has been the most important driver of deforestation in the Chaco[4], particularly for soybean in Argentina[5], and a proportion of previously converted grazing lands are being switched to soy[6]. Traditional small farms have been replaced by larger fields[7]. These are considered future pressures in Paraguay.
Cattle ranching	Clearance of forest to create cattle pasture is the primary driver of deforestation in parts of the Chaco, particularly in Paraguay[8, 9], and remains important in Argentina, mainly under extensive systems[10]. The soy and cattle industries are increasingly closely interlinked in the region[11], including through transnational investments[12, 13].
Smallholder farming	Indigenous people and traditional criollos farmers are being displaced by large scale agriculture and cattle ranching and are moving into remaining forests, potentially adding further deforestation pressure[14]. Much of the displacement took place through uneven competition in the land markets that works against local farmers and communities[15].
Charcoal production	Commercial charcoal production for export is significant, particularly in Paraguay[16], although it is mainly from areas that are being cleared for other purposes. Charcoal-making by smallholders causes mainly degradation in Argentina.
Small-scale timber extraction	Small-scale timber extraction for fuelwood is only a minor forest use and the number of users is declining, in part because deforestation means supplies are no longer available and different energy sources are being introduced[17].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation



Underlying causes

Agricultural demand is a major driver of deforestation, and it is also accompanied by land-use intensification[18]. Regulation of deforestation in the region has been hampered by a number of factors, including the importance of the agricultural sector, relatively low carbon stocks compared with other forest areas and the prevalence of private land tenure[19]. In addition, uneven land competition stimulated by government policies has led to the concentration of agricultural activities on a smaller number of large-scale farms in the Chaco, to the detriment of small-scale farmers who have tended to be marginalized[15].

Responses

Protected areas	The region is currently under-represented by protected areas with poor representation of terrestrial vertebrates; in 2009 protected areas covered 9% of the Chaco[20] and isolation of protected areas is a serious problem[21].
Payment for ecosystem services	A payment for ecosystem services (PES) scheme in Argentina provides funding for farmers. WWF has promoted a PES scheme in Paraguay[22].
Voluntary standards	The Roundtable on Responsible Soy (RTRS) operates in the countries of the Chaco and is promoting production without further conversion of natural ecosystems.
Land-use zoning	Zoning policies apply in the Argentine Chaco to balance agriculture and conservation under the 2007 Forest Law, yet the environmental outcomes remain unclear[23].
Recognition of IPLCs	Granting indigenous land title in Argentina is still fairly limited. In Bolivia, 17 indigenous territories were formalized in favour of Guarani communities covering 1Mha, out of a total of 6.7Mha that were claimed[24].
Land tenure security	Only a few small-scale farmers are involved in land tenure claims in the Argentinian Chaco; many do not have formal title and are in danger of being evicted. So far, land tenure processes have not substantially reduced forest loss[14].
Forest laws	A national "Forest Law" was passed in Argentina in 2007. In Bolivia, several regulations have been passed in recent years favouring expansion of the agricultural frontier[25].

Deployment at wider scale | Actively used and expanding | Project-specific, experimental

Outcomes

Existing protected areas are important, but currently insufficient and their isolation is a serious problem[21]. PES schemes pay far less than could be earned through conversion to soy and are for a length of time of the farmer's choosing so that lands of high potential value tend to stay in the scheme for less time[26]. Success is partly due to the strength of different sub-national governments[27]. In spite of existing and new forest regulations, the pressures on indigenous people's land appear to have increased, with effects on deforestation[28]. The extent to which the forest law in Argentina has been successful in conserving forest is disputed; some analysts claim that it has reduced deforestation[29], while others highlight continued deforestation[30] even within protected areas[2], and say provincial governments are unable to enforce the law effectively.

Recommended future actions

- Urgently strengthen the protected area system, making it more representative, and conserve ecological corridors.
- Use consumer pressure to step up moratoria and use of certification for soy and beef, including pressure on companies deeply involved in the trade[31].

References

1. Zak, M.R., Cabido, M., and Hodgson, J.G. 2004. Do subtropical seasonal forests in the Gran Chaco, Argentina, have a future? *Biological Conservation* 120(4): 589-598.
2. Volante, J.N. and Seghezzo, L. 2018. Can't see the forest for the trees: Can declining deforestation trends in the Argentinian Chaco region be ascribed to efficient law enforcement? *Ecological Economics* 146: 408-413.
3. Arévalos, A., Ortiz, E., Báez, M., Benitez, C., Allegretti, L., and Dure, A. 2015. *Monitoreo mensual del cambio de uso y cobertura de la tierra, incendios y variación de la cubierta de aguas en el Gran Chaco Americano*. Avina. sabersocial.virtual.avina.net/Conocimiento.aspx?documentId=127.
4. Hoyos, L.E., Cabido, M.R., and Cingolani, A.M. 2018. A multivariate approach to study drivers of land-cover changes through remote sensing in the Dry Chaco of Argentina. *ISPRS International Journal of Geo-Information* 7(5): 170.
5. Fehlenberg, V., Baumann, M., Gasparri, N.I., Piquer-Rodriguez, M., Gavier-Pizarro, G., and Kuemmerle, T. 2017. The role of soybean production as an underlying driver of deforestation in the South American Chaco. *Global Environmental Change* 45: 24-34.
6. Baumann, M., Gasparri, I., Piquer-Rodríguez, M., Gavier Pizarro, G., Griffiths, P., Hostert, P., and Kuemmerle, T. 2017. Carbon emissions from agricultural expansion and intensification in the Chaco. *Global Change Biology* 23(5): 1902-1916.
7. Graesser, J., Ramankutty, N., and Coomes, O.T. 2018. Increasing expansion of large-scale crop production onto deforested land in sub-Andean South America. *Environmental Research Letters* 13(8): 084021.
8. Baumann, M., Israel, C., Piquer-Rodríguez, M., Gavier-Pizarro, G., Volante, J.N., and Kuemmerle, T. 2017. Deforestation and cattle expansion in the Paraguayan Chaco 1987–2012. *Regional Environmental Change* 17(4): 1179-1191.
9. Caldas, M.M., Goodin, D., Sherwood, S., Campos Krauer, J.M., and Wisely, S.M. 2015. Land-cover change in the Paraguayan Chaco: 2000–2011. *Journal of Land Use Science* 10(1): 1-18.
10. Fernández, P.D., Kuemmerle, T., Baumann, M., Grau, H.R., Nasca, J.A., Radrizzani, A., and Gasparri, N.I. 2020. Understanding the distribution of cattle production systems in the South American Chaco. *Journal of Land Use Science*: 1-17.
11. Gasparri, N.I. and de Waroux, Y.l.P. 2015. The coupling of South American soybean and cattle production frontiers: New challenges for conservation policy and land change science. *Conservation Letters* 8(4): 290-298.
12. le Polain de Waroux, Y. 2019. Capital has no homeland: The formation of transnational producer cohorts in South America's commodity frontiers. *Geoforum* 105: 131-144.
13. le Polain de Waroux, Y., Baumann, M., Gasparri, N.I., Gavier-Pizarro, G., Godar, J., Kuemmerle, T., ... Meyfroidt, P. 2018. Rents, actors, and the expansion of commodity frontiers in the Gran Chaco. *Annals of the American Association of Geographers* 108(1): 204-225.
14. Tschopp, M.N., Ceddia, M.G., Bardsley, N., Inguaggiato, C., and Hernandez, H. Unpublished. *Land tenure (in)security and investment in sustainable agricultural practices by small-scale farmers in the Chaco Salteño. 4th Open Science Meeting of Global Land Programme*. 2019. Bern, Switzerland.
15. Baumann, M., Piquer-Rodríguez, M., Fehlenberg, V., Gavier Pizarro, G., and Kuemmerle, T. 2016. *Land-use competition in the South American Chaco*. In: J. Niewöhner, et al. (eds), *Land Use Competition. Human-Environment Interactions*, pp 215-232. Springer, Amsterdam, New York, Berlin.
16. Cannon, J.C. 2017. Charcoal and cattle ranching tearing apart the Gran Chaco. *Mongabay*, 19 July. Available from: news.mongabay.com/2017/07/charcoal-and-cattle-tearing-apart-the-gran-chaco
17. Krapovickas, J., Sacchi, L.V., and Hafner, R. 2016. Firewood supply and consumption in the context of agrarian change: the North Argentine Chaco from 1990 to 2010. *International Journal of the Commons* 1-(1): 220–243.
18. Piquer-Rodríguez, M., Butsic, V., Gärtner, P., Macchi, L., Baumann, M., Gavier Pizarro, G., ... Kuemmerle, T. 2018. Drivers of agricultural land-use change in the Argentine Pampas and Chaco regions. *Applied Geography* 91: 111-122.
19. Nolte, C., le Polain de Waroux, Y., Munger, J., Reis, T.N.P., and Lambin, E.F. 2017. Conditions influencing the adoption of effective anti-deforestation policies in South America's commodity frontiers. *Global Environmental Change* 43: 1-14.
20. Nori, J., Torres, R., Lescano, J.N., Cordier, J.M., Periago, M.E., and Baldo, D. 2016. Protected areas and spatial conservation priorities for endemic vertebrates of the Gran Chaco, one of the most threatened ecoregions of the world. *Diversity and Distributions* 22(12): 1212-1219.
21. Matteucci, S.D. and Camino, M. 2012. Protected areas isolation in the Chaco Region, Argentina. *Journal of Geography and Geology* 4(3): 15-28.
22. WWF. 2013. La ley de pago por servicios ambientales es la solución para disminuir la deforestación. Available from: www.wwf.org.py/?209071/la-ley-de-pago-por-servicios-ambientales-es-la-solucin-para-disminuir-la-deforestacin
23. Torrella, S.n.A., Piquer-Rodrìguez, M., Levers, C., Ginzburg, R., Gavier-Pizarro, G., and Kuemmerle, T. 2018. Multiscale spatial planning to maintain forest connectivity in the Argentine Chaco in the face of deforestation. *Ecology and Society* 23(4).
24. Tamburini, L. 2019. *Bolivia: Atlas Sociopolítico sobre los Territorios Indígenas ne las Tierras Bajas*. CEJIS, IWGIA, Bosques del Mundo and Diakonia, Santa Cruz de la Sierra, Bolivia.
25. Romero-Muñoz, A., Jansen, M., Nuñez, A.M., Toledo, M., Almonacid, R.V., and Kuemmerle, T. 2019. Fires scorching Bolivia's Chiquitano forest. *Science* 366(6469): 1082-1082.
26. Núñez-Regueiro, M.M., Fletcher, R.J., Pienaar, E.F., Branch, L.C., Volante, J.N., and Rifai, S. 2019. Adding the temporal dimension to spatial patterns of payment for ecosystem services enrollment. *Ecosystem Services* 36: 100906.
27. Alcañiz, I. and Gutierrez, R.A. 2020. Between the global commodity boom and subnational state capacities: Payment for environmental services to fight deforestation in Argentina. *Global Environmental Politics* 20(1): 38-59.
28. Ceddia, M.G. and Zepharovich, E. 2017. Jevons paradox and the loss of natural habitat in the Argentinean Chaco: The impact of the indigenous communities' land titling and the Forest Law in the province of Salta. *Land Use Policy* 69: 608-617.
29. Nolte, C., Gobbi, B., le Polain de Waroux, Y., Piquer-Rodríguez, M., Butsic, V., and Lambin, E.F. 2017. Decentralized Land use zoning reduces large-scale deforestation in a major agricultural frontier. *Ecological Economics* 136: 30-40.
30. Camba Sans, G., Aguiar, S., Vallejos, M., and Paruelo, J. 2018. Assessing the effectiveness of a land zoning policy in the Dry Chaco. The case of Santiago del Estero, Argentina. *Land Use Policy* 70: 313-321.
31. *The Guardian*. 2019. Links with deforestation in the Chaco: companies' full responses. Available from: www.theguardian.com/environment/2019/oct/05/deforestation-chaco-companies-full-responses

BRAZILIAN CERRADO

The Brazilian Cerrado, which covers over 200Mha, is the world's most biodiverse savannah. With more than 11,000 native plant species, as well as large sums of mammal, fish, bird, amphibian and reptile species, it is recognized as a global biodiversity hotpot[1, 2]. The Cerrado plays an essential role in supporting Brazil's water cycle as the source of eight of the country's 12 river basins[3, 4]. Pasture and large-scale agriculture have expanded rapidly across the region over the past four decades, rapidly transforming the Cerrado[5]. Ongoing clearing may reduce precipitation and increase local temperatures, putting remaining vegetation, livelihoods and continued agricultural production in this region at risk[6].

Drivers of deforestation

Cattle ranching	The majority of cleared areas become pasture, but stocking rates on most pastures are low[8]. Expansion of pasture is also connected with land speculation and future transition to soy and other high-priced crops.
Large-scale agriculture	Most soy produced in the Cerrado is used for animal feed, supplying both domestic and international markets[9]. Unlike in the cattle sector, productivity in the soy sector is generally high[10]. Cotton, maize, coffee and silviculture are other important crops.
Fires	Fire is traditionally used in the Cerrado as a land management strategy, putting farmers at odds with environmental agencies which seek to limit fires around protected areas[11].
Mining operations	Increasingly a risk as measures that expand the area available to mining and that reduce the requirements for environmental assessments of new mines make their way through Brazil's legislative bodies[12, 13].
Charcoal production	For use in the steel industry, which has large mills in Minas Gerais[14]. Previously solely produced from native vegetation, now wood from eucalyptus plantations is also used[15].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Underlying causes include weak public protection for natural vegetation, especially compared to the Amazon. Only 7.5% of the Cerrado falls in public protected areas[16], and private landowners are only required to maintain 20-35% of their property under native vegetation under Brazil's Forest Code. The proximity of the Cerrado to international markets, including Europe, and to large national markets along the country's coast increases incentives to expand agriculture and ranching, and the importance of the region for production of steel and hydroelectric power. Land speculation is a significant additional cause of conversion, linked to the opportunity for a future transition to agriculture.

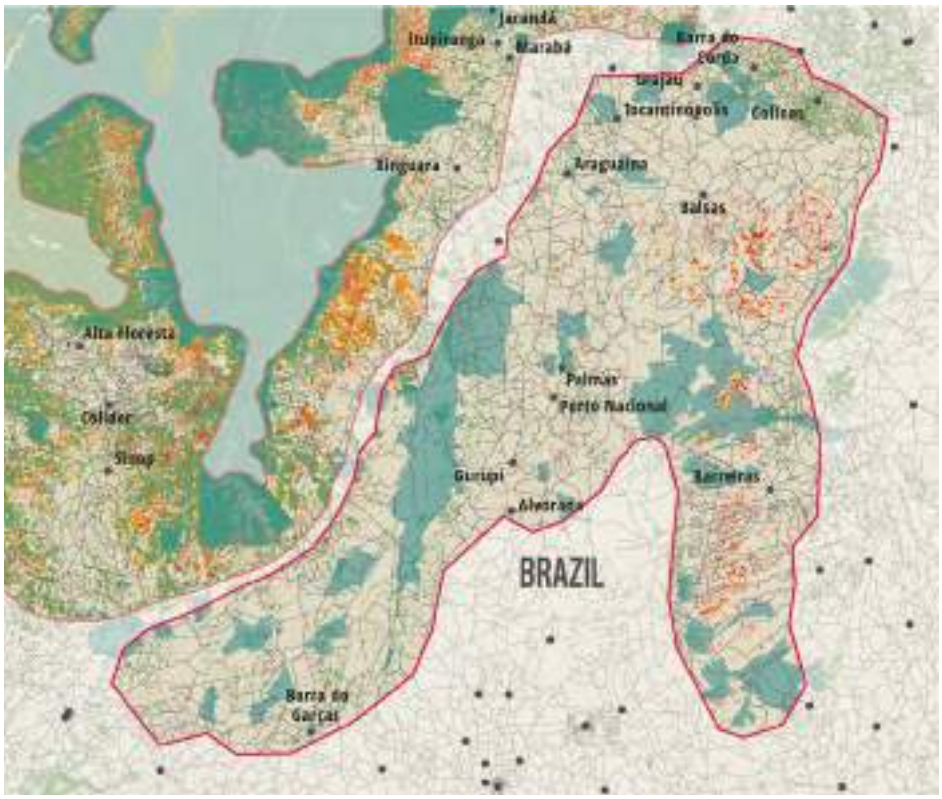
Countries, region	Brazil, Cerrado
Forest type	Dry forests, gallery forests, woody savannah, grasslands
Total area	71.7Mha
Forest area in 2018	5.6Mha of forests (7.8% of total deforestation front area) when looking only at forest estimates based on a global assessment; 46.9Mha (65.0% of total deforestation front area) when looking at all natural ecosystems based on INPE[7] *
Forest loss 2004-2017	3.0Mha of forests (32.8% of forest area in 2000) when looking only at estimates from Terra-i; 9.6Mha (16.9% of all natural ecosystems area in 2000) based on INPE[7] (*)
Location of deforestation	Throughout, but mostly concentrated in Matopiba (northern region) and Mato Grosso state
Total forest core area in 2018	0.4Mha (7.7% of forests in 2018) when looking only at forest estimates based on a global assessment
Fragmented forests 2000-2018	0.3M ha (3.5% of forest area in 2000) when looking only at forest estimates based on a global assessment
Accumulated burned area, 2002-2019	3.7Mha (40.5% of forest area in 2000) when looking only at forest estimates based on a global assessment
Deforestation trend	Decreased between the early 2000s and the late 2000s but has recently ticked up
Future trends	Trends to persistent deforestation

* Note: Estimates form national sources are considered here instead of Terra-I estimates.

Key responses

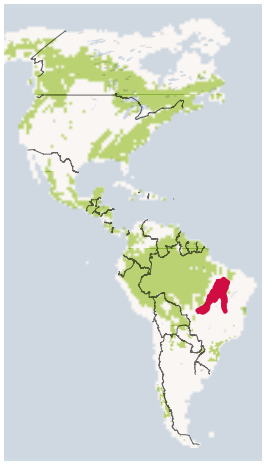
Protected areas	Protected areas cover about 210,000 ha; the majority of these are "sustainable use" protected areas, in which certain extractive activities are permitted[17].
Recognition of IPLCs	Indigenous reserves cover nearly 100,000 ha of the Cerrado (about 5%)[17].
Land-use zoning	The Forest Code specifies a certain portion of each property must be set aside for conservation; the national environmental registry allows landowners to plan these set-asides and declare them to environmental agencies[18, 19].
Deforestation monitoring	Official annual monitoring of vegetation loss was recently launched[20], allowing for the assessment of overall clearing trends and deforestation trends on individual properties when overlaid on the national environmental registry.
Traceability of supply	Some soy companies are moving toward mapping their suppliers and assessing their land use[21]. In late 2017, more than 70 companies (soy and meat producers and traders) signed the Cerrado Manifesto to prevent further destruction of natural vegetation in the Cerrado[22].
REDD+ projects	National REDD+ strategy could be integrated into public Cerrado protection policies by creating incentives for retaining and restoring Cerrado vegetation[8].

Deployment at wider scale
Actively used and expanding
Project-specific, experimental



Forest loss
Deforestation year
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Protected Areas

Forest
Forest
Deforestation Fronts



Main outcomes

The Cerrado has long been Brazil's environmental "sacrifice zone"[23], due to the relatively weak protections it is afforded under the Forest Code and the protected areas system. As a result, most deforestation and conversion in the Cerrado is permissible under law[9] Private sector initiatives to monitor soybean and cattle producers have not materialized[24].

Recommended future actions

- Expand protected areas to at least 17% of the minimum called for under the Convention on Biological Diversity (CBD)[28].
- Reduce deforestation on private properties with market initiatives for sustainable production and through payments for environmental services (PES) [25, 26].
- Expand technical assistance to incentivize productivity in the cattle sector[27].

References

1. Ministry of the Environment Brazil (MMA). 2020. The biomes – Cerrado. Available from: www.mma.gov.br/biomas/cerrado
2. Cardoso Da Silva, J.M. and Bates, J.M. 2002. Biogeographic patterns and conservation in the South American Cerrado: A tropical savanna hotspot. *BioScience* 52(3): 225-234.
3. Vieira, R.R.S., Ribeiro, B.R., Resende, F.M., Brum, F.T., Machado, N., Sales, L.P., ... Loyola, R. 2018. Compliance to Brazil's Forest Code will not protect biodiversity and ecosystem services. *Diversity and Distributions* 24(4): 434-438.
4. Lima, J.E.F.W. 2011. Situação e perspectivas sobre as aguas do Cerrado. *Ciência e Cultura* 63(3).
5. Klink, C.A. and Machado, R.B. 2005. Conservation of the Brazilian Cerrado. *Conservation Biology* 19(3): 707-713.
6. Costa, M.H. and Pires, G.F. 2010. Effects of Amazon and Central Brazil deforestation scenarios on the duration of the dry season in the arc of deforestation. *International Journal of Climatology* 30(13): 1970-1979.
7. Instituto Nacional de Pesquisas Espaciais [INPE]. 2020. TerraBrasilis. Ministério de Ciência e Tecnologia, São José dos Campos, Brazil. Available from: terrabrasilis.dpi.inpe.br/downloads
8. Strassburg, B.B.N., Brooks, T., Feltran-Barbieri, R., Iribarrem, A., Crouzeilles, R., Loyola, R., ... Balmford, A. 2017. Moment of truth for the Cerrado hotspot. *Nature Ecology & Evolution* 1(4): 0099.
9. Rausch, L.L., Gibbs, H.K., Schelly, I., Brandão Jr, A., Morton, D.C., Filho, A.C., ... Meyer, D. 2019. Soy expansion in Brazil's Cerrado. *Conservation Letters* 12(6): e12671.
10. Rada, N. 2013. Assessing Brazil's Cerrado agricultural miracle. *Food Policy* 38: 146-155.
11. Eloy, L., Schmidt, I.B., Borges, S.L., Ferreira, M.C., and Dos Santos, T.A. 2019. Seasonal fire management by traditional cattle ranchers prevents the spread of wildfire in the Brazilian Cerrado. *Ambio* 48(8): 890-899.
12. Sonter, L.J., Herrera, D., Barrett, D.J., Galford, G.L., Moran, C.J., and Soares-Filho, B.S. 2017. Mining drives extensive deforestation in the Brazilian Amazon. *Nature Communications* 8(1): 1013.
13. Ferreira, J., Aragão, L.E.O.C., Barlow, J., Barreto, P., Berenguer, E., Bustamante, M., ... Zuanon, J. 2014. Brazil's environmental leadership at risk. *Science* 346(6210): 706-707.
14. Ratter, J.A., Ribeiro, J.F., and Bridgewater, S. 1997. The Brazilian Cerrado vegetation and threats to its biodiversity. *Annals of Botany* 80(3): 223-230.
15. Alho, C.J.R. and Martins, E.d.S. 1995. *Bit by bit the Cerrado loses space*. World Wide Fund for nature (WWF), Brasiia, Brazil.,
16. Strassburg, B.B.N., Latawiec, A., and Balmford, A. 2016. Brazil: Urgent action on Cerrado extinctions. *Nature* 540: 199.
17. Eloy, L., Aubertin, C., Toni, F., Lúcio, S.L.B., and Bosgiraud, M. 2016. On the margins of soy farms: traditional populations and selective environmental policies in the Brazilian Cerrado. *The Journal of Peasant Studies* 43(2): 494-516.
18. Sparovek, G., Berndes, G., Barretto, A.G.d.O.P., and Klug, I.L.F. 2012. The revision of the Brazilian Forest Act: increased deforestation or a historic step towards balancing agricultural development and nature conservation? *Environmental Science & Policy* 16: 65-72.
19. Soares-Filho, B., Rajão, R., Macedo, M., Carneiro, A., Costa, W., Coe, M., ... Alencar, A. 2014. Cracking Brazil's Forest Code. *Science* 344(6182): 363-364.
20. National Institute of Spatial Research (INPE). 2020. Projeto Monitoramento Cerrado. Available from: cerrado.obt.inpe.br [accessed 24 March 2020].
21. World Business Council on Sustainable Development. 2019. *Soft Commodities Forum progress report December 2019: Building transparent and traceable soy supply chains in Brazil's Cerrado region*. Available from: docs.wbcsd.org/2019/12/WBCSD_Soft_Commodities_Forum_progress_report.pdf
22. Belmaker, G. 2018. More companies sign on to Cerrado Manifesto. *Mongabay,* 6 August. Available from: news.mongabay.com/2018/08/more-companies-sign-on-to-cerrado-manifesto
23. Brannstrom, C. 2009. South America's neoliberal agricultural frontiers: Places of environmental sacrifice or conservation opportunity. *AMBIO: A Journal of the Human Environment* 38(3): 141-149.
24. Nepstad, L.S., Gerber, J.S., Hill, J.D., Dias, L.C.P., Costa, M.H., and West, P.C. 2019. Pathways for recent Cerrado soybean expansion: extending the soy moratorium and implementing integrated crop livestock systems with soybeans. *Environmental Research Letters* 14(4): 044029.
25. Soterroni, A.C., Ramos, F.M., Mosnier, A., Fargione, J., Andrade, P.R., Baumgarten, L., ... Polasky, S. 2019. Expanding the Soy Moratorium to Brazil's Cerrado. *Science Advances* 5(7): eaav7336.
26. Gebara, M.F. 2017. Can REDD+ help Brazil roll back rising deforestation rates? *CIFOR Forests News*, 23 June. Available from: forestsnews.cifor.org/50288/can-redd-help-brazil-roll-back-rising-deforestation-rates?fnl=en
27. Strassburg, B.B.N., Latawiec, A.E., Barioni, L.G., Nobre, C.A., da Silva, V.P., Valentim, J.F., ... Assad, E.D. 2014. When enough should be enough: Improving the use of current agricultural lands could meet production demands and spare natural habitats in Brazil. *Global Environmental Change* 28: 84-97.

CHOCÓ-DARIÉN

The moist forests of the Chocó-Darién, separated from the Amazon by the Andes, are rich in biodiversity. There are still intact forest areas, despite continuing large-scale forest loss. Protected areas are helping, along with efforts to introduce carbon credit schemes and sustainable forest management.

Drivers of deforestation

Cattle ranching	The most significant driver overall[3] and the largest agent of change in 2010-2015 in all three countries (94% in Panama, 76% in Colombia, and 59% in Ecuador)[4].
Smallholder farming	Relatively small-scale farming, including coca production[5], bananas[6] and oil palm[7], is responsible for much of forest loss in Colombia and Panama and is important in Ecuador[4].
Large-scale agriculture	Significant, particularly in Colombia and Ecuador (mainly oil palm).
Mining operations	Concessions covered over 960,000ha by 2011 and there are 20 oil blocks in Colombia[2]. Most current mining is illegal, uncontrolled and thus hard to measure[8].
Road expansion	Road building and proximity to roads[9] are both important drivers of forest loss in some areas.
Urban expansion	Small impact[9].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Population growth, insecure tenure, corruption and armed conflict. New roads, railroads, ports and oil infrastructure are planned[2].

Countries, region	Ecuador, Colombia, Panama
Forest type	Lowland and mountain tropical forest, mangrove
Total area	1.3Mha
Forest area in 2018	1.1Mha (85.3% of total deforestation front area)
Forest loss 2004-2017	0.03Mha (2.3% of forest area in 2000)
Location of deforestation	Mainly in Ecuador[1]
Total forest core area in 2018	0.6Mha (54.4% of forests in 2018)
Fragmented forests 2000-2018	0.05Mha (4.2% of forest area in 2000)
Accumulated burned area, 2002-2019	0.02Mha (2.1% of forest area in 2000)
Deforestation trend	Decreased until 2015, but has increased again in recent years
Future trends	Analyses project losses over 30-40 years of ~1.5Mha (9% of total)[2]

Responses

Protected areas	Protected areas and indigenous territories cover over 2.5Mha of the Chocó. They are generally successful[2], although losses have been noted by the Ministry of Environment in Colombia[10].
Carbon trading	The Chocó-Darién Conservation Corridor leverages carbon credits to protect community-owned forests on Colombia's Atlantic coast[11].
Sustainable production	WWF is supporting sustainable production capacities of local communities in Ecuador in order to reduce agricultural frontier expansion.
Policy initiatives	The 5 Great Forests Initiative is a multi-government initiative to protect Mesoamerican forests, including the Darien; its aims include eliminating illegal cattle ranching. In Ecuador, the Socio Bosque programme provides economic support for poorer private and communal landholders who maintain forest cover, and the country's Nationally Determined Contributions (NDC) and REDD+ strategy prioritizes the Choco.
Sustainable forestry	Some sustainable harvesting methods have been introduced in Panama[12].
Land-use zoning	A major land-use planning exercise by WWF has identified priority areas for conservation[13].
Restoration	Forest restoration in the Ecuadorian Choco has been prioritised in the government's National Reforestation Plan.

Deployment at wider scale
Actively used and expanding
Project-specific, experimental

Main outcomes

Much of the area remains intact, but efforts have yet to reduce the rate of forest loss significantly; indeed, it has been increasing in some parts. There are now some government commitments to limit the scale of conversion.

Recommended future actions

- Establish more protected areas.
- As much of the forest will continue to be used, explore alternatives that retain forest cover, including particularly carbon credits.

