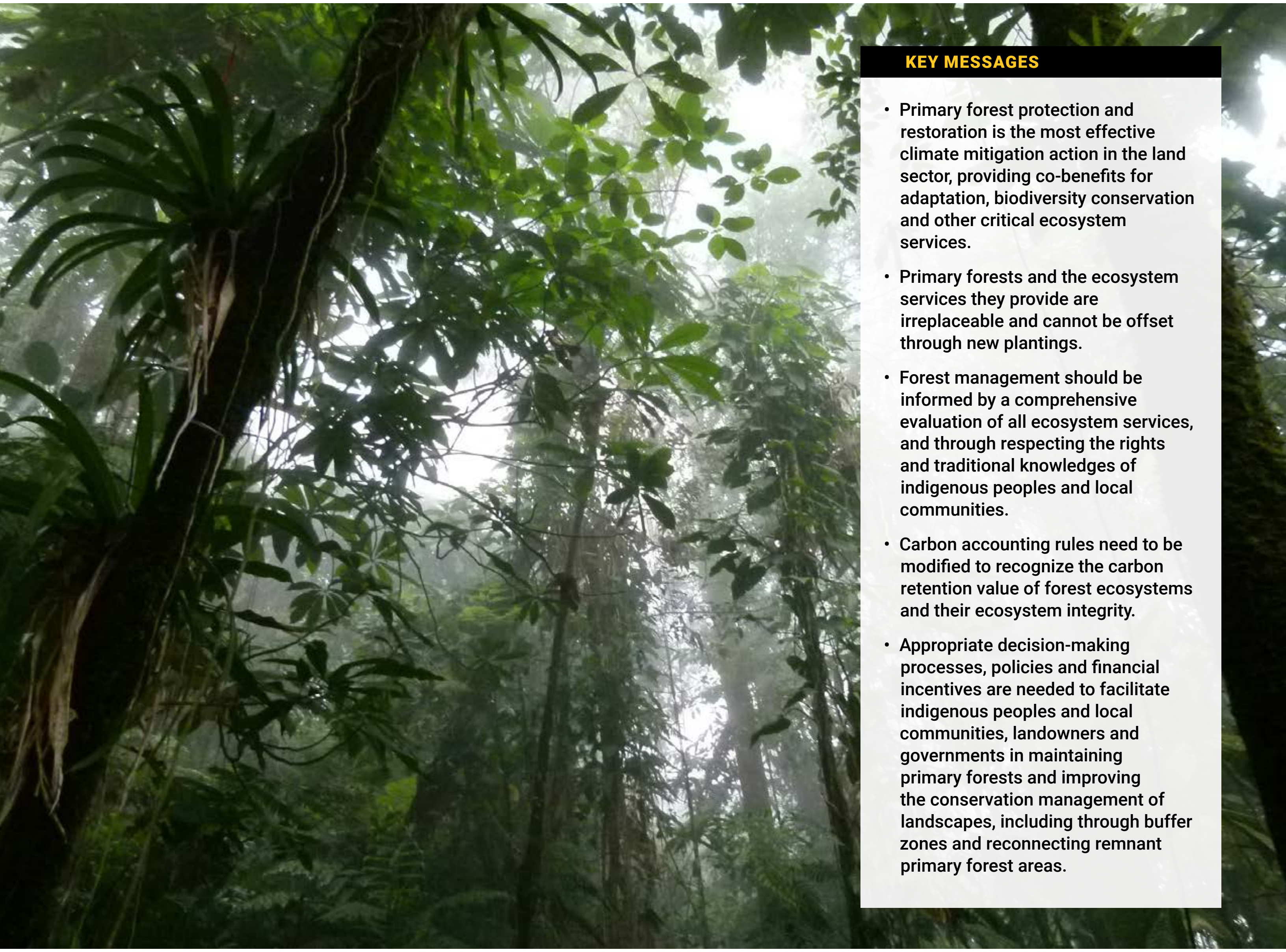
The Land Gap Report

2022

Governments' over-reliance on carbon removals could push ecosystems, land rights and food security to the brink with new land area equivalent to 50 percent of the world's croplands currently being required to meet targets. Climate pledges should focus on protecting and restoring existing ecosystems with carbon benefits.

Chapter 3: Forest ecosystem protection and restoration



KEY MESSAGES

- Primary forest protection and restoration is the most effective climate mitigation action in the land sector, providing co-benefits for adaptation, biodiversity conservation and other critical ecosystem services.
- Primary forests and the ecosystem services they provide are irreplaceable and cannot be offset through new plantings.
- Forest management should be informed by a comprehensive evaluation of all ecosystem services, and through respecting the rights and traditional knowledges of indigenous peoples and local communities.
- Carbon accounting rules need to be modified to recognize the carbon retention value of forest ecosystems and their ecosystem integrity.
- Appropriate decision-making processes, policies and financial incentives are needed to facilitate indigenous peoples and local communities, landowners and governments in maintaining primary forests and improving the conservation management of landscapes, including through buffer zones and reconnecting remnant primary forest areas.

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Deforestation and degradation have contributed 35 percent of total historical anthropogenic emissions and 12 percent of emissions this century (IPCC, 2013). One-third of Earth's natural forests are gone, about one-third of forests are degraded by extractive land use, and only one-third remain in a primary state (see **Box 1**). Primary forest is currently being lost at a rate of 3.4 million ha every year. However, forest conservation management and the ecological restoration of forests play a critical role in climate change mitigation. Forests can contribute to a comprehensive mitigation strategy by:

- retaining an accumulated stock of living and dead biomass carbon and soil organic carbon (carbon retention value);
- maintaining the natural terrestrial carbon sink to buffer some of the impact of elevated atmospheric CO_2 concentration from fossil fuel emissions; and
- removing CO_2 from the atmosphere through ongoing growth of primary forests and restoration of secondary natural forests and other degraded forest land.

Retaining carbon stored in forests and preventing its emission to the atmosphere is the prime mitigation opportunity offered by the land sector. Immediate emissions reductions can be achieved by changing current land use and forest management to halt deforestation and forest degradation. Such changes in management must be exercised in a manner that respects human rights, including those of IPs and LCs, and incorporates public participation in decision-making.

Forests remove carbon continuously from the atmosphere and are currently estimated to provide a sink of −7.6 ± 49 Gt CO_2e per year, with 30 percent from tropical and subtropical forests, 47 percent from temperate forests, and 21 percent from boreal forests (Harris *et al*., 2021). However, this sink has been declining due to emissions from forest loss and degradation, interacting with increasing impacts from climate change (Raupach *et al*., 2014; Brienen *et al*., 2015; Steffen *et al*.; 2017, Gatti *et al*.; 2021, Zhu *et al*., 2021; Anderegg *et al*., 2022). It is therefore critical to conserve forest biodiversity and related ecological processes to help maintain their sink capacity.

Forest landscapes have significant potential to remove CO_2, given the extent to which forests have and are being lost and degraded (Mackey *et al*., 2013). Removals though forest restoration and afforestation have been included in assessments of pathways to net zero emissions (IPCC, 2022b) and many pledges made in NDCs could not otherwise be met. However, planted trees take decades or even centuries to accumulate sufficient carbon to replace that lost through deforestation and degradation. Moreover, trees planted for wood supply or biofuel production become sources of emissions, and are not a mitigation solution.

The mitigation and other ecosystem benefits of primary and natural forests will be conserved and enhanced by ensuring the rights of IPs and LCs to their land, culture and sustainable livelihoods. Indigenous peoples have rights to or manage approximately 37 percent of all remaining natural lands (Garnett *et al*., 2018). When these tenure rights to collectively managed land are combined with participatory decision-making, cultural motivation and resources to support planning and governance, protection of forest carbon stocks and biodiversity can be achieved together with sustainable livelihoods (see **Box 3**).

Despite the mitigation potential of conservation management of forests, very little climate funding (~5 percent) is used to support improved practices (Barber *et al*., 2020). International policy and funding mechanisms do not adequately prioritize the protection of primary forests to retain their carbon stocks for mitigation over the restoration of degraded forests or the establishment of plantations, which provide far fewer benefits. Nor do these mechanisms emphasize ecological restoration: almost half of government 'restoration' pledges are in fact for commercial plantations (Fagan *et al*., 2020).

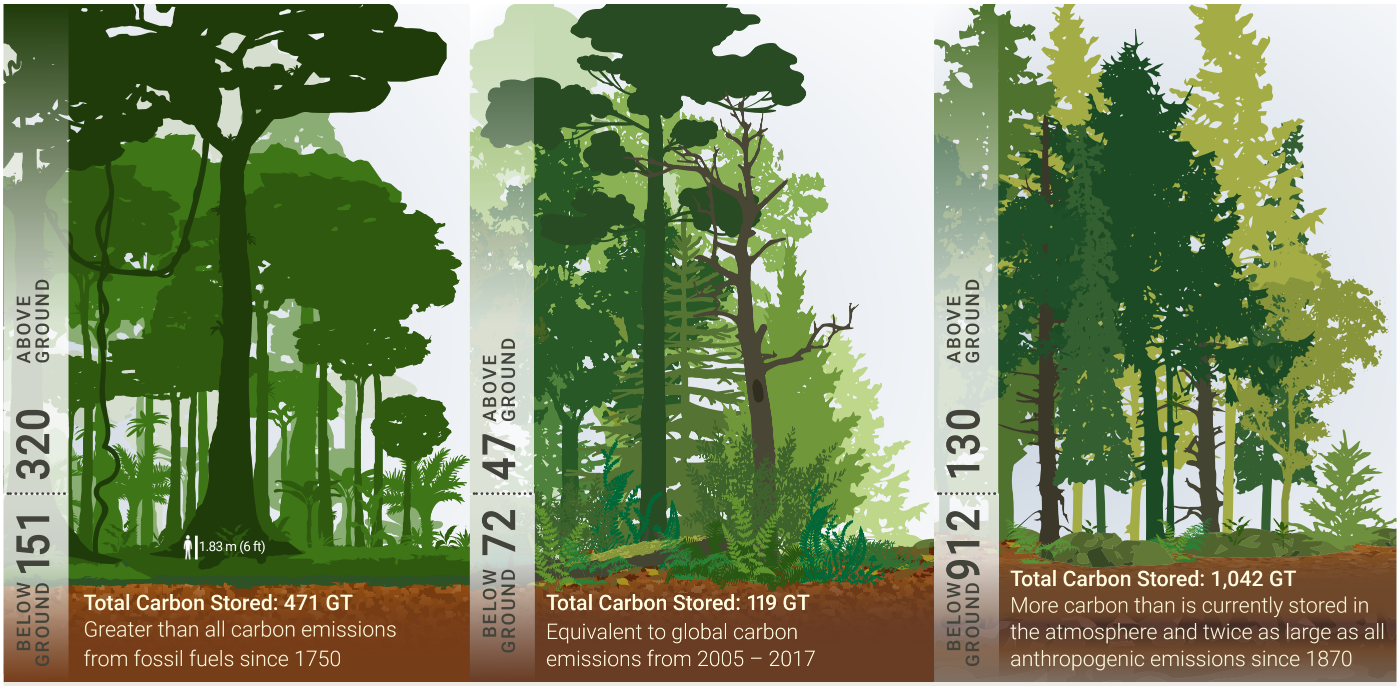
This chapter explains the critical importance of primary forests for climate mitigation, describes the state of the world's forests, and outlines the barriers that are currently hindering effective mitigation and the planned activities for forests under NDCs. It goes on to propose solutions that would improve the integrity of primary and other forest ecosystems and support just and equitable benefit-sharing of ecosystem functions and services for IPs and LCs, as well as for all life on Earth.

3.1 The importance of primary forests for climate mitigation

Primary forest protection and restoration is the most effective climate mitigation action in the land sector, providing co-benefits for adaptation, biodiversity conservation and other critical ecosystem services.

3.1.1 Description of primary forests

Primary forests are naturally regenerating forests of native species, whose composition, structure and function are dominated by natural ecological and evolutionary processes, including natural disturbance regimes (FAO and UNEP, 2020; IUCN, 2020; Mackey *et al*., 2020). These forests are not subject to modern industrial land use, but most are the customary lands of IPs and LCs (**Box 6**). Primary forests have irreplaceable value for their biodiversity, carbon storage, other ecosystem functions, Box 1 **Primary forest biomes**



Primary Tropical Forests

Tropical forests store 471 Gt C and roughly half is stored in primary forests.

The attributes below contribute to primary forest stability and resilience to threats from disease, invasive plants, feral animals, drought and fire and enhance ecosystem adapt ive capacity to climate change and other stresses:

- Mammal, bird, reptile and insect seed dispersers and pollinators ensure trees including long lived hardwood species replant themselves and renew the forest.
- Forest fauna and flora drive efficient nutrient and water cycles sustaining healthy forest growth.
- The closed forest canopy creates an interior microclimate sheltering the understorey and maintaining moist, shady and cool conditions.
- Water retained below the canopy stimulates rapid and dense tree and other vegetation growth.
- The canopy transpires water driving convection which in turn can generate regional cloud cover and rainfall.

Primary Temperate Forests

Temperate forests are the most depleted of any forest biome covering roughly one third of their original extent compared to 45% for tropical forests and 65% for boreal forests. Primary temperate forests sequester and store vast amounts of atmospheric carbon in living and dead biomass and soil organic matter, holding onto it for centuries. Their carbon storage value is demonstrated by:

- The highest known biomass (above ground live and dead) of 187kg/m² is in Victorian mountain ash forests.
- Trees can tower to 100+ metres and live for over 1,000yrs.
- Large old trees sequester carbon at 3 times the rate of smaller trees, contribute 76% of the biomass in an old forest but only 43% of tree numbers.
- When old forests are cut down two thirds or more of their stored carbon is released to the atmosphere. Logging emissions are not offset by planting new trees or carbon stored in harvested wood products.

Primary Boreal Forests

Boreal forests store about 65% of the world's forest ecosystem carbon which is mostly held below ground in peat and mineral soils.

The cold wet environment in boreal forests slows decomposition on the forest floor leading to thick layers of moss and litter and soils that can be metres deep storing as much as 85% of the ecosystem's carbon.

- Carbon stored in the mineral soils of boreal forests has a turnover rate of approximately 50 years, more than twice as long as that in temperate or tropical forests.
- Peat found in fens and bogs of boreal forests store 270 billion tonnes of carbon across the boreal forest landscape.
- Clear cut logging does not mimic naturally occurring fire in boreal landscapes as fires do not combust tree boles and the resulting carbon stored in dead standing trees and woody debris is longer lived than most sawn timber products by at least a factor of two.

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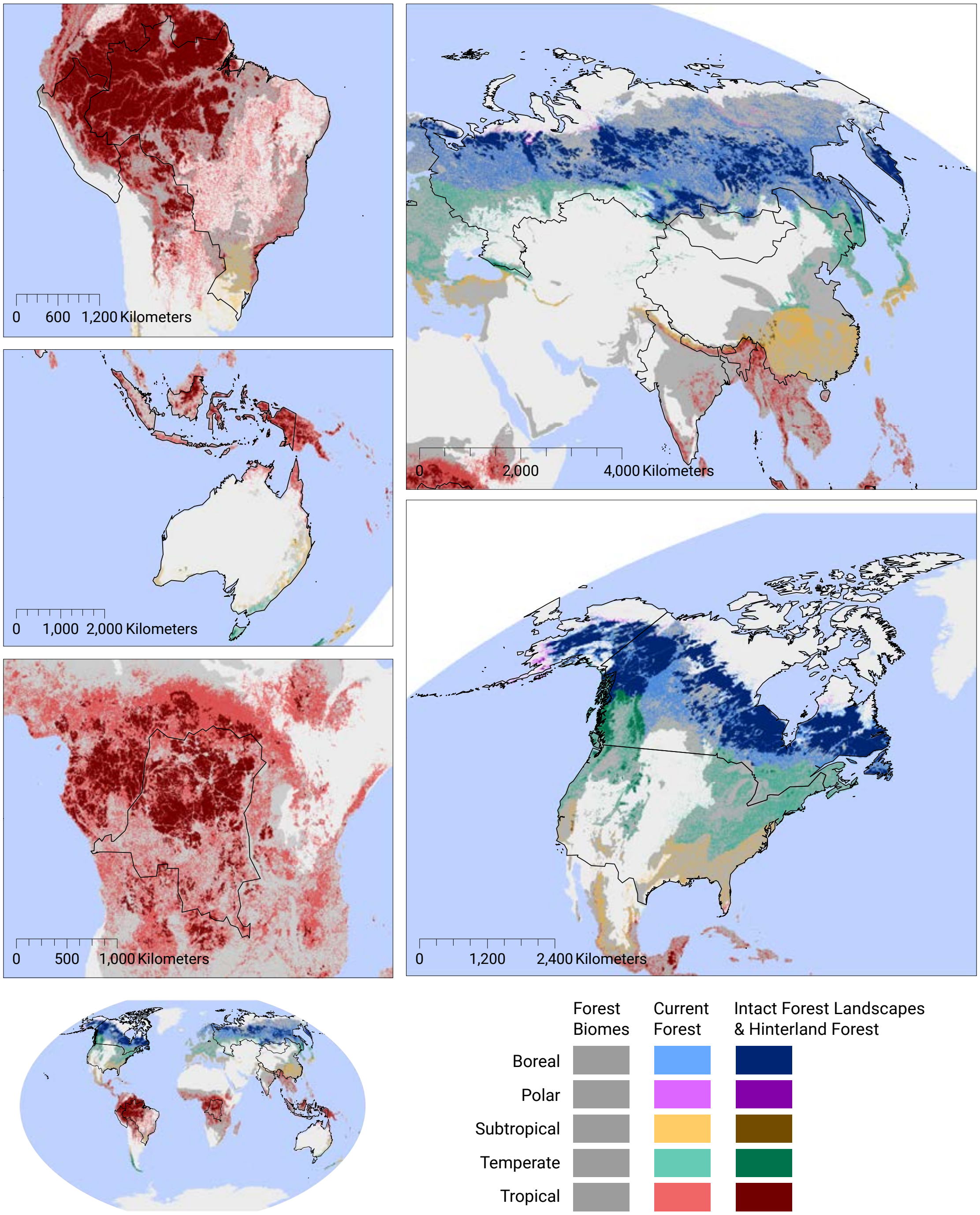
Figure 3.1 **Global Forest Extent for Global Ecological Zones**

Extent of forest biomes (pre-agricultural era), current extent of forest area, and primary forests proxy.[1] The top ten forested countries are shown by black outlines (the Russian Federation, Brazil, Canada, the United States of America, China, Australia, the Democratic Republic of the Congo, Indonesia, Peru, India)



Sources: Global Ecological Zones (FAO, 2012); Pre-agricultural era extent (Billington *et al*., 1997; Current extent canopy cover (Hansen *et al*., 2013); Canopy height (Lang *et al*., 2022); Structural classes (Carnahan, 1977; Specht, 1970); Primary forest proxy at global scale using Intact Forest Landscapes in temperate and boreal zones (Potopov *et al*., 2017) and hinterland forest in tropical and subtropical zones (Tyukavina *et al*., 2016) (this does not include small areas of primary forest). Areas of forest lost have been masked out up until 2021 (Hansen et al. 2013).

1 Forest area is defined by FAO in terms of tree cover and land use. It does not include tree cover predominantly under agricultural or urban land use, but does include areas with temporary loss of tree cover through forest management or natural disturbance (FAO and UNEP, 2020).

including cultural and heritage values, and for sustaining the livelihoods and culture of IPs and LCs (FAO and UNEP 2020; IPCC, 2022b) (see **Box 3**).

Primary forests represent the highest level of ecosystem integrity along a continuum of ecosystem condition that reflects the impacts of human activities – from minimal to severe. This highest level is thus the reference condition (or benchmark) for assessing change in ecosystem condition in the past and potential gains in the future. Ecosystem integrity is defined as the system's capacity to maintain composition, structure and function over time within a natural range of variability at landscape scales, and based on ecological and evolutionary processes. Ecosystems with a high level of integrity have the capacity for self-organization, regeneration and adaptation by maintaining a diversity of organisms and their interrelationships (UN *et al*., 2021; IPCC, 2022a).

Ecosystem integrity is underpinned by the functional role of biodiversity in ecological processes that results in a forest having a maximum degree of resilience and adaptive capacity (Thompson *et al*., 2009). Biodiversity refers to the diversity of species, the genetic diversity within species, and the diversity of ecological communities, including interactions across trophic levels. At the ecosystem level, it encompasses the diversity in composition, structure and function, and stabilizing feedbacks such as nutrient cycling. Consequently, if forests are degraded, species are lost and the functioning of the ecosystem is diminished. Naturally evolved patterns of biodiversity comprise the most stable and resilient ecosystems and, within their system limits, provide natural resistance to threats that are increasing with climate change, such as pests, disease, drought and fire. It follows that the carbon stored in ecosystems with higher levels of integrity are more stable and resilient.

The role of primary forests in climate mitigation provides opportunities for transformative change in conservation management of forests, based on recognition of the carbon retention value and the provision of a wide range of other ecosystem services. Protecting the remaining primary forests and engaging in large-scale ecological restoration of degraded forests is essential for solving the biodiversity, climate change, social justice and zoonotic disease crises (Barber *et al*., 2020; Dobson *et al*., 2020).