Forest loss
Deforestation year
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- Protected Areas

Forest
- Forest
- Deforestation Fronts

References

1. Mosandl, R., Stimm S.G.B. and Weber, M. 2008. Ecuador suffers the highest deforestation rate in South America. In: Beck, E. et al. (eds). *Gradients in a Tropical Mountain Ecosystem of Ecuador. Ecological Studies 198*, pp 37-40. Springer-Verlag, Berlin Heidelberg.
2. WWF. 2014. *Landscape management in Chóco Darién priority watersheds*. WWF-Colombia, Cali.
3. Herlihy, P. 1989. Opening Panama's Darien Gap. *Journal of Cultural Geography* 9(2): 42-59.
4. Fagua, J.C. and Ramsey, R.D. 2019. Geospatial modeling of land cover change in the Chocó-Darien global ecoregion of South America; One of most biodiverse and rainy areas in the world. *PLOS ONE* 14(2): e0211324.
5. Dávalos, L.M., Bejarano, A.C., Hall, M.A., Correa, H.L., Corthals, A., and Espejo, O.J. 2011. Forests and drugs: Coca-driven deforestation in tropical biodiversity hotspots. *Environmental Science & Technology* 45(4): 1219-1227.
6. Mongabay. 2006. Colombia. Available from: rainforests.mongabay.com/20colombia.htm (accessed 26 March 2020).
7. Volckhausen, T. 2018. How Colombia became Latin America's palm oil powerhouse. *Mongabay,* 31 May. Available from: news.mongabay.com/2018/05/how-colombia-became-latin-americas-palm-oil-powerhouse
8. Cardona, F. 2018. 66% of Colombia's gold is mined illegally: UN study. *Colombia Reports*, 19 June. Available from: https://colombiareports.com/66-of-colombias-gold-is-mined-illegally-un-study
9. Fagua, J.C., Baggio, J.A., and Ramsey, R.D. 2019. Drivers of forest cover changes in the Chocó-Darien Global Ecoregion of South America. *Ecosphere* 10(3): e02648.
10. Haruna, A. 2010. *Measuring protected areas' impacts on deforestation in Panama*. Duke University.
11. UNDC. nd. Chocó-Darién Conservation Corridor – Colombia. Available from: unfccc.int/climate-action/momentum-for-change/activity-database/momentum-for-change-Chocó-Darién-conservation-corridor [accessed 15 April 2020].
12. WCS. 2020. Critical new initiative to protect Mesoamerica's five great forests launches during UN climate summit. *WCS Newsroom*, 22 September. Available from: newsroom.wcs.org/News-Releases/articleType/ArticleView/articleId/13091/Critical-New-Initiative-to-Protect-Mesoamericas-Five-Great-Forests-Launches-During-UN-Climate-Summit.aspx
13. WWF. 2007. Responsible forestry in Panama. Available from: www.wwfca.org/?97460/Responsible-forestry-in-Panama

THE MAYA FOREST

The Maya Forest constitutes one of the largest tropical forest areas in the Americas. It provides significant environmental services, including carbon sequestration and biodiversity, as well as vital forest resources for rural communities. While this region has long been subject to deforestation, frontiers of forest loss have changed over time. In the last decade, deforestation has shifted from southern to north-western Petén (Guatemala), and has increasingly advanced over north-eastern Campeche and southern Quintana Roo (Mexico)[1, 2]. Deforestation drivers have also changed. If cattle ranching and slash-and-burn were the main drivers in the past, commercial farming (small-scale but especially large-scale) now plays an increasingly important role[3, 4].

Drivers of deforestation

Cattle ranching	Extensive cattle production causing forest degradation and clearance of primary forests and secondary vegetation[1, 5]; in certain regions, this is linked with land speculation, drug trafficking[6] and even money laundering[7].
Smallholder farming	Linked to expansion of traditional smallholder agriculture, including shifting cultivation, and extensive cattle production[4, 5], but also increasingly to cash crop production[4, 8].
Large-scale agriculture	Expansion of intensive cropland production (oil palm and soybean, particularly in Mexico) over pastures but in certain regions, such as northern Campeche[2, 4] and southern Petén[3, 9], over forests.
Fires	Fire is associated with deforestation, as it is often used as a tool to clear land (in both subsistence and commercial farming)[10]), but also because large-scale fires affect large areas in the region[11] and may facilitate permanent land-use conversion from forest to agricultural land[12].
Logging	Industrial logging is less important than in the past[13]. Negative environmental effects are associated with illegal logging[14, 15] as well as with some cases of unsustainable community forestry[16].
Fuelwood and charcoal	Selective logging for fuelwood and charcoal is common in the region[17, 18]. Under some circumstances, these practices are related to forest degradation[4].
Urban expansion	Growing urban centres and tourist developments have led to deforestation in some regions, such as in coastal Yucatan[11][4].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

The shift from collective (sometimes customary) to more individual land tenure regimes has been associated with land purchases by large-scale producers and greater levels of deforestation[19-21]. In some regions, organized crime has fuelled sales of forested land for cattle ranching and, to a lesser extent, large-scale agriculture[6]. Additionally, in certain regions of the Maya Forest, the government has been promoting farming of certain cash crops, like oil palm, which might lead to forest loss and degradation[22-24].

Countries, region	Belize, Guatemala and Mexico
Forest type	Humid and sub-humid tropical forests
Total area	13.4Mha
Forest area in 2018	10.2Mha (75.9% of total deforestation front area)
Forest loss 2004-2017	0.5Mha (5.0% of forest area in 2000)
Location of deforestation	South-eastern Chiapas, southern and north-eastern Campeche, southern Quintana Roo, northern and central Petén, and central Belize.
Total forest core area in 2018	5.1Mha (49.7% of forests in 2018)
Fragmented forests 2000-2018	1.5Mha (14.0% of forest area in 2000)
Accumulated burned area, 2002-2019	2.4Mha (22.1% of forest area in 2000)
Deforestation trend	Downward trend in Calakmul[1], but upward trends in northwest Petén and northeast Campeche[1]
Future trends	An increase in commercial farming is expected, at a small scale and particularly at a large scale, which will lead to additional deforestation

Main outcomes

Protected areas along with secure collective land tenure regimes have proven effective in containing deforestation[8, 19]. Persisting deforestation has been associated with land speculation and encroachment of public land[33]. Agricultural intensification incentives can, under some circumstances, be effective in halting deforestation, but lack environmental safeguards and sufficient integration with environmental policies[26, 35]. Efforts at ensuring value chain sustainability through voluntary standards or other mechanisms have been insufficient.

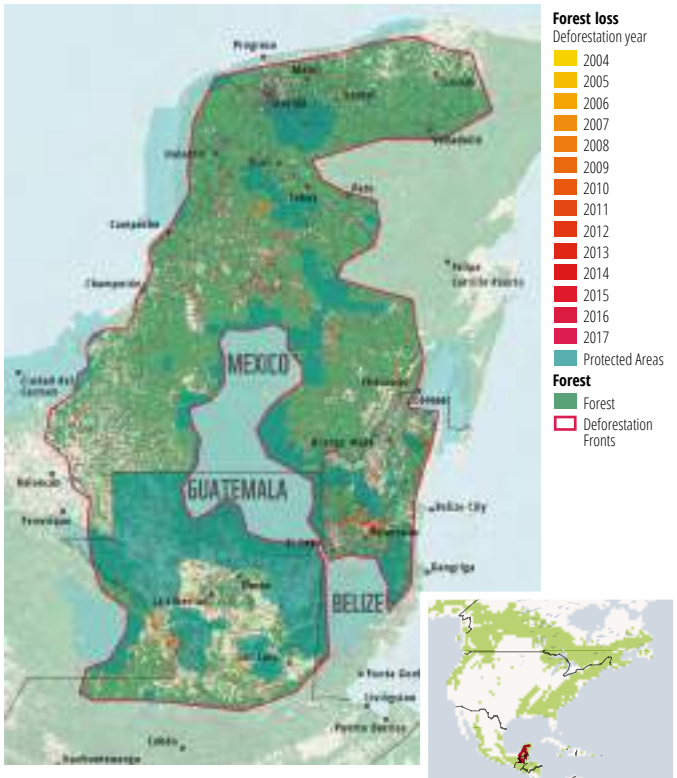
Recommended future actions

- Strengthen inclusive and participatory governance arrangements and improve capabilities for effective protected areas management.
- Secure land tenure or resource rights for rural communities.
- Strengthen and scale up community forestry projects, which have been shown to be linked to low deforestation rates, and reverse unsustainable timber extraction in community lands where it is still occuring.
- Improve the linkage between agricultural intensification incentives, positive livelihoods and environmental outcomes.
- Monitor and improve value chain sustainability.
- Evaluate the effect that current public policies and infrastructure plans are having or will have in the region, such as:
- The Mexican federal programme *Sembrando Vida*, which is incentivizing reforestation of degraded lands with milpa and fruit trees – it has been suspected that some well-conserved areas might purposefully be degraded in order to access such incentives.
- The *Tren Maya*, which seeks to connect various cities of the Peninsula and will also create a new population and tourist centre, which might impact forest cover.
- The Mirador Basin Project within the Maya Biosphere Reserve, which proposes increasing tourism access and infrastructure (hotels and trains) and changes to the current scheme of land management.

Key responses

Protected areas	Conservation areas protect over 5.8Mha of tropical rainforest from conversion to cattle ranching and agriculture. Some of these areas have proven effective[25], while others face increasing threats[7].
Recognition of IPLCs	The Maya Forest has large areas titled as indigenous and local community lands, particularly in Mexico. This is associated with low deforestation rates, particularly where forests are managed collectively[8, 19].
Agricultural intensification	In order to prevent the expansion of the agricultural frontier, government subsidies have increasingly fostered agricultural intensification[26], but not always with sufficient safeguards to prevent deforestation[27, 28].
Payment for environmental services	PES programmes have been partially effective at temporarily halting deforestation in the Maya Forest[29, 30], but their coverage has been limited.
Community forestry	Community forestry is associated with lower deforestation rates across the Maya Forest[5, 31]. The number of communities successfully managing their forest resources is still limited as constraints sometimes outnumber opportunities in forest management[13, 32].
REDD+ projects	Several REDD+ projects have been implemented in the region. Recent studies point to mixed results, both at environmental and at social level[33, 34].
Voluntary standards	Environmental certification has become increasingly common for certain commodity crops such as palm oil. There is, however, little information on their effectiveness in containing deforestation in the context of the Maya Forest.

Deployment at wider scale | Actively used and expanding | Project-specific, experimental



References

1. Bonilla-Moheno, M. and Aide, T.M. 2020. Beyond deforestation: Land cover transitions in Mexico. *Agricultural Systems $V 178*.
2. Ellis, E.A., Romero Montero, J.A., Hernández Gómez, I.U., Porter-Bolland, L., and Ellis, P.W. 2017. Private property and Mennonites are major drivers of forest cover loss in central Yucatan Peninsula, Mexico. *Land Use Policy* 69: 474-484.
3. Furumo, P.R. and Aide, T.M. 2017. Characterizing commercial oil palm expansion in Latin America: land use change and trade. *Environmental Research Letters* 12(2): 024008.
4. Ellis, E.A., Romero Montero, J., and Hernández Gómez, I.U. 2015. *Evaluación y mapeo de la deforestación en la Península de Yucatán.* Alianza México REDD+, Ciudad de México.
5. Ellis, E.A., Navarro Martínez, A., García Ortega, M., Hernández Gómez, I.U., and Chacón Castillo, D. 2020. Forest cover dynamics in the Selva Maya of Central and Southern Quintana Roo, Mexico: deforestation or degradation? *Journal of Land Use Science* 15(1): 1-27.
6. McSweeney, K., Nielsen, E.A., Taylor, M.J., Wrathall, D.J., Pearson, Z., Wang, O., and Plumb, S.T. 2014. Drug policy as conservation policy: Narco-deforestation. *Science* 343(6170): 489-490.
7. Devine, J.A., Currit, N., Reygadas, Y., Liller, L.I., and Allen, G. 2020. Drug trafficking, cattle ranching and land use and land cover change in Guatemala's Maya Biosphere Reserve. *Land Use Policy* 95: 104578.
8. Lawrence, T.J., Morreale, S.J., and Stedman, R.C. 2019. Distant political-economic forces and global-to-local pathway to impacts on forests of Ejido landscapes across Yucatán, México. *Land Degradation & Development* 30(17): 2021-2032.
9. Duarte, C., Aurelio Juárez, M., Pérez, G., and Gálvez, J. 2012. *Análisis de la dinámica de expansión del cultivo de la palma africana en Guatemala: un enfoque cartográfico.* In: J. Gálvez (ed), *Perfil Ambiental de Guatemala 2010-2012: Vulnerabilidad local y creciente construcción de riesgo*, pp. 340-362. Universidad Rafael Landívar, Ciudad de Guatemala.
10. Millones, M., Rogan, J., Ii, B.L., Parmentier, B., Harris, R., and Griffith, D. 2017. Fire data as proxy for anthropogenic landscape change in the Yucatán. *Land* 6: 61.
11. Ellis, E.A., Romero Montero, J.A., and Hernández Gómez, I.U. 2017. Deforestation processes in the state of Quintana Roo, Mexico: The role of land use and community forestry. *Tropical Conservation Science* 10: 1940082917697259.
12. Juárez-Orozco, S.M., Siebe, C., and Fernández y Fernández, D. 2017. Causes and effects of forest fires in tropical rainforests: A bibliometric approach. *Tropical Conservation Science* 10: 1940082917737207.
13. Carías Vega, D. 2019. Community-based forestry and community forestry enterprises in Quintana Roo, Mexico and Petén, Guatemala: how have policies, history, and culture shaped their trajectories? *Journal of Sustainable Forestry* 38(7): 651-669.
14. Wainwright, J.D. and Zempel, C.L. 2018. The colonial roots of forest extraction: Rosewood exploitation in southern Belize. *Development and Change* 49(1): 37-62.
15. Chicas, S.D., Omine, K., Ford, J.B., Sugimura, K., and Yoshida, K. 2017. Using spatial metrics and surveys for the assessment of trans-boundary deforestation in protected areas of the Maya Mountain Massif: Belize-Guatemala border. *Journal of Environmental Management* 187: 320-329.
16. Radachowsky, J., Ramos, V.H., McNab, R., Baur, E.H., and Kazakov, N. 2012. Forest concessions in the Maya Biosphere Reserve, Guatemala: A decade later. *Forest ecology and management* 268: 18-28.
17. Aguirre-Cortés, E., López-Martínez, J.O., Vargas-Larreta, B., Pat-Fernández, J.M., and Macario-Mendoza, P. 2018. Preferences for the use of firewood in a cultural landscape in southern Mexico. *Revista Chapingo serie ciencias forestales y del ambiente* 24: 147-160.
18. Oliva, M., García-Frapolli, E., Porter-Bolland, L., and Montiel, S. 2019. Early detection of conflicts for the management of protected areas: The case of charcoal production in the Los Petenes Biosphere Reserve, Mexico. *Environmental Management* 64(1): 52-63.
19. Miteva, D.A., Ellis, P.W., Ellis, E.A., and Griscom, B.W. 2019. The role of property rights in shaping the effectiveness of protected areas and resisting forest loss in the Yucatan Peninsula. *PLOS ONE* 14(5): e0215820.
20. Grünberg, J., Grandia, L., Milian, B., et al. 2012. *Tierra e igualdad: Desafíos para la administración de tierras en Petén, Guatemala. Reporte para el Banco Mundial.*
21. Castellanos-Navarrete, A. and Jansen, K. 2015. Oil palm expansion without enclosure: smallholders and environmental narratives. *The Journal of Peasant Studies* 42(3-4): 791-816.
22. Soberanes, R. 2019. México: la palma aceitera amenaza una región emblemática de conservación. *Mongabay*, 9 October. Available from: es.mongabay.com/2019/10/palma-de-aceite-en-mexico-amenaza-areas-protegidas-en-campeche
23. Echanove H., F. 2016. La expansión del cultivo de la soja en Campeche, México: Problemática y perspectivas. *Anales de Geografía de la Universidad Complutense* 36(1): 49-69.
24. Rivera de la R., A.R. and Ortiz, R. 2017. Producción de soya transgénica y miel en Yucatán, México. Impactos en la sustentabilidad de productores en Tekax. *Revista de Economía* 34(88): 45-81.
25. Rodriguez Solorzano, C. and Fleischman, F. 2018. Institutional legacies explain the comparative efficacy of protected areas: Evidence from the Calakmul and Maya Biosphere Reserves of Mexico and Guatemala. *Global Environmental Change* 50: 278-288.
26. Dobler-Morales, C., Roy Chowdhury, R., and Schmook, B. 2019. Governing intensification: the influence of state institutions on smallholder farming strategies in Calakmul, Mexico. *Journal of Land Use Science*: 1-19.
27. Schmook, B. and Vance, C. 2009. Agricultural policy, market barriers, and deforestation: The case of Mexico's Southern Yucatan. *World Development* 37: 1015-1025.
28. Castellanos-Navarrete, A. and Jansen, K. 2017. Why do smallholders plant biofuel crops? The 'politics of consent' in Mexico. *Geoforum* 87: 15-27.
29. Ramirez-Reyes, C., Sims, K.R.E., Potapov, P., and Radeloff, V.C. 2018. Payments for ecosystem services in Mexico reduce forest fragmentation. *Ecological Applications* 28(8): 1982-1997.
30. Costedoat, S., Corbera, E., Ezzine-de-Blas, D., Honey-Rosés, J., Baylis, K., and Castillo-Santiago, M.A. 2015. How effective are biodiversity conservation payments in Mexico? *PLOS ONE* 10(3): e0119881.
31. Ellis, E.A., Montero, S.A., Hernández Gómez, I.U., Romero Montero, J.A., Ellis, P.W., Rodríguez-Ward, D., ... Putz, F.E. 2019. Reduced-impact logging practices reduce forest disturbance and carbon emissions in community managed forests on the Yucatán Peninsula, Mexico. *Forest Ecology and Management* 437: 396-410.
32. Ellis, E.A., Kainer, K.A., Sierra-Huelsz, J.A., Negreros-Castillo, P., Rodriguez-Ward, D., and DiGiano, M. 2015. Endurance and adaptation of community forest management in Quintana Roo, Mexico. *Forests* 6(11): 4295-4327.
33. Trench, T., Larson, A.M., and Amico, L. 2017. *Multilevel governance and land use in Chiapas and Yucatan. Lessons for REDD+ in Mexico.* CIFOR, Bogor, Indonesia.
34. Kongsager, R. and Corbera, E. 2015. Linking mitigation and adaptation in carbon forestry projects: Evidence from Belize. *World Development 76*: 132-146.
35. Izquierdo-Tort, S., Ortiz-Rosas, F., and Vázquez-Cisneros, P.A. 2019. 'Partial' participation in payments for environmental services (PES): Land enrolment and forest loss in the Mexican Lacandona rainforest. *Land Use Policy* 87: 103950.

LIBERIA/IVORY COAST/ GHANA

The forests of West Africa, also referred to as the Upper Guinea forest, stretch from Guinea to Ghana. They are under pressure not only from the expansion of commercial agriculture and mining, but also from local peoples' resource use in their quest for improved livelihoods. Different initiatives are in place to support smallholders and communities, ensure sustainable supply of agricultural commodities such as cocoa and palm oil, and regulate and control illegal logging.

Countries, region	Liberia, Ivory Coast, Ghana
Forest type	Moist and dry semi-deciduous forest in the south, and savannah woodlands in the north
Total area	30.0Mha
Forest area in 2018	12.3Mha (40.9% of total deforestation front area)
Forest loss 2004-2017	0.8Mha (5.6% of forest area in 2000)
Location of deforestation	In western portion of Liberia and southwest portion of Ghana.
Total forest core area in 2018	4.0Mha (32.9% of forests in 2018)
Fragmented forests 2000-2018	2.7Mha (19.0% of forest area in 2000)
Accumulated burned area, 2002-2019	2.4Mha (17.4% of forest area in 2000)
Deforestation trend	Increased, particularly in Liberia and Ghana
Future trends	Increase may continue over time

Drivers of deforestation

Smallhold farming	Shifting cultivation and expansion of tree crops[1, 2], including cocoa, the latter mainly in Ghana. Some of these crops are established after forest clearing, and smallholders migrate into new forestlands looking for more fertile ground after plantations age[3-5] .
Commercial logging	Under way legally and illegally, also in protected forest reserves (e.g. in some southern regions of Ghana) which constitute the main remaining tracts of primary tropical forests[6]. Logging is stimulated by demand from local and foreign buyers[6]. In Liberia, logging companies are behind community forestlands[7].
Fuelwood and charcoal	People rely on fuelwood and charcoal as their energy source. This has profound effects on the standing forests, which are the source of raw materials. Some charcoal production originates from smallholder lands and some from non-designated public lands[2].
Mining operations	A threat for biodiverse areas in western Liberia[8], and expanding in some forest reserves in Ghana. This is associated with the opening of roads to prospective mining sites under construction[6], but also triggered by illegal gold mining[4], such as in the Dunkwa region in Ghana where some cocoa farmers have sold their lands to miners[9].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

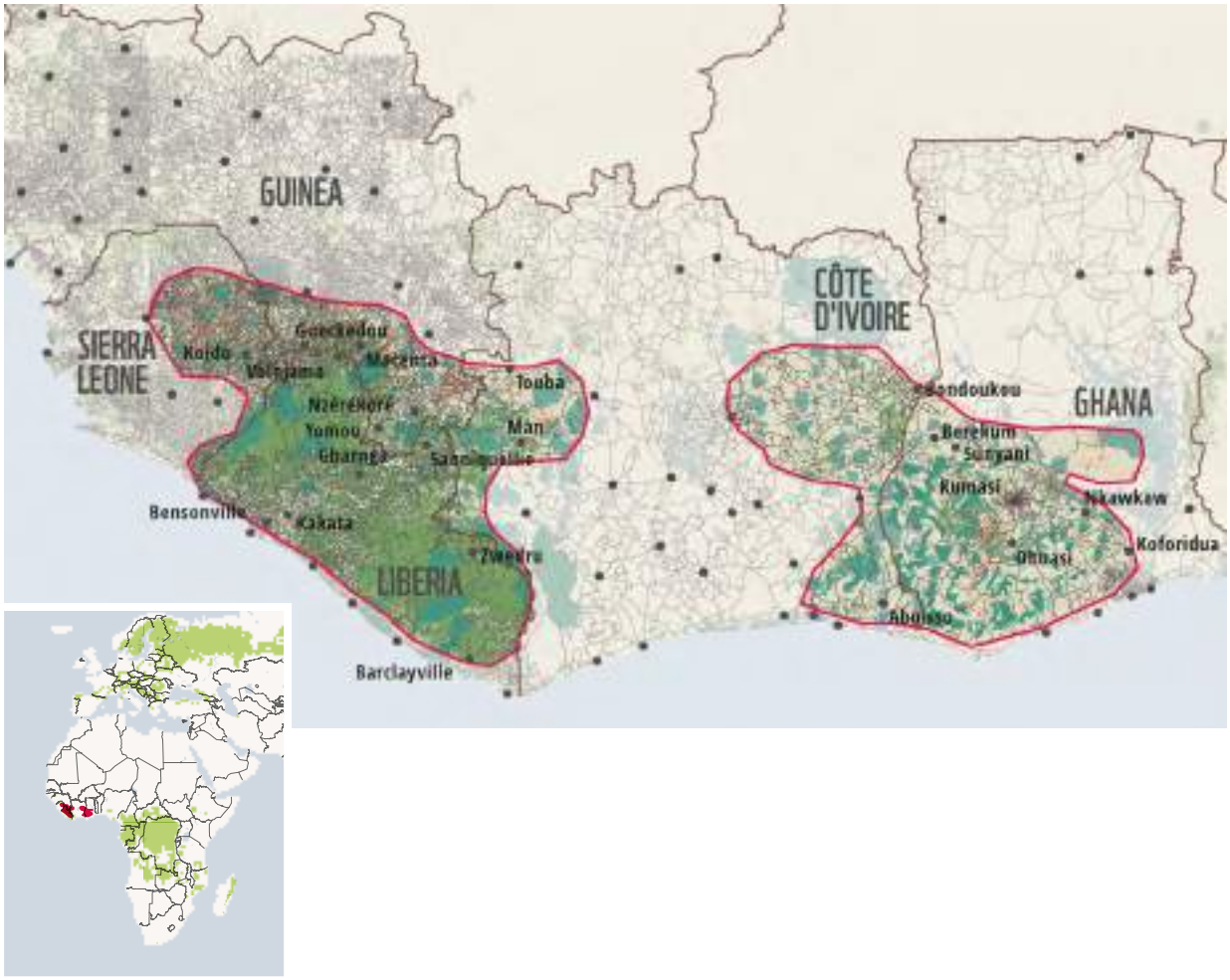
Underlying causes

Link to an increase in settlements close to forest reserves with unclear tenure, and tenure issues relating to settlements that existed before the reserves' demarcation[1]. A growing urban population and presence of foreign investors increasing the demand for timber and minerals add pressure on the forests[6].

Responses

Protected areas	Nearly 2,000 protected areas cover around 10% of West Africa as a whole, but around 90% of these protected areas are small and dominated by forest reserves. There are 53 protected areas with international designations, including 17 Biosphere Reserves [10]
Timber legality	Ghana signed a voluntary partnership agreement (VPA) with the EU which includes a wood traceability system from production zones to end buyers[11], although progress is slow due to strong vested interests among political elites[12]. Liberia has also signed a VPA with the EU, but the process in practice is slower[13].
Voluntary standards	Some palm oil companies have embraced RSPO standards to reduce impacts of plantation development on high conservation value (HCV) areas. Public and private partnerships for supporting sustainable commodity supply linked to zero deforestation goals have been set up in the context of the African Palm Oil Initiative (APOI) and the Cocoa and Forests Initiative (CFI)[14]. Companies have signed on to the TFA 2020 Alliance aimed at achieving zero deforestation.
Recognition of IPLCs	Initiatives to enhance local tenure rights are in place in Ghana through the Community Resource Management Area (CREMAs) [15]; a Land Rights Act in Liberia allows communities ownership of ancestral lands but does not apply retroactively[16].
Concessions	Around half the land in Liberia has been allocated for concessions for logging, agriculture, mining and conservation[2]. Most of the industrial concessions have not yet been developed, so future deforestation and forest degradation depends heavily upon how these allocated areas are developed in the context of rising population and consumption.
REDD+ projects	Liberia made a zero-deforestation commitment and entered a partnership with the government of Norway for REDD+ and agricultural development in 2014[17], yet efforts aimed at building the reference level are still ongoing[18]. In Ghana, the REDD+ programme includes support to climate-smart cocoa practices by improving access to inputs and services, including replanting, to enhance the productivity of farms[15]. Ghana has agreed on performance-based payments for carbon reduction of up to US$50 million under the Forest Carbon Partnership Facility (FCPF)[19]

Deployment at wider scale
Actively used and expanding
Project-specific, experimental



Main outcomes

Efforts to tackle deforestation and forest degradation have still to prove effective. RSPO sustainability standards have to be embraced more extensively by palm oil companies, for protecting HCV areas and local people's rights. Initiatives for enhancing performance of smallholder cocoa producers are showing good results and committing all key companies, traders and processors across the value chain[20]. While efforts to halt illegal logging are in place, persistent extraction driven by expanding demand makes it a difficult to control timber harvesting[6]

Recommended future actions

- Improve enforcement against illegal logging while providing the means for smallholders and communities to undertake sustainable forest management [6].
- Support agricultural intensification on existing farmlands to reduce pressure on forest areas for expansion of commercial crops[1].
- Monitor compliance with environmental regulations for plantations development and mining operations, along with compliance with social safeguards.

References

1. Acheampong, E.O., Macgregor, C.J., Sloan, S., and Sayer, J. 2019. Deforestation is driven by agricultural expansion in Ghana's forest reserves. *Scientific African* 5: e00146.
2. FDA. 2016. *National strategy for reducing emissions from deforestation and forest degradation (REDD+) in Liberia*. Forestry Development Authority, REDD+ Implementation Unit, Liberia. www.ltsi.co.uk/wp-content/uploads/2015/01/Technical-Annex-A-REDD-Strategy-final.pdf.
3. Ruf, F., Schroth, G., and Doffangui, K. 2015. Climate change, cocoa migrations and deforestation in West Africa: What does the past tell us about the future? *Sustainability Science* 10(1): 101-111.
4. Weisse, M. and Goldman, E.D. 2019. The world lost a Belgium-sized area of primary rainforests last year. WRI. www.wri.org/blog/2019/04/world-lost-belgium-sized-area-primary-rainforests-last-year.
5. Wessel, M. 2015. Cocoa production in West Africa, a review and analysis of recent developments. *Netherlands Journal of Agricultural Science* 74-75: 1-7.
6. Yoda, A.S.S. 2019. 'We have cut them all': Ghana struggles to protect its last old-growth forests. *Mongabay*, 28 Augst. Available from: news.mongabay.com/2019/08/we-have-cut-them-all-ghana-struggles-to-protect-its-last-old-growth-forests
7. Global Witness. 2018. *Power to the people? How communities are exploiting community forestry in Liberia.* Global Witness, London, UK. Available from: www.globalwitness.org/en/campaigns/forests/power-people
8. Johnson, S.D.R. 2015. *A national biodiversity offset scheme: a road map for Liberia's mining sector*. World Bank Group, Washington, DC, USA. Available from: documents.worldbank.org/curated/en/183611467991015452/A-national-biodiversity-offset-scheme-a-road-map-for-Liberia-s-mining-sector
9. Taylor, K. 2018. Illegal gold mining boom threatens cocoa farmers (and your chocolate). *National Georgraphic*, 6 March. Available from: www.nationalgeographic.com/news/2018/03/ghana-gold-mining-cocoa-environment
10. USAID. 2020. Biodiversity and Protected Areas in West Africa. Available from: eros.usgs.gov/westafrica/biodiversity-protected-areas.
11. EU FLEGT Facility. 2017. The Ghana-EU Voluntary Partnership Agreement. Available from: www.euflegt.efi.int/background-ghana
12. Hansen, C.P. and Lund, J. 2010. Neither fast, nor easy: The prospect of reduced emissions from deforestation and degradation (REDD) in Ghana. *International Forestry Review* 11: 439-455.
13. EU FLEGT Facility. 2017. The Liberia-EU Voluntary Partnership Agreement. Available from: www.euflegt.efi.int/background-liberia
14. Carodenuto, S. 2019. Governance of zero deforestation cocoa in West Africa: New forms of public-private interaction. *Environmental Policy and Governance* 29(1): 55-66.
15. The Forestry Comission of Ghana. 2019. Rejoinder: The world lost a Belgium-sized area of primary rainforest last year. Available from: www.fcghana.org/news.php?news=142
16. O'Mahony, J. 2019. Liberia's new land rights law hailed as victory, but critics say it's not enough. *Mongabay*, 22 March. Available from: news.mongabay.com/2019/03/liberias-new-land-rights-law-hailed-as-victory-but-critics-say-its-not-enough.
17. Government of the Republic of Liberia and the Government of the Kingdom of Norway. 2014. Letter of Intent between the Government of the Republic of Liberia and the Government of the Kingdom of Norway on "Cooperation on reducing greenhouse gas emissions from deforestation and forest degradation (REDD+1) and developing Liberia's agriculture sector". Available from: www.regjeringen.no/contentassets/b8b93fa03bda4ac893d065d26d64075b/letterofintentliberia.pdf
18. FAO. 2018. Liberia getting ready to measure its REDD+ actions. Available from: www.fao.org/redd/news/detail/en/c/1114014
19. Forest Carbon Partnership Facility. 2019. Ghana signs landmark deal with World Bank to cut carbon emissions and reduce deforestation. Available from: www.worldbank.org/en/news/press-release/2019/07/09/ghana-signs-landmark-deal-with-world-bank-to-cut-carbon-emissions-and-reduce-deforestation
20. Somarriba, E. and Lopez-Sampson, A. 2018. *Coffee and Cocoa Agroforestry Systems: Pathways to Deforestation, Reforestation, and Tree Cover Change*. CATIE, PROFOR, The World Bank, Turrialba, Costa Rica. www.profor.info/sites/profor.info/files/Coffee_Case%20study_LEAVES_2018.pdf

CAMEROON

The region still holds huge forest areas, with approximately 40% forest cover across the country[1]. Multiple drivers are present in the forest frontiers in Cameroon from mining, logging, and agriculture. Both, traditional and artisanal practices embraced by local populations co-exist with industrial economies, which tend to interact in multiple ways. Major causes of deforestation are linked to agriculture, particularly linked to the expansion of commercial crops. Industrial logging and artisanal timber harvesting contribute to forest degradation. Progress has been made to halt deforestation, but signicant institutional, social and economic challenges still persist.

Drivers of deforestation

Smallholder farming	Small-scale farming and shifting cultivation are a major cause of forest loss[2-4], though some estimate that commodity crop farming is now a more important driver[5]. Commodity crop farming in Cameroon for palm oil production in particular is still often undertaken at a small scale, though production is for sale rather than subsistence[6]. The same can be found for maize and peanuts[7].
Large-scale agriculture	Large-scale commercial agriculture is also cited as an important and growing driver of deforestation[2], particularly for rubber and oil palm in southwest Cameroon[5, 8, 9]. Some palm oil smallholders may not be strictly large scale but still manage hundreds of hectares[10, 11].
Fuelwood charcoal	Wood energy demand, for both charcoal and fuelwood, is an ongoing moderate driver of degradation and deforestation; it has less impact than agriculture, though the two are connected[2, 4].
Large-scale and small-scale logging	Commercial logging makes a moderate contribution to deforestation in Cameroon[2, 12], and has a larger impact on forest degradation. The domestic market, mostly supplied by small-scale logging, is bigger than the export market supplied by larger commercial operators[2].
Infrastructure expansion	Infrastructure expansion is present but less frequently cited as a driver of deforestation[2, 4]. Cameroon has received infrastructure investment from China. Most of these infrastructure projects have been in forested areas, and have been linked to deforestation[13].
Urban expansion	Urban expansion is minor driver of deforestation, including as connected to fuelwood and charcoal demand[2, 4].
Cattle ranching	Cattle ranching is present but not a frequently cited driver of deforestation[2, 4].
Mining operations	Mining has been cited as an emerging driver of deforestation that must be monitored in the coming years[2].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Countries, region	Cameroon, Central Africa
Forest type	Tropical moist forest
Total area	10.3Mha
Forest area in 2018	8.2Mha (79.4% of total deforestation front area)
Forest loss 2004-2017	0.4Mha (4.9% of forest area in 2000)
Location of deforestation	Deforestation is primarily located in the south, south-west and north-east of the country
Total forest core area in 2018	4.5Mha (55.4% of forests in 2018)
Fragmented forests 2000-2018	1.1M ha (12.6% of forest area in 2000)
Accumulated burned area, 2002-2019	1.4Mha (16.9% of forest area in 2000)
Deforestation trend	Decreased with some oscillations until 2014, but has increased again more recently
Future trends	Deforestation linked to agriculture may continue, though a variety of responses may help decrease deforestation rates

Underlying causes

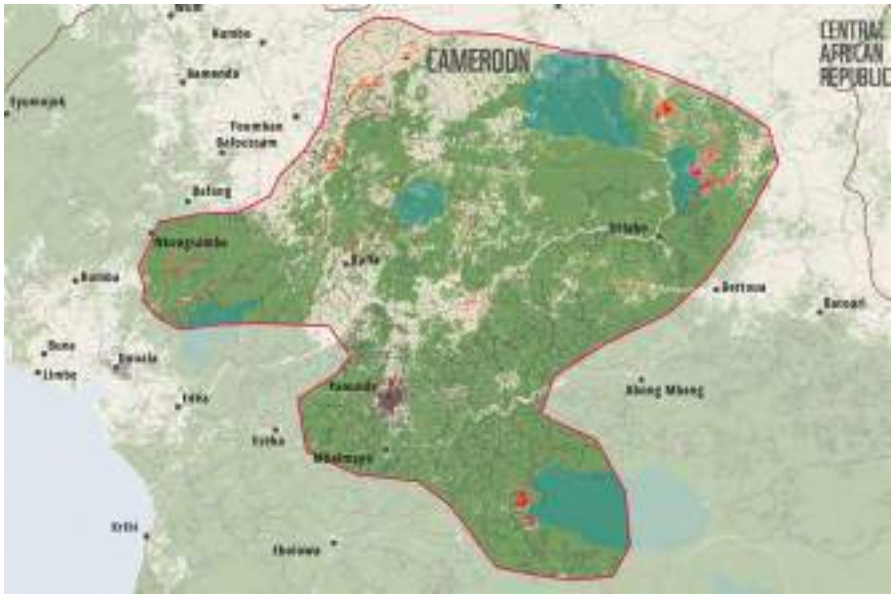
Underlying drivers of deforestation include institutional and policy factors (property rights and policies), demographics (population growth and population pressure), and economic changes (market growth and economic structures)[2]. Policy failure and corruption have played a role in continued illegal logging in Cameroon[14]

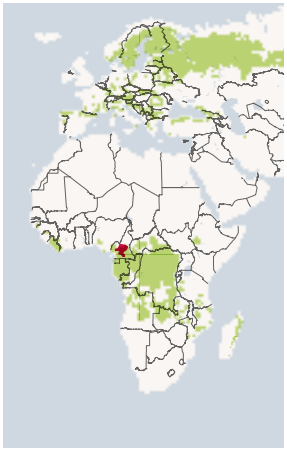
Main outcomes

Small and large-scale agriculture continue to be primary drivers of deforestation, while wood energy demand along with industrial and artisanal logging are important secondary drivers. Underlying drivers of deforestation related to property rights and policies indicate that deforestation will continue unless these root causes are adequately addressed. Focus on Forest Law Enforcement, Legality, and Governance (FLEGT) has been particularly prominent, but its effectiveness is uncertain.

Recommended future actions

- Enforce existing policy responses to address deforestation, including sustainable forest management, forest monitoring and diversification of livelihoods[4].
- Complement efforts focused on illegal timber with enhanced responses related to agriculture as a primary driver of deforestation.
- Promote certification of agricultural commodities to improve the practices and livelihoods of medium- and small-scale producers.





Key responses

Timber legality and assurance systems	Forest Law Enforcement, Legality, and Governance (FLEGT) activities include a voluntary partnership agreement (VPA) with the EU, to which Cameroon exports about 60% of its timber[1]. The VPA encourages legal timber production, and also works to improve forest governance and law enforcement.
Protected areas	Empirical evidence has shown that protected areas have low rates of deforestation, but also that low deforestation rates are likely more influenced by the remote locations of parks rather than by park designation[15].
PES including REDD+	REDD+ has been a focus of deforestation studies and response options in recent years[3, 16]. Increased coordination among stakeholders on REDD+ in Cameroon has improved progress, and further implementation may be successful if it offers multiple benefits for people and biodiversity[17].
Forest landscape restoration	Cameroon pledged to restore a very ambitious 12Mha of forest under the Bonn Challenge. This effort has included FLEGT (described above) and a review of forest law[18].
Integrated land-use planning	The forest law of the 1990s provides for 1) a permanent forest estate that is intended to remain forested and 2) a non-permanent forest estate that can be converted to other land use. In addition, a law was passed in 2011 defining the framework for land-use planning and sustainable development planning.
Recognition of IPLCs	Community forest legislation was put in place in 1994, and 182 community forests were active in Cameroon by 2016. Results have been mixed: community forests have struggled with illegal logging, and are seen by some as an impediment to FLEGT VPA efforts[19, 20].
Improving agricultural yields	Increasing farm yields may limit deforestation, while also noting that land tenure laws can incentivize deforestation, as well as the lack of tenure security[8].
Voluntary standards	To manage deforestation related to oil palm expansion, efforts have been undertaken to establish RSPO standards for sustainable palm oil production in Cameroon[21, 22]. Forest certification has been found to have potential to reduce unsustainable use of forests in Cameroon[23]. A recent study did not find reduced deforestation in certified forest concessions, but did assert potential for future impacts under expanded certification[15]. Cocoa certification is also developing in Cameroon[24].

Deployment at wider scale | Actively used and expanding | Project-specific, experimental

References

1. EU FLEGT. *The Cameroon-EU Voluntary Partnership Agreement.*
2. Tegegne, Y.T., Lindner, M., Fobissie, K., and Kanninen, M. 2016. Evolution of drivers of deforestation and forest degradation in the Congo Basin forests: Exploring possible policy options to address forest loss. *Land Use Policy* 51: 312-324.
3. Bellassen, V. and Gitz, V. 2008. Reducing emissions from deforestation and degradation in Cameroon – Assessing costs and benefits. *Ecological Economics* 68(1-2): 336-344.
4. Epule, E.T., Peng, C., Lepage, L., and Chen, Z. 2014. Policy options towards deforestation reduction in Cameroon: An analysis based on a systematic approach. *Land Use Policy* 36: 405-415.
5. Ordway, E.M., Asner, G.P., and Lambin, E.F. 2017. Deforestation risk due to commodity crop expansion in sub-Saharan Africa. *Environmental Research Letters* 12(4).
6. Nchanji, Y.K., Tataw, O., Nkongho, R.N., and Levang, P. 2013. *Artisanal Milling of Palm Oil in Cameroon.* CIFOR, Bogor, Indonesia. www.cifor.org/publications/pdf_files/WPapers/WP128Nchanji.pdf
7. Scales, I.R. 2011. Farming at the forest frontier: Land use and landscape change in western Madagascar, 1896-2005. *Environment and History* 17(4): 499-524.
8. Ordway, E.M., Naylor, R.L., Nkongho, R.N., and Lambin, E.F. 2017. Oil palm expansion in Cameroon: Insights into sustainability opportunities and challenges in Africa. *Global Environmental Change* 47: 190-200.
9. Ordway, E.M., Naylor, R.L., Nkongho, R.N., and Lambin, E.F. 2019. Oil palm expansion and deforestation in Southwest Cameroon associated with proliferation of informal mills. *Nature Communications* 10(1): 1-11.
10. Nkongho, R.N., Feintrenie, L., and Levang, P. 2014. Strengths and weaknesses of the smallholder oil palm sector in Cameroon. *OCL – Oilseeds and fats* 21(2).
11. Nkongho, R.N., Feintrenie, L., and Levang, P. 2014. The non-industrial palm oil sector in Cameroon. CIFOR, Bogor, Indonesia.
12. Lescuyer, G., Tsanga, R., Essiane, E., Barthélémy, M., Embolo, X., Hadji, A., ... Logo, P.B. 2017. *National demand for sawnwood in Cameroon.* CIFOR, Bogor, Indonesia. Available from: www.cifor.org/knowledge/publication/6375
13. Mayers, J., Nguiffo, S., and Assembe-mvondo, S. *China in Cameroon's forests.* IIED, London.
14. Cerutti, P.O., Tacconi, L., Lescuyer, G., and Nasi, R. 2013. Cameroon's hidden harvest: Commercial chainsaw logging, corruption, and livelihoods. *Society and Natural Resources* 26(5): 539-553.
15. Panlasigui, S., Rico-Straffon, J., Pfaff, A., Swenson, J., and Loucks, C. 2018. Impacts of certification, uncertified concessions, and protected areas on forest loss in Cameroon, 2000 to 2013. *Biological Conservation* 227: 160-166.
16. Ministry of Environment Cameroon. 2018. National REDD+ Action Programme on Reducing Emissions from Deforestation and Forest Degradation, Sustainable Management of Forests, Conservation of Forests and Enhancement of Forest Carbon Stocks.
17. Somorin, O.A., Visseren-Hamakers, I.J., Arts, B., Sonwa, D.J., and Tiani, A.M. 2014. REDD+ policy strategy in Cameroon: Actors, institutions and governance. *Environmental Science and Policy* 35: 87-97.
18. Dave, R., Saint-Laurent, C., Murray, L., Antunes Daldegan, G., Brouwer, R., de Mattos Scaramuzza, C.A., ... Pearson, T. 2019. *Second Bonn Challenge progress report: application of the Barometer in 2018.* IUCN, Gland, Switzerland.
19. Mutoni, L. 2019. *Community Forestry in Cameroon – an overview of the community perspective.* Forest Peoples Programme. Available from: www.forestpeoples.org/en/node/50409
20. Larrubia, C.J., Tabi Eckebil, P.P., Nzoyem Saha, N., Tchantchouang, J.C., Kerkhofs, B., Beauquin, A., ... Lescuyer, G. 2013. Forêts communautaires camerounaises et Plan d'action FLEGT : quel prix pour la légalité? *Bois et Forêts des Tropiques* 317(3): 71-80.
21. Salisbury, C. 2016. Palm oil's new frontier: averting a great ape catastrophe in Cameroon. *Mongabay,* 1 April. Available from: news.mongabay.com/2016/04/palm-oils-new-frontier-averting-a-great-ape-catastrophe-in-cameroon
22. ZSL. *Sustainable palm oil and conservation in Cameroon.* Zoological Society of London.
23. Cerutti, P.O., Tacconi, L., Nasi, R., and Lescuyer, G. 2011. Legal vs. certified timber: Preliminary impacts of forest certification in Cameroon. *Forest Policy and Economics* 13(3): 184-190.
24. Lescuyer, G., Boutinot, L., Goglio, P., and Bassanaga, S. 2020. *Analyse de la chaîne de valeur du cacao au Cameroun. Rapport pour l'Union Européenne.* DG-DEVCO, Value Chain Analysis for Development project, Brusells, Belgium. 121pp.

GABON/CAMEROON/ REPUBLIC OF CONGO

Spread over three countries – Gabon, Cameroon and the Republic of Congo – the Tri-National Dja-Odzala-Minkébé (TRIDOM) region still holds large forest areas, but deforestation, particularly driven by smallholder farming and large-scale agriculture, is expected to increase with likely future development of roads. Mining also places pressures on the forest frontiers. Improved policies are in place aimed at sustainable forest management, forest monitoring and diversification of livelihoods but are in need of more effective enforcement as well as wider resources and institutional support.

Drivers of deforestation

Smallholder farming	Currently small-scale farming and shifting cultivation is a major cause of forest loss[1-3]. Commodity crop farming[4] is increasing, with medium-scale cacao plantations along the roads throughout TRIDOM. Commodity crop farming for palm oil production in particular is still often undertaken at a small scale.
Large-scale agriculture	Large-scale commercial agriculture is an important and growing driver of deforestation[3], particularly for palm oil and rubber production. In the Republic of Congo, the government has allocated 120,000 ha for oil palm development in the middle of TRIDOM. In Cameroon a rubber plantation near the Dja reserve has plans to expand. All three countries have expansion of industrial agriculture in their national development plans. Large-scale agriculture not only directly impacts deforestation but also has significant indirect impacts such as through the influx of workers, families and services into thinly populated places.
Fuelwood and charcoal	Wood energy demand, both for charcoal and fuelwood, is an ongoing moderate driver of deforestation and degradation[2, 3].
Large-scale logging	Commercial logging makes a moderate contribution to deforestation in TRIDOM but contributes significantly to forest degradation.
Mining operations	Artisanall small-scale mining is significant in Gabon, and has expanded into forest landscapes, including the border with Cameroon. Artisanal and small-scale miners in Gabon who primarily mine gold and, to a lesser extent, diamonds. In buffer zones of parks, artisanal mining is explicitly allowed by law[6].
Infrastructure expansion	Infrastructure expansion is a present but less frequently cited driver of deforestation[2, 3]. All three countries have received significant infrastructure investment from China. The Sangmelima-Ouesso road, which has been improved and is being paved, opens up the heart of the TRIDOM, and facilitates logging, bushmeat trade and migration processes. Another road with major impact is the Ouesso–Brazzaville road (now completely paved), which has opened the forests east of Odzala National Park. The 600 MW Chollet hydropower dam, to be built on the Dja river in a pristine area on the Cameroon-Congo border, could have a huge impact on forests. Most infrastructure projects have been in forested areas, and they have been linked to deforestation[5].
Urban expansion	Urban expansion is a minor driver of deforestation, including as connected to fuelwood and charcoal demand[2, 3].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Countries, region	Gabon, Cameroon, Republic of Congo, Central Africa
Forest type	Tropical moist forest
Total area	11.5Mha
Forest area in 2018	11.2Mha (97.1% of total deforestation front area)
Forest loss 2004-2017	0.1Mha (1.0% of forest area in 2000)
Location of deforestation	Northern portion of Gabon, in the border with Cameroon and Republic of Congo
Total forest core area in 2018	9.9Mha (88.7% of forests in 2018)
Fragmented forests 2000-2018	0.4Mha (3.7% of forest area in 2000)
Accumulated burned area, 2002-2019	0.1Mha (0.8% of forest area in 2000)
Deforestation trend	Increasing, with oscillations
Future trends	Deforestation is expected to increase due to various economic development initiatives and population growth

Underlying causes

Underlying drivers of deforestation include institutional and policy factors (property rights and policies), demographics (population growth and population pressure), and economic changes (market growth and economic structures)[3]. Policy failure and corruption have played a role in continued illegal logging in Cameroon, Gabon and the Republic of Congo[7].

Main outcomes

Small- and large-scale agriculture continue to be primary drivers of deforestation, while wood energy demand and industrial and artisanal logging are important secondary drivers. Underlying drivers of deforestation related to property rights and policies indicate that deforestation will continue unless these root causes are adequately addressed.

Recommended future actions

- Enforce existing policy responses to deforestation, including sustainable forest management, forest monitoring and diversification of livelihoods[2].
- Promote land-use planning taking into account high conservation value areas to prevent allocation of prime forest areas for industrial development.
- Complement efforts focused on illegal timber with enhanced responses related to agriculture as a primary driver of deforestation.

Key responses

Timber legality and assurance systems	Cameroon has a voluntary partnership agreement (VPA) with the EU that encourages legal timber production, and works to improve forest governance and law enforcement. Gabon declared in 2019 that by 2021 all timber needs to be FSC certified. Gabon also plans to aggressively increase forest cover under community forestry arrangements to reduce illegal logging.
PES including REDD+	REDD+ and other climate funding mechanisms have been a focus of deforestation studies and response options in recent years[2, 8]. This has resulted in tangible climate funding for Gabon through the Central African Forest Initiative (CAFI). The Republic of Congo is also on track to receive CAFI funding. Several other initiatives (Green Climate Fund, Nationally Appropriate Mitigation Actions) may result in additional funding for these countries in the near future to offer multiple benefits for people and biodiversity[9].
Integrated land-use planning	The Cameroon forest law of 1994 provides for a permanent forest estate that is intended to remain forested and a non-permanent forest estate that can be converted to other land uses. In addition, a law was passed in 2011 defining the framework for land-use planning and sustainable development planning. Cameroon, under the new GEF-7 programme, aims to harmonize land-use planning for the TRIDOM zone. Gabon and Congo both aim to harmonize land-use planning under their respective CAFI programmes. There is no TRIDOM transboundary land-use planning initiative active across the three countries.
Improved agriculture	The Republic of Congo government has declared that it will focus its agricultural development in the savannah zone to protect the forest zone. Gabon intends to focus its agroindustry development outside areas of high conservation value (HCV); its current oil palm expansion is mainly in the savannah zone.
Protected areas	Empirical evidence has shown that protected areas have low rates of deforestation, but also that low deforestation rates are likely more influenced by the remote locations of parks rather than by park designation[10].
Forest landscape restoration	Cameroon pledged to restore 12Mha of forest under the Bonn Challenge[11].
Improving agricultural yields	One study suggests that increasing farm yields may limit deforestation, while also noting that weak land tenure laws can incentivize deforestation[12].
Voluntary standards (RSPO)	To manage deforestation related to oil palm expansion, efforts have been undertaken to establish RSPO standards for sustainable palm oil production in Cameroon, Congo[13, 14]. The Gabonese government has already stated that it wants to develop certified palm oil.
Voluntary standards (forest certification)	Forest certification has been found to have potential to reduce unsustainable use of forests in Cameroon[15]. A recent study in Cameroon did not find reduced deforestation in certified forest concessions, but did assert potential for future impacts under expanded certification[10]. However, several FSC-certified logging operators have sold their concessions or dropped FSC certification. A recent change was the decision by the government of Cameroon to degazette the previously FSC-certified Wijma logging concession to make it a oil palm concession. Republic of Congo currently holds the largest areas of FSC-certified natural tropical forest in the world. Gabon intends to move to 100% FSC for all its industrial logging concessions.
Recognition of IPLCs	Community forest legislation was put in place in Cameroon in 1994, and 182 community forests were active in Cameroon by 2016. In the Republic of Congo, community forestry is not yet a legal instrument. Results have been mixed: community forests have struggled with illegal logging, and are seen by some as an impediment to FLEGT VPA efforts[16].

Deployment at wider scale | Actively used and expanding | Project-specific, experimental

References

1. Bellassen, V. and Gitz, V. 2008. Reducing Emissions from Deforestation and Degradation in Cameroon Assessing costs and benefits. *Ecological Economics* 68(1-2): 336-344.
2. Epule, E.T., Peng, C., Lepage, L., and Chen, Z. 2014. Policy options towards deforestation reduction in Cameroon: An analysis based on a systematic approach. *Land Use Policy* 36: 405-415.
3. Tegegne, Y.T., Lindner, M., Fobissie, K., and Kanninen, M. 2016. Evolution of drivers of deforestation and forest degradation in the Congo Basin forests: Exploring possible policy options to address forest loss. *Land Use Policy* 51: 312-324.
4. Ordway, E.M., Asner, G.P., and Lambin, E.F. 2017. Deforestation risk due to commodity crop expansion in sub-Saharan Africa. *Environmental Research Letters* 12(4).
5. Mayers, J., Nguiffo, S., and Assembe-mvondo, S. *China in Cameroon's forests.* IIED, London.
6. PROFOR. 2013. *Artisanal mining in critical ecosystems: A look at Gabon, Liberia and Madagascar.* The World Bank, Washington, DC, USA. www.profor.info/sites/profor.info/files/ASM-brochure.pdf.
7. Cerutti, P.O., Tacconi, L., Lescuyer, G., and Nasi, R. 2013. Cameroon's hidden harvest: Commercial chainsaw logging, corruption, and livelihoods. *Society and Natural Resources* 26(5): 539-553.
8. Ministry of Environment Cameroon. 2018. National REDD+ Action Programme on Reducing Emissions from Deforestation and Forest Degradation, Sustainable Management of Forests, Conservation of Forests and Enhancement of Forest Carbon Stocks.
9. Somorin, O.A., Visseren-Hamakers, I.J., Arts, B., Sonwa, D.J., and Tiani, A.M. 2014. REDD+ policy strategy in Cameroon: Actors, institutions and governance. *Environmental Science and Policy* 35: 87-97.
10. Panlasigui, S., Rico-Straffon, J., Pfaff, A., Swenson, J., and Loucks, C. 2018. Impacts of certification, uncertified concessions, and protected areas on forest loss in Cameroon, 2000 to 2013. *Biological Conservation* 227: 160-166.
11. Dave, R., Saint-Laurent, C., Murray, L., Antunes Daldegan, G., Brouwer, R., de Mattos Scaramuzza, C.A., . . . Pearson, T. 2019. *Second Bonn Challenge progress report: application of the Barometer in 2018.* IUCN, Gland, Switzerland.
12. Ordway, E.M., Naylor, R.L., Nkongho, R.N., and Lambin, E.F. 2017. Oil palm expansion in Cameroon: Insights into sustainability opportunities and challenges in Africa. *Global Environmental Change* 47: 190-200.
13. Salisbury, C. 2016. Palm oil's new frontier: averting a great ape catastrophe in Cameroon. *Mongabay,* 1 April. Available from: news.mongabay.com/2016/04/palm-oils-new-frontier-averting-a-great-ape-catastrophe-in-cameroon
14. ZSL. *Sustainable palm oil and conservation in Cameroon.* Zoological Society of London.
15. Cerutti, P.O., Tacconi, L., Nasi, R., and Lescuyer, G. 2011. Legal vs. certified timber: Preliminary impacts of forest certification in Cameroon. *Forest Policy and Economics* 13(3): 184-190.
16. Mutoni, L. 2019. *Community Forestry in Cameroon – an overview of the community perspective.* Forest Peoples Programme. Available from: www.forestpeoples.org/en/node/50409

DEMOCRATIC REPUBLIC OF THE CONGO AND CENTRAL AFRICAN REPUBLIC

This region still holds large and intact forest areas, although the rate of deforestation has accelerated in recent years. Much of the forest conversion is driven by small-scale and shifting agriculture, and timber harvest for charcoal production which contributes to deforestation and forest degradation. The growth of large-scale agriculture is limited mainly due to poor development of infrastructure. Main challenges are linked to support development, green energy sources for cooking fuel and alleviating poverty while protecting existing natural forests, and biodiversity.

Drivers of deforestation

Smallholder farming	Small-scale, shifting agriculture causes over 90% of forest loss[2, 3], particularly for cassava, oil palm, cocoa and maize[4]. It is projected to increase[5] although large areas of forest still remain[6].
Charcoal production	Significant in DRC, particularly closer to large towns and cities, with estimates of over 90% of the population using charcoal for cooking, due to lack of affordable energy alternatives[6], although likely more related to degradation than deforestation.
Large-scale agriculture	A minor driver for oil palm[7], rubber, soy and cocoa[8]; some estimates are as low as 1% of total loss[9]. Fall in oil and gas prices is likely to drive additional industrial-scale agriculture in the region.
Timber extraction	Less significant than other drivers[10] and smaller than other Congo Basin countries but it occurs widely, is increasing[11], is probably unsustainable[12], and opens up forests for agriculture[13]. Includes much illegal logging[14, 15] mainly for domestic markets[16], and also some to Chinese and other export markets[17].
Mining operations	Increasing, particularly in DRC[18], involving foreign investors like China[19] and small-scale, often illegal artisanal miners[20], including in protected areas[21] but mainly in savannah[22].
Roads and infrastructure	Doubled inside concessions in the Congo Basin since 2003[23], associated with increased forest loss[24] and foreign investment. However, DRC has seen less expansion than other countries in the region and also some abandonment of logging roads.

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Population increase is a major, perhaps the most important, cause[25], along with poor market access[26] and lack of affordable energy alternatives to charcoal. Profits from oil and gas may have spurred rural-to-urban migration, reducing the rate of forest loss[27]. Conflict occurs widely; this can increase forest loss by increasing illegal cutting, but can also reduce rate of loss due to mining[28]. Research suggests that even in areas that have largely been cleared, almost half the land may still be primary or secondary forest[29]. Policy and weak governance or corruption are also important contributory factors to current forest loss.

Countries, region	Democratic Republic of the Congo (DRC) and Central African Republic (CAR), Central Africa
Forest type	Tropical moist forest, dry forest
Total area	45.6Mha
Forest area in 2018	36.3Mha (79.8% of total deforestation front area)
Forest loss 2004-2017	0.7Mha (1.8% of forest area in 2000)
Location of deforestation	Main fronts in east and south of the region
Total forest core area in 2018	17.4Mha (48.0% of forests in 2018)
Fragmented forests 2000-2018	6.9M ha (18.1% of forest area in 2000)
Accumulated burned area, 2002-2019	7.4Mha (19.4% of forest area in 2000)
Deforestation trend	Increasing, but still relatively low in both DRC and CAR. Intensified loss radiating from cities like Beni and Kisangani[1]
Future trends	Likely to increase

Responses

Protected areas	Protected areas cover 1.18Mha of CAR, 18% of the country[30]; and 32.4Mha of DRC, almost 14% of the country[30]. They are judged fairly successful at maintaining forest cover[31], even in conditions of conflict[28].
REDD+	There is much interest in REDD+, and some schemes, but institutional structures in DRC hamper progress[32] and have created competition between state and customary authorities[33]. CAR has a grant to develop a national REDD+ investment framework[34].
Restoration	CAR has committed to restore 3.5Mha under the Bonn Challenge, and DRC 8Mha[35]
Voluntary standards	DRC has a national FSC standard[36] and has had certified concessions, although following a complaint from Greenpeace one FSC certificate was withdrawn in 2011[37]. DRC and CAR had no active FSC certificates as of 2018[38].
Timber legality	DRC signed the Brazzaville Declaration in 2018, aimed at protecting some of the world's great peat deposits[39], although recent plans put this commitment in doubt[40].

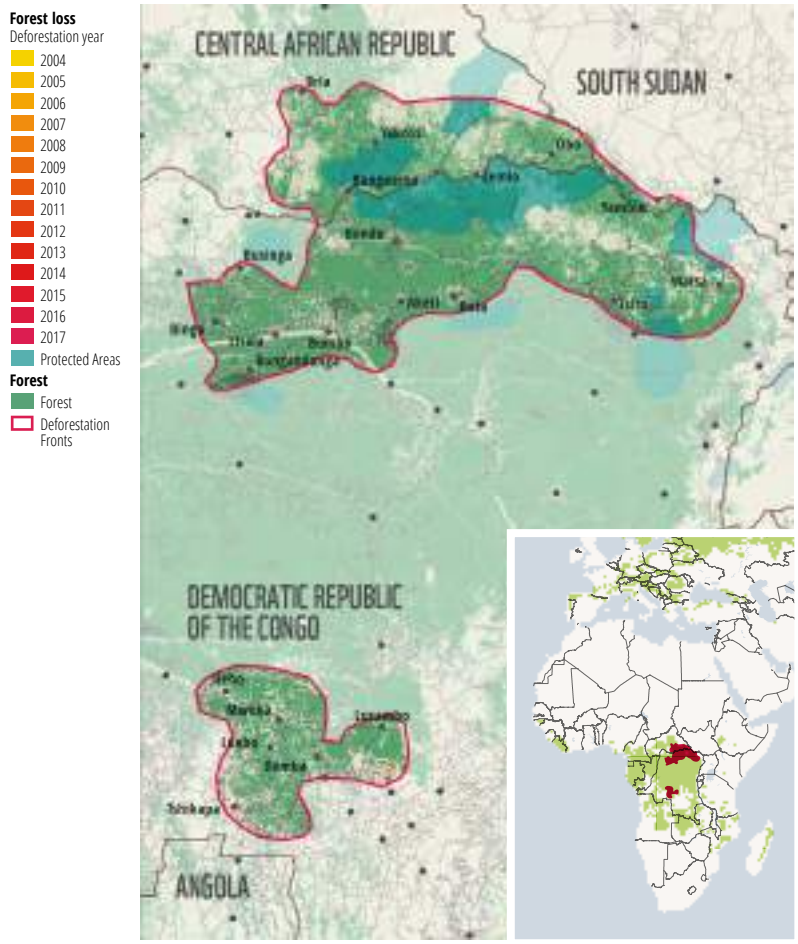
Deployment at wider scale
Actively used and expanding
Project-specific, experimental

Main outcomes

Smallholder agriculture that results from the development of human settlements in the forest frontiers continues to be the main driver of deforestation in DRC and CAR, since there is still a relatively low pressure from commercial activities. Forest degradation and deforestation is also due to a high reliance of people on charcoal as the main source of energy for cooking, and timber markets beyond the countries' boundaries. Efforts to support local livelihoods and compensate for local conservation efforts, largely embraced withing REDD+, still need to be consolidated and scaled up to achieve meaningful impacts.