3.1.2 State of the world's forests

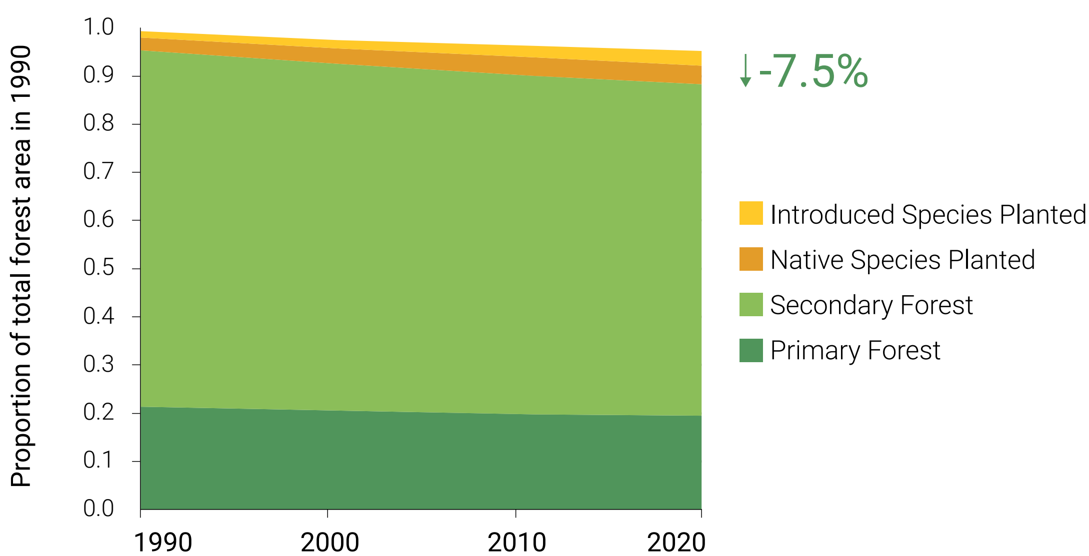
Forests currently cover 4,060 million ha or 30.8 percent of global land area (FAO and UNEP, 2020) and two-thirds of these forests occur in just ten countries (see **Figure 3.1**, **Table 3.2**). The area that is classified as primary forest (1,110 million ha) represents 34 percent of the forest area reported, and 75 percent occurs in the Russian Federation, Brazil, Canada, USA, and the Democratic Republic of the Congo (in order of forest area) (FAO FRA, 2020).

Forest areas in categories of forest type and management type show trends over the last three decades of decreasing area overall, with a decrease in natural forests and an increase in planted forests (see **Figure 3.2**). The total area of forest loss (-420 million ha from 1990 to 2020) is much higher than the net forest area decrease (-178 million ha). But the difference between

Figure 3.2 **Proportion of total forest area in 1990 to 2020**

In naturally regenerated forest subdivided into primary and secondary forests, and in planted forest subdivided into native and introduced species. Total forest area and naturally regenerated forest has decreased over the three decades, but planted forests have increased.

Data source: FAO FRA, 2020



forest areas lost and gained is important: forest loss is from naturally regenerated forests, whereas the area of forest gain is from planted forests and young regeneration, with lower carbon stocks and lower levels of ecosystem integrity. In addition, the reported area of forest loss represents land clearing and does not account for degradation of forests resulting from logging and other human disturbances. Hence, the forest statistics of changes in area underestimate the decrease in carbon stocks and impact on biodiversity and ecosystem integrity. Forest loss occurs particularly in developing countries in tropical forests, but both deforestation and degradation also occur in developed countries with temperate and boreal forests.

The total ecosystem carbon stock in the current extant forest is 680 Gt C (above-ground and below-ground living biomass, soil organic carbon (0 - 30 cm depth) calculated from global maps) shows differences in the total stock and distribution between components by biome (see **Figures 3.3** and **3.4**). This global carbon stock in forests decreased from 668 Gt C in 1990 to 662 Gt C in 2020, due to a net decline in forest area (FAO FRA 2020) (shown in **Figure 3.2**). However, carbon loss due to degradation of existing forest area and changes in forest management type are poorly calibrated in the remotely-sensed data and models, and hence is likely to be underestimated. Estimates of carbon loss from forests indicate that forest degradation may be as significant for carbon losses as deforestation (Baccini *et al*., 2017).

3.2 Barriers to achieving effective mitigation

This section discusses four barriers to achieving effective mitigation through improved conservation management: (i) understanding the role of forests in mitigation; (ii) trade-offs between and synergistic uses of forest ecosystem services; (iii) drivers of carbon stock loss; and (iv) policy failures.

3.2.1 Understanding the role of forests in mitigation

Forest ecosystems play a key role in the global carbon cycle and therefore also in regulating the climate system. Yet forest conservation management and ecological restoration have been largely overlooked in current and proposed actions under NDCs and by non-governmental organization (NGO) and private sector programmes. Instead, there is a misguided focus on tree planting, which ignores the scientific fact that the accumulated stock of carbon and its longevity, not the carbon removal rate, is the principal mitigation value of forests. Furthermore, prioritizing tree planting fails to consider the multiple ecosystem service benefits provided by primary forests, including clean water.

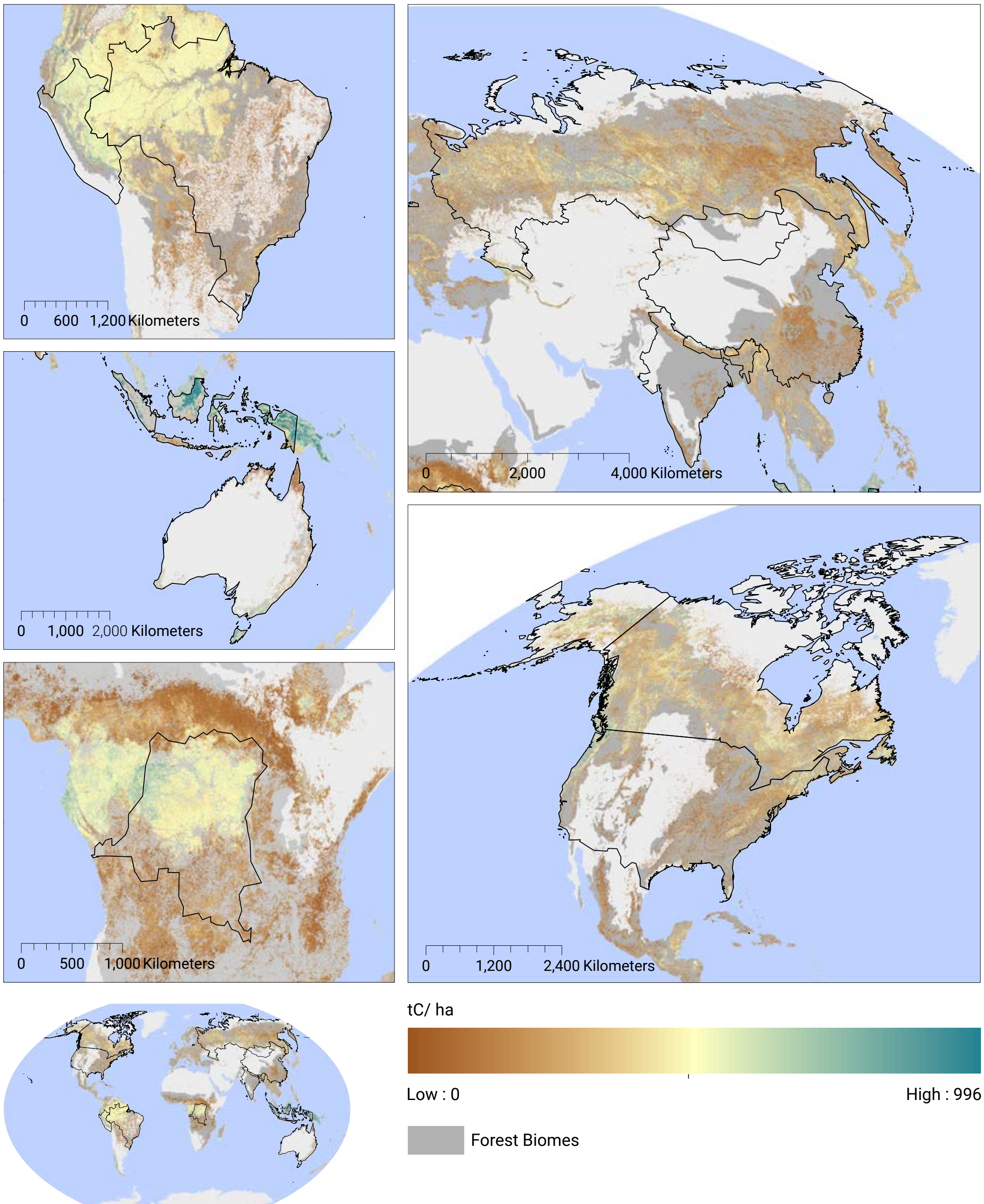
Long-lived, stable and resilient carbon stocks stored in ecosystems with high levels of integrity act as a reservoir in the biosphere, and thus serve to keep carbon out of the atmosphere (Mackey at al., 2008; Barber *et al*., 2020; WEF, 2020). It follows that the feedbacks between climate and biodiversity are two-way, whereby the changing climate can have a negative impact on biodiversity, which in turn reduces the stability and resilience of ecosystems and increases the likelihood of emitting carbon into the atmosphere – creating a mutually reinforcing downward spiral. Conversely, ecologically restoring degraded forests can improve biodiversity, increase forest stability and resilience, and lower the risk of emissions. The ability of forests to adapt to a rapidly changing environment depends on maintaining biodiversity, so as to allow ongoing evolutionary processes and natural selection to enable them to persist or adapt. Maintaining biodiversity and ecosystem integrity is thus an essential foundation for successful climate mitigation and the provision of all ecosystem services on which humanity relies, not merely a co-benefit.

Carbon accounting rules used to report national GHG inventories and develop the current pledges for NDCs (IPCC, 2006, 2019b) assume that only annual flows need to be estimated. This assumption is appropriate for fossil fuel emissions, which are one-way flows. However, this mechanism is inadequate to account for the two-way flows between the land and atmosphere, with emissions and removals (Mackey *et al*., 2013). Reporting net emissions in the land sector, and using this to assess progress towards the goal of 'net zero' emissions (Allen *et al*., 2022), is misconceived because it conflates removals by natural forest growth with emissions from human activities. This net accounting obscures the emissions from logging and masks the mitigation benefits of protecting and restoring forests (Mackey *et al*., 2022a).

The current carbon accounting system also fails to register the risk of carbon stock loss and how this differs with the level of ecosystem integrity. Rather, carbon is considered to be fungible. All carbon stocks are in effect assumed to have the same stability, longevity and resilience (Ajani *et al*., 2013). Carbon lost from primary forest is not offset by planting new trees as the ecosystem integrity is lower, and hence the risk of loss is higher. Assuming it can be offset creates a carbon debt by permanently reducing the carbon stored in the landscape and increasing the stock in the atmosphere. Similarly, fossil fuel carbon and ecosystem carbon are not fungible; they are fundamentally different in terms of the stability of their carbon stocks. The reporting in GHG inventories of net emissions has mistakenly allowed the removals from natural forest growth to offset an equivalent amount of the emissions from fossil fuel use (Mackey *et al*., 2022a). The perverse outcome is that this use of forest removals as an offset mechanism has lessened the incentives and market forces to reduce fossil fuel emissions.