Recommended future actions

- Increase public and private sector commitments to sustainable development of agriculture through adoption of best management practices and multi-stakeholder initiatives aimed at deforestation-free commodity supply. WWF is testing an "integrated agribusiness-conservation model" in Cameroon to engage smallholder farmers in deforestation-free food supply chains, which if successful could be replicated in the entire Congo Basin.
- Large scale investment in alternative (green) energy projects to convert urban dwellers from charcoal for cooking. Such alternatives must be competitively priced to reduce the demand, which is increasing apace with the rate of population growth



References

1. Harris, N.L., Goldman, E., Gabris, C., Nordling, J., Minnemeyer, S., Ansari, S., ... Potapov, P. 2017. Using spatial statistics to identify emerging hot spots of forest loss. *Environmental Research Letters* 12(2): 024012.
2. Tyukavina, A., Hansen, M.C., Potapov, P., Parker, D., Okpa, C., Stehman, S.V., ... Turubanova, S. 2018. Congo Basin forest loss dominated by increasing smallholder clearing. *Science Advances* 4(11): eaat2993.
3. Bogaert, J., Bamba, I., Koffi, K.J., et al. 2008. Fragmentation of forest landscapes in Central Africa: Causes, consequences and management. In: Lafortezza, R., Chen, J., Sanasi, G., and Crow, T.R. (eds), *Patterns and Processes in Forest Landscapes*, pp 67-87. Springer.
4. Mosnier, A., Camara, G., Carvalho Ywata, A., Havlík, P., Kapos, V., Kraxner, F., ... Valin, H. 2016. *Disentangling the effects of local and global drivers of deforestation with the GLOBIOM model*. Beijing: GLP 3rd Open Science Meeting, 25 October.
5. Tollens, E. 2010. *Potential impacts of agricultural development on the forest cover of the Congo Basin*. The World Bank, Washington DC, USA.
6. Ickowitz, A., Slayback, D., Asanzi, P., and Nasi, R. 2015. *Agriculture and deforestation in the Democratic Republic of the Congo: A synthesis of the current state of knowledge*. CIFOR, Bogor, Indonesia.
7. Rainforest Foundation. 2013. *Seeds of Destruction: Expansion of industrial oil palm in the Congo Basin: Potential impacts on forests and people*. Rainforest Foundation, London, UK.
8. De Beule, H., Jassogne, L., and van Asten, P. 2014. *Cocoa: Driver of Deforestation in the Democratic Republic of the Congo?* CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Copenhagen, Denmark.
9. Seymour, F. and Harris, N.L. 2019. Reducing tropical deforestation. *Science* 365(6455): 756-757.
10. Mayaux, P., Pekel, J.-F., Desclée, B., Donnay, F., Lupi, A., Achard, F., ... Belward, A. 2013. State and evolution of the African rainforests between 1990 and 2010. *Philosophical Transactions of the Royal Society B: Biological Sciences* 368(1625): 20120300.
11. Lukumbuzya, K. and Sianga, C. 2017. *Overview of the Timber Trade in East and Southern Africa: National Perspectives and Regional Trade Linkages*. TRAFFIC and WWF, Cambridge, UK. 53pp. www.traffic.org/site/assets/files/2154/timber-trade-east-southern-africa.pdf
12. Nasi, R., Billand, A., and Vliet, N. 2011. Managing for timber and biodiversity in the Congo Basin. *Forest Ecology and Management* 268: 103-111.
13. Samndong, R.A., Bush, G., Vatn, A., and Chapman, M. 2018. Institutional analysis of causes of deforestation in REDD+ pilot sites in the Equateur province: Implication for REDD+ in the Democratic Republic of Congo. *Land Use Policy* 76: 664-674.
14. Global Witness. 2015. *Exporting Impunity: How Congo's rainforest is illegally logged for international markets*. London, UK.
15. Megevand, C. 2013. *Deforestation Trends in the Congo Basin: Reconciling Economic Growth and Forest Protection*. World Bank, Washington DC, USA.
16. Lawson, S. 2014. *Illegal Logging in the Democratic Republic of Congo. EER PP 2014/03*. Chatham House, London, UK.
17. TEREA, FORM International. 2012. *Quel avenir pour les produits bois éco-certifiés africains sur le marché européen?* ATIBT, Paris, France. www.atibt.org/wp-content/uploads/2017/06/Etude-ECOFORAF.pdf.
18. Global Witness. 2012. *Rigged? The scramble for Africa's oil, gas and minerals*. London, UK.
19. Putzel, L., Assembe-Mvondo, S., Ndong, L.B.B., Banioguila, R.P., Cerutti, P., Tieguhong, J.C., ... Mala, W. 2011. *Chinese Trade and Investment in the Forests of the Congo Basin*. CIFOR, Bogor, Indonesia.
20. Ingram, V., Tieguhong, J.C., Schure, J., Nkamgnia, E., and Tadjuidje, M.H. 2011. Where artisanal mines and forest meet: Socio-economic and environmental impacts in the Congo Basin. *Natural Resources Forum* 35(4): 304-320.
21. Reed, E. and Miranda, M. 2007. *Assessment of the Mining Sector and Infrastructure Development in the Congo Basin Region*. WWF-US, Washington DC, USA.
22. Trimble Land Administration. nd. DRC Mining Cadastre Portal. Available from: drclicences.cami.cd/en [accessed 26 February 2020].
23. Kleinschroth, F., Laporte, N., Laurance, W.F., Goetz, S.J., and Ghazoul, J. 2019. Road expansion and persistence in forests of the Congo Basin. *Nature Sustainability* 2(7): 628-634.
24. Couturier, S. 2019. The global scar on Congo forests. *Nature Sustainability* 2(7): 547-548.
25. Defourny, P., Delhage, C., and Kibambe Lubamba, J.P. 2011. *Analyse quantitative des causes de la déforestation et de la degradation des forêts en République démocratique du Congo: Rapport final*. Université catholique de Louvaib, Belgium.
26. Moonen, P.C.J., Verbist, B., Schaepherders, J., Bwama Meyi, M., Van Rompaey, A., and Muys, B. 2016. Actor-based identification of deforestation drivers paves the road to effective REDD+ in DR Congo. *Land Use Policy* 58: 123-132.
27. Rudel, T.K. 2013. The national determinants of deforestation in sub-Saharan Africa. *Philosophical Transactions of the Royal Society B: Biological Sciences* 368(1625): 20120405.
28. Butsic, V., Baumann, M., Shortland, A., Walker, S., and Kuemmerle, T. 2015. Conservation and conflict in the Democratic Republic of Congo: The impacts of warfare, mining, and protected areas on deforestation. *Biological Conservation* 191: 266-273.
29. Molinario, G., Hansen, M.C., Potapov, P.V., Tyukavina, A., Stehman, S., Barker, B., and Humber, M. 2017. Quantification of land cover and land use within the rural complex of the Democratic Republic of Congo. *Environmental Research Letters* 12(10): 104001.
30. Protected Planet. 2020. Central African Republic, Africa. Available from: www.protectedplanet.net/country/CAF [accessed 25 February 2020].
31. Duveiller, G., Defourny, P., Desclée, B., and Mayaux, P. 2008. Deforestation in Central Africa: Estimates at regional, national and landscape levels by advanced processing of systematically-distributed Landsat extracts. *Remote Sensing of Environment* 112(5): 1969-1981.
32. Mpoyi, A.M., Nyamwoga, F.B., Kabamba, F.M., and Assembe Mvondo, S. 2013. *The context of REDD+ in the Democratic Republic of Congo: Drivers, agents and institutions*. CIFOR, Bogor, Indonesia.
33. Samndong, R.A. and Vatn, A. 2018. Competing tenures: Implications for REDD+ in the Democratic Republic of Congo. *Forests* 9(11): 662.
34. CAFI. 2019. Central African Republic: Advancing its national REDD+ process in spite of instability Available from: https://www.cafi.org/content/cafi/en/home/partner-countries/central-african-republic.html
35. AFR100. 2020. Commitment Tracker. Available from: afr100.org [accessed 22 February 2020].
36. FSC. 2020. FSC Forest Stewardship Standard for the Democratic Republic of the Congo. Available from: fsc.org/en/document-centre/documents/resource/188 [accessed 22 February 2020].
37. FSC. 2020. SODEFOR. Available from: fsc.org/en/node/18802 [accessed 22 February 2020].
38. Global Forest Atlas. nd. Forest Certification and Legality in the Congo. Available from: globalforestatlas.yale.edu/congo/forests-and-logging/forest-certification [accessed 22 February 2020].
39. FAO. 2018. Guarding the planet's carbon treasure – three countries sign the Brazzaville Declaration. Available from: http://www.fao.org/redd/news/detail/en/c/1110709/
40. Weston, P. 2020. Plan to drain Congo peat bog for oil could release vast amount of carbon. *The Guardian*, 28 February. Available from: www.theguardian.com/environment/2020/feb/28/ridiculous-plan-to-drain-congo-peat-bog-could-release-vast-amount-of-carbon-aoe

ANGOLA

Angola has large areas of miombo forest remaining. These were preserved and even expanded slightly during the long civil war, but are now being converted on a large scale, mainly for subsistence agriculture but also larger-scale cropping and charcoal making.

Drivers of deforestation

Smallholder farming	The major driver of change since the end of hostilities has been conversion of miombo woodland to agriculture (including slash-and-burn)[2], particularly small-scale crops suitable for drylands[3], as people moved back into former conflict areas[4]. Degradation is often a precursor to complete conversion of forests in farming areas[2].
Fuelwood and charcoal	Charcoal and fuelwood are major priorities for many rural dwellers, and influence large areas of miombo. They are a primary factor in forest degradation[5], rather than complete deforestation[6]. Charcoal is particularly important along roads[3].
Transport infrastructure	Deforestation often begins along new roads and was also associated with construction of the Benguela railway in the past[7].
Large-scale agriculture	Large-scale land acquisitions, covering several million hectares, started in the late 1980s and accelerated after 2002. Produce has been mainly for domestic consumption; companies are often foreign-owned[8].
Timber extraction	The timber trade has oscilated over time but is now increasing again. It is important for both domestic use and for export[3]. Illegal logging takes place on a large scale, including for Chinese companies[9].
Fire	Bushfires are used to clear for agriculture[3]. Uncontrolled fires are destroying large areas of forest and also harming the livelihoods of local San communities[10].
Urban expansion	Deforestation tends to spread out from major cities[11], although urban development is also reducing shifting agriculture and other practices that degrade or destroy forests.
Tree plantations	Angola had 100,000ha of plantations before independence[8]; it is not clear if new plantations are being established. Some plantations are logged illegally[12].
Mining operations	Mining has large environmental impacts and is a cause of deforestation in some areas[13].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Countries, region	Angola, Central Africa
Forest type	Miombo
Total area	10.5Mha
Forest area in 2018	4.2Mha (39.6% of total deforestation front area)
Forest loss 2004-2017	0.1Mha (3.1% of forest area in 2000)
Location of deforestation	Mainly in the south and east
Total forest core area in 2018	1.1Mha (27.4% of forests in 2018)
Fragmented forests 2000-2018	0.3Mha (6.5% of forest area in 2000)
Total burned area	1.9Mha (43.4% of forest area in 2000)
Deforestation trend	Historically a slight increase in miombo 1990-2000[1], but loss grew sharply after the civil war. Increasing, with oscillations over time
Future trends	Deforestation has increased over the past decade; future direction is unclear

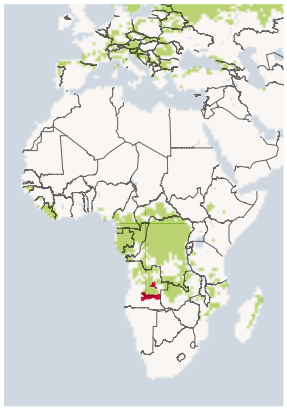
Underlying causes

The 27-year civil war damaged nature[14] but also meant that whole areas were effectively left alone; the end of hostilities has rapidly increased the rate of land-use change. This has been fuelled by population growth, an influx of oil wealth and continuing issues relating to corruption

Key responses

Protected areas	There are 14 protected areas covering around 12% of the country[15]. During the war these areas were badly poached, and habitats destroyed. There is currently some optimism of greater management effectiveness[16], although there is also a need for more protected areas; few of the current total are in miombo, and most are effectively unmanaged.
Recognition of IPLCs	Angola voted in favour of the UN Declaration on the Rights of Indigenous Peoples on 13 September 2007, but the San, Himba and other groups continue to experience land expropriations and other problems[17].
Timber legality	The government of Angola announced new rules to curb illegality in the timber trade in 2018[18].
Land-use zoning	There are efforts to address land tenure, but they remain partial and not always effective[19]; issues of expropriation of land by the elite and companies continue to occur.
Fire management	Angola has been seeking collaboration with FAO in addressing the issue of fire, including through community education programmes[20].
REDD +	Angola had no REDD+ projects in 2016,[21] although the potential is recognized[22].

Deployment at wider scale
Actively used and expanding
Project-specific, experimental



Main outcomes

Most of the responses seem to be at an initial stage of discussion and pronouncements rather than concrete actions; even the protected area system is recognized as being ineffective and too small. The need for a national certification scheme is still being discussed[23].

Recommended future actions

- Increase coverage and management within protected areas.
- Ramp up responses such as certification and REDD+.
- Strengthen enforcement of government regulations, particularly regarding logging, land acquisition and fire management.

References

1. Cabral, A.I.R., Vasconcelos, M.J., Oom, D., and Sardinha, R. 2009. *Deforestation or regrowth? A quantification of forest extension in the miombo of Angola for the period 1990-2000*. In *33rd International Symposium on Remote Sensing of Environment*.
2. Schneibel, A., Frantz, D., Röder, A., Stellmes, M., Fischer, K., and Hill, J. 2017. Using annual Landsat time series for the detection of dry forest degradation processes in South-Central Angola. *Remote Sensing* 9(9): 905.
3. Mendelsohn, J.M. 2019. Landscape changes in Angola. In: Huntley, B., Russo, V., Lages, F., and Ferrand, N. (eds). *Biodiversity of Angola*, pp 123-137. Springer, Dordrecht.
4. Wallenfang, J., Finckh, M., Oldeland, J., and Revermann, R. 2015. Impact of shifting cultivation on dense tropical woodlands in southeast Angola. *Tropical Conservation Science* 8(4): 863-892, 30.
5. Chiteculo, V., Lojka, B., Surový, P., Verner, V., Panagiotidis, D., and Woitsch, J. 2018. Value chain of charcoal production and implications for forest degradation: Case study of Bié province, Angola. *Environments* 5(11): 113.
6. Chiteculo, V., Surovy, P., and Panagiotidis, D. 2018. Does management matter? Assessment on Miombo Forests in Angola. *Scientia Agriculturae Bohemica* 49.
7. Chiteculo, V., Abdollahnejad, A., Panagiotidis, D., Surový, P., and Sharma, R.P. 2019. Defining deforestation patterns using satellite images from 2000 and 2017: Assessment of forest management in Miombo Forests – A case study of Huambo province in Angola. *Sustainability* 11(1): 98.
8. de Grassi, A. and Ovadia, J. 2017. Trajectories of large-scale land acquisition dynamics in Angola: Diversity, histories, and implications for the political economy of development in Africa. *Land Use Policy* 67: 115-125.
9. Gutner, J.C. and Azulay, J.V. 2018. Angola: Chinese continue to plunder forests for timber. Africa Sustainable Conservation News. Available from: africasustainableconservation.com/2018/01/04/angola-chinese-continue-to-plunder-forests-for-timber
10. Marques de Morais, R. 2019. Angola's San community under threat from burning forests. Maka Angola. Available from: www.makaangola.org/2019/10/angolas-san-community-under-threat-from-burning-forests
11. Chiteculo, V., Hájek, M., and Kubová, P. 2018. Production and Commercialization of Timber in Angola after the Declaration of Independence. *Scientia Agriculturae Bohemica* 49(1): 38.
12. Evangelista, J. 2017. Why illegal logging in Angola must stop. Available from: www.howwemadeitinafrica.com/illegal-deforestation-angola-must-stop/57430
13. Ferreira-Baptista, L., Manuel, J., Francisco Aguiar, P., and João Pereira, M. 2018. Impact of mining on the environment and water resources in northeastern Angola. In: Revermann, R., Krewenka, K.M., Schmiedel, U., Olwoch, J.M., Helmschrot, J., and Jürgens, N. (eds). *Climate change and adaptive land management in southern Africa – assessments, changes, challenges, and solutions*, pp 155-159. Klaus Hess Publishers, Göttingen and Windhoek.
14. Huntley, B.J. 2017. *Wildlife at War in Angola: The rise and fall of an African Eden*. Protea Book House, Pretoria.
15. Protected Planet. 2020. Angola, Africa. Available from: www.protectedplanet.net/country/AGO [accessed 22 March 2020].
16. Huntley, B.J., Beja, P., Vaz Pinto, P., Russo, V., Veríssimo, L., and Morais, M. 2019. Biodiversity conservation: history, protected areas and hotspots. In: Huntley, B., Russo, V., Lages, F., and Ferrand, N. (eds). *Biodiversity of Angola*, pp 495-512. Springer, Dordrecht.
17. IWGIA. 2019. Indigenus People in Angola. Available from: www.iwgia.org/en/angola.html [accessed 22 March 2020].
18. Angola Press Agency. 2018. Angola: Agriculture sets new rules for logging. *All Africa,* 25 January. Available from: https://allafrica.com/stories/201801260154.html
19. Carranza, F. and Treakle, J. 2014. *Land, territorial development and family farming in Angola: A holistic approach to community-based natural resource governance: The cases of Bie, Huambo and Huila Provinces*. FAO, Rome, Italy.
20. ANGOP. 2019. Angola seeks UN support to control fires. Available from: www.angop.ao/angola/en_us/noticias/ambiente/2019/7/35/Angola-seeks-support-control-fires,fc176d72-a1f6-4be2-a906-9a0647d8fd65.html
21. International Database on REDD+ projects and programmes. Countries of REDD+ projects worldwide. Available from: www.reddprojectsdatabase.org/view/countries.php [accessed 22 March 2020]
22. Leite, A., Cáceres, A., Melo, M., Mills, M.S.L., and Monteiro, A.T. 2018. Reducing emissions from deforestation and forest degradation in Angola: Insights from the scarp forest conservation 'hotspot'. *Land Degradation & Development* 29(12): 4291-4300.
23. Matambo, S.T., Olmos, S.E., Soto, B.F., Million, J.M.F., Aquino, A., Ngouana Kengne, C.V., ... Tembe Bilale, N.H.G. 2019. *Environment and Renewable Natural Resources in Angola - Opportunities to Diversify the National Economy, Generate Income for local communities, enhance environmental management capacity and build resilience to climate change*. World Bank Group, Environment and Natural Resources Management (ENRM) Global Practice (GP) Washington DC, USA. Available from: documents1.worldbank.org/curated/en/864671554294508064/pdf/Opportunities-to-Diversify-the-National-Economy-Generate-Income-for-Local-Communities-Enhance-Environmental-Management-Capacity-and-Build-Resilience-to-Climate-Change.pdf

ZAMBIA

Zambia is undergoing high and increasing rates of forest loss, but still has large forest resources. Attempts at control have largely failed outside protected areas, and forest reserves have also been lost.)

Drivers of deforestation

Smallholder farming	The main driver, linked to rural population growth[1] and the demand for land for subsistence agriculture[2], expansion of cash crops like tobacco and cotton, and poor farming that exhausts soils and encourages additional land clearance[3].
Charcoal	The key driver in some areas[4]; extraction increases fire risk[5]. Urban charcoal use persists even if electricity is available due to frequent outages and load shedding[6, 7]. Supplies close to 87% of domestic energy needs and 30% of rural industry requirements, e.g. brickmaking.
Timber extraction	Significant, for domestic use and export, and opens up the forest to disturbance including fire[8]. Illegal felling is rampant, e.g. illegal rosewood costs Zambia US$3.2 million a year[9]. Zambia exports mainly to the Southern African Development Community (SADC) region but also to China and Taiwan. Although log exports are officially banned, these occur, particularly to DRC[10].
Fire	FAO estimates 5% of forest burns each year[8]; often through accidental spread during burning of crop residues and cropland preparation[3].
Livestock grazing	Significant in some places and overgrazing is reported[10]; burning to increase grazing also results in fires in forests.
Mining operations	Causes some deforestation but is a minor factor overall[11].
Road expansion	Stimulates deforestation by opening to agricultural expansion and charcoal production[12].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Amongst underlying causes, population pressure has direct impacts on forest cover through pressure for land[13]. Greater security of forest tenure is associated with better forest condition, while greater dependence on forests for livelihoods tends to create poorer forest condition[14].

Countries, region	Zambia, Southern Africa
Forest type	Tropical dry forest (miombo)
Total area	15.9Mha
Forest area in 2018	10.3Mha (64.5% of total deforestation front area)
Forest loss 2004-2017	0.4Mha (3.7% of forest area in 2000)
Location of deforestation	Principally in the southeast of the country
Total forest core area in 2018	4.1Mha (40.1% of forests in 2018)
Fragmented forests 2000-2018	1.1Mha (10.4% of forest area in 2000)
Accumulated burned area, 2002-2019	7.5Mha (70.1% of forest area in 2000)
Deforestation trend	Increasing, more than doubled from 2010-2018 compared to the previous decade
Future trends	Likely to increase

Responses

Protected areas	641 protected areas covering 41.26% of the country; but 555 of these are forest reserves with varying degrees of effectiveness[15]. Nonetheless, protected areas, including national forests, are identified as important for forest recovery[16].
PES incl. REDD+	Research shows Zambian forests are still a major carbon sink despite losses, and growth rates may be being stimulated by higher CO2 levels[5]. Carbon markets are important with a World Bank BioCarbon Fund project aiming to take a landscape approach to reducing forest loss[18].
Charcoal alternatives	Government efforts focus on providing alternatives to charcoal, with increasing productivity and income seen as a key factor[17].
Voluntary standards	A process has been ongoing since the 1990s, but still no certified forest[19]. Tenure issues are problematic because all forests are state-owned[20].

Deployment at wider scale
Actively used and expanding
Project-specific, experimental

Main outcomes

Despite efforts by the government, donors and NGOs, deforestation is continuing in Zambia, driven primarily by rising numbers of people using inefficient agriculture. Major structural interventions will be needed to reverse these trends. The San people remain seriously disadvantaged in the country.

Recommended future actions

- Increase effectiveness of the existing protected area network, particularly the large number of forest reserves, possibly through a planned rationalization of the system.
- Develop carbon markets.
- Address the worrying lack of certified forests.

References

1. Nkolola, N., Nyasa, L., and Ngonga, C. 2016. Drivers of deforestation in the miombo woodlands and their impacts on the environment. *Advances in Research* 6: 1-7.
2. Ngoma, H., Pelletier, J., Mulenga, B.P., and Subakanya, M. 2019. *Climate-smart agriculture, cropland expansion and deforestation in Zambia: linkages, processes and drivers*. Indaba Agricultural Policy Research Institute, Lusaka, Zambia.
3. Wathum, G., Seebauer, M., and Carodenuto, S. 2016. *Drivers of Deforestation and Forest Degradation in Eastern Province, Zambia: Zambia Integrated Forested Landscape Program*. The World Bank, Washington DC, USA.
4. Pelletier, J. 2017. Agriculture expansion, wood energy and woody encroachment in the Miombo woodlands: striving towards sustainability in Zambia. Fall Meeting of the American Geophysical Society.
5. Pelletier, J., Barrett, C.B., Trainor, A.M., and Siampale, A. 2018. *In*tensification of forest disturbances caused by charcoal production in dry tropical forests (miombo woodland) in Zambia. Fall Meeting of the American Geophysical Society.
6. Mulenga, B.P., Tembo, S.T., and Richardson, R.B. 2019. Electricity access and charcoal consumption among urban households in Zambia. *Development Southern Africa* 36(5): 585-599.
7. Samboko, P., Dlamini, C., Moombe, K., and Syampungani, S. 2016. *Load shedding and charcoal use in Zambia: What are the implications on forest resources*. Indaba Agricultural Policy Research Institute (IAPRI), Lusaka, Zambia.
8. Chomba, B.M., Tembo, O., Mutandi, K., Mtongo, C.S., and Makano, A. 2012. *Drivers of deforestation, identification of threatened forests and forest cobenefits other than carbon from REDD+ implementation in Zambia*. A consultancy report prepared for the Forestry Department and the Food and Agriculture Organization of the United Nations under the national UN-REDD Programme. Ministry of Lands, Natural Resources and Environmental Protection, Lusaka, Zambia.
9. PROFOR. 2018. Food and forests: We can have them both. www.profor.info/content/food-and-forests-we-can-have-them-both
10. Lukumbuzya, K. and Sianga, C. 2017. *Overview of the Timber Trade in East and Southern Africa: National Perspectives and Regional Trade Linkages*. TRAFFIC and WWF, Cambridge, UK. 53pp. www.traffic.org/site/assets/files/2154/timber-trade-east-southern-africa.pdf
11. Vinya, R., Syampungani, S., Kasumu, E.C., Monde, C., and Kasubika, R. 2011. *Preliminary study on the drivers of deforestation and potential for REDD+ in Zambia*. FAO/Zambian Ministry of Lands and Natural Resources, Lusaka, Zambia.
12. Pelletier, J., Paquette, A., Mbindo, K., Zimba, N., Siampale, A., Chendauka, B., ... Roberts, J.W. 2018. Carbon sink despite large deforestation in African tropical dry forests (miombo woodlands). *Environmental Research Letters* 13: 094017.
13. Ferrer Velasco, R., Köthke, M., Lippe, M., and Günter, S. 2020. Scale and context dependency of deforestation drivers: Insights from spatial econometrics in the tropics. *PLOS ONE* 15(1): e0226830.
14. Stickler, M.M., Huntingdon, H., Haflett, A., Petrova, S., and Bouvier, I. 2017. Does de facto forest tenure affect forest condition? Community perceptions from Zambia. *Forest Policy and Economics* 85(1): 32-45.
15. Protected Planet. 2020. Zambia. Available from: www.protectedplanet.net/country/ZM [last accessed 23 February 2020].
16. Phiri, D., Morgenroth, J., and Xu, C. 2019. Long-term land cover change in Zambia: An assessment of driving factors. *Science of the Total Environment* 697: 134206.
17. Mulenga, B.P., Hadunka, P., and Richardson, R.B. 2017. Rural households' participation in charcoal production in Zambia: Does agricultural productivity play a role? *Journal of Forest Economics* 26: 56-62.
18. World Bank. 2018. Zambia takes the keys away from 'drivers' of deforestation. Available from: www.worldbank.org/en/news/feature/2018/03/02/zambia-takes-the-keys-away-from-drivers-of-deforestation
19. Kalonga, S.K., Teketay, D., Mutta, D., Hassan, A., Road, M., and Estate, R. 2019. Status of forest certification in eastern and southern Africa sub-regions. *Journal of Rural Development* 4(1): 109-123.
20. Njovu, F.C. 2004. Forest certification in Zambia. In: *Forest Certification in Developing and Transitioning societies: Social, economic and ecological effects*. Yale School of Forestry and Environmental Studies, New Haven, USA.

MOZAMBIQUE

Mozambique remains a highly forested country, but deforestation has been steadily increasing since 2000. The majority of deforestation and forest degradation is related to unsustainable agricultural practices and timber extraction. Mozambique's forests contribute with multiple social, economic and environmental benefits, which continue to be threatened in spite of current responses.

Drivers of deforestation

Smallholder farming	Small-scale agriculture is a major cause of forest loss[1-4], accounting for 46% of biomass loss in one study of central Mozambique[1]. According to Global Forest Watch (GFW), small-scale agriculture accounted for more than 90% of total forest cover loss from 2001-2015[5].
Fuelwood and charcoal production	Fuelwood and charcoal production are the next most cited drivers of deforestation[1, 6], including both local fuelwood collection[7] and charcoal production to meet urban energy demand[8]. .
Urban expansion	Urban expansion has been associated with 12% of deforestation in Mozambique[9]. According to GFW data, this was a small but consistent driver of permanent deforestation between 2001-2015[5].
Small-scale timber extraction	Logging is a small but steady driver of deforestation[1, 6, 10]. Illegal logging has been a persistent problem[11], but has also received government attention for reform[12]. Mozambique is among the top African timber exporters to China[13, 14].
Large-scale agriculture	Large-scale agriculture is a very small contributor to deforestation[4], limited to 3% of biomass loss for one study in central Mozambique[1]. Large-scale agriculture expansion into forest land has accordingly been much smaller than small-scale agriculture expansion in forest land[15].
Fires	Wildland fires have long been a cause of some deforestation in Mozambique, primarily linked to purposefully set fires for land clearing[16].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

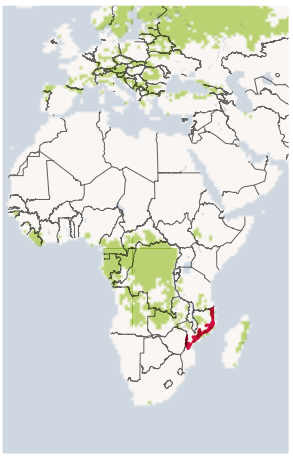
Underlying drivers of deforestation in Mozambique are broadly linked to technological (such as inefficient use of fuelwood), demographic (high demand for wood from urban areas), economic (inefficient commercial agriculture markets) and institutional factors (limited institutional and law enforcement capacity)[6]. Additional underlying drivers include urban energy demand,[11] population pressure and food insecurity[7].

Countries, region	Mozambique, Southern Africa
Forest type	Subtropical forests
Total area	21.9Mha
Forest area in 2018	9.0Mha (40.9% of total deforestation front area)
Forest loss 2004-2017	0.3Mha (2.7% of forest area in 2000)
Location of deforestation	Mostly in the west and east, although relatively scattered
Total forest core area in 2018	2.8M ha (31.0% of forests in 2018)
Fragmented forests 2000-2018	1.5M ha (15.6%, of forest area in 2000)
Accumulated burned area, 2002-2019	5.0Mha (51.5% of forest area in 2000)
Deforestation trend	Increasing, with oscillations
Future trends	Small-scale agriculture is likely to remain an important driver of deforestation

Key responses

Land-use zoning—community forestry	Zoning exercises have been conducted in several areas[4]. Integrated policies[17] and additional support for community forestry and agroforestry have been called for[18]. As of 2005, Mozambique law requires 20% of proceeds from management of forests to be returned to local communities[6].
Recognition of IPLCs	Community registration of land-use rights for local communities has been ongoing since the 2000s. Mozambique's legislation on community land-use rights is thought to be among the most progressive in Africa[19].
Timber legality	Mozambique introduced governance reforms in the forest sector to limit illegal logging in 2018[20], and has implemented export bans on raw logs and total bans on several species[21].
Protected areas	Protected areas in Mozambique, such as the Niassa National Reserve, have been found to have lower deforestation rates than surrounding areas[22].
REDD+ strategy	REDD+ is often listed as a response option[6, 18], and the country has developed its national REDD implementation strategy[23].
Voluntary standards	Mozambique had 60,000ha of FSC-certified forest as of 2015[24]. This is a small area but represents the majority of planted forest land in Mozambique.
Fire management	Various fire management policies have been implemented, including both support for fire management in parks and community-based fire management.

Deployment at wider scale
Actively used and expanding
Project-specific, experimental



Forest loss
Deforestation year
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- Protected Areas

Forest
- Forest
- Deforestation Fronts

Main outcomes

Small-scale agriculture continues to be a primary driver of deforestation, while wood energy demand, illegal logging and urban expansion are important secondary drivers. Underlying drivers of deforestation related to limited institutional and law enforcement capacity indicate that deforestation may continue.

Recommended future actions

- Implement policy and governance initiatives for curbing deforestation[25], building on recent efforts around land-use zoning and timber legality.

References

1. Ryan, C.M., Berry, N.J., and Joshi, N. 2014. Quantifying the causes of deforestation and degradation and creating transparent REDD+ baselines: A method and case study from central Mozambique. *Applied Geography* 53: 45-54.
2. Temudo, M.P. and Silva, J.M.N. 2012. Agriculture and forest cover changes in post-war Mozambique. *Journal of Land Use Science* 7(4): 425-442.
3. World Bank. 2018. *Mozambique Country Forestry Note*.
4. Di Matteo, F. and Schoneveld, G.C. 2016. *Agricultural investments in Mozambique: An analysis of investment trends, business models and social and environmental conduct*. CIFOR, Bogor, Indonesia.
5. WRI. *Global Forest Watch Dashboard*.
6. Sitoe, A., Salomao, A., and Wertz-Kanounnikoff, S. 2012. *The context of REDD+ in Mozambique*. CIFOR, Bogor, Indonesia.
7. IUCN. *Mozambique Restoration Opportunities Asssessment Methodology (ROAM)*.
8. Sedano, F., Silva, J.A., Machoco, R., Meque, C.H., Sitoe, A., Ribeiro, N., ... Tucker, C.J. 2016. The impact of charcoal production on forest degradation: A case study in Tete, Mozambique. *Environmental Research Letters* 11(9).
9. World Bank. 2018. *Forests of Mozambique: A Snapshot*.
10. FCPF. 2018. *Zambezia Integrated Landscape Management: Country responses to CFP's questions on Advanced Draft ERPD*.
11. Hui, N. 2016. Mozambique faces race against time to end illegal logging. *The Guardian*, 31 August. Available from: https://www.theguardian.com/sustainable-business/2016/aug/31/mozambique-illegal-logging-china-timber-deforestation.
12. World Bank. 2017. World Bank injects $47 million to stem deforestation in Mozambique. www.worldbank.org/en/news/press-release/2017/03/07/world-bank-injects-47-million-to-stem-deforestation-in-mozambique
13. EIA. 2018. *African Log Bans Matter*. Environmental Investigation Agency.
14. Lukumbuzya, K. and Sianga, C. 2017. *Overview of the Timber Trade in East and Southern Africa: National Perspectives and Regional Trade Linkages*. TRAFFIC and WWF, Cambridge, UK. 53pp. www.traffic.org/site/assets/files/2154/timber-trade-east-southern-africa.pdf.
15. Bey, A., Jetimane, J., Lisboa, S.N., Ribeiro, N., Sitoe, A., and Meyfroidt, P. 2020. Mapping smallholder and large-scale cropland dynamics with a flexible classification system and pixel-based composites in an emerging frontier of Mozambique. *Remote Sensing of Environment* 239: 111611.
16. Cochrane, M.A. 2009. *Tropical Fire Ecology: Climate Change, Land Use, and Ecosystem Dynamics*. Springer, New York, USA.
17. Ellegard, A. and Nordstrom, M. 2003. Deforestation for the poor? Renewable Energy for Development.
18. Mitchard, E.T.A., Meir, P., Ryan, C.M., Woollen, E.S., Williams, M., Goodman, L.E., ... Saatchi, S.S. 2013. A novel application of satellite radar data: Measuring carbon sequestration and detecting degradation in a community forestry project in Mozambique. *Plant Ecology and Diversity* 6(1): 159-170.
19. Cabral, L. and Norfolk, S. 2016. *Inclusive Land Governance in Mozambique: Good Law, Bad Politics?* Institute of Development Studies.
20. Farge, E. 2018. Mozambique reforms timber sector to counter illegal logging. *Reuters*.
21. Forest Legality Initiative. 2018. *Logging and Export Bans*.
22. Allen, J.R., Grossmann, F., Craig, R., Nelson, A., Maina, J., Flower, K., ... Watson, J.E.M. 2017. Patterns of forest loss in one of Africa last remaining wilderness areas: Nlassa National Reserve *Parks* 23(2).
23. FCPF. 2018. Mozambique puts newly approved national REDD+ strategy into action. Forest Carbon Partnership Facility.
24. Kalonga, S.K., Teketay, D., Mutta, D., Hassan, A., Road, M., and Estate, R. 2019. Status of forest certification in eastern and southern Africa sub-regions. *Journal of Rural Development* 4: 109-123.
25. Hervey, A.F. 2012. *Why governance matters: a comparative study of the causes of deforestation in the miombo woodlands of Zambia and Mozambique, 1990-2010*. London School of Economics and Political Science.

MADAGASCAR

Madagascar has been impacted by significant deforestation in the past, but primary forests still account for a quarter of forest cover. The island nation of Madagascar has developed its own distinct ecosystems and extraordinary wildlife. Around 95% of Madagascar's reptiles, 89% of its plant life, and 92% of its mammals exist nowhere else on Earth. The forests are under growing pressure from agriculture, fuelwood and charcoal extraction, and also from uncontrolled fires.

Drivers of deforestation

Smallholder farming	Small-scale agriculture, largely slash-and-burn, is a major cause of forest loss, and has cultural importance[1-3]. Some small-scale agriculture is for cash crops, such as maize and peanuts[4], and for international markets, such as vanilla[5].
Fuelwood and charcoal	Fuelwood and charcoal demand is an important driver of deforestation[6-8].7–9 As charcoal is a primary cooking fuel in urban areas, charcoal-related deforestation grows out of urban areas[8].
Fires	Both uncontrolled wildfires and fires set for grazing lands, often related to cattle ranching, have contributed to deforestation for a long time[9]. Fires are also sometimes accidentally started by charcoal makers[10].
Cattle ranching	Cattle ranching has been a long-time driver of deforestation in Madagascar[2, 7].
Small-scale logging	Commercial logging is a minor driver of deforestation[11]. Illegal logging of rare wood such as rosewood is significant[12, 13].
Mining operations	Both large-scale and artisanal mining, including gemstone mining, are contributing to deforestation in remaining forest areas[14].
Road expansion	Transport infrastructure is a persistent factor in deforestation in Madagascar[15, 16].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Underlying drivers of deforestation include migration and property rights[7], as well as demographic growth and governance[2], and limited law enforcement. Economic factors are also important: a sustainable financial mechanism to combat deforestation is lacking.

Countries, region	Madagascar, Southern Africa
Forest type	Tropical moist forest to the east, and dry to the west
Total area	20.1Mha
Forest area in 2018	6.3Mha (31.5% of total deforestation front area)
Forest loss 2004-2017	0.7Mha (9.0% of forest area in 2000)
Location of deforestation	Mostly in west and east, although relatively scattered
Total forest core area in 2018	1.2Mha (18.9% of forests in 2018)
Fragmented forests 2000-2018	1.9Mha (24.9% of forest area in 2000)
Accumulated burned area, 2002-2019	1.3Mha (17.7% of forest area in 2000)
Deforestation trend	Increasing
Future trends	Deforestation related to small-scale agriculture and wood energy demand may continue

Responses

Protected areas	Protected areas have been studied and found to be effective at limiting deforestation in Madagascar[1, 16].
PES including REDD+	REDD+ has been posited as a potential response[17].
Land-use zones—community forests	Community forest management (without commercial logging) has also been found effective in limiting deforestation[11].
Charcoal alternatives	A regulation system for natural forest production, fuelwood plantations and promotion of efficient cookstoves have been initiated to provide an alternative and more sustainable source of wood and charcoal[6]. Additional alternatives to cooking wood and charcoal are needed.
Deforestation monitoring	Deforestation monitoring has been ongoing[18] and funding and efforts have expanded with REDD+[19].

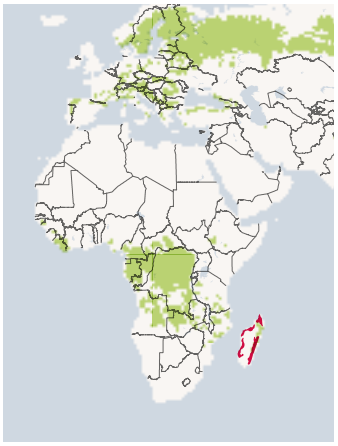
Deployment at wider scale
Actively used and expanding
Project-specific, experimental

Main outcomes

Small-scale agriculture and wood energy demand continue to be primary drivers of deforestation.

Recommended future actions

- Enforce existing laws to combat deforestation[20], in combination with a sustainable financing mechanism for forests.
- Initiate spatial coordination of agricultural and forest land at the district or landscape level.
- Promote reforestation, agroforestry and alternatives to cooking with wood and charcoal, as this is a primary driver of deforestation.



Forest loss
Deforestation year
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- Protected Areas

Forest
- Forest
- Deforestation Fronts

References

1. Desbureaux, S. and Brimont, L. 2015. Between economic loss and social identity: The multi-dimensional cost of avoiding deforestation in Eastern Madagascar. *Ecological Economics* 118: 10-20.
2. Vieilledent, G., Grinand, C., Rakotomalala, F.A., Ranaivosoa, R., Rakotoarijaona, J.R., Allnutt, T.F., and Achard, F. 2018. Combining global tree cover loss data with historical national forest cover maps to look at six decades of deforestation and forest fragmentation in Madagascar. *Biological Conservation* 222: 189-197.
3. Zaehringer, J., Eckert, S., and Messerli, P. 2015. Revealing regional deforestation dynamics in north-eastern Madagascar – Insights from multi-temporal land cover change analysis. *Land* 4(2): 454-474.
4. Scales, I.R. 2011. Farming at the forest frontier: Land use and landscape change in western Madagascar, 1896-2005. *Environment and History* 17(4): 499-524.
5. Moser, C. 2008. An economic analysis of deforestation in Madagascar in the 1990s. *Environmental Sciences* 5(2): 91-108.
6. Bucht, K. 2015. *Plantation projects in Madagascar: approaches, objectives and reflections for fuelwood production.* Tropical Resources Institute.
7. Casse, T., Milhøj, A., Ranaivoson, S., and Randriamanarivo, J.R. 2004. Causes of deforestation in southwestern Madagascar: What do we know? *Forest Policy and Economics* 6(1): 33-48.
8. Onishi, N. 2016. Africa's charcoal economy is cooking. The trees are paying. *The New York Times,* 26 June. www.nytimes.com/2016/06/26/world/africa/africas-charcoal-economy-is-cooking-the-trees-are-paying.html
9. LCLUC. nd. Deforestation in Madagascar. Available from: lcluc.umd.edu/hotspot/deforestation-madagascar [accessed 11 August 2020].
10. Friedberg, S. 2019. Demand for charcoal threatens the forest of Madagascar's last hunter-gatherers. *Mongabay,* 3 October. Available from: news.mongabay.com/2019/10/demand-for-charcoal-threatens-the-forest-of-madagascars-last-hunter-gatherers
11. Rasolofoson, R.A., Ferraro, P.J., Jenkins, C.N., and Jones, J.P.G. 2015. Effectiveness of community forest management at reducing deforestation in Madagascar. *Biological Conservation* 184: 271-277.
12. EIA. 2014. The ongoing illegal logging crisis in Madagascar – An EIA Briefing for CITES SC65: 1-8.
13. Ford, T. 2013. Madagascar's forests vanish to feed taste for rosewood in west and China. *The Guardian,* 23 Devember. www.theguardian.com/world/2013/dec/23/madagascar-illegal-logging-rosewood-smuggling
14. Tuliis, P. 2019. How illegal mining is threatening Madagascar's endangered lemurs. *National Geographic,* 6 March. www.nationalgeographic.com/animals/2019/03/sapphire-mining-fuels-lemur-deaths-in-madagascar
15. Allnutt, T.F., Asner, G.P., Golden, C.D., and Powell, G.V.N. 2013. Mapping recent deforestation and forest disturbance in northeastern Madagascar. *Tropical Conservation Science* 6(1): 1-15.
16. Eklund, J., Blanchet, F.G., Nyman, J., Rocha, R., Virtanen, T., and Cabeza, M. 2016. Contrasting spatial and temporal trends of protected area effectiveness in mitigating deforestation in Madagascar. *Biological Conservation* 203: 290-297.
17. Grinand, C., Rakotomalala, F., Gond, V., Vaudry, R., Bernoux, M., and Vieilledent, G. 2013. Estimating deforestation in tropical humid and dry forests in Madagascar from 2000 to 2010 using multi-date Landsat satellite images and the random forests classifier. *Remote Sensing of Environment* 139: 68-80.
18. ONE, DGF, MNP, and WCS. 2015. *Changement de la couverture de forets naturelles a Madagascar.* Antananarivo, Madagascar.
19. Rakotomala, F.A., Rabenandrasana, J.C., Andriambahiny, J.E., Rajaonson, R., Andriamalala, F., Burren, C., ... Grinand, C. 2015. Estimation de la deforestation des forets humides a Madagascar utilisant une classification multidate d'images lands at entre 2005, 2010 et 2013. *Revue Francaise de Photogrammetrie et de Teledetection* 212(211-212): 11-23.
20. Kotler, S. 2010. How one scientist is battling deforestation in Madagascar. *The Guardian,* 1 July. www.theguardian.com/environment/2010/jul/01/scientists-deforestation-madagascar.

CAMBODIA

Cambodia boasts diverse forest ecosystems, including the largest intact dry forests in Indochina – a mosaic of habitats home to large quantity and diversity of species. Deforestation between 2001 and 2018 was among the highest in the world and the remaining high value forests continue to be under pressure from population growth, illegal logging and land concessions. In recent years, the government has implemented stricter measures to crack down on illegal timber trade and land deals.

Countries, region	Cambodia, Lower Mekong
Forest type	Deciduous and semi-evergreen, evergreen forest
Total area	6.7Mha
Forest area in 2018	3.3Mha (49.0% of total deforestation front area)
Forest loss 2004-2017	0.8Mha (19.6% of forest area in 2000)
Location of deforestation	North and northeast Cambodia
Total forest core area in 2018	1.5Mha (44.7% of forests in 2018)
Fragmented forests 2000-2018	0.3Mha (8.1% of forest area in 2000)
Accumulated burned area, 2002-2019	1.7Mha (41.6% of forest area in 2000)
Deforestation trend	Upward trend with drastic increase from 2009 to 2013, followed by slow decline
Future trends	Deforestation may continue expanding but at lower rate if recent interventions remain effective

Underlying causes

Forest governance challenges include limited law enforcement capacity and lack of coordination between ministries responsible for forest management, ELCs and land titles. This can lead to overlapping claims[17] as well as weak management coordination of social land concessions and ELCs in high value forests areas. Illegal logging also remains a challenge[3, 18]. Forest sector reform suffers from limited technical and institutional capacity and resources in forest management (knowledge, human resources, etc.)[19]. Increasing regional and global market demand for agricultural commodities[20] and forest sector reforms in neighbouring countries, such as logging bans, have increased pressure on Cambodia's land sector[21].

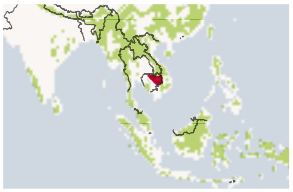
Drivers of deforestation

Large-scale agriculture	Large-scale industrial agriculture plantations are established through economic land concessions (ELCs) by local and international companies[1]. Rubber is the most significant commodity in the deforestation front, accounting for half of total ELC areas of 2.2Mha.[2] In some cases, the use of ELCs has been alleged as an instrument to legally log timber (conversion timber)[3].
Smallholder farming	In 2014, 1.2Mha of forest area was de-gazetted to issue land titles to landless communities[2]. Alongside legal conversion, there is also illegal conversion by land speculators[4]. The relative role of subsistence farming as a deforestation driver has been decreasing over time[3] but remains significant in relatively remote areas (e.g. north-western uplands)[5].
Urban expansion	Expansion of settlements in rural areas has been triggered by population growth and social policies encouraging rural migration and resettlement[5].
Illegal logging	Timber concessions for selective logging are effectively suspended, but illegal logging of high value species from forestlands adjacent to ELCs, mining concession areas and hydropower projects has been alleged; timbers is then "laundered" to become legal[3].
Fuelwood/ charcoal	Over 80% of the population (both rural and urban) relies on traditional biomass for cooking[6]. It is estimated that a typical household may consume 1-2 tonnes of fuelwood per year[4].
Fire	90% of dry season forest fires are caused by smallholders and industrial plantations clearing land for crops[5]. Climate change is exposing forests to a longer dry period, reducing forest productivity and resilience, and increasing the risk of fire[2].
Tree plantations	Over 100,000ha of ELCs allocated for pulp and paper plantations[3]. Outside ELCs, instances of conversion of natural forests to tree plantations by foreign aid programmes within the context of climate change mitigation have been reported (e.g. in Prey Long forest)[7].
Mining operations	The mining sector in Cambodia is considered not well developed and small scale[8]. Most mining concessions are in east and northeast Cambodia for metals, industrial minerals, energy and gemstones, with few in production[9]. Actual mining operations may have limited deforestation impact, but can be a source of illegal logging and forest degradation. Unlicensed artisanal gold mining operations are widespread and bring multiple social and environmental challenges[10].
Hydropower	As of 2019, seven dams are in operation with combined output of 4,700GWh in 2018, a more than 60% increase from 2017[11]. The latest and biggest Lower Sesean II dam, with reservoir size estimated at 7,500ha to 33,560ha, has caused large-scale destruction and community displacement via roads, reservoir and flooding[12, 13].
Road expansion	Presently not a major driver, road networks will become increasingly important. Cambodia has over 61,000km of road network, most of which is unpaved rural roads[14]. The proposed development of national roads, such as the Northern Sub-corridor (which runs through the deforestation from Bangkok, Thailand to Quinhon, Viet Nam, via Siem Reap, Cambodia), is projected to bring positive economic impact to northern Cambodia[15], but the negative effects of roads on forest cover have also been documented[16].

- Primary cause of forest loss and/or severe degradation
- Secondary cause of forest loss and/or severe degradation
- Less important cause of forest loss and/or severe degradation

Main outcomes

Protected areas are found to be representative of forests of biodiversity priority and high carbon density[28]. Lower deforestation rates are found inside protected areas than outside, but not all types are equally effective[16]. Allocation of social land concessions to poor landless families is linked to forest loss, but tenure security of local communities can be an effective strategy to reduce deforestation and forest degradation[29, 30]. Approximately one-third of forest loss nationwide between 2000 and 2016 may be attributable to ELCs[31], but the rate may be slowing due to moratoria on new concessions and cancellation of some ELCs[32]. Recent government efforts to tackle illegal logging and timber trade have sent positive signals about its commitment to improving resource governance.



Key responses

Protected areas	Protected areas have expanded significantly in Cambodia, totalling 7.5Mha (41% of country land cover)[22]. New protected areas totalling more than 62,000ha were established in 2018[23].
Recognition of IPLCs	Through social land concession allocation and land registration, increasing areas of forestland are being granted to poor landless households for residential use and farming. Additionally, the National Forest Programme (2010-2029) set a target to allocate 2Mha of production forest for establishing community forestry and to allow those living within protected areas to establish community protected areas[19].
Moratoria	Timber concessions for selective logging are effectively suspended[3]. The moratorium on granting new ELCs in 2012 increased the rate of forest loss inside existing ELCs in the short term due to the fear of concession licences being revoked[18]. The government has also postponed the construction of new hydropower dams on the Mekong River for 10 years[24].
Payment for ecosystem services (PES)	PES schemes are currently being implemented at small scale with some success in reducing deforestation[25]. Well-designed PES schemes have large potential as a vehicle for developing a green economy[25], but some of these PES projects face challenges including unclear legal frameworks and property rights and the lack of sustainable financing mechanisms[26].
REDD+ projects	The national REDD+ strategy was officially endorsed in 2017 and is at the core of Cambodia's nationally determined contributions (NDC) to the Paris Agreement. The REDD+ action and investment plan was drafted in 2019 and several pilots are now in place[27].
Timber legality	In earlier 2019, the government established a National Commission on Anti-Forest Crimes aiming to crack down on all illegal logging and timber trade across the country. As a result, a few ELCs have been confiscated and several high-profile illegal-logging perpetrators have been arrested and prosecuted.

Deployment at wider scale | Actively used and expanding | Project-specific, experimental

Recommended future actions

- Invest more resources in proper management with adequate capacity in protected areas.
- Promote spatial planning for land use at landscape level to better allocate land for economic development and conservation.
- Continue efforts to strengthen land management, forest governance and law enforcement.
- Improve agricultural productivity for smallholders to decouple population growth and deforestation[33].

References

1. Davis, K.F., Yu, K., Rulli, M.C., Pichdara, L., and D'Odorico, P. 2015. Accelerated deforestation driven by large-scale land acquisitions in Cambodia. *Nature Geoscience* 8(10): 772-775.
2. The Kingdom of Cambodia. 2017. *Cambodia National REDD+ Strategy 2017-2026.* redd.unfccc.int/files/20180813_national_redd__strategy_cambodia.pdf
3. Forest Trends. 2015. *Conversion Timber, Forest Monitoring, and Land-Use Governance in Cambodia.* www.forest-trends.org/wp-content/uploads/2015/07/Cambodia-Concessions-Report-small-size.pdf
4. Poffenberger, M. 2009. Cambodia's forests and climate change: Mitigating drivers of deforestation. *Natural Resources Forum* 33(4): 285-296.
5. Kong, R., Diepart, J.-C., Castella, J.-C., Lestrelin, G., Tivet, F., Belmain, E., and Bégué, A. 2019. Understanding the drivers of deforestation and agricultural transformations in the Northwestern uplands of Cambodia. *Applied Geography* 102: 84-98.
6. GERES. 2015. *Biomass Energy Consumption Patterns in Cambodia: Challenges and Opportunities.* Group for the Environment, Renewable Energy and Solidarity (GERES). www.eurocham-cambodia.org/uploads/85746-geres.pdf
7. Scheidel, A. and Work, C. 2018. Forest plantations and climate change discourses: New powers of 'green' grabbing in Cambodia. *Land Use Policy* 77: 9-18.
8. Open Development. 2015. Cambodia Mining. Available from: opendevelopmentcambodia.net/topics/mining [accessed 15 May 2020].
9. Ministry of Industry, Mines and Energy. 2013. *Current Situation of Mining Industry in Cambodia.* mric.jogmec.go.jp/public/kouenkai/2013-03/briefing_130315_02a.pdf
10. Spiegel, S.J. 2014. Rural place-making, globalization and the extractive sector: Insights from gold mining areas in Kratie and Ratanakiri, Cambodia. *Journal of Rural Studies* 36: 300-310.
11. Electricity Authority of Cambodia. 2019. *Report on power sector of the Kingdom of Cambodia. From Data for the Year 2018.* www.eac.gov.kh/site/viewfile?param=annual_report%2Fenglish%2FAnnual-Report-2018-en.pdf&lang=en
12. NASA. 2017. A new reservoir in Cambodia. NASA Earth Observatory. earthobservatory.nasa.gov/images/91761/a-new-reservoir-in-cambodia
13. International Rivers. n.d. Lower Sesan 2 Dam. Available from: www.internationalrivers.org/campaigns/lower-sesan-2-dam
14. Asian Development Bank. 2019. *Cambiodia Transport Sector Assessment, Strategy, and Road Map.* dx.doi.org/10.22617/TCS190449-2
15. Isono, I. 2019. Economic impact of new sub-corridor development in the Mekong region. In: M. Ishida (ed). *Cross-border Transport Facilitation in Inland ASEAN and the ASEAN Economic Community, ERIA Research Project Report FY2017 no.18*, pp 192-209. ERIA and IDE-JETRO, Jakarta, Indonesia.
16. Beauchamp, E., Clements, T., and Milner-Gulland, E.J. 2018. Exploring trade-offs between development and conservation outcomes in Northern Cambodia. *Land Use Policy* 71: 431-444.
17. Hak, S., McAndrew, J., and Neef, A. 2018. Impact of government policies and corporate land grabs on indigenous people's access to common lands and livelihood resilience in northeast Cambodia. *Land* 7(4): 122.
18. Oldenburg, C. and Neef, A. 2014. Reversing land grabs or aggravating tenure insecurity? Competing perspectives on economic land concessions and land titling in Cambodia. *Law and Development Review* 7(1): 49–77.
19. The Kingdom of Cambodia. 2010. *National Forest Program 2010-2029 Unofficial English Translation.* www.cdc-crdb.gov.kh/cdc/documents/Sector_Strategy/6_Forestry_Reform/National_Forest_Programme_2010_2029_Eng.pdf
20. Grogan, K., Pflugmacher, D., Hostert, P., Mertz, O., and Fensholt, R. 2019. Unravelling the link between global rubber price and tropical deforestation in Cambodia. *Nature Plants* 5.
21. Ingalls, M.L., Meyfroidt, P., To, P.X., Kenney-Lazar, M., and Epprecht, M. 2018. The transboundary displacement of deforestation under REDD+: Problematic intersections between the trade of forest-risk commodities and land grabbing in the Mekong region. *Global Environmental Change* 50: 255-267.
22. OpenDevelopment. 2016. Cambodia Protected Areas. [last accessed: 15 May 2020], available from: https://opendevelopmentcambodia.net/topics/protected-areas/.
23. WWF. 2018. WWF-Cambodia congratulates government on the designation of Sambo and Prasob as Wildlife Sanctuarie.
24. Thul, P.C. 2020. Cambodia halts mainstream Mekong River dam plans for 10 years, official says, available from: https://www.reuters.com/article/us-mekong-river-cambodia/cambodia-halts-mainstream-mekong-river-dam-plans-for-10-years-official-says-idUSKBN215187.
25. Chervier, C. and Costedoat, S. 2017. Heterogeneous Impact of a Collective Payment for Environmental Services Scheme on Reducing Deforestation in Cambodia. *World Development.*
26. S., Y. and S., V. 2019. *Payment for Ecosystem Services in Cambodia: Challenges and Potential.* In: S. M. and P., C. (eds), *Water and Power. Advances in Global Change Research 64.*
27. REDD+ Cambodia. nd. Cambodia REDD+ Programme. [last accessed: 13 May 2020], available from: =http://www.cambodia-redd.org/
28. Neugarten, R.A., Moull, K., Martinez, N.A., Andriamaro, L., Bernard, C., Bonham, C., ... Turner, W. 2020. Trends in protected area representation of biodiversity and ecosystem services in five tropical countries. *Ecosystem Services* 42: 101078.
29. Lambrick, F., Brown, N.D., Lawrence, A., and Bebber, D.P. 2014. Effectiveness of Community Forestry in Prey Long Forest, Cambodia. *Conservation Biology* 28(2): 372-381.
30. Singh, M., Evans, D., Chevance, J.-B., Tan, B.S., Wiggins, N., Kong, L., and Sakhoeun, S. 2018. Evaluating the ability of community-protected forests in Cambodia to prevent deforestation and degradation using temporal remote sensing data. *Ecology and Evolution* 8(20): 10175-10191.
31. Magliocca, N.R., Khuc, Q.V., de Bremond, A., and Ellicott, E.A. 2020. Direct and indirect land-use change caused by large-scale land acquisitions in Cambodia. *Environmental Research Letters* 15(2): 024010.
32. Sovannara, L. and Nan, T. 2015. *Community Land Registration and Economic Land Concessions in Mondulkiri Province. Parliamentary Institute of Cambodia.* https://www.pic.org.kh/images/2015Research/20160421_Community%20Land%20Registration%20and%20Economic%20Land%20Concessions%20in%20Mondulkiri%20Province_EN.pdf
33. Michinaka, T., Miyamoto, M., Yokota, Y., Sokh, H., Lao, S., and Ma, V. 2013. Factors Affecting Forest Area Changes in Cambodia: An Econometric Approach. *Journal of Sustainable Development* 6: 12-25.