Figure 3.3 **Total ecosystem carbon extant in forest**

Global spatial distribution of total ecosystem carbon density (Mg C ha-1), including above- and below-ground biomass, dead biomass and soil organic carbon (0 - 30cm depth) in the current extant forest. Top ten forested countries are shown with black outlines.



Sources: for above-ground living biomass GlobBiomas (Santoro *et al*., 2018); below-ground living biomass derived from a root: shoot ratio (IPCC, 2019b); dead biomass based on averages from site and inventory data for each biome (Pan *et al*., 2011); soil organic carbon (0–30 cm depth) from GSOC (FAO, 2019); carbon concentration of biomass (IPCC, 2006).

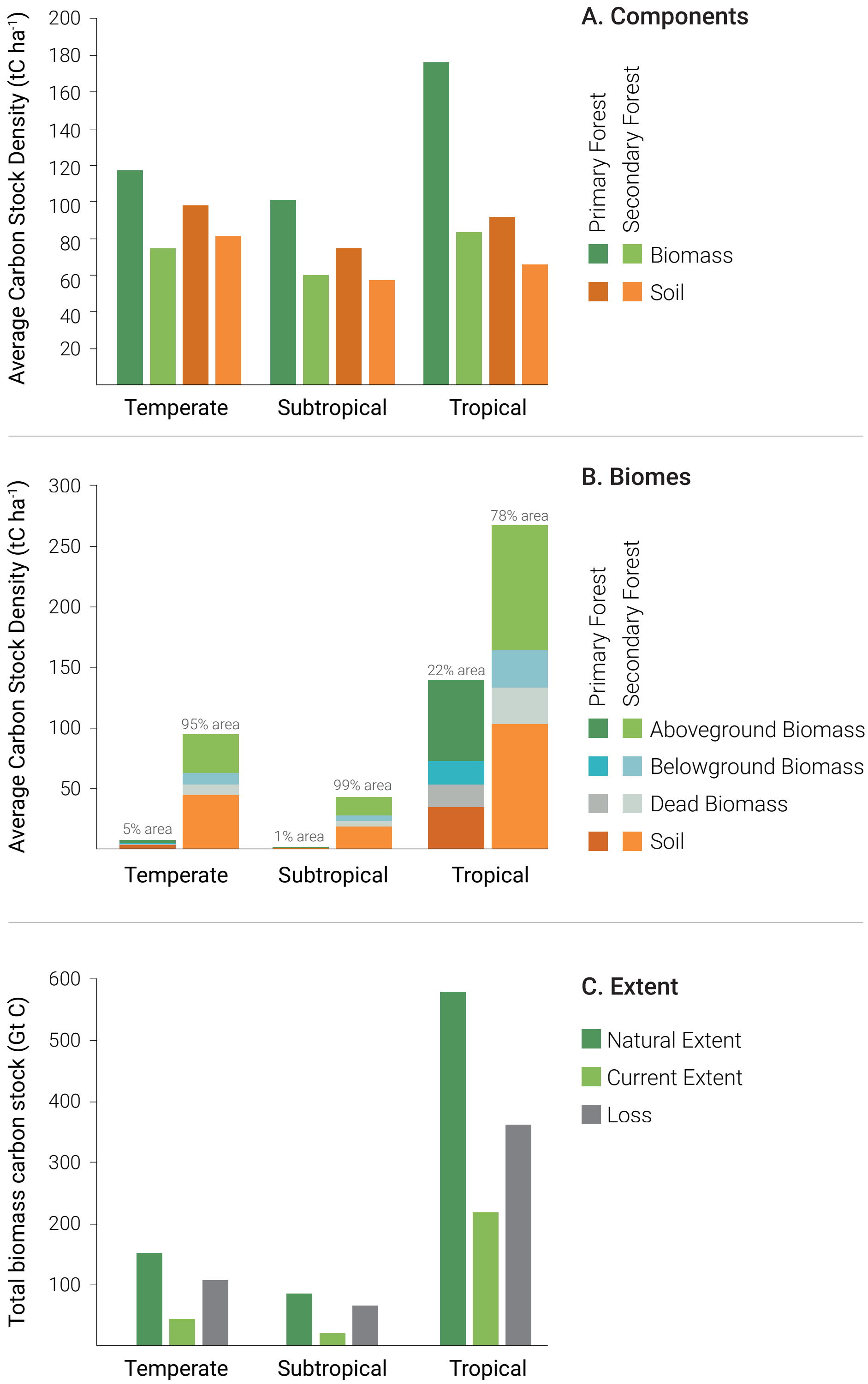
Figure 3.4 **Carbon stock by components, biomes and extent**[10]

(a) Carbon stock density of biomass and soil comparing primary and secondary forests in each biome;

(b) Total ecosystem carbon stock by components in primary and secondary forest, and showing the percent of area occupied by each category; and

(c) Biomass carbon stock in the natural extent of forest, the current extent, and the difference between these extents as the loss in carbon stock.

(Boreal biome not included in comparisons because of uncertainty in defining forest boundaries and high variability in biomass across the large regions.)



Source: Derived from the spatial data in Figures 3.3 and 3.4. Carbon stock estimated in natural extent of forests assuming the carbon stock density of primary forest.

The role of wood products for mitigation has been misrepresented, creating the false impression that carbon stored in products has a greater benefit than that stored in forest ecosystems. The promotion of wood for construction as a mitigation strategy is based on the false assumption that wood provides emissions reduction benefits. Due to changes in how harvested wood products were accounted between the 2006 and 2019 IPCC guidelines, the carbon sink in wood products was halved (Kayo *et al*., 2021). There is little evidence that wood is replacing steel and aluminium in major construction projects, and while the production of such materials is currently emissions-intensive compared with wood, the situation will reverse as soon as these products transition to renewable, non-carbon energy sources. The use of wood for construction will always produce net emissions because the forest carbon stock is maintained at a lower level than an unlogged forest (Keith *et al*., 2014, 2015). Wood products do provide a store of carbon for their lifetime, but this is small and ineffective as a mitigation action, compared with maintaining forests intact (Law *et al*., 2018). Only 30 percent of harvested wood is used for what is classified as long-lived wood products (sawn wood and veneer) (FAO, 2020) and these have an average longevity of 35 years (IPCC, 2014b).

Burning wood for bioenergy is similarly misrepresented. Forest biomass is not clean energy because burning it releases CO_2 emissions which are instantaneous, but their removal from the atmosphere takes a long time, thereby creating a significant time lag (Mackey *et al*., 2022a). This is not a mitigation action for achieving net zero and competes with real clean energy sources, such as solar photovoltaic and wind (Brack, 2017; Booth, 2018, 2022; Law *et al*., 2018; Sterman *et al*., 2018; Keith *et al*., 2022). Again, carbon accounting rules are at fault. Emissions from combustion to produce bioenergy are not counted in the energy sector, nor in the facility or country where it is consumed, and so cannot be compared with other energy sources (Pulles *et al*., 2022). And, as noted in **section 3.3.2**, logging emissions are netted out by ongoing natural growth in the rest of the forest estate.

3.2.2 Trade-offs between and synergistic uses of ecosystem services

Forests provide a multitude of ecosystem services that often go unrecognized and are therefore not included in evaluations of the costs and benefits of extractive activities versus protecting and restoring forest ecosystems. The ongoing provision of the quantity and quality of all ecosystem services, including global

Table 3.1 **Forest management to support mitigation activities also results in gains or losses of other ecosystem services**

Mitigation activity	Gain in ecosystem and cultural values	Loss in ecosystem and cultural values
Protection of primary forests	• Climate regulation • Cultural values • Many other services	• No future wood supply • No industrial-scale activities • Potential for access restrictions affecting indigenous peoples and other resource-dependent groups
Restoration of degraded secondary forest	• Climate regulation • Cultural values • Many other services	• No future wood supply • No industrial-scale activities
Improved silvicultural practices	• Improved ecosystem services • Potential for increased access supporting a pastoral or nomadic livelihood	• Change in wood supply
Reforestation* on abandoned or marginal land	• Improved ecosystem services • Potential wood supply • No change in agricultural production	• Reduced potential for other land uses • Potential for indigenous peoples and other resource-dependent groups who may use the land for grazing, agriculture, cultural heritage
Reforestation* on agricultural land	• Improved ecosystem services • Potential wood supply	• Reduced land area for agricultural production

* Activities include both reforestation and afforestation, as defined by the IPCC (2006), which refers to the establishment of trees on land that had previously been cleared of forest; the distinction depends on the time that the land has been cleared and other land uses.

climate regulation through the retention of carbon stocks, is directly linked to the integrity of forest ecosystems. However, as a finite resource, changes in the way forests are used may create trade-offs between the use of certain services, or enable opportunities for synergies. Hence, evaluations of climate mitigation strategies should include impacts on ecosystem integrity and adaptive capacity, and consequently the provision of all ecosystem services.

Forest land uses that involve trade-offs with climate mitigation include clearing for expansion of agriculture; livestock grazing; mining; and production of wood for timber, pulp and bioenergy. These activities result in deforestation and degradation that reduce ecosystem carbon stocks and cause emissions, exacerbate biodiversity loss, and reduce the quality and quantity of water, aesthetic and cultural values, and non-wood forest products important to local and regional communities.

Table 3.2 **Mitigation actions specified in climate pledges for the top ten forested countries, including developed and developing countries, and classified by criteria for their mitigation benefit**

Assessment against criteria: Low | Moderate | High

		Criteria for mitigation benefit		
	Mitigation activity	**Trade-off with other land uses/ resources**	**Action in critical time period**	**Providing co-benefits**
Russian Federation	Forest management	Moderate	Low	Moderate
Brazil	Forest planting	Low	Low	Low
	Eliminate illegal deforestation	High	High	High
Canada	Afforestation	Low	Low	Low
	Conserve carbon-rich ecosystems	High	High	High
	Protect 30% of land by 2030	High	High	High
United States of America	Reforestation of 54 million ha	Low	Low	Moderate
	Reduced forest harvest	Moderate	High	High
	Forest restoration	High	Moderate	High
	Forest protection and management	High	High	High
China	Afforestation	Low	Low	Moderate
	Restoration	Moderate	Low	Moderate
	Protection	High	High	High
Australia	Soil carbon on farms	High	Low	High
	Mixed species planting on farms	Moderate	Low	High
	Afforestation	Moderate	Low	High
Democratic Republic of the Congo	Afforestation	Low	Low	Moderate
	Forest protection and management	High	High	High
Indonesia	Moratorium on clearing primary forests	High	High	High
	Reduced impact forest harvesting	Moderate	High	Moderate
	Afforestation for land rehabilitation	Moderate	Low	Low
	Restoration of mangroves	High	Moderate	High
Peru	Restoration through commercial forest plantations	High	Low	Low
India	Afforestation to increase tree cover	Low	Low	Low

Forest protection and restoration support the synergistic provision of many ecosystem services, in addition to carbon retention and climate mitigation. These include local climate regulation; supply of freshwater through water yield and filtration; the provision of clean air; sources of genetic material; the provision of non-wood products, including food and medicinal products for IPs and LCs; habitat maintenance for biodiversity; pollination services; soil quality, erosion control and sediment retention services; flood mitigation; biological control; and aesthetic, recreational, educational and spiritual services. A major barrier is the lack of recognition of many of these ecosystem services and of standardized methods for their monitoring and valuation in relation to different forest management regimes. Nonetheless, it is possible to provide an indicative assessment of the likely gains and losses in ecosystem services resulting from changes in forest management (see **Table 3.1**).