LAOS

Laos maintains some of the largest remaining intact forests in mainland Southeast Asia, which are home to diverse species. People are heavily dependent on forests for food, water, energy and income. Surrounded by more economically advanced neighbours, the country is susceptible to external investment in the land and energy sectors driving deforestation.

Drivers of deforestation

Smallholder farming	Under contract farming schemes, large areas of forest are converted to annual crops (e.g. maize, cassava, sugarcane) and commercial perennial plantations (e.g. rubber, coffee, cacao, pepper) for regional and global markets[1]. Shifting cultivation practised by nearly 70% of Lao population drives forest degradation rather than deforestation[2]; however, fallow lands are more prone to conversion[3, 4]. When plantations are established on fallow lands, communities go further into forests to clear land for farming[5].
Large-scale agriculture	Rubber, sugarcane, biofuel and coffee are the major commodities in southern Laos[6]. Commercial agriculture is fragmented with average concession size under 500ha[7], often in areas relatively accessible from the nearest district capital[8]. In some cases, the granting of concessions has been used as a mechanism to circumvent the timber logging ban[9].
Tree plantations	Both concessions and smallholder plantations of fast-growing trees such as eucalyptus and acacia have been promoted[10], but contract farming is the main mechanism for establishing new plantations[11]. Approximately 0.5Mha of plantations have been established in Laos[6]. Legally, industrial tree plantations can be developed only on degraded or barren land, but in reality they are often established on forested land[12].
Hydropower	Several dam projects and power line construction have led to large-scale forest clearance. Displacement of communities by hydropower projects indirectly contributes to deforestation away from the project sites[11].
Transport infrastructure	Distance to main roads was one of the most important predictors of forest cover decrease between 2006 and 2012[4]. Laos has the least developed rail, waterway and road network in the region. More investment in transportation infrastructure, including major projects such as East-West Corridors, will have impact on forest cover change[13].
Mining operations	Mining is the most significant subsector in terms of total projects and area under investment (21% and 50% respectively)[8], though the forest area cleared for mining sites is much smaller than the concession area. Estimated 5,000ha-14,000ha deforestation by mining per year, with both large-scale and artisanal mining contributing[7].
Logging	Commercial logging as a driver may be declining in recent years due to stricter law enforcement[1,14], but logging for household consumption has increased as rural population grows[2]. Despite stricter law enforcement, illegal logging remains widespread, often carried out by local villagers who may work as hired laborers for Vietnamese traders or by concession holders who clear forest beyond their premises[15].
Fuelwood and charcoal	Mostly for subsistence consumption but also for local and regional markets through vast web of informal networks[16].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Countries, region	Laos, Lower Mekong
Forest type	Humid tropical evergreen forests
Total area	3.6 Mha
Forest area in 2018	2.8Mha (79.1% of total deforestation front area)
Forest loss 2004-2017	0.1Mha (3.0% of forest area in 2000)
Location of deforestation	Central and southern Laos
Total forest core area in 2018	1.7Mha (59.8% of forests in 2018)
Fragmented forests 2000-2018	0.3Mha (8.7% of forest area in 2000)
Accumulated burned area, 2002-2019	0.5Mha (16.2% of forest area in 2000)
Deforestation trend	Increasing – upward trends till 2016, stabilization since then
Future trends	Deforestation rate gradually stabilizing, but remaining relatively high

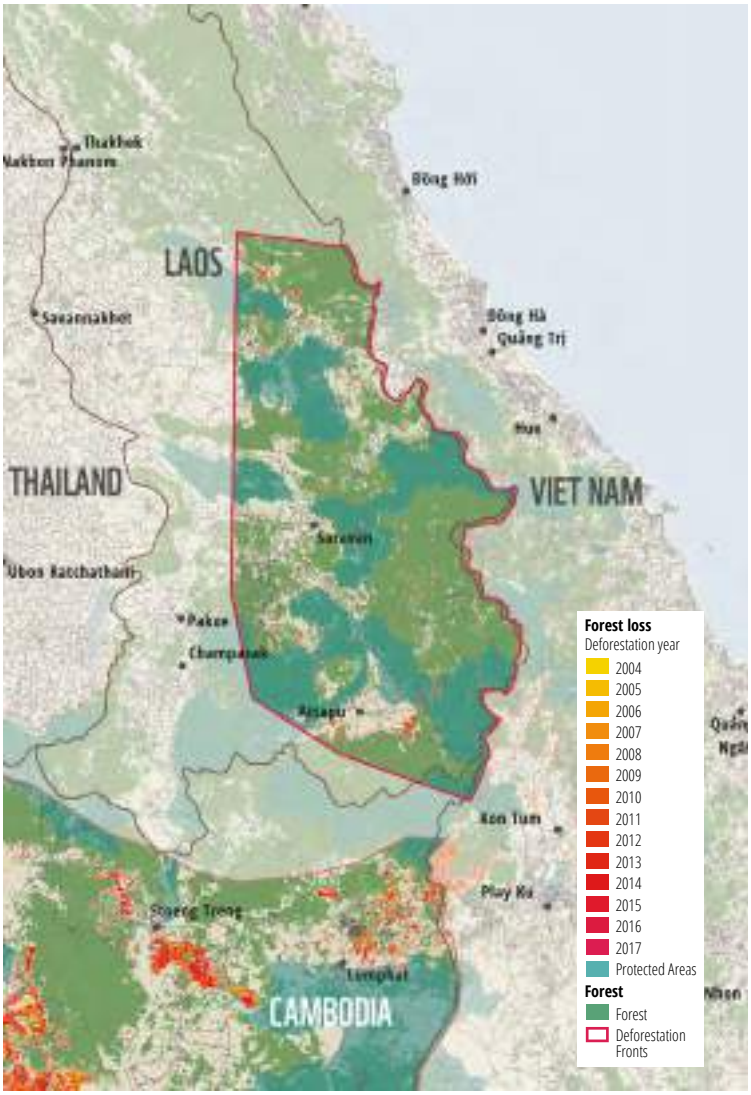
Responses

Protected areas	The 2007 Forest Law classifies two types of forest for protection – protection forests (for ecosystem services) and conservation forests (for nature and biodiversity)[19]. Laos has 24 national protected areas[20] but no complete inventory exists for provincial or district protected areas. IUCN-registered protected areas cover 3.86Mha (16.7% of land area)[21].
Tenure rights	Customary tenure rights associated with shifting cultivation exist in most rural, mountainous areas. A land titling programme funded by donor agencies in the 1990s and 2000s sought to promote land rights by delineating village boundaries and developing village land management plans[6].
Timber legality	Laos banned log exports in 2016[14] and has made steady progress in negotiating EU FLEGT/VPA[22]. Stricter legality enforcement is overall positive, but there are also strong signs of leakage effects from Viet Nam[9].
Land-use zoning	Numerous programmes actively support land-use planning, including a new initiative to in villages around Xe Sap protected area in the south of Laos[23].
REDD+ projects	REDD+ projects in Laos are mostly small-scale, early stage pilots[24].
Voluntary standards	Limited uptake of forest certification; however, a nationwide decade-long effort to promote the development of forest management plans at village level helps the first step of putting sustainable harvesting into practice
Rural livelihoods development	Numerous sustainable livelihoods projects/ programmes led by government, local civil society organizations and international NGOs.

Deployment at wider scale
Actively used and expanding
Project-specific, experimental

Underlying causes

The proximity to Viet Nam and Thailand, major regional and global hubs for commodity processing, makes the country susceptible to external investment in the land and energy sectors driving deforestation. Poverty coupled with heavy reliance on natural resources for both livelihoods and national economy put strain of forests[17]. Forest laws and policies are well designed, but lack of capacity and institutional inefficiencies at multiple levels hamper their implementation and enforcement[18].



Main outcomes

Two out of Laos' three protected area categories have a negligible impact on deforestation, while the strictest protection category has reduced deforestation rates by 24 to 33%; however, many PAs are not in biodiversity priority areas[25]. Formalization of customary tenure rights has the benefit of empowering rural communities, but has also led to loss of access to land by those practising shifting cultivation[26], granting of large concessions to companies from neighbouring countries and escalating land conflicts[27]. Strengthening timber legality may have short-term effects on reducing illegal logging and timber trade, curbing deforestation[28]. Small-scale REDD+ projects have not been effective due to omission of high deforestation potential areas and inability to address main drivers[29].

Recommended future actions

- Promote landscape-level land-use planning that includes mapping and strengthening of the management plan of high conservation value forests.
- Establish community-based economic development models in protected area buffer zones that include equitable benefit sharing from ecosystem services provision.
- Scale up improved plantation forest management and sustainable supply chains of timber and other forestry products (e.g. rubber), with the use of forest certification wherever feasible.

References

1. Tuan, D.A. 2015. *USAID Lowering Emissions in Asia's Forests (USAID LEAF): Drivers of Forest Change in the Greater Mekong Subregion – Vietnam Country Report*. www.leafasia.org/sites/default/files/resources/Vietnam%20Final-Revised-Nov2015.pdf
2. Lestrelin, G., Trockenbrodt, M., Phanvilay, K., Thongmanivong, S., Vongvisouk T, Pham, T., and Castella, J.-C. 2013. *The context of REDD+ in the Lao People's Democratic Republic: Drivers, agents and institutions*. CIFOR, Bogor, Indonesia. www.cifor.org/publications/pdf_files/OccPapers/OP-92.pdf
3. Baird, I. 2014. Degraded forest, degraded land and the development of industrial tree plantations in Laos. *Singapore Journal of Tropical Geography* 35: 328-344.
4. Phompila, C., Lewis, M., Ostendorf, B., and Clarke, K. 2017. Forest cover changes in Lao tropical forests: Physical and socio-economic factors are the most important drivers. *Land* 6(2): 23.
5. Meyfroidt, P., Vu, T.P., and Hoang, V.A. 2013. Trajectories of deforestation, coffee expansion and displacement of shifting cultivation in the Central Highlands of Vietnam. *Global Environmental Change* 23(5): 1187-1198.
6. Hurni, K. and Fox, J. 2018. The expansion of tree-based boom crops in mainland Southeast Asia: 2001 to 2014. *Journal of Land Use Science* 13(1-2): 198-219.
7. Thomas, I.L. 2015. *USAID Lowering Emissions in Asia's Forests (USAID LEAF): Drivers of Forest Change in the Greater Mekong Subregion – Lao PDR Country Report*. www.leafasia.org/sites/default/files/resources/Lao%20PDR%20Final-Revised-Nov2015.pdf
8. Schönweger, O., Heinimann, A., Epprecht, M., Lu, J., Thalongsengchanh, P., and Bernensia, G. 2012. *Concessions and leases in the Lao PDR: taking stock of land investments*. Center for Development and Environment (CDE) data. opendevelopmentmekong.net/library_record/concessions-and-leases-in-the-lao-pdr-taking-stock-of-land-investments
9. Ingalls, M.L., Meyfroidt, P., To, P.X., Kenney-Lazar, M., and Epprecht, M. 2018. The transboundary displacement of deforestation under REDD+: Problematic intersections between the trade of forest-risk commodities and land grabbing in the Mekong region. *Global Environmental Change* 50: 255-267.
10. Chanthalath, X., Yong, L., Beckline, M., and Inthilath, S. 2017. Assessing the socioecological perspectives of eucalyptus cultivation and plantation expansion in Laos. *Open Access Library Journal* 4: 1-15.
11. Ingalls, M.L., Diepart, J.-C., Truong, N., Hayward, D., Neil, T., Phomphakdy, C., ... Tagliarino, N. 2018. *State of Land in the Mekong Region*. Centre for Development and Environment, University of Bern, Switzerland and Mekong Region Land Governance, Vientiane, Lao PDR. doi.org/10.7892/boris.120285
12. Forest Trends. 2011. *Baseline study 2, LAO PDR: Overview of Forest Governance, Markets and Trade for FLEGT Asia Regional Programme*. www.researchgate.net/publication/277714187_BASELINE_STUDY_2_LAO_PDR_Overview_of_Forest_Governance_Markets_and_Trade
13. Open Development Mekong. 2019. Infrastructure. Available from: opendevelopmentmekong.net/topics/infrastructure
14. To, P.X., Treanor, N.B., and Canby, K. 2017. *Impacts of the Laos Log and Sawnwood Export Bans: Significant Reductions in the Exports to Major Markets of Vietnam and China in 2016*. Forest Trends, Washington, DC, USA. www.forest-trends.org/wp-content/uploads/imported/Laos%20Export%20Ban%20Final.pdf.
15. Environmental Investigation Agency. 2011. *Crossroads: The Illicit Timber Trade Between Laos and Vietnam*. Environmental Investigation Agency, London. landportal.org/library/resources/mlrf1613/crossroads-illicit-timber-trade-between-laos-and-vietnam
16. Barney, K. 2016. Sparking development or consuming the countryside? Lao charcoal commodity networks in the Mekong Region. *Asia Pacific Viewpoint* 57(2): 194-206.
17. Boillat, S., Dao, H., Bottazzi, P., Sandoval, Y., Luna, A., Thongmanivong, S., ... Giraut, F. 2015. Integrating Forest Cover Change with Census Data: Drivers and Contexts from Bolivia and the Lao PDR. *Land* 4(1): 45-82.
18. Gritten, D., Lewis, S.R., Breukink, G., Mo, K., Thuy, D.T.T., and Delattre, E. 2019. Assessing forest governance in the countries of the Greater Mekong subregion. *Forests* 10(1): 47.
19. Forest Legality Initiative. Lao PDR.
20. Ministry of Natural Resources and the Environment (MoNRE). 2016. *National Biodiversity Strategy and Action Plan for Lao PDR 2016-2025*. Vientiane, Lao PDR. www.cbd.int/doc/world/la/la-nbsap-v2-en.pdf
21. IUCN. Protected Planet Database. Lao PDR.
22. European Council. 2018. EU and Vietnam sign an agreement for better enforcement of forest law, governance and trade. www.consilium.europa.eu/en/press/press-releases/2018/10/19/eu-and-vietnam-sign-an-agreement-for-better-enforcement-of-forest-law-governance-and-trade
23. WWF. 2016. CARBI project. greatermekong.panda.org/our_solutions/projects/carbi
24. Dwyer, M.B. and Ingalls, M. 2015. *REDD+ at the crossroads Choices and tradeoffs for 2015–2020 in Laos*. Center for International Forestry Research (CIFOR) Bogor, Indonesia. www.cifor.org/publications/pdf_files/WPapers/WP179Dwyer.pdf.
25. Kukkonen, M.O. and Tammi, I. 2019. Systematic reassessment of Laos' protected area network. *Biological Conservation* 229: 142-151.
26. FAO and MRLG. 2019. *Challenges and opportunities of recognizing and protecting customary tenure systems in the Lao People's Democratic Republic*. FAO and MRLG, Bangkok, Thailand. www.fao.org/3/CA1035EN/ca1035en.pdf
27. Baird, I.G. 2019. Problems for the plantations: Challenges for large-scale land concessions in Laos and Cambodia. *Journal of Agrarian Change* 20(3): 387-407.
28. Lewin, A., Mo, K., Scheyvens, H., and Gabai, S. 2019. Forest certification: More than a market-based tool. Experiences from the Asia Pacific region. *Sustainability* 11(9): 2600.
29. Ramcilovic-Suominen, S. 2019. REDD+ as a tool for state territorialization: managing forests and people in Laos. *Journal of Political Ecology* 26.

MYANMAR

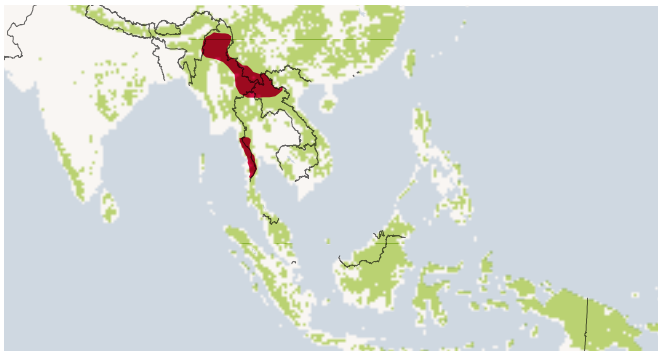
The forests of Myanmar are home to incredible biodiversity, including important tiger and Asian elephant populations. But from 2010 to 2015 Myanmar had the third highest annual net loss of forest area in the world, losing an average of half a million hectares of forest every year. Agricultural conversion, logging and infrastructure development threaten the forests that millions of people rely on directly for their livelihoods.

Drivers of deforestation

Large-scale agriculture	Common crops (rice, nut trees, maize, rubber and oil palm[1]) were responsible for 1Mha of forest conversion between 2002 and 2014[2]. Most large-scale agriculture concessions were allocated in forest reserves[3] mainly in Kachin and Tanintharyi, in heavily forested and politically contested regions[4]. Rubber and oil palm plantations are both concentrated in the south, and suffer from low productivity and lack of oversight. Less than half of rubber plantations are tapped[5]; one-third of plantations are planted outside concession boundaries[6]. Logging is a motivation for companies to acquire agricultural concessions (legal conversion)[7]. Based on the government's new economic policy and spatial modelling of cropland expansion, forest conversion for agricultural production is expected to increase[8].
Logging	Legal and illegal logging are leading causes of forest degradation, but can also be linked to deforestation. Logging in excess of annual allowable cut is common[9] and illegal logging increased significantly after legal logging[1]. A large proportion of logs exported from Myanmar into global markets are illegal, mostly transported by land from Kachin state to China[10] as well as to Thailand and Viet Nam[11].
Smallholder farming	Progressive shift from smallholder farming (1975-1990) to industrial plantations (post-2000)[12]. Shifting cultivation's significance has decreased since 2000 and is expected to decrease further[13]. In southern Myanmar, the traditional practice of shifting cultivation has mostly disappeared, but establishment of permanent orchards by smallholders has increased.
Hydropower	Between 2002 and 2014, 140,000ha forests were affected by hydropower development, with an additional 250,000ha potentially affected by planned projects[14]. Logging in anticipation of proposed dam projects is also common (legal conversion)[7]. Some projects have been suspended due to public outcry over environmental and social impacts (e.g. Myitsone Dam in Kachin state would inundate 76,600ha of forest)[15].
Mining	90,000ha of potential mining sites identified (including 52,000ha operating sites), mostly in the north (Kachin, Sagaing). Significant expansion in 2002-2015 and new mining legislation intends to encourage more foreign investment[16].
Fuelwood and charcoal	85% of Myanmar's population depends on wood and charcoal for fuel. Annual fuelwood extraction increased from 68 million m3 to 86 million m3 between 2000 and 2013[13]. Increase in rural settlement areas has led to greater demand for fuelwood in nearby forest[17]. Additionally, charcoal export to China increased by more than 2,500%[18].
Transport infrastructure	Road infrastructure tends to be poorly planned and designed, which has contributed directly to forest loss and soil degradation[19]. In Kachin and Shan states, road construction has been followed by the establishment of rubber concessions[20].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Countries, region	Myanmar, Lower Mekong
Forest type	Evergreen and semi-evergreen forest
Total area	34.5Mha
Forest area in 2018	28.4M ha (82.4% of total deforestation front area)
Forest loss 2004-2017	1.0Mha (3.5% of forest area in 2000)
Location of deforestation	North (Kachin and Shan States); south (Tanintharyi)
Total forest core area in 2018	17.7Mha (62.2% of forests in 2018)
Fragmented forests 2000-2018	1.6Mha (5.4% of forest area in 2000)
Accumulated burned area, 2002-2019	5.9Mha (20.2% of forest area in 2018)
Deforestation trend	Increasing, oscillating annually but steady upward trend
Future trends	Continued expansion, with possibility of slowing down if nationwide actions are taken



Underlying causes

Overlapping and conflicting priorities and agendas by the forestry and agriculture sectors and weak tenure security are main causes[21, 22]. Political and military conflicts are linked to lower deforestation in conflict areas, but result in higher deforestation elsewhere due to displacement of communities and lack of law enforcement. Deforestation also increased following the ceasefire[8]. Domestic, regional and global demand for natural resources, energy and commodities, especially from China, also puts pressure on forests.

Main outcomes

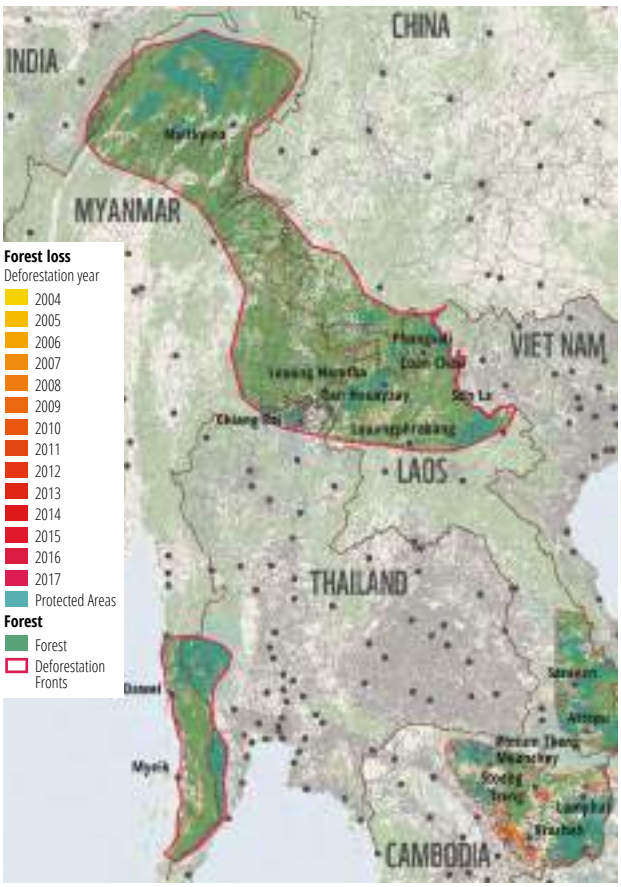
Area-based interventions can be effective when adequately implemented, but are hampered by the lack of coordination across different government agencies and sectors. Sector-based interventions are only emerging so their effectiveness remains to be seen.

Recommended future actions

- Implement zero-deforestation supply chain commitments for rubber and other commodities.
- Promote timber legality and community forestry.
- Strengthen and scale up land-use planning that incorporates enforcement, community-based support, private sector investment and spatial monitoring.

Key responses

Protected areas	The Myanmar government has a target of formally designating 10% of the country's area for its protected area system[23] (current 6.35% or 4.27Mha[24]). Preliminary evidence suggests forest loss is lower inside national parks than in surrounding areas[8, 25].
Recognition of IPLCs	The 2012 Farmland Law allows farmland cultivation rights to be attained and traded through land-use certificates, but only 15% of households obtain the certificates[22]. Also ongoing efforts to establish community forestry with 3,840 groups covering 217,000ha formed by 2017, with mixed results[26].
Land-use zoning	Inactive concessions on forest reserves with intact forest cover were cancelled under the Vacant, Fallow and Virgin Land Law and efforts to secure remaining HCV forests have been initiated[27]. Multiple international environmental NGOs are engaged in Tanintharyi to help devise land-use planning taking into consideration natural capital and species conservation as well as social needs[28].
REDD+ related initiatives	The government began implementing its UN-REDD national programme in 2016[29]. The government has also proposed to reduce deforestation by 50% and restore 900,000ha by 2030 (pending for final approval) as part of its nationally determined contribution (NDC) under UNFCCC.
Timber legality	Log export ban enacted since 2014, yet cross-border trade with China has continued, especially for high value species[30]. Voluntary partnership agreement (VPA) negotiations with the EU began in 2013 with ongoing progress in capacity building for civil society and development of timber legality assurance systems[31]. Engagement of civil society has potential to address underlying causes of deforestation[32].
Traceability of supply	Myanmar joined the Extractive Industries Transparency Initiative (EITI) in 2014, covering mining and timber sectors. It has achieved "meaningful progress" status[33] but it is too soon to tell if this will have measurable impacts on deforestation. The Global Platform for Sustainable Natural Rubber was launched as a multistakeholder platform to, among other objectives, increase supply chain transparency and traceability[34].



Deployment at wider scale | Actively used and expanding | Project-specific, experimental

References

1. Connette, G., Oswald, P., Songer, M., and Leimgruber, P. 2016. Mapping distinct forest types improves overall forest identification based on multi-spectral landsat imagery for Myanmar's Tanintharyi region. *Remote Sensing* 8(11): 882.
2. Treue, T., Springate-Baginski, O., and Htun, K. 2016. *Legally and Illegally Logged out: Extent and Drivers of Deforestation & Forest Degradation in Myanmar*. EcoDev/ALARM. alarmmyanmar.org/pdf/Extent%20and%20Drivers%20of%20deforestation%20and%20Forest%20Degradation%20in%20Myanmar.pdf
3. Oo, T.N., Hlaing, E.E.S., Aye, Y.Y., Chan, N., Maung, N.L., Phyoe, S.S., ... San, S.M. 2020. *The context of REDD+ in Myanmar: Drivers, agents and institutions*. CIFOR, Bogor, Indonesia. doi.org/10.17528/cifor/007556.
4. Donald, P.F., Round, P.D., Dai We Aung, T., Grindley, M., Steinmetz, R., Shwe, N.M., and Buchanan, G.M. 2015. Social reform and a growing crisis for southern Myanmar's unique forests. *Conservation Biology* 29(5): 1485-1488.
5. van Asselt, J., Htoo, K., and Dorosh, P. 2017. *Prospects for the Myanmar Rubber Sector: An Analysis of the Viability of Smallholder Production in Mon State*. IFPRI, Washington DC, USA. ssrn.com/abstract=2926007
6. Nomura, K., Mitchard, E.T.A., Patenaude, G., Bastide, J., Oswald, P., and Nwe, T. 2019. Oil palm concessions in southern Myanmar consist mostly of unconverted forest. *Scientific Reports* 9(1): 11931.
7. Woods, K. 2015. *Commercial Agriculture Expansion in Myanmar: Links to Deforestation, Conversion Timber, and Land Conflicts*. Forest Trends, Washington, DC, USA. www.forest-trends.org/wp-content/uploads/2015/03/Conversion_Timber_in_Myanmar-1.pdf
8. Zhang, Y., Prescott, G.W., Tay, R.E., Dickens, B.L., Webb, E.L., Htun, S., ... Carrasco, L.R. 2018. Dramatic cropland expansion in Myanmar following political reforms threatens biodiversity. *Scientific Reports* 8(1): 16558.
9. Springate-Baginski, O., Treue, T., and Htun, K. 2015. *Beyond over-logging? From military era timber exploitation towards democratic and sustainable forest governance*. EcoDev/ALARM. alarmmyanmar.org/pdf/Beyond%20over-logging%20policy%20brief.pdf
10. EIA. 2019. *State of Corruption: The top level conspiracy behind the global trade in Myanmar's stolen teak*. Environmental Investigation Agency. eia-international.org/wp-content/uploads/EIA-report-State-of-Corruption.pdf
11. Cao, N.A. 2017. *Timber Trafficking in Vietnam*. Palgrave Macmillan.
12. Nicholas, K., Fanzo, J., and MacManus, K. 2018. Palm iol in Myanmar: A spatiotemporal analysis of the effects of industrial farming on biodiversity loss. *Global Health: Science and Practice* 6(1): 210-222.
13. UN-REDD/Myanmar Program. 2017. *Drivers of deforestation and forest degradation in Myanmar*. www.myanmar-redd.org/wp-content/uploads/2017/10/Myanmar-Drivers-Report-final_Eng-Version.pdf.
14. IFC. 2017. *Strategic Environmental Assessment (SEA) of the Hydropower Sector: Baseline Assessment Reports. Yangon and Nay Pyi Taw, Myanmar*. International Finance Corporation, Washington DC, USA. documents.worldbank.org/curated/en/126001548867293771/pdf/134197-WP-MM-v1-SEA-Baseline-Assessment-Introduction-PUBLIC.pdf
15. Lim, C.L., Prescott, G.W., De Alban, J.D.T., Ziegler, A.D., and Webb, E.L. 2017. Untangling the proximate causes and underlying drivers of deforestation and forest degradation in Myanmar. *Conservation Biology* 31(6): 1362-1372.
16. Connette, K., Connette, G., Bernd, A., Phyo, P., Aung, K., Tun, Y., ... Songer, M. 2016. Assessment of mining extent and expansion in Myanmar based on freely-available satellite imagery. *Remote Sensing* 8: 912.
17. Sein, C.C., Aye, Z.M., and Razafindrabe, B.H.N. 2015. Study on consumption of fuel wood and its impacts to forest resources in Taungyi District. *Global Science Research Journal* 3(2): 43–51.
18. Forest Trends. 2014. *Analysis of the China-Myanmar Timber Trade*. Forest Trends, Washington DC, USA. www.forest-trends.org/publications/analysis-of-the-china-myanmar-timber-trade
19. Helsingen, H., Myint, S.N.W., Bhagabati, N., Dixon, A., Olwero, N., Kelly, A., and Tang, D. 2015. *A better road to Dawei: protecting wildlife, sustaining nature, benefitting people*. WWF, Yangon, Myanmar. d2ouvy59p0dg6k.cloudfront.net/downloads/wwfmmr_betterroadtodawei.pdf
20. Kramer, T. and Woods, K. 2012. *Financing Dispossession – China's Opium Substitution Programme in Northern Burma*. Transnational Institute. www.tni.org/my/node/1308
21. Prescott, G.W., Sutherland, W.J., Aguirre, D., Baird, M., Bowman, V., Brunner, J., ... Webb, E.L. 2017. Political transition and emergent forest-conservation issues in Myanmar. *Conservation Biology* 31(6): 1257-1270.
22. Scurrah, N., Hirsch, P., and Woods, K. 2015. The political economy of land governance in Myanmar. In: *Land grabbing, conflict and agrarian environmental transformations: perspectives from East and Southeast Asia*. Chiang Mai University.
23. Ministry of Environmental Conservation and Forestry (MOECAF). 2011. *The Republic of the Union of Myanmar: National Biodiversity Strategy and Action Plan*. Ministry of Environmental Conservation and Forestry (MOECAF), Naypyidaw, Myanmar.
24. IUCN. 2020. IUCN Protected Planet Database. Available from: www.protectedplanet.net/country/MM
25. Connette, G.M., Oswald, P., Thura, M.K., LaJeunesse Connette, K.J., Grindley, M.E., Songer, M., ... Mulcahy, D.G. 2017. Rapid forest clearing in a Myanmar proposed national park threatens two newly discovered species of geckos (Gekkonidae: Cyrtodactylus). *PLOS ONE* 12(4): e0174432.
26. Erni, C. 2018. *Indigenous peoples, land rights and forest conservation in Myanmar*. IWGIA and POINT, Yangon, Myanmar. www.iwgia.org/images/documents/Books/Indigenous%20peoples,%20land%20rights%20and%20forest%20conservation%20in%20Myanmar.pdf.
27. Baskett, J.P.C. 2016. *Myanmar oil palm plantations: A productivity and sustainability review; Report no. 28 of the Tanintharyi Conservation Programme, a joint initiative of Fauna & Flora International and the Myanmar Forest Department*. Available from: www.supplychainge.org/fileadmin/reporters/all_files/Myanmar-Oil-Palm-Plantations-productivity-and-sustainability-review-en.pdf
28. Myanmar's Natural Capital. Available from: www.myanmarnaturalcapital.org/en/natural-capital
29. REDD+ Myanmar. Available from: www.myanmar-redd.org/redd-myanmar/about-redd-myanmar
30. EIA. 2015. *Organised Chaos: The illicit overland timber trade between Myanmar and China*. Environmental Investigation Agency.
31. EU Flegy Facility. 2020. Myanmar Progress. Available from: www.euflegt.efi.int/activities-myanmar [accessed 11 August 2020]
32. EIA. 2018. *Forest Governance in Myanmar*. Environmental Investigation Agency. eia-international.org/report/forest-governance-in-myanmar
33. Extractive Industries Transparency Initiative (EITI). 2020. Myanmar Overivew. Available from: eiti.org/myanmar#assessment-card-progress-by-requirement [accessed 11 August 2020].
34. Global Platform for Sustainable Natural Rubber (GPSNR). 2020. About GPSNR. Available from: www.gpsnr.org

SUMATRA

The island of Sumatra has a long history of human intervention and comprises a diversity of land uses involving smallholder farming and large-scale plantations for palm oil and pulpwood production. Much of the population is rural but there is increasing urbanization and infrastructure expansion. A significant portion of Sumatra's natural forests have been lost since the mid-1980s.