The likely effectiveness of the current NDC forest-based mitigation pledges by countries is hard to determine because descriptions of activities are mostly very general and unquantified. It is therefore difficult to assess the potential land requirements, trade-offs with other ecosystem services, community needs and aspirations, and mitigation benefits. Mitigation activities should be assessed in terms of the area of forest required for carbon dioxide removals, the types of forest management that will produce the greatest removals and carbon storage, and the optimum management to meet multiple objectives and provision, including the protection of biodiversity and the provision of other ecosystem services.

The land area required for dedicated carbon dioxide removals pledged in the NDCs for emissions reduction is 1.2 billion ha globally, and involves a range of mitigation activities for forest land, as well as agricultural and rangelands. However, there will invariably be competing uses for both forested and cleared land. Fundamental criteria for assessing the mitigation benefits of an action include examining: (i) whether there are trade-offs with community needs, biodiversity protection, and other land uses; (ii) if the action produces a change in carbon storage or removals within the critical time period for mitigation (the next one to three decades); or (iii) degradation in the provision of co-benefits (see **Table 3.2**).

Protecting existing forests is the only activity that provides the highest benefits against all criteria. The critical time period for action was the criterion with the lowest scores for many activities. This criterion has not been considered adequately in many NDCs that have focused on a target of net zero emissions by 2050, without calculating the accumulated carbon emissions in the atmosphere that will result from the intervening 28 years of activities producing emissions (Keith *et al*., 2022).

Forest protection and restoration support the synergistic provision of many ecosystem services, in addition to carbon retention and climate mitigation.

The lack of details in NDC-proposed forest-based mitigation activities makes them difficult to implement and attract investment. Australia provides no information about off-farm land sector abatement except to state ‘savanna burning’ and ‘native forest management’. Moreover, the proposed mitigation does not specify avoiding land sector emissions by reducing deforestation or logging, despite the obvious benefits (Mackey *et al*., 2022b). Peru simply states that relying on land use, land-use change and forestry sinks to achieve its climate targets should be avoided as much as possible, given the high chance of carbon loss through deforestation, natural disturbance, or competition for land.

We present case studies in temperate forests in southeastern Australia and the Kayapo Territory of Brazil to illustrate the impact of competing uses of forests on their carbon storage, ecosystem integrity and capacity for mitigation (see **Boxes 2** and **3**).

3.2.3 Drivers of carbon stock loss

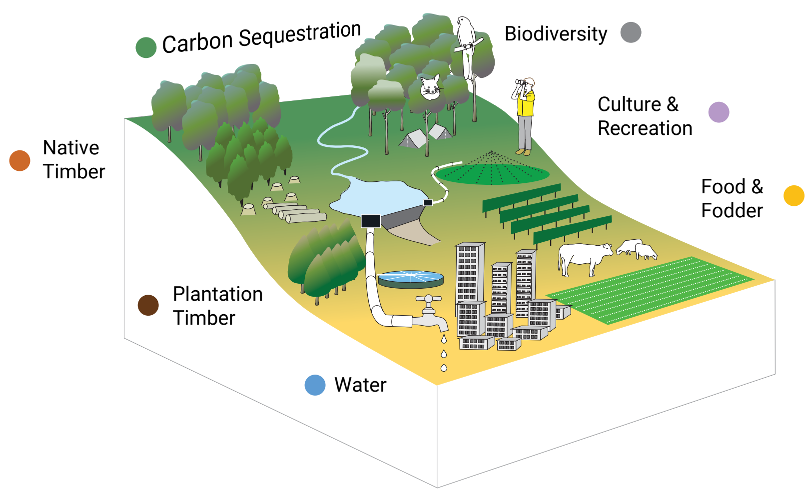
Deforestation and degradation are causing continued loss of forest carbon stocks. The drivers of these activities are demand for food and energy to supply a growing global population and changing patterns of consumption. In particular, marketing in developed countries influences the supply chain and logging practices in developing countries (Davergne and Lister, 2011; Donofrio *et al*., 2017; Sen, 2017; Curtis *et al*., 2018).

Deforestation results from agricultural expansion for crops and pasture (see **section 2.2** and **Chapter 5**), plantations, industrial timber extraction, clearing for mining and infrastructure, urban expansion, fuelwood extraction for commercial bioenergy and local fuel, and fires, which are often associated with roading and logging-site development (Fearnside, 2017; Potopov *et al*., 2017; Curtis *et al*., 2018). These drivers differ among regions and are context- specific, depending on local social, economic and environmental factors. In tropical and subtropical countries, large-

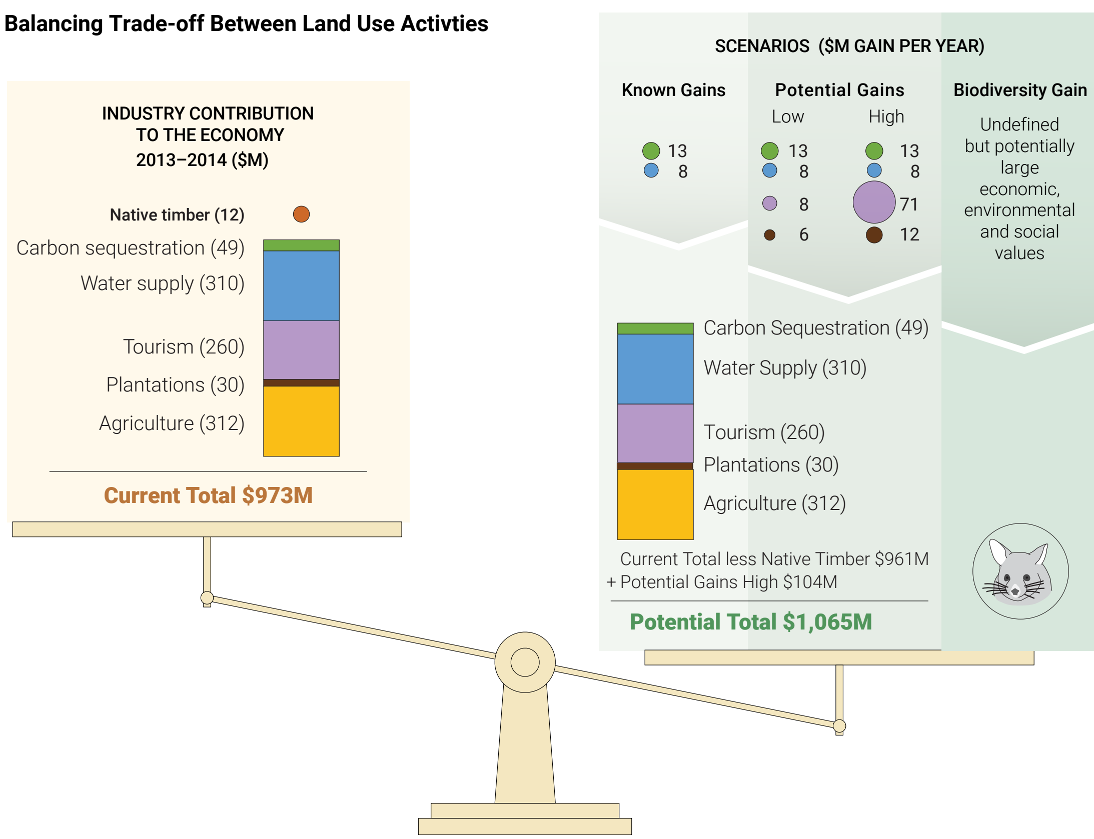
Box 2 **Central Highlands of Victoria case study**

The wet temperate eucalypt forests in the Central Highlands of Victoria, Australia illustrate the usefulness of the UN System of Environmental Economic Accounting Ecosystem Accounting (SEEA_EA) framework (UN *et al.*, 2021) for assessing the effects of forest management on carbon stocks and the trade-offs in the provisioning of key ecosystem services: carbon sequestration, water supply, biodiversity conservation, culture and recreation, native timber and plantation timber provisioning, and food and fodder provisioning. Scenarios of known gains and potential gains in provisioning of these ecosystem services showed that their value and contribution to gross domestic product (GDP) (industry, value added) was higher in forests managed for protection where native forest logging was ceased. This demonstration of the trade-offs between forest management for protection or production was used to inform decision-making about contentious land-use issues (Keith *et al.*, 2017, 2019).

Ecosystem Services



Balancing Trade-off Between Land Use Activties



Box 3 **Kayapo case study**

In the southeast of the Brazilian Amazon, the Kayapo territory has proven a formidable barrier to forest destruction thanks to de facto protection services – the 9,000+ indigenous inhabitants, who have fiercely defended their lands for generations. Kayapo culture and survival depends on primary forest and riverine ecosystems.

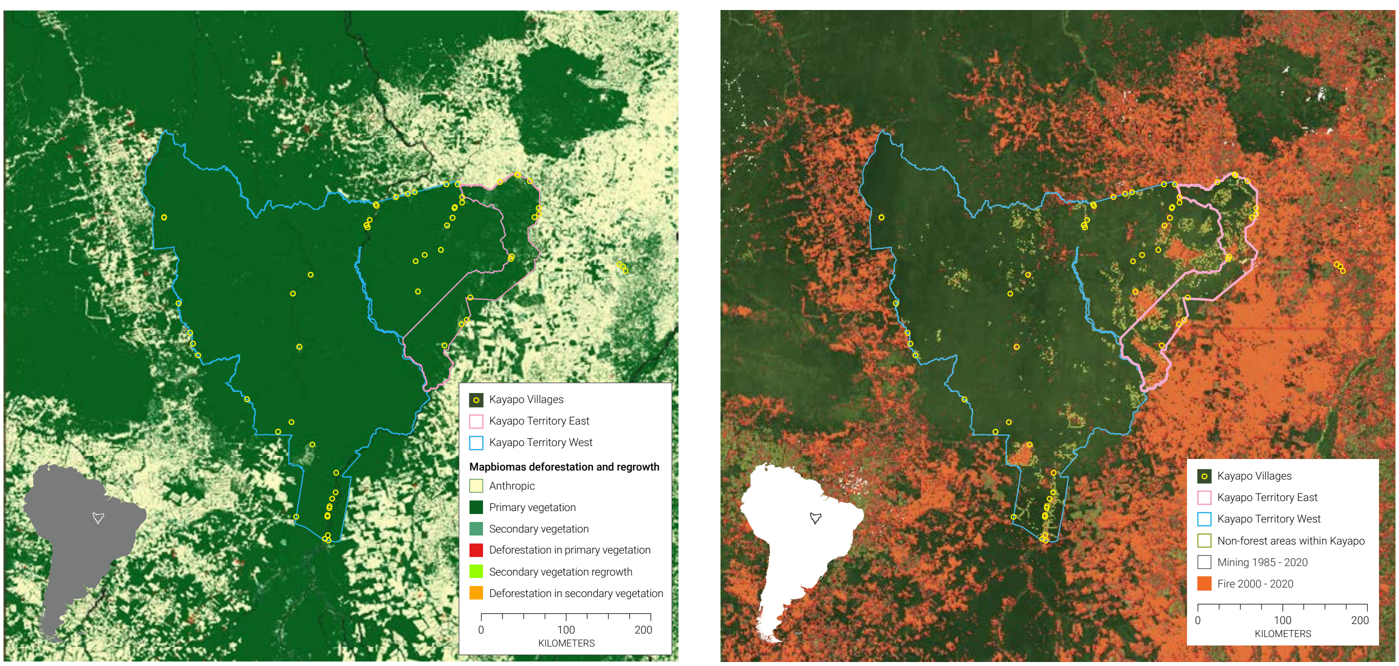
Indigenous territories are protected under the constitution of Brazil, but Kayapo lands are under siege from agricultural frontiers in the region of the Amazon with the highest rate of deforestation. Without adequate surveillance and protection in this lawless region of weak governance, ranchers, loggers, goldminers and commercial fishers invade the territory. Recognizing their need for help to secure their borders and develop sustainable income generation, the Kayapo forged alliances with conservation NGOs more than 20 years ago.