Drivers of deforestation

Large-scale oil palm plantations	Expansion of oil palm plantations (8Mha) has been another important deforestation driver in both logged forests and peatlands[1]. Palm oil processors have more processing capacity than they can supply from their own plantations, so the industry relies on third party suppliers including 'independent smallholders'[1] without having full traceability to raw material origins.
Tree plantations	Natural forest clearance to produce pulp and develop pulpwood plantations has been one of the main drivers of deforestation in Sumatra, with Riau province having the highest area of pulpwood plantation concessions (4.8Mha)[1]. There is a gap between wood supply from existing plantations and existing and planned milling capacity[4], exacerbated by extensive forest/land fires in 2015, and the industry continues to be involved in deforestation.
Smallholder farming	Linked to a significant increase in 'independent smallholder'supplying palm oil[5, 6]. Often these farmers face several constraints to adopt improved production practices[7].
Fires	Fires are often used to clear land after deforestation before planting crops or developing plantations[8]. Use of fires is problematic, especially on Sumatra's deforested peatlands that are drained by the pulp and paper and palm oil industries to maintain their plantations and made vulnerable to being burnt for a long time[9].
Road expansion	There is an expanding network of local roads, and the completion of the Trans-Sumatra Highway could threaten three critical areas of remnant forests by facilitating human incursions[10].
Mining operations	There are several large-scale mining operations, along with small-scale coal mining[11] and small-scale gold mining, e.g. in West Sumatra. These operations tend to place indirect pressures on forests[12].
Commercial logging	Encroachment and illegal logging in retired logging concessions has decreased but still occurs. Localized illegal logging at smaller scales is difficult to stamp out[13].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Underlying causes are related to business and government emphasis on using natural resources as the main driver of economic development, which results in land allocation for plantations and mining. These activities are associated with speculative land occupation and increased rural population pressure. A related issue is the lack of incentive systems for local stakeholders to protect their forests.

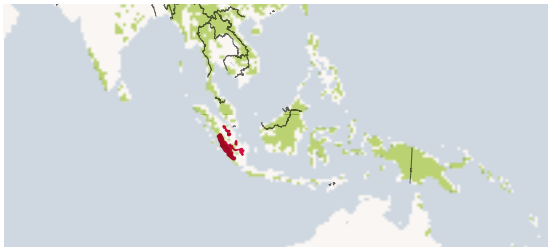
Countries, region	Sumatra island, Indonesia
Forest type	Humid tropical forests
Total area	14.3Mha
Forest area in 2018	7.7Mha (54.0% of total deforestation front area)
Forest loss 2004-2017	2.5Mha (25.2% of forest area in 2000)
Location of deforestation	Deforestation is more active in the central eastern and northeastern portions of the island, particularly in Riau province[1]
Total forest core area in 2018	3.6Mha (46.4% of forests in 2018)
Fragmented forests 2000-2018	1.4M ha (14.4% of forest area in 2000)
Accumulated burned area, 2002-2019	0.6Mha (6.5% of forest area in 2018)
Deforestation trend	Deforestation persists but has tended to stabilize, with oscillations, in the last few years. According to official estimates, deforestation in Sumatra was higher between 2006-09 and increased again in 2015, but has decreased since[2, 3]. Only 20% of Indonesian deforestation in 2017-18 was in Sumatra[3].
Future trends	Deforestation of the last remaining forests will continue but likely following a downward trend over time

Main outcomes

Protected areas have not been effective in halting deforestation across the region given their limited coverage, and their exposure to encroachment[25]. The moratorium on new permits for the conversion of primary forest and peatlands[15] and the more recent moratorium on the conversion of peatlands have contributed to reducing deforestation and pressure on peatlands[26, 27]. Voluntary zero-deforestation commitments by palm oil companies have been inadequate in preventing deforestation since they exclude a number of medium-size plantations, and have limited influence on the performance of smallholders[28] – indeed, a lack of plantation traceability means smallholders and their risks are not even identified. Companies have not restored peatlands despite the legal requirements, which have also recently been revoked[29].

Recommended future actions

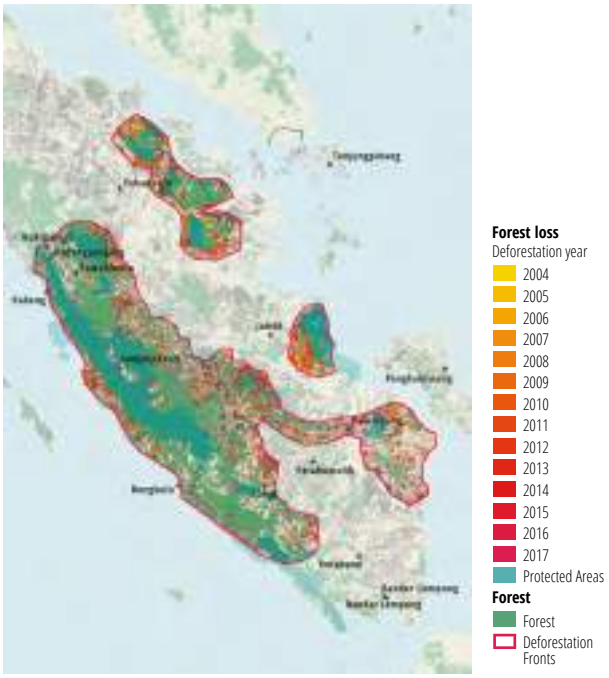
- Improve alignment between government policies and global market trends and efforts to curb emissions from land-use change and deforestation.
- Ensure that government policies to stop deforestation and conversion and restore peatlands are more strongly implemented and followed by commercial actors in the field.
- Strengthen coordination between key stakeholders across sectors as well as national and provincial governments to ensure that plantation expansion into forest areas and peatlands is being constrained at all levels.
- Enhance monitoring of zero deforestation commitments made by major producers, buyers and investors while ensuring greater transparency and disclosure of progress.
- Expand efforts to support smallholders to implement best management practices and access finance and premiums markets.
- Develop partnerships to link corporate actors and government bodies to advance sustainable supply and conservation, embracing wider landscape approaches.



Key responses

Protected areas	Most parks and reserves are found on the island's mountain ridge, but few cover its vast low-lying areas and peat swamps. Total protected area in Sumatra covers 11Mha[14].
Moratoria	To regulate forest conversion, the government issued a moratorium on new conversion permits in primary forests and peatlands in 2011[15], and in 2016 enacted a moratorium banning expansion in peatlands[16]. In 2018, the president enacted a moratorium on new oil palm plantation licences for three years and a review of existing palm oil company licences.
Land use zoning	Some provincial governments have developed land-use plans that guide land allocation decisions and green growth plans, e.g. in Aceh[17] and South Sumatra[18].
Fire management	Measures to prevent fire have been associated with the moratorium on peatlands as well as with regulations and efforts towards peatland restoration and greater enforcement[19].
Voluntary standards	The largest palm oil corporate groups embraced Roundtable on Sustainable Palm Oil (RSPO) certification and deforestation-free commitments, yet their involvement in deforestation continues due to difficulties in putting in place traceability systems for their third-party suppliers[14]. Forest concessions have embraced reduced-impact logging practices and forest certification[12]. The largest pulp and paper companies have been disassociated by the Forest Stewardship Council (FSC) and have not yet eliminated deforestation from ther supply chains[1].
Mandatory standards	The government of Indonesia introduced the Indonesian Sustainable Palm Oil (ISPO, in 2011) scheme and Timber Legality Assurance System (SVLK, in 2009) as mandatory certification for all commercial plantation operators. The latter was recognized as the basis of the EU voluntary partnership agreement (VPA) that came into effect in 2014[20]. However, both are only legality standards and do not guarantee chain of custody or zero deforestation.
REDD+ projects	21 REDD+ projects were identified by UN-REDD by 2013 with a varied focus on rehabilitation of mangroves, peatland restoration, ecosystem restoration and others[21].
Traceability of supply	Key corporate groups with plantations in Sumatra have recently committed to zero deforestation, yet following different approaches and timelines[22]. Some corporate groups are individually progressing in putting in place traceability systems, and a coalition of palm oil producers and buyers are implementing a monitoring system labelled RADD (Radar Alerts for Detecting Deforestation)[23]. Major pulp and paper companies have better plantation traceability, but are not fully transparent.
Sustainable finance	Several specific projects and initiatives have been implemented at the municipal level to support sustainable supply, accompanied by efforts to de-risk investments[24].

Deployment at wider scale | Actively used and expanding | Project-specific, experimental



References

1. Eyes on the Forest. 2020. Sumatra, Eyes on the Forest. Jikalahari, Walhi, WWF, available from: http://maps.eyesontheforest.or.id/.
2. MoEF. 2016. *National Forest Reference Emission Level for Deforestation and Forest Degradation: In the Context of Decision 1/CP.16 para 70 UNFCCC (Encourages developing country Parties to contribute to mitigation actions in the forest sector), Directorate General of Climate Change*. The Ministry of Environment and Forestry, Jakarta, Indonesia.
3. KLHK. 2019. *Deforestasi Indonesia Tahun 2017-2018*. Kementerian Lingkungan Hidup dan Kehutanan, Jakarta, Indonesia.
4. Christopher Barr, Fitri, A., Silvius, M., Supartinah, W., Cassady, G., and Fitra, S. 2016. 'Too Little, Too Late' from APP on Sustainability. [last accessed: Feb. 29, 2020], available from: https://www.triplepundit.com/story/2016/too-little-too-late-app-sustainability/22526.
5. Jelsma, I., Woittiez, L., Jean, O., and Dharmawan, A. 2019. Do wealthy farmers implement better agricultural practices? An assessment of implementation of Good Agricultural Practices among different types of independent oil palm smallholders in Riau, Indonesia. *Agricultural Systems* 170.
6. Bosc, P.-M. and Gaillard, C. 2018. *Understanding smallholders in oil palm cultivation: a case study from Sumatra*. pp 361-382.
7. Schoneveld, G.C., van der Haar, S., Ekowati, D., Andrianto, A., Komarudin, H., Okarda, B., . . . Pacheco, P. 2019. Certification, good agricultural practice and smallholder heterogeneity: Differentiated pathways for resolving compliance gaps in the Indonesian oil palm sector. *Global Environmental Change* 57: 101933.
8. Purnomo, H., Shantiko, B., Sitorus, S., Gunawan, H., Achdiawan, R., Kartodihardjo, H., and Dewayani, A.A. 2017. Fire economy and actor network of forest and land fires in Indonesia. *Forest Policy and Economics* 78: 21-31.
9. CAMS. 2019. The Copernicus Atmosphere Monitoring Service tracks extent and pollution from fires across Indonesia. [last accessed: Feb. 29, 2020], available from: https://atmosphere.copernicus.eu/copernicus-atmosphere-monitoring-service-tracks-extent-and-pollution-fires-across-indonesia.
10. Sloan, S., Alamgir, M., Campbell, M.J., Setyawati, T., and Laurance, W.F. 2019. Development Corridors and Remnant-Forest Conservation in Sumatra, Indonesia. *Tropical Conservation Science* 12: 1940082919889509.
11. Ministry of Energy and Mineral Resources. 2018. Indonesia Investments: Coal. [last accessed: Feb. 29, 2020], available from: https://www.indonesia-investments.com/business/commodities/coal/item236.
12. Putra, E.I. 2020. In Sumatra, authorities fight a resurgence of illegal gold mining. [last accessed: Feb. 29, 2020], available from: https://news.mongabay.com/2020/02/indonesia-sumatra-gold-mining-illegal-deforestation-environment/.
13. Yolamalinda, Karimi, S., and Febriamansyah, R. 2017. *Chapter 10 - Forest Management and Illegal Logging in West Sumatra: The Case of Sangir, South Solok*. In: R. Febriamansyah, Yonariza, Ullah, R., and Shivakoti, G.P. (eds), *Redefining Diversity & Dynamics of Natural Resources Management in Asia, Volume 4*, pp 129-137. Elsevier.
14. Gaveau, D.L.A., Curran, L.M., Paoli, G.D., Carlson, K.M., Wells, P., Besse-Rimba, A., . . . Leader-Williams, N. 2012. Examining protected area effectiveness in Sumatra: importance of regulations governing unprotected lands. *Conservation Letters* 5(2): 142-148.
15. Busch, J., Ferretti-Gallon, K., Engelmann, J., Wright, M., Austin, K.G., Stolle, F., . . . Baccini, A. 2015. Reductions in emissions from deforestation from Indonesia's moratorium on new oil palm, timber, and logging concessions. *Proceedings of the National Academy of Sciences* 112(5): 1328-1333.
16. President of the Republic of Indonesia, *Regulation of the Government of the Republic of Indonesia Number 57 of 2016 Concerning Amendment to Government Regulation No 71 of 2014 Concerning Peatland Ecosystem Protection and Management. Pub. L. No. 57/2016 (2016)*. 2016: Jakarta, Indonesia.
17. IDH. 2020. Producers and buyers explore Verified Sourcing Area. [last accessed: Feb. 29, 2020], available from: https://www.idhsustainabletrade.com/landscapes/aceh-indonesia/.
18. IDH. 2020. Responsible palm oil as catalyst for Green Growth. [last accessed: Feb. 29, 2020], available from: https://www.idhsustainabletrade.com/landscapes/south-sumatra/.
19. Normile, D. 2019. Indonesia's fires are bad, but new measures prevented them from becoming worse. *Science*.
20. Fishman, A. and Obidzinski, K. 2015. Verified Legal? Ramifications of the EU Timber Regulation and Indonesia's Voluntary Partnership Agreement for the Legality of Indonesian Timber. *International Forestry Review* 17(1): 10-19.
21. UN-REDD. 2013. highlight of redd+ related projects in indonesia [last accessed: Feb. 29, 2020], available from: https://www.unredd.net/index.php?option=com_docman&view=download&alias=11221-highlight-of-redd-related-projects-in-indonesia-11221&category_slug=posters-1686&Itemid=134.
22. Forest Trends. 2018. *Zooming In: Companies, Commodities, & Traceability Commitments that Count, 2018*. Forest Trends, Wahsington DC, USA. https://www.forest-trends.org/publications/zooming-in/.
23. WRI. 2019. *RELEASE: Palm Oil Industry to Jointly Develop Radar Monitoring Technology to Detect Deforestation*. World Resources Institute, Washington DC. https://www.wri.org/news/2019/10/release-palm-oil-industry-jointly-develop-radar-monitoring-technology-detect.
24. Bronkhorst, E., Cavallo, E., van Dorth tot Medler, M.-M., Klinghammer, S., Smit, H.H., Gijsenbergh, A., and van der Laan, C. 2017. *Current practices and innovations in smallholder palm oil finance in Indonesia and Malaysia: Long-term financing solutions to promote sustainable supply chains. Occasional Paper 177*. CIFOR., Bogor, Indonesia.
25. Brun, C., Cook, A.R., Lee, J.S.H., Wich, S.A., Koh, L.P., and Carrasco, L.R. 2015. Analysis of deforestation and protected area effectiveness in Indonesia: A comparison of Bayesian spatial models. *Global Environmental Change* 31: 285-295.
26. NYDF Assessment Partners. 2019. *Protecting and Restoring Forests: A Story of Large Commitments yet Limited Progress. New York Declaration on Forests Five-Year Assessment Report*. Climate Focus (coordinator and editor). https://forestdeclaration.org/.
27. MoEF. 2018. *The state of Indonesia's forests 2018*. Ministry of Environment and Forestry, Jakarta, Indonesia. http://perpustakaan.bappenas.go.id/lontar/file?file=digital/191959-%5B_Konten_%5D-Konten%20E2337.pdf.
28. Taylor, R. and Streck, C. 2018. *The elusive impact of the deforestation-free supply chain movement*. World Resources Institute, Climate Focus, Washington, DC.
29. Jong, H.N. 2019. Dangerous' new regulation puts Indonesia's carbon-rich peatlands at risk. [last accessed: May 30, 2020], available from: https://news.mongabay.com/2019/07/dangerous-new-regulation-puts-indonesias-carbon-rich-peatlands-at-risk/.

BORNEO

The island of Borneo contains highly biodiverse forests, and communities with rich cultures and strong relationship with the forests. Pressure from logging operations, followed by in-migration and plantation developments have placed pressure on forests, affecting mainly lowland and peat swamp forests. Multiple efforts have been implemented by government and the private sector to guide land use and support local populatiions, yet several challenges persist to conserve the remaining natural forests.

Drivers of deforestation

Tree plantations	Pulp and wood plantations developed in Indonesian Borneo reached about 5.9Mha in 2014. Much of this expansion has been in lowland forests in West and East Kalimantan[1]. In Indonesian Borneo, the expansion of tree plantations has been declining since the early 2000s with some oscillations[4], but tree plantations have increased since 2010 in Malaysian Borneo[5, 6].
Large-scale oil palm plantations	Oil palm plantations are an important source of revenue[1, 7], and have expanded in logged forests and peatlands[8]. Oil palm covered 2.4Mha in 2005, doubled to 4.9Mha in 2010, and reached more than 7Mha by 2015[1]. The expansion has recently declined from more than half a million hectares annually on average in 2008-2012[4], but companies hold large forested areas as "land banks"[9].
Smallholder farming	Expansion of smallholder farming systems and, more importantly, adoption of oil palm by smallholders in Indonesian Borneo have increased pressures on forests[10]; this is also linked to in-migration to palm oil production zones, and plantation workers investing in small-scale oil palm plantations[11]. In Sabah state in Malaysian Borneo, smallholder rubber plantations are also leading to deforestation[6].
Fires	Traditionally used for clearing land, but often spreads into drained peatlands. Some burnt tracts of forest do not recover, and tend to convert into shrubland and grasslands[12]. In Sarawak, where oil palm plantations are not allowed to use fire for land clearing, fires are rare.
Transport infrastructure	There is ongoing expansion of tertiary and local roads into the heart of Borneo. Planned road investment associated with the Pan-Borneo Highway may increase pressure on forests[13]. Several hydropower dams have been developed in Sarawak that resulted in localized deforestation where dam reservoirs were created, particularly during the period between 2000 and 2015.
Timber extraction	Poor forest management of production forest areas often leads to forest degradation. A portion of these forests that have a lower commercial value for timber have been exposed to encroachment and conversion to other land uses, including plantations[14].
Mining	In Indonesian Borneo, mining operations, mainly for coal, are small in area but have indirect impacts on road expansion and influx of people[1]; dynamics depend on oscillating demand[15]. Gold mining is gaining momentum in Sabah (Malaysian Borneo[16].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

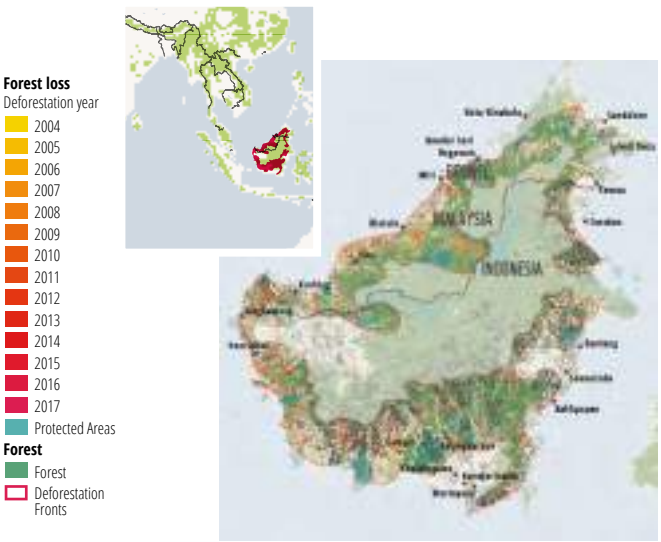
Underlying causes

Underlying causes differ between Indonesian and Malaysian Borneo. In Indonesia, they are linked to misguided policies and processes of land concession allocation, along with land appropriation involving local elites[17]. Foremost among these is the prioritization of mining and plantation licences (considered strategic for national development) over commercial logging in production forests. Investments in mining and plantations, following growing international and domestic demand for commodities (e.g. palm oil, coal), have also fuelled forest conversion, as well as pressures due to in-migration to frontier areas.

Countries, region	Malaysia (Sarawak and Sabah), Indonesia (Kalimantan) and Brunei
Forest type	Humid tropical forests (lowland and upland), montane forest, peat swamp forests
Total area	35.5Mha
Forest area in 2018	21.5Mha (60.7% of total deforestation front area)
Forest loss in 2004-2017	5.8Mha (21.9% of forest area in 2000)
Location of deforestation	In Indonesian Borneo, deforestation is slowing in West and Central Kalimantan, and increasing in East Kalimantan. In Malaysian Borneo, deforestation in absolute terms has been higher in the state of Sarawak[1]
Total forest core area in 2018	11.3Mha (52.7% of forests in 2018)
Fragmented forests 2000-2018	3.3Mha (12.4% of forest area in 2000)
Accumulated burned area, 2002-2019	1.2Mha (4.6% of forest area in 2000)
Deforestation trend	Deforestation increased up to 2015, followed by a decrease since then. In Indonesian Borneo, official estimates indicate that deforestation remained between 200,000 ha and 300,000 ha per year between 2000 and 2014, and was around 500,000 ha in 2015[2], decreasing since then to 150,000 ha in 2017/18[3].
Future trends	Deforestation may continue expanding, but likely to slower rates

Main outcomes

Illegal logging has declined due to timber monitoring efforts[29], which have been complemented with increased monitoring of deforestation in Sarawak[30]. In Indonesian Borneo, deforestation from industrial oil palm plantations has decreased over time, which results from strengthened law enforcement to prevent forest fires and land clearing[31], and likely from the moratoria on forest and peatland conversion. Certification of oil palm plantations may have contributed to reduced deforestation, but not fire or peatland clearance[32]. There has not been any significant fire on peat in Sarawak in recent years due to stringent regulations. In Indonesian Borneo, remaining deforestation is associated with pressure from smallholders and medium-size plantations that do not have zero-deforestation commitments or other voluntary commitments. The difficulty for small- and medium-scale operations to comply with these commitments has called into question their potential to prevent deforestation and peatland conversion at regional scales[33].



Key responses

Protected areas	The Heart of Borneo is the main conservation agreement to maintain established protected areas and wildlife corridors, and support sustainable management of production forests[1].
Moratoria	The Indonesian government issued a moratorium on new conversion permits in primary forests and peatlands in 2011[18], and in 2016 enacted a moratorium banning expansion in peatlands[19]. Sarawak has announced no more new development on peat and no new licences for timber concessions[20].
Land-use zoning	Provincial governments have developed land-use plans that guide land allocation decisions, accompanied by green growth plans[21]. Sarawak has a land-use policy to set aside at least 57% of land to be under permanent forest and protected areas. In Sabah, the land-use policy aims to set aside 30% of land under protected areas and 50% under forest cover[22].
Voluntary standards	The largest palm oil corporate groups have embraced Roundtable on Sustainable Palm Oil (RSPO) certification and deforestation-free commitments, and some have put in place traceability systems to trace third-party suppliers[14]. In Sarawak, certification is mandatory for all timber concessions[20].
Timber legality	In 2009, the Indonesia government established a timber legality assurance system known as SVLK. It was recognized as the basis of the EU voluntary partnership agreement that came into effect in 2014[13]. In Sabah, a timber legality assurance system was issued in 2016, and a similar system was issued in Sarawak in 2018[23].
Mandatory standards	In 2011, the government of Indonesia introduced the Indonesian Sustainable Palm Oil (ISPO) scheme as a requirement for all commercial plantation operators. Progress has varied but ISPO is still very much part of the palm oil sustainability plans. In 2017, the Malaysian government announced that the Malaysian Sustainable Palm Oil standard would be mandatory for all palm oil areas by 2019[24], yet this deadline was not met and was pushed to 2020.
REDD+ projects	To date, 27 REDD+ projects have been established in Kalimantan, and a few in Sabah, with diverse targets, timelines, scope and operational approaches[25].
Traceability of supply	The main palm oil corporate groups (e.g. Cargill, GAR, Musim Mas, Sime Darby Plantation and Wilmar) issued deforestation-free commitments and put in place traceability systems[26].
Sustainable finance	Several specific projects and initiatives have been implemented at the municipal level to de-risk investments, mainly to support sustainable palm oil supply[27].
Sustainable livelihoods	Several projects exist to enhance land management and agricultural supply and build alternative livelihoods, such as those implemented by IDH in West Kalimantan[28].

Deployment at wider scale | Actively used and expanding | Project-specific, experimental

Recommended future actions

- Strengthen the coordination and enforcement of land-use regulations, and continue to constraint expansion of plantations in peatlands.
- Cap the expansion of large-scale plantations in Indonesian Borneo, following the models adopted by governments in Sarawak and Sabah.
- Clarify tenure for local villagers and those settled in public lands, and improve incentives to enhance the productivity and environmental performance of smallholders.
- Implement more active policies supporting local livelihoods and avoiding further land encroachment.
- Integrate support for fire management and alternative livelihoods for local villagers, and build technical, financial and institutional capacity for local villagers to manage and protect their forests.

References

1. Wulffraat, S., Greenwood, C., Faisal, K.F., and Sucipto, D. 2017. *The Environmental Status of Borneo*. WWF Indonesia, WWF Malasyia. https://d2ouvy59p0dg6k.cloudfront.net/downloads/full_report_hob_2016_rev_12_190917__lowres_.pdf.
2. MoEF. 2016. *National Forest Reference Emission Level for Deforestation and Forest Degradation: In the Context of Decision 1/CP.16 para 70 UNFCCC (Encourages developing country Parties to contribute to mitigation actions in the forest sector), Directorate General of Climate Change*. The Ministry of Environment and Forestry, Jakarta, Indonesia.
3. KLHK. 2019. *Deforestasi Indonesia Tahun 2017-2018*. Kementerian Lingkungan Hidup dan Kehutanan, Jakarta, Indonesia.
4. Gaveau, D.L.A., Locatelli, B., Salim, M.A., Yaen, H., Pacheco, P., and Sheil, D. 2019. Rise and fall of forest loss and industrial plantations in Borneo (2000–2017). *Conservation Letters* 12(3): e12622.
5. Hon, J. and Shibata, S. 1970. A Review on Land Use in the Malaysian State of Sarawak, Borneo and Recommendations for Wildlife Conservation Inside Production Forest Environment. *Borneo Journal of Resource Science and Technology* 3: 22-35.
6. Sabah Forestry Department. 2017. *Annual Report 2017*Sabah, Malaysia. http://www.forest.sabah.gov.my/docs/ar/ar2017.pdf.
7. Lim, F.K.S., Carrasco, L.R., McHardy, J., and Edwards, D.P. 2019. Land rents drive oil palm expansion dynamics in Indonesia. *Environmental Research Letters* 14(7): 7.
8. Gaveau, D.L.A., Sheil, D., Husnayaen, Salim, M.A., Arjasakusuma, S., Ancrenaz, M., . . . Meijaard, E. 2016. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. *Scientific Reports* 6: 32017.
9. Chain Reaction Research. 2017. *Banks Finance More Palm Oil Than Investors: Investors Face Indirect Exposure*. Aidenviroment, Climate Advisers, Profundo, Amsterdam, Netherlands. https://chainreactionresearch.files.wordpress.com/2017/02/banks-financing-palm-oil-crr-170203.pdf.
10. Pacheco, P., Gnych, S., Dermawan, A., Komarudin, H., and Okarda, B. 2017. *The palm oil global value chain: Implications for economic growth and social and environmental sustainability*. CIFOR, Bogor, Indonesia.
11. Watts, J.D. and Irawan, S. 2016. *A Profile of Small-scale Oil Palm Farmers and The Challenges of Farming Independently: The Case of Seruyan and Kotawaringin Barat Districts in Central Kalimantan, Indonesia*. Institut Penelitian Inovasi Bumi (INOBU), Jakarta, Indonesia. http://inobu.org/download/INOBU_Smallholders_Final.pdf.
12. Austin, K.G., Schwantes, A., Gu, Y., and Kasibhatla, P.S. 2019. What causes deforestation in Indonesia? *Environmental Research Letters* 14(2): 024007.
13. Sloan, S., Campbell, M.J., Alamgir, M., Lechner, A.M., Engert, J., and Laurance, W.F. 2019. Trans-national conservation and infrastructure development in the Heart of Borneo. *PLOS ONE* 14(9): e0221947.
14. Casson, A., Muliastra, Y., and Obidzinski, K. 2014. *Large-scale plantations, bioenergy developments and land use change in Indonesia*. Center for International Forestry Research (CIFOR), Bogor, Indonesia.
15. Apriando, T. 2017. Who owns Indonesia's deadly abandoned coal mines? An investigation into the people, and the institutional failures, responsible for the abandoned coal mine pits scattered across Indonesian Borneo. [last accessed: 24 Feb. 2020], available from: https://news.mongabay.com/2017/05/who-owns-indonesias-deadly-abandoned-coal-mines/.
16. Sario, R. 2016. Feedback sought on gold mine. [last accessed: April 15, 2020], available from: https://www.thestar.com.my/metro/community/2016/10/26/feedback-sought-on-gold-mine-state-authorities-reviewing-environmental-impact-of-mining-gold-in-tawa.
17. Project, T.G. 2019. What we learned from two years of investigating corrupt land deals in Indonesia And what it says about how to fix the nation's deforestation and land-rights crisis. [last accessed: 24 Feb. 2020], available from: https://thegeckoproject.org/indonesiaforsale/home.
18. Busch, J., Ferretti-Gallon, K., Engelmann, J., Wright, M., Austin, K.G., Stolle, F., . . . Baccini, A. 2015. Reductions in emissions from deforestation from Indonesia's moratorium on new oil palm, timber, and logging concessions. *Proceedings of the National Academy of Sciences* 112(5): 1328-1333.
19. President of the Republic of Indonesia, *Regulation of the Government of the Republic of Indonesia Number 57 of 2016 Concerning Amendment to Government Regulation No 71 of 2014 Concerning Peatland Ecosystem Protection and Management. Pub. L. No. 57/2016 (2016)*. 2016: Jakarta, Indonesia.
20. Ling, S. 2018. Forest management certification compulsory for all logging areas in Sarawak from 2022, available from: https://www.thestar.com.my/news/nation/2018/12/04/forest-mgmt-certification-compulsory-for-all-logging-areas-in-swak-from-2022/.
21. GGGI Indonesia. 2014. Indonesia Program, available from: http://gggi.org/wp-content/uploads/2012/12/Indonesia-leaflet544-248-1.pdf.
22. Sarawak Government. 2019. Sarawak Targets 1 Million Hectares Of Totally Protected Land Areas By 2020. [last accessed: April 17, 2020], available from: https://www.sarawak.gov.my/web/home/news_view/223/13221/.
23. Malaysian Timber Industry Board, *Malaysia: Country Progress on Timber Legality Assurance Efforts* in *Sub-Regional Training Workshop on Timber Legality Assurance*. 2018: Chiang Mai, Thailand
24. Sivanadam, H. 2017. MSPO certification mandatory by 2019. [last accessed: April 15, 2020], available from: https://www.thestar.com.my/news/nation/2017/02/25/mspo-certification-mandatory-by-2019-govt-aims-for-sustainable-oil-palm-industry/.
25. UN-REDD. 2013. highlight of redd+ related projects in indonesia [last accessed: Feb. 29, 2020], available from: https://www.unredd.net/index.php?option=com_docman&view=download&alias=11221-highlight-of-redd-related-projects-in-indonesia-11221&category_slug=posters-1686&Itemid=134.
26. Forest Trends. 2018. *Zooming In: Companies, Commodities, & Traceability Commitments that Count, 2018*. Forest Trends, Wahsington DC, USA. https://www.forest-trends.org/publications/zooming-in/.
27. Luttrell, C., Komarudin, H., Zrust, M., Pacheco, P., Limberg, G., Nurfatriani, F., . . . Antika, F. 2018. *Implementing sustainability commitments for palm oil in Indonesia: governance arrangements of sustainability initiatives involving public and private actors*. CIFOR, Bogor, Indonesia.
28. IDH. 2020. Responsible palm oil, alternative livelihoods and land reform policies. [last accessed: Feb. 29, 2020], available from: https://www.idhsustainabletrade.com/landscapes/west-kalimantan/.
29. McDermott, C.L., Hirons, M., and Setyowati, A. 2020. The Interplay of Global Governance with Domestic and Local Access: Insights from the FLEGT VPAs in Ghana and Indonesia. *Society & Natural Resources* 33(2): 261-279.
30. Ling, S. 2014. Adenan unveils tough action plan against illegal logging. [last accessed: April 15, 2020], available from: https://www.thestar.com.my/news/nation/2014/11/20/timber-thieves-beware-beware-beware-cm-unveils-tough-action-plan-against-illegal-logging/.
31. Wijaya, A., Samadhi, T.N., and Juliane, R. 2019. Indonesia Is Reducing Deforestation, but Problem Areas Remain. [last accessed: 24 Feb. 2020], available from: https://www.wri.org/blog/2019/07/indonesia-reducing-deforestation-problem-areas-remain.
32. Carlson, K.M., Heilmayr, R., Gibbs, H.K., Noojipady, P., Burns, D.N., Morton, D.C., . . . Kremen, C. 2018. Effect of oil palm sustainability certification on deforestation and fire in Indonesia. *Proceedings of the National Academy of Sciences of the United States of America* 115(1): 121-126.
33. Pirard, R., Schulz, N., and Benedict, J. 2020. Transparency gaps in Indonesian palm oil supply chains. [last accessed: 24 Feb. 2020], available from: https://medium.com/trase/transparency-gaps-in-indonesian-palm-oil-supply-chains-106777d8942e.

NEW GUINEA – INDONESIA AND PAPUA NEW GUINEA

The island of New Guinea is sometimes seen as the "last frontier": it still has large natural forests with rich biodiversity and many indigenous groups. These forests, however, have undergone substantial losses – particularly in Papua New Guinea (PNG), but also increasingly in Papua Indonesia. The region is unusual in that the timber trade is still a major driver of forest loss, although it has now been overtaken by pulpwood and palm oil.

Drivers of deforestation

Subsistence agriculture	Probably largest cause of deforestation overall[8], relying heavily on swidden (shifting cultivation), although disputes remain about its relative importance compared to timber.
Logging	PNG was the world's largest tropical timber exporter in 2014[9], much as raw logs[10]. 15Mha have been identified for timber but logging usually causes degradation rather than deforestation[11]. Most operations in PNG are probably illegal[12, 13], whereas this is not the case in Papua Indonesia[14], where there were 73 concessions in 2018[5].
Commercial agriculture	Increasing, including oil palm expansion[11] especially in PNG but also West Papua[15], where the legality of concession development has been questioned[16]. Smallholders are also changing from subsistence to commercial production of crops like sweet potato[17].
Pulpwood plantations	There were 15 pulpwood concessions in 2018, responsible for clearing about 577,300ha of forest[2].
Road expansion	An increasing pressure, with a decision to double the road network in PNG over the next three years, much of it through lowland forest[18], and for a Trans-Papua highway through Papua Indonesia[19].
Mining operations	Mining is controversial[20] but only a minor direct cause of forest loss[21]. In 2018 in Papua Indonesia there were 120 concessions responsible for 75,500ha of forest loss since 2000[5].
Fire	Fires occur, although their role in permanent forest loss is unclear[11].

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Forest loss in both countries has long been exacerbated by weak governance, internal political disputes and land tenure systems susceptible to exploitation by outsiders able to strike deals with local chiefs[22].

Countries, region	Papua New Guinea (PNG), Indonesia (Papua)
Forest type	Upland/lowland tropical moist
Total area	35.7Mha
Forest area in 2018	30.6Mha (85.7% of total deforestation front area)
Forest loss in 2004-2017	1.3Mha (4.0% of forest area in 2000)
Location of deforestation	Highest losses in lowlands:[1] Madang, Morobe and Sepik, New Britain and New Ireland[2].
Total forest core area in 2018	21.8Mha (71.4% of forests in 2018)
Fragmented forests 2000-2018	1.3Mha (4.1%, of forest area in 2000)
Accumulated burned area, 2002-2019	0.4Mha (1.2% of forest area in 2000)
Deforestation trend	Increased[3]; low official figures in Papua Indonesia disputed[4, 5]. Also fragmentation[6]. According to official estimates deforestation in Indonesian Papua has doubled from about 40,000ha on average per year duing 2006-2009 to about 80,000ha during 2014/15 and 2017/18[7].
Future trends	Likely to increase if current trends continue

Responses

Protected areas	Protected areas covered 1,724,800ha of PNG, 3.69% of the country, and 6,844,900ha of remaining forest area in Papua Indonesia in 2018[5].
REDD+	Voluntary governance standards for REDD+ are being developed[23]. Most REDD+ schemes under discussion currently rely on reduced impact logging rather than setting forest aside from development[11].
Land-use planning	The governors of Indonesia's Papua and West Papua provinces signed a pledge to conserve 70% of the land in their jurisdictions[24]. The UK government is currently supporting work in Indonesian Papua to introduce a number of climate initiatives that aim to replace planned deforestation in the region[25].
Voluntary standards	PNG recently launched a second version of a National Forest Stewardship Standard[26]; in late 2019 there were three certified companies and one application outstanding[27]. West Papua also has some Forest Stewardship Council (FSC) certified operations although one is currently in dispute[28].
Sustainable forest management	In PNG, six schemes promoting small-scale timber operations by local communities, using portable sawmills, all failed to be financially viable once donor funding ceased[29].
Timber legality	Papua Indonesia has made strong commitments to conservation of its remaining forests, although it is still unclear how this will work in practice[30].
Recognition of IPLCs	Customary land formalization has been introduced but the processes have sometimes been captured by powerful individuals or companies, so have contributed to neither poverty reduction nor forest conservation[31].

Deployment at wider scale
Actively used and expanding
Project-specific, experimental

Main outcomes

There are serious problems with the effectiveness of protected areas[32]. Papua Indonesia has lost 46,678 ha inside protected areas since 2000[5]. The island is still heavily forested, particularly in the western half, but development is building. West Papua has some of the most intact tropical forest left in the world, so deforestation fronts here are particularly worrying.

Recommended future actions

- In Papua Indonesia, support the implementation of the provincial government declaration that commits to protect 70% of the land mass.
- Provide alternative economic development measures that align with providing incentives for government to maintain forest cover.
- Recognize Indigenous land rights and take local rights into account in any sustainable forest management.
- Increase the protected area network, while recognizing the challenge of integrating this into existing land tenure arrangements: this might be an area where other effective area-based conservation measures (OECMs) and REDD+ projects offer real advantages.
- Develop realistic pathways to promote sustainable forest management.

References

1. Bingeding, N. 2011. *Reducing emissions from deforestation and degradation of forests in Papua New Guinea: Issues and Options*. The National Research Institute. NRI Boroko, PNG.
2. Shearman, P. and Bryan, J. 2010. A bioregional analysis of the distribution of rainforest cover, deforestation and degradation in Papua New Guinea. *Austral Ecology* 36: 9-24.
3. Miettinen, J., Shi, c., and Liew, S.C. 2011. Deforestation rates in insular Southeast Asia between 2000 and 2010. *Global Change Biology* 17(7): 2261-2270.
4. Harfenist, E. 2015. Deforestation may be ramping up in Papua, West Papua. *Mongabay*, 27 January. Available from: news.mongabay.com/2015/01/deforestation-may-be-ramping-up-in-papua-west-papua
5. CIFOR. 2020. Atlas Borneo. Available from: atlas.cifor.org/papua
6. Sam, K., Koane, B., Jeppy, S., and Novotny, V. 2014. Effect of forest fragmentation on bird species richness in Papua New Guinea. *Journal of Field Ornithology* 85(2): 152-167.
7. KLHK. 2019. *Deforestasi Indonesia Tahun 2017-2018*. Kementerian Lingkungan Hidup dan Kehutanan, Jakarta, Indonesia.
8. Bryan, J., Shearman, P., Ash, J., and Kirkpatrick, J.B. 2010. Estimating rainforest biomass stocks and carbon loss from deforestation and degradation in Papua New Guinea 1972–2002: Best estimates, uncertainties and research needs. *Journal of Environmental Management* 91(4): 995-1001.
9. Mousseau, F. and Lau, P. 2015. *The Great Timber Heist: The logging industry in Papua New Guinea*. The Oakland Institute, Oakland, California.
10. Laurance, W., Kakul, T., Tom, M., Wahya, R., and Laurance, S. 2012. Defeating the "resource curse": Key priorities for conserving Papua New Guinea's native forests. *Biological Conservation* 151: 35–40.
11. Babon, A. and Gowae, G.Y. 2013. *The context of REDD+ in Papua New Guinea: Drivers, agents and institutions*. CIFOR, Bogor, Indonesia.
12. Forest Trends. 2006. *Logging, Legality and Livelihoods in PNG: Synthesis of Official Assessments of the Large-Scale Logging Industry*. Washington DC, USA.
13. Lawson, S. 2014. *Illegal logging in Papua New Guinea*. Energy, Environment and Resources EER PP 2014/04. Chatham House, London, UK.
14. Chitra, J., Wijaya, A., and Firmansyah, R. 2017. Balancing development and forest protection in Papua. Global Forest Watch. Available from: blog.globalforestwatch.org/places-to-watch/balancing-development-and-forest-protection-in-papua
15. Austin, K.G., Mosnier, A., Pirker, J., McCallum, I., Fritz, S., and Kasibhatla, P.S. 2017. Shifting patterns of oil palm driven deforestation in Indonesia and implications for zero-deforestation commitments. *Land Use Policy* 69: 41-48.
16. Kesaulija, F.F., Sadsoeitoebeon, B.M.G., Peday, H.F.Z., Tokede, M.J., Komarudin, H., Andriani, R., and Obidzinski, K. 2014. *Oil palm estate development and its impact on forests and local communities in West Papua: A case study on the Prafi Plain*. CIFOR, Bogor, Indonesia.
17. Fujinuma, R., Kirchhof, G., Ramakrishna, A., Sirabis, W., Yapo, J., Woruba, D., ... Menzies, N. 2018. Intensified sweet potato production in Papua New Guinea drives plant nutrient decline over the last decade. *Agriculture, Ecosystems & Environment* 254: 10-19.
18. Alamgir, M., Sloan, S., Campbell, M.J., Engert, J., Kiele, R., Porolak, G., ... Laurance, W.F. 2019. Infrastructure expansion challenges sustainable development in Papua New Guinea. *PLOS ONE* 14(7): e0219408.
19. Cabinet Secretariat of the Government of Indonesia. 2018. Government commits to continue Trans-Papua project. Available from: setkab.go.id/en/government-commits-to-continue-trans-papua-project
20. Jell-Bahlsen, S. and Jell, G. 2012. The trans-national gold curse of Papua New Guinea. *Dialectical Anthropology* 36(3): 317-341.
21. Shearman, P.L., Ash, J., Mackey, B., Bryan, J.E., and Lokes, B. 2009. Forest conversion and degradation in Papua New Guinea 1972–2002. *Biotropica* 41(3): 379-390.
22. Filer, C. and Sekhran, N. 1998. *Loggers, donors and resource owners*. IIED, London.
23. Maraseni, T. and Cadman, T. 2017. *Development of Quality-of-Governance Standards for Reducing Emission from Deforestation and Forest Degradation in Papua New Guinea*. Papua New Guinea Forest Authority, ITTO, University of Southern Queensland and Griffith University, Brisbane, Australia.
24. Paino, C. 2018. In West Papua's Arfak Mountains, local leaders plot ecotourism boom. *Mongabay*, 9 November. Available from: news.mongabay.com/2018/11/in-west-papuas-arfak-mountains-local-leaders-plot-ecotourism-boom
25. Development Tracker. 2020. Supporting a sustainable future for Papua's forests. UK Foreign, Commonwealth and Development Office. Available from: devtracker.dfid.gov.uk/projects/GB-GOV-1-300185
26. FSC. 2020. Papua New Guinea Launches Version 2.0 of the National Forest Stewardship Standard. Available from: fsc.org/en/news/papua-new-guinea-launches-version-20-of-the-national-forest-stewardship-standard
27. The National. 2019. Authority hopes to improve forest management, access market. 16 October. Available from: www.thenational.com.pg/authority-hopes-to-improve-forest-management-access-market/
28. Taylor, M. 2019. Ethical wood body warns Indonesian palm oil firm over forest clearing. *Reuters*, 25 July. Available from: www.reuters.com/article/us-indonesia-environment-forests/ethical-wood-body-warns-indonesian-palm-oil-firm-over-forest-clearing-idUSKCN1UK1M5
29. Scudder, M.G., Herbohn, J.L., and Baynes, J. 2018. The failure of eco-forestry as a small-scale native forest management model in Papua New Guinea. *Land Use Policy* 77: 696-704.
30. Andriansyah, M.N., Firmamsyah, R., Wijaya, A., and Chitra, J. 2018. Indonesia's last forest frontier: 3 facts to know about Papua. World Resources Institute. Available from: www.wri.org/blog/2018/11/indonesias-last-forest-frontier-3-facts-know-about-papua.
31. Hambloch, C. 2018. Land formalization turned land rush: the case of the palm oil industry in Papua New Guinea. World Bank Conference on Land and Poverty. Washington DC, USA.
32. Melick, D., Kinch, J., and Govan, H. 2012. How global biodiversity targets risk becoming counterproductive: The case of Papua New Guinea. *Conservation and Society* 10(4): 344-353.

EASTERN AUSTRALIA

The forests of Eastern Australia are considered a global biodiversity hotspot[1]. Nearly half of the original forested area has been lost, with great variation among forest types[2]. The once vast brigalow and grassy box forests of inland eastern Australia have been cleared below 10% and are now endangered or critically endangered[3]. Over 700 native plant and animal species are threatened by forest habitat destruction including the iconic koala[4]. Deforestation primarily for pasture development is ongoing at a significant level although highly dispersed in the Eastern Australia front[5, 6]. Fires of unprecedented ferocity due to climate change are likely also driving forest loss or change, particularly of the unique Gondwanan relict rainforests[7].

Drivers of deforestation

Livestock 	Development of livestock pasture is the chief driver of forest loss in Eastern Australia, accounting for 75%[8, 9]. There was a spike in large-scale clearing for crops in Queensland after laws were weakened in 2013, but these crops were primarily grain and fodder for livestock[10]. This loophole was closed in 2018[11].
Forestry 	Harvest for timber is a minor driver of loss, accounting for 16%, mostly in the state of New South Wales (NSW). Intensified logging of state forests, in addition to significant private native forestry[12], make it the primary driver of deforestation and degradation in NSW[13].
Fire and drought	Increasing frequency and intensity of fires due to anthropogenic climate change, enhanced by forest fragmentation and weed invasion, is predicted to result in transition of large areas of forest to woodland or savannah[1]. The 2019-20 summer bushfires burned 7.3Mha of the Eastern Australia forests, almost all in NSW. For at least 1Mha of this, the forest canopy burned[2]. Half of all Gondwanan rainforests burnt, and may not recover[2, 14].
Cropping	Conversion of grazing land to cropping land is the primary driver of clearing in northwest NSW, driven by increased returns and land speculation to increase land values.

Primary cause of forest loss and/or severe degradation
Secondary cause of forest loss and/or severe degradation
Less important cause of forest loss and/or severe degradation

Underlying causes

Grazing land capital value is increased greatly with forest clearing; landholders are often mortgaged to banks and are under pressure to extract more value by clearing[15]. Climate change is a significant and growing cause of deforestation because of increasingly severe droughts, fires and low humidity affecting production and driving forest loss[16].

Countries, region	Australia, Oceania
Forest type	Mostly eucalypt or acacia-dominated subhumid tropical, subtropical and temperate forests and woodlands
Total area	101.5Mha
Forest area in 2018	20.5Mha (20.2% of total deforestation front) based on forest estimates from a global assessment; ~45Mha remains of original 86Mha (52%), with ~6Mha secondary forest cover based on SLATS[5]
Forest loss 2004-2017	0.7Mha of forests (3.5% of forest area in 2000) based on Terra-I estimates; 0.97Mha (4.6% of forest area in 2000) based on WWF-Australia estimates; ~2Mha 2004-2017, up to 5Mha when secondary forest clearing is included based on SLATS[5]
Location of deforestation	Inland and coastal areas of the states of Queensland and New South Wales
Total forest core area in 2018	9.9Mha (48.5% of forests in 2018) based on forest area from estimates from a global assessment
Fragmented forests 2000-2018	1.2Mha (5.7% of forest area in 2000) based on estimates from a global assessment
Accumulated burned area, 2002-2019	6.5Mha (30.8% of forest area in 2018) based on estimates from a global assessment
Deforestation trend	Increasing again after a period of decline as legal restrictions weakened[5]
Future trends	Uncertain – no immediate prospects of decline

Main outcomes

Growth of protected areas has largely stalled due to lack of government interest, except for rapid growth of indigenous protected areas, which are largely in unforested arid areas[17]. Vegetation laws are governments' preferred approach to reduce deforestation but have had a chequered history and are now universally weaker than they were in the mid-2000s. Deforestation-free beef is a major and promising innovation in preventing deforestation, but progress is slow and there is still no accepted operational methodology or facility to verify or certify products as deforestation free[22].

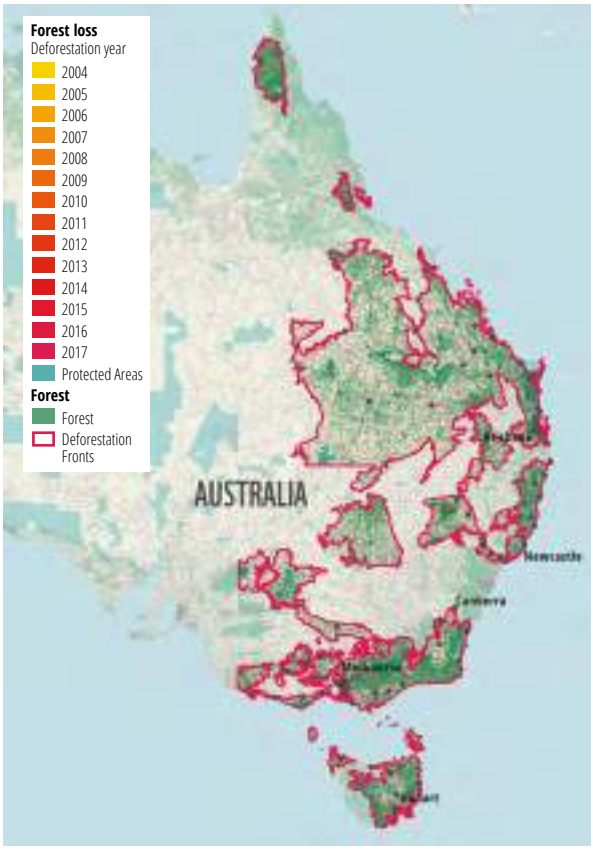
Recommended future actions

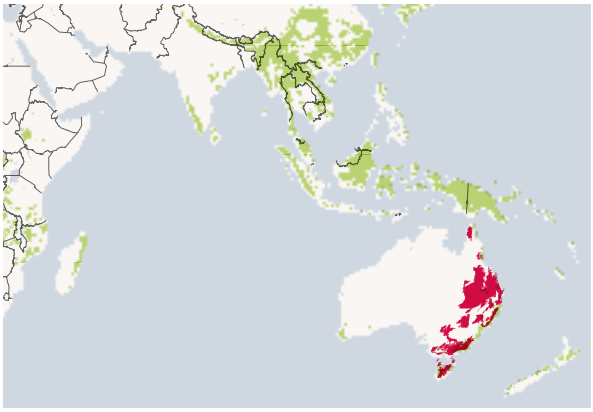
- Increase investments in protected areas and strengthen forest protection laws.
- Promote verifiable progress in deforestation-free supply chains, especially for beef.
- Enhance funding to support farmers and graziers to regenerate forests, with incentives for those who demonstrate improved forest condition.
- Develop policies and structures to support a transition from native forest logging to plantations and independently certified forest management.

Key responses

Protected areas	Protected areas growth stalled in Australia when the key national government grants programme was terminated in 2013; at its height the programme resulted in 2.5Mha of high conservation value land protected, although not all of this was in Eastern Australia[17]. Indigenous protected areas have grown dramatically, but these are mostly in arid areas where deforestation was never an issue[18]. Private protected areas have grown steadily, but these are not generally protected against mining[19].
National threatened species law	The national Environment Protection and Biodiversity Conservation Act, if enforced, could have prevented a great deal of clearing including of secondary forests with threatened species habitats. A comprehensive failure by agricultural developers to observe the law and the regulator to enforce it undermined its effectiveness[20].
State vegetation laws	State vegetation management laws have played a leading role in reducing the loss of primary forests since 2000, but laws have since been weakened in every state[15]. Laws in Queensland were weakened in 2013 and in NSW in 2017. Although laws were partly restored in Queensland in 2018, this has yet to have a significant impact on clearing rates, which have been increasing since 2011 after major declines in the previous decade[5].
Deforestation-free beef	The industry marketing body Meat and Livestock Australia has committed to carbon neutrality for the beef industry by 2030[21]. The Australian Red Meat Council's Australian Beef Sustainability Framework has begun collecting data on deforestation due to beef[22]. Major retailers have made commitments to remove deforestation from supply chains, but none of these have been operationalized as yet[8].
Land restoration, carbon farming and environmental stewardship	The Australian, Queensland and NSW governments have a range of markets to support carbon offsets and land restoration, particularly to financially reward graziers and farmers who allow natural forest regeneration. Additional financing and long-term funding security is required to expand and improve these schemes, secured with covenants on land titles or carbon farming contracts to provide permanent protection. These would assist conservation of Australia's globally significant forest carbon stocks, enabling them to be actively managed as a carbon sink to deliver increased carbon abatement and sequestration to support a safe climate.

Deployment at wider scale | Actively used and expanding | Project-specific, experimental





References

1. Williams, K.J., Ford, A., Rosauer, D.F., Silva, N.D., Mittermeier, R., Bruce, C., ... Margules, C. 2011. Forests of East Australia: the 35th biodiversity hotspot. In: Keith, D.A. (ed). *Biodiversity hotspots*, pp 295-310. Springer, Berlin, Heidelberg.
2. Government of Australia. 2020. National Vegetation Information System (NVIS). Available from: www.environment.gov.au/land/native-vegetation/national-vegetation-information-system [accessed 30 May 2020].
3. Government of Australia. 2020. EPBC Act List of Threatened Ecological Communities. Available from: www.environment.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl [accessed 17 March 2020].
4. Government of Australia. 2020. Species Profile and Threats Database. Available from: www.environment.gov.au/cgi-bin/sprat/public/sprat.pl [accessed 12 March 2020].
5. Government of Queensland. 2019. Statewide Landcover and Trees Study (SLATS). Available from: www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/slats/slats-reports [accessed 12 March 2020].
6. Government of New South Wales. 2018. Native vegetation reports and resources. Available from: www.environment.nsw.gov.au/topics/animals-and-plants/native-vegetation/reports-and-resources/reports [accessed 17 March 2020].
7. Baldwin, C. and Ross, H. 2019. Our warming climate and fire's role in the Australian landscape. *Australasian Journal of Environmental Management* 26(4): 305-310.
8. Wilderness Society. 2019. *Drivers of deforestation and land clearing in Queensland.* Queensland, Australia. www.wilderness.org.au/images/resources/The_Drivers_of_Deforestation_Land-clearing_Qld_Report.pdf
9. McAlpine, C., Etter, A., Seabrook, L., and Laurance, W. 2009. Increasing world consumption of beef as a driver of regional and global change: A call for policy action based on evidence from Queensland (Australia), Colombia and Brazil. *Global Environmental Change* 19: 21-33.
10. Taylor, M.F.J. 2018. Bushland destruction in Queensland since laws axed. WWF-Australia, Queensland, Australia. www.wwf.org.au/ArticleDocuments/360/pub-briefing-bushland-destruction-in-queensland-since-laws-axed-9feb18.pdf.aspx
11. Government of Queensland. 2018. Palaszczuk government delivers on vegetation management. statements.qld.gov.au/Statement/2018/5/3/palaszczuk-government-delivers-on-vegetation-management
12. Druce, A. 2018. Tree change: LLS to take on $465m private native forestry sector in NSW. *The Land,* 29 March. Available from: www.theland.com.au/story/5312259/tree-change-lls-to-absorb-and-boost-465m-private-native-forestry
13. Gonzalez, P., Neilson, R.P., Lenihan, J.M., and Drapek, R.J. 2019. Global patterns in the vulnerability of ecosystems to vegetation shifts due to climate change. *Global Ecology and Biogeography* 19: 755-768.
14. Cox, L. and Evershed, N. 2020. 'It's heart-wrenching': 80% of Blue Mountains and 50% of Gondwana rainforests burn in bushfires. *The Guardian,* 17 January. www.theguardian.com/environment/2020/jan/17/its-heart-wrenching-80-of-blue-mountains-and-50-of-gondwana-rainforests-burn-in-bushfires
15. Evans, M.C. 2016. Deforestation in Australia: drivers, trends and policy responses. *Pacific Conservation Biology* 22(2): 130-150.
16. Bowman, D.M.J.S., Murphy, B.P., Neyland, D.L.J., Williamson, G.J., and Prior, L.D. 2014. Abrupt fire regime change may cause landscape-wide loss of mature obligate seeder forests. *Global Change Biology* 20(3): 1008-1015.
17. Taylor, M., Fitzsimons, J., and Sattler, P. 2014. *Building Nature's Safety Net 2014: A decade of protected area achievements in Australia.* WWF-Australia, Sydney. www.wwf.org.au/buildingnaturesafetynet2014
18. Taylor, M.F.J. 2017. *Building Nature's Safety Net 2016: State of Australian terrestrial protected areas 2010-2016.* WWF-Australia, Sydney. www.wwf.org.au/ArticleDocuments/353/pub-building-natures-safety-net-2016-28jun17.pdf.aspx?Embed=Y
19. Adams, V.M. and Moon, K. 2013. Security and equity of conservation covenants: Contradictions of private protected area policies in Australia. *Land Use Policy* 30(1): 114-119.
20. Ward, M.S., Simmonds, J.S., Reside, A.E., Watson, J.E.M., Rhodes, J.R., Possingham, H.P., ... Taylor, M. 2019. Lots of loss with little scrutiny: The attrition of habitat critical for threatened species in Australia. *Conservation Science and Practice* 1(11): e117.
21. Band, P. 2019. Sustainabilty on the world stage. Meat and Livestock Australia. Available from: https://www.mla.com.au/news-and-events/industry-news/cn30-on-the-world-stage/?clean=true
22. The Australian Beef Sustainability Framework. 2019. Balance of tree and grass cover. Available from: www.sustainableaustralianbeef.com.au/balance-of-tree-and-grass-cover.