The Kayapo–NGO alliance has implemented conservation and development programmes that continue to grow and empower Kayapo communities, enabling them to protect more than 10 million ha of their forested territory, which stores approximately 1.9 Pg C. This vast area has high conservation significance, being rich in biodiversity and extensive enough to protect large-scale ecological processes. As well as rainforest, the Kayapo territories span portions of the threatened *cerrado* (savannah-woodland) biome and preserve high numbers of endemic fauna and flora species. Evidence for the effectiveness of this approach is provided in the following maps.

Figure 3.5 **Kayapo territories**

a) The boundary of the Kayapo Territory in relation to the remaining primary forest and deforested land (labelled 'anthropic' land cover); b) The Kayapo Territory in relation to burned and unburned land. Under natural conditions, wet tropical primary forest is resistant to wildfires as the closed canopies create moist microclimates. Non-forest areas, such as cerrado, located within the perimeter of the primary forest are more fire-prone and typically experiences wildfires. In a region lacking effective governance, more than 1.2 million ha of Kayapo territory have been lost to illegal gold mining and logging, largely along the eastern border, and the area has experienced more human-driven wildfires. The well-organized Kayapo Alliance in the western sectors has been more successful in resisting such incursions.

a) **b)**



Source: The land-cover and wildfire data were sourced from the MAPBIOMA programme (https://mapbiomas.org/). The mapping of fire scars in Brazil was based on mosaics of images from Landsat satellites, with a spatial resolution of 30 m for the period 1985 to 2020.

scale commercial agriculture for cattle ranching and cultivation of soybean and palm oil are the main drivers of deforestation, but clearing also occurs due to shifting agriculture and small-scale commercial farms (Hosonuma *et al*., 2012; Seymour and Harris, 2019). In temperate and boreal regions, deforestation rates are lower, but still significant in some regions, with Australia having the highest rate of deforestation in the developed world (with a rate of 0.28 percent in the 1990s and 0.26 percent in the 2000s (Pan *et al*., 2011), but decreasing in the past decade).

Degradation is best understood as a reduction in the ecosystem integrity of the forest, attributable to the impacts of human land-use activities, including forest management for commodity production. The composition, structure, function and productivity of the ecosystem is impacted by these land uses, resulting in reduced capacity to deliver the full suite of ecosystem services (CBD, 2006; van Lierop *et al*., 2015; FAO and UNEP, 2020; Prăvălie, 2021; IPBES, 2022; van der Esch *et al*., 2022).

The main drivers of forest degradation are commercial logging, followed by fuelwood collection and charcoal production, uncontrolled fires and livestock grazing in forests (Hosonuma *et al*., 2012; Putz *et al*., 2014; Keith *et al*., 2015, 2017; Erb *et al*., 2018; Taubert *et al*., 2019; Maxwell *et al*.; 2019, Mackey *et al*., 2020). Forests managed for wood commodity production comprise one-third of the world's forests (Puettmann *et al*., 2015). This type of land use invariably results in removing trees, damaging remaining trees and other vegetation, soils and waterways (Mayer *et al*., 2020), and younger even-aged stands dominated by commercially valuable tree species (Puettmann *et al*., 2015; Pearson *et al*., 2017; Mackey *et al*., 2020). Emissions from logging have probably been underestimated and the resulting carbon stock at landscape scale is reduced by 30 to 70 percent (Noormets *et al*., 2015; Arneth *et al*., 2017; Erb *et al*., 2018; Keith *et al*., 2022). Biodiversity is reduced due to removal and damage to vegetation and disturbance of habitats. At landscape scale, degradation from the construction of infrastructure involves fragmentation, resulting in restricted connectivity, diminished ecological processes and greater impact of edge effects (Laurance *et al*., 2006, 2014). The remaining forest has increased vulnerabilities to drought, wildfire, pests, pathogens, weeds and drier microclimates (Briant *et al*., 2010; Lindenmayer *et al*., 2021; Wilson *et al*., 2022). Degradation caused by previous land use can be permanent or irrecoverable. Examples include soil erosion, irreversible change in pedogenic processes, pollution, and the extinction of species This means that the carbon carrying capacity is reduced and can never fully regain its previous stock.

The impacts of degradation are poorly recognized and there is little monitoring of its impacts. Forest degradation is not formally defined in international agreements and a range of definitions and criteria are used by countries, including when reporting to FAO's Forest Research Assessment (FAO FRA, 2020). The lack of an internationally agreed operational definition of degraded forests has hindered reporting against targets that are used to assess progress towards mitigation through land management. These include SDG 15.3.1 'Proportion of land that is degraded over total land area' (UN 2019), Aichi Biodiversity Target 5 'Degradation and fragmentation is significantly reduced' (CBD, 2020), and the UN Strategic Plan for Forests goal 1 'Increase efforts to prevent forest degradation' (UN, 2017). In addition, classification systems for forests do not include characteristics representing ecological condition and the divergence from benchmark levels of ecosystem integrity.

The lack of an internationally agreed operational definition of degraded forests has hindered reporting against targets that are used to assess progress towards mitigation through land management.

3.2.4 Failures in policy

Primary forests are irreplaceable due to their value in climate mitigation and in conserving biodiversity. Continuing deforestation and degradation demonstrate persistent failures in international and national climate policy and targets to protect forests. Annual forest loss remained at 10 million ha in 2015–2020 (the area of Iceland every year) (FAO and UNEP, 2020). Rates of degradation due to fragmentation appear to be increasing (FAO and UNEP, 2022). *The Sustainable Development Goals Report 2019* (UN, 2019) indicated that 20 percent of the Earth's surface was in a degraded state between 2000 and 2015, with the highest proportion of 36 percent recorded in Oceania. In the five-yearly review of progress towards halving deforestation rates, as per the New York Declaration on Forests, in noting failure to achieve this goal, comments were made about the 'tragic' failure of the initiative to protect primary forests (NYDF, 2019). These statistics illustrate the extent of current policy failure. Climate and forest mitigation strategies have failed to prevent deforestation and have actually fostered degradation in some areas by subsidizing logging, even at low intensities (Hansen *et al*., 2013; Keenan *et al*., 2015; Curtis *et* *al*., 2018; NYDF, 2019). For countries with high forest area but low deforestation rates (HFLD), which contain 24 percent of the world's forests, there are few policies and programmes to support improved conservation management of their primary forests (UNDP *et al*., 2019).

There has been no explicit implementation of Article 4.1(d) of the UNFCCC (1992), which calls for the conservation of ecosystem carbon reservoirs (or stocks), nor of the ecosystem provision in Article 5 of the Paris Agreement (UNFCCC, 2015). This means that the assumption of carbon being fungible remains unchallenged and countries continue to report annual flows of carbon that net-out emissions from the fossil fuel sector with removals in the land sector, which are largely through forest growth. Poor policies have led to high-profile initiatives that focus on tree planting, such as the Bonn Challenge, having perverse outcomes. While tackling desertification is a valuable objective, tree planting will only slowly accumulate carbon and benefit mitigation. Many tree planting initiatives have little or no ecological benefit and are at high risk of medium- to long-term failure. Even worse, focusing on tree planting deflects attention from the urgency and immediate benefits of protecting and restoring forest ecosystems. Improving the conservation management of primary and other natural forests provides long-term integrated benefits for climate mitigation and adaptation, biodiversity conservation, and other essential ecosystem services. The mitigation value of preventing emissions now from causing damage to and loss of, primary forests far outweighs the benefits of trying to restore them in the future. There is increasing recognition of the need for holistic solutions in the land sector that integrate management for climate, biodiversity and climate-resilient development. However, achieving these solutions will require transformation in approaches to forest management and an evaluation of the benefits of all ecosystem services (Barber *et al*., 2020; Morgan *et al*., 2022).

3.3 Proposed solutions: prioritizing, incentivizing and financing forest management for mitigation on the basis of ecosystem integrity

The scientific imperative of reducing emissions now and minimizing the risk of future loss necessitates maintaining and restoring the integrity of forest ecosystems. We can scale up ambition by transforming forest management to support multiple objectives and close the land gap. The changes are essential to address the interlinked climate and biodiversity crises that require reducing gross emissions from all sectors, combined with increasing carbon storage in ecosystems and reversing the trajectory of biodiversity loss and ecosystem decline. Improving the conservation management of primary forests and restoration of natural forest ecosystems to support a wide range of ecosystem services can deliver social, environmental and economic benefits. Key factors required to achieve this transformation include: reforming the rules for carbon accounting and priorities for forest mitigation actions; identifying and appropriately valuing all the ecosystem services that provide social, environmental and economic benefits, inclusive of their magnitude, longevity and synergies; reducing the risk of loss of carbon stocks due to disturbance events by improving the integrity of forest ecosystems; and reforming policies and practices of governments, businesses and communities to promote synergistic and holistic solutions that provide optimum benefits. Such a transformation will enable strategies to be implemented that minimize barriers and prioritize effective mitigation. These changes in forest management are needed in all biomes (tropical, boreal and temperate) and forest ecosystem types, and across both developed and developing countries.

3.3.1 Opportunities for addressing the interlinked climate and biodiversity crises

Policy guidance has been slowly evolving in response to increasing recognition of the role of nature in climate mitigation (see **Box 4**). Drivers for this change include recognition that deforestation is a major contributor to GHG accumulation in the atmosphere, as well as IPCC conclusions that it is not feasible to achieve climate goals through reductions in fossil fuel emissions alone (IPCC, 2019a, 2022b). Also important is the expectation by state parties that the deep and rapid cuts now needed in fossil fuel emissions may be lessened by scaling up nature-based solutions (as indicated by their inclusion in NDCs, see **Table 3.2**). This has led to increasing awareness of the nexus between the climate and biodiversity crises, which is slowly shifting the global policy focus towards encouraging synergistic climate and biodiversity actions. The scale of both crises was recognized at the first joint Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)/IPCC workshop, held in 2021 (Pörtner *et al*., 2021), which clearly identified where synergies lie: emphasizing the importance of protecting and restoring carbon and species-rich ecosystems such as forests; and stressing that each crisis amplifies the other and that neither crisis will be solved unless they are solved together. Recent decisions under the Rio Conventions and recommendations by IPBES/IPCC and IPCC (2022b) (see **Box 4**) are important steps forward that may afford some opportunities to address the interlinked climate and biodiversity crises. However, they are as yet insufficient to ensure that the right priorities are implemented by state parties in their NDCs. The crux of the issue is that forests – and the integrity of their ecosystems – cannot continue to be traded off for other land uses, with the IPCC recognizing that carbon lost from carbon-dense ecosystems such as primary forest is irrecoverable by 2050 (IPCC, 2022b).

3.3.2 Comprehensive carbon accounting to inform policy

Comprehensive carbon accounting of stocks and flows enables the true change in the carbon stock of the atmosphere to be defined and the mitigation benefits of forests and other ecosystems to be recognized and realized. The rules for carbon accounting need to provide information about the carbon

Box 4 **Evolution of policies leading to current opportunities from international decisions**

Chronology of relevant declarations

- 2007 Conference of the Parties (COP) 14 in Bali: REDD+ adopted for negotiation.
- 2011 COP 17 in Durban: The South African COP President noted: "Forests are central to the world".
- 2014 New York Declaration on Forests: An ambitious programme to "cut natural forest loss in half by 2020 and strive to end it by 2030".
- 2018 COP 24 in Katowice: The COP President made his initiative saving the world's forests for climate and biodiversity.
- 2021 COP 26 in Glasgow: The Global Forest Finance pledge committed USDD 12 billion for 2021–2025 to help protect, restore and sustainably manage forests to meet climate, biodiversity and sustainable development objectives, recognizing the rights and roles of indigenous communities.

Decisions under the Rio Conventions

- Paris Agreement (2015) expectations were raised that Article 5 pertaining to all ecosystems (5.1) and especially forests (5.2) would be informed by paragraphs 12 &13 of the Preamble, which referred to Article 4.1(d) of the UNFCCC and noted the importance of ensuring the integrity of all ecosystems and the protection of biodiversity. Article 4.1(d) "responds to longstanding concerns that biodiversity and ecosystem integrity risks are not sufficiently considered by parties when taking climate action" (Carazo 2017).
- CBD COP 14 (2018) expressed deep concern that "escalating destruction, degradation and fragmentation of ecosystems would reduce the capacity of ecosystems to store carbon and lead to increases in greenhouse gas emissions, reduce the resilience and stability of ecosystems, and make the climate change crisis ever more challenging" (CBD 14/5).
- CBD COP 14 (2018) recognized the exceptional importance of primary forests for biodiversity conservation and the urgent necessity to avoid major fragmentation, damage to and loss of primary forests of the planet (CBD 14/30).
- UNFCCC COP 25 (2019) delivered the first decision since the Paris Agreement on the importance of "integrating action to prevent biodiversity loss and climate change" (i/CP25, para 15).
- UNFCCC COP 26 (2021) – The Glasgow Declaration emphasized "the importance of protecting, conserving and restoring nature and ecosystems, including forests and other terrestrial and marine ecosystems, to achieve the long-term global goal of the Convention" (CMA/3.para 21 and 1.CP/26 para 38).

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- 7.4.1.3 "Avoiding the conversion of carbon-rich primary peatlands, coastal wetlands and forests is particularly important as most carbon lost from those ecosystems are irrecoverable through restoration by the 2050 timeline of achieving net zero carbon emissions" (Goldstein *et al*., 2020).
- 7.42, 28 "Among the mitigation options, the protection, improved management, and restoration of forests and other ecosystems (wetlands, savannas and grasslands) have the largest potential to reduce emissions and/or sequester carbon at 7.3 (3.9–13.1) GtCO2-eq yr-1 (up to USD100 tCO2-eq-1), with measures that 'protect' having the single highest total mitigation and mitigation densities (mitigation per area) in AFOLU (Table 7.3, Figure 7.11".
- 7.5.3 "the protection of high biodiversity ecosystems such as primary forests (SDG15) deliver high synergies with GHG abatement".
- International Union for Conservation of Nature Policy Statement on Primary Forests Including Intact Forest Landscapes (IUCN PF-IFL 2020) policy developed, explaining the importance of primary forests for climate mitigation and biodiversity protection and enabling differentiation of forests based on their integrity.

stocks and flows in all pools and the impact of human activities on each pool, in order to ensure that decisions reflect the true change in carbon stock of the atmosphere. Given that emissions reductions and increased removals are needed in all sectors, mitigation activities can be made transparent and optimized by accounting for fossil fuel emissions and forest (and other ecosystem) emissions and removals with separate reporting, targets and financial mechanisms (Ajani *et al*., 2013). This would prevent the practice of 'offsetting' between and within sectors, and avoid reporting only net emissions (Keith *et al*., 2021, 2022).

Such a comprehensive carbon accounting system is incorporated in the UN System of Environmental Economic Accounting Ecosystem Accounting (SEEA_EA) (UN *et al*., 2021), which follows statistical standards and can thus be integrated with other environmental and economic accounts and provide information to support all international conventions and national policies. Data are reported on the relative integrity of all ecosystems and thus the relative value of, and risks, to the ecosystem services they provide. Metrics describing the state and trends of ecosystem assets, the flow of ecosystem services and benefits to people form accounts for the environment that can be linked to the national accounts of all countries. The ability to reflect the superior value of high integrity ecosystems, such as primary forests, on a country's balance sheet, will enable all countries to see the value for their national economy of maintaining ecosystems in good condition and restoring degraded ecosystems.

The comprehensive carbon accounting system offered by the SEEA_EA provides an important opportunity to bridge the silos of the Rio Conventions and inform the SDGs by revealing synergies among the objectives of conventions and demonstrating the benefits of integrating climate and biodiversity actions to better inform decision-making. Adopting this approach will enable the intent of the COP 25 and COP 26 decisions (see **Box 4**) to be operationalized, so that the mitigation value of ecosystem protection, conservation and restoration are better revealed, and their carbon stocks and stock changes are reported appropriately for the Global Stocktake. Presenting information through the SEEA_EA provides a key tool to incorporate the benefits of forest ecosystems into land-use decision-making and economic planning. This system will be particularly valuable for HFLD countries to demonstrate the value of, and secure funding for, improved conservation management of their primary forests. Comprehensive carbon accounting that follows the SEEA_EA guidelines provides the most prospective pathway for filling the gaps in the current UNFCCC rules in five fundamental components (see **Box 5**).

Such an approach to carbon accounting will help to bridge the divide in the global carbon budget between reported country GHG inventories and what the atmosphere actually sees. Linking carbon accounting to ecosystem condition will enable action on both climate and biodiversity to be integrated into mitigation planning. It is critically important to ensure that climate action achieves robust outcomes for both the fossil fuel sector and the land sector, including forests. By utilizing the SEEA_EA, robust mitigation outcomes in forests can be achieved, as the system reveals the carbon benefits of maintaining existing relatively stable and long-lived primary forest carbon stocks and improving conservation management of forests to increase carbon removals from the atmosphere and accumulation in stable carbon storage.

3.3.3 Prioritizing actions to support mitigation and multiple ecosystem services

Fostering synergistic climate and biodiversity action will maintain and enhance ecosystem integrity and hence the provision of all ecosystem services to society, including indigenous peoples and local communities. Optimizing the benefits for achieving climate goals, as well as goals for maintaining ecosystem integrity, biodiversity conservation and sustainable livelihoods (Mackey 2015, 2020) requires the following actions, in order of priority:

1. **Protect** – prevent carbon stock loss from long-lived stable reservoirs in primary forest ecosystems.
2. **Restore** – increase carbon stocks through restoration, regeneration and connectivity of secondary forests.
3. **Replant** – where ecologically appropriate, increase carbon stocks through community-based replanting with native mixed species on previously cleared land.

The conservation management of forests for carbon storage in combination with multiple ecosystem services can help to close the land gap. This requires a holistic approach to forest management based on retaining ecosystem integrity to achieve climate, biodiversity, social, cultural and economic outcomes. Protecting the services provided by forests with a high level of ecosystem integrity provides many benefits for people, including for communities in the local area and surrounding region. Potential benefits include downstream water supply, resisting fire, protecting non-timber products, food supply and habitat to support pollinators. With effective rights-based and community-driven planning and governance, the conservation management of primary forests is a lower-risk investment compared with new plantings, which are more vulnerable to threatening processes that cause mortality, such as pests, diseases, drought and fire, and are liable to be logged.

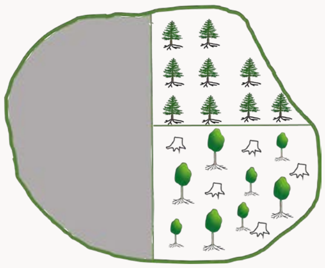
Protecting primary forests is the highest priority because they are critical for providing the ecosystem service of global climate regulation in the form of carbon retention, with the highest mag-

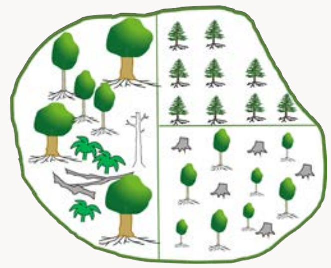
Box 5 **Reforming carbon accounting**

Existing UNFCCC Rules → **Comprehensive Carbon Accounting**

1. Comprehensive Carbon Accounts – all lands, sectors and activities

- Managed lands
- Human activities



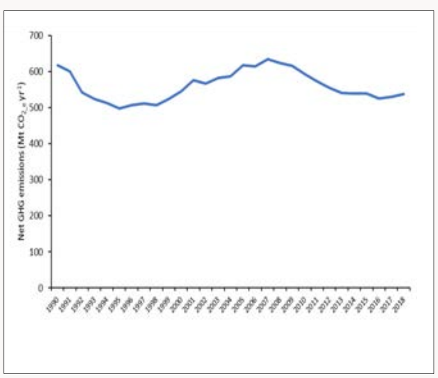


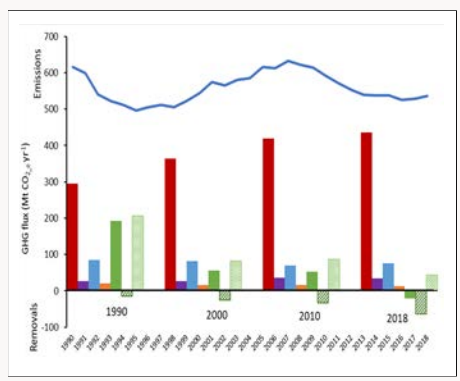
- All lands
- All processes
- Landscape scales

- Carbon accounts need to be comprehensive of all lands, sectors and activities, not limited to those specified as managed by humans.
- Accounting for all stocks and stock changes allows the impacts on the global carbon cycle to be quantified and track stock changes tracked between the biosphere (i.e., natural forests and other ecosystems) and the atmosphere.
- All carbon pools in living and dead biomass and soils are included.
- Assessments are at landscape scales that incorporate different forest ecosystem types and age distributions, and not just comparing individual stands or age classes.

2. All Carbon Stocks and Stock Changes

- Annual net emissions





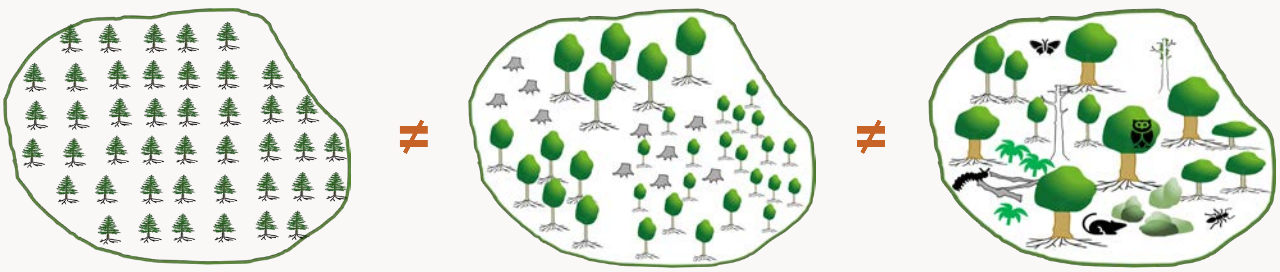
- Gross emissions (losses)
- Gross removals (gains)
- Disaggregated by sector

- All carbon stocks and stock changes need to be reported as gross emissions (losses) and removals (gains), not just present annual net emissions.
- Reporting of carbon stocks allows the value of ecosystems as assets to be included on the balance sheet, as well as the profit and loss that only shows the annual flows.
- Data are disaggregated by sector, not the current "netting out" of emissions from human activities by the removals from plant growth, which makes the land sector appear "carbon positive".
- Policy makers need to see where the emissions are coming from, and removals going to, in each sector in order to identify and assess mitigation strategies.

Sectors | Energy | Industry | Agriculture Waste | LULUCF | removals | emissions

Box 5 **Reforming carbon accounting** (continued)

3. Condition of Carbon Stock Matters



Low Ecosystem Integrity
Transformation to human-modified ecosystems minimises biodiversity and ecological functioning.

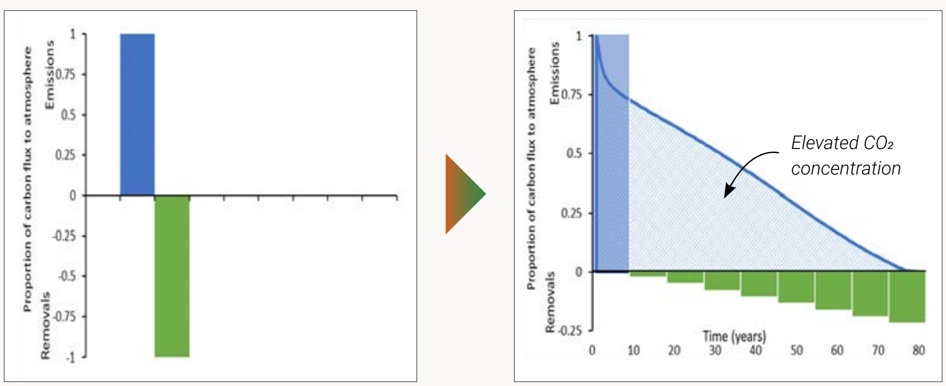
Moderate Ecosystem Integrity
Disturbance disrupts biotic trophic interactions and reduces resilience to disturbance.

High Ecosystem Integrity
Biodiversity confers resilience and adaptive capacity of ecosystems.

- The condition of carbon stocks in ecosystem reservoirs matters for assessing the capacity for carbon retention, and conversely the risk of loss.
- Ecosystem condition should be classified and included in the accounts. Ecosystems in good condition have a high level of ecosystem integrity resulting in them being more resistant, long-lived and resilient compared to those in poor condition.

4. Time Horizon Critical

- **Instantaneous emissions and removals recorded**



- **Instantaneous Emissions**
- **Long-term removals**
- **Time lag causes carbon debt**

Source: Keith et al. 2022

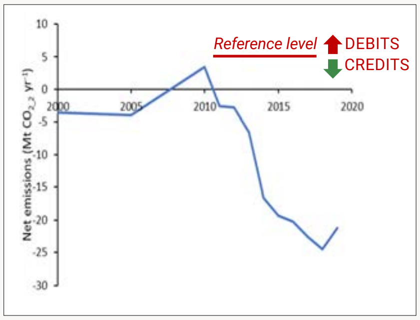
Emissions Removals

- The difference in timing between instantaneous emissions from combustion, and the long-term (decades to centuries) of removals by forest growth, means the elevated atmospheric CO2 concentration cannot be compensated forest removals, in the critical decades (2022-2050) that matter for limiting global warming.
- It is the accumulated stock of carbon and its longevity in the atmosphere that are the critical metrics for the climate, not the annual rate of net emissions. Hence, emissions and removals that occur over different time horizons should not be allowed as offsets.
- Activities may be carbon neutral over many decades or centuries, (if the carbon stocks of the reference condition are regained), but they are never climate neutral.

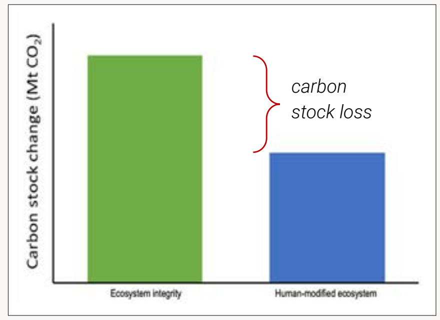
Box 5 **Reforming carbon accounting** (continued)

5. Reference Level for Accounting

- **Pre-defined reference level**
- **Calculate net annual emissions**



Source: Australian National Inventory Report 2021



Emissions Removals

- **Reference level is ecosystem integrity**
- **Calculate change in carbon stock**

- Current reference level is based on net annual emissions caused by current human activities and projected into the future.
- The reference level, used as the baseline for calculating change in carbon stocks over time, should represent the carbon stock of the ecosystem with high ecosystem integrity in its natural state, that is the carbon carrying capacity. This is the maximum carbon storage in primary forest ecosystems at the landscape scale under natural disturbance regimes.
- Assessing change from this reference level reveals the true loss of carbon due to human activities, and the potential gain in carbon stocks through restoration.
- Reference levels should incorporate long time horizons that reflect the full extent of carbon dynamics at landscape scales.

nitude, longevity, stability and resilience of any forest carbon stocks. These carbon stocks are irrecoverable on timescales relevant for mitigation (Goldstein *et al*., 2020). Effective protection of primary forests, including intact forest landscapes, requires regulatory and governance change, improved recognition of the rights of and support for IPs and LCs and their roles in planning and governance, and mechanisms that directly address the drivers of continued deforestation and forest degradation, including industrial logging.

Restoration actions for forests should improve the conservation management, foster natural regeneration of previously logged natural forests, and preserve and replenish natural capital – the soil, water and biodiversity (UNCCD, 2022). Restoration can entail a variety of objectives and actions, but should involve the permanent re-establishment of native species. Forms of restoration include rehabilitation (restoration of desired species, structure or process to an existing ecosystem), reconstruction (restoration of native plants on land used for other purposes), reclamation (restoration of severely degraded land devoid of vegetation), and replacement (species or provenances maladapted to a given location and unable to migrate are replaced with new and more climate-resilient vegetation) (Stanturf *et al*., 2014). Restoration action that buffers and reconnects areas of primary and other natural forests will deliver the most resilient, stable and long-term climate and biodiversity outcomes. Overcoming the increasing impact of fragmentation caused by roads for logging and mining and transmission lines is crucial, as core habitats and ecological processes are diminished (Goosem, 2007; Briant *et al*., 2010; Haddad *et al*., 2015; Ibisch *et al*., 2016; Taubert *et al*., 2019).

Restoration priorities should be based on the time needed to restore ecosystem integrity, connectivity between habitats, and the capacity to supply ecosystem services. For example, fostering the recovery of secondary natural forests delivers superior and faster climate mitigation, adaptation, biodiversity and ecosystem service benefits than planting new trees, particularly monoculture plantations. Most forms of ecological restoration will increase the storage and longevity of carbon stocks, but effectiveness will differ depending on the ecosystem condition.

One example of the potential benefits of restoration in Europe is a predicted scenario showing that reducing timber harvesting from the current 77 percent of annual wood increment to 50 percent of the increment would increase the carbon stock in forests – equivalent to double the current annual removals of CO_2 from the atmosphere by forests. This additional removal of CO_2 (242 Mt CO_2 per year) corresponds to over 5 percent of current total annual European Union emissions. The study demonstrated that this reduction in harvesting could be made possible by phasing out wood-based bioenergy (which contributes 87 percent of feedstock for bioenergy) and reducing wood consumption for short-lived products from pulp (Greenpeace, 2020).

Reforestation programmes need to make a clear distinction between planting trees on degraded land that is not currently productive, and land that is currently producing food or fibre or other services. Re/afforestation for carbon plantings should not compete with other important land uses, including food production (commercial, smallholder and/or subsistence) and, where appropriate, plantations for wood supply. Reforestation and afforestation should not be considered a priority activity for mitigation because the benefit of carbon accumulation is slow and so does not address the urgent need for climate action. Even the carbon stocks are not assured, as many tree planting projects have not been monitored and are unable to confirm survival of the trees. Some are harvested within one or a few decades to supply short-lived products or energy. However, in areas of degraded land or abandoned land uses, reforestation that is well planned can provide benefits of sequestering carbon and fostering recovery of biodiversity (Di Sacco *et al*., 2021). Caution should be applied to carbon markets that incentivize monoculture tree crop planting, including for bioenergy, which could jeopardize food production and land rights and have little or no meaningful climate mitigation benefit (Fleischman *et al*., 2020).

Protecting primary forests is the highest priority because they are critical for providing the ecosystem service of global climate regulation in the form of carbon retention, with the highest magnitude, longevity, stability and resilience of any forest carbon stocks. These carbon stocks are irrecoverable on timescales relevant for mitigation.

However, restoration to ameliorate degradation is a critical activity that can help to address many social, environmental and economic problems, while contributing to climate mitigation. The important role of restoration is manifest in the UN Decade of Restoration (2021– 030), which aims to "prevent, halt and reverse the degradation of ecosystems world-wide", including natural, agricultural and urban environments (UN, 2022). There are many forms of restoration initiative, but among the most effective are those that address severe degradation due to soil erosion, desertification and salinization. Landscape-scale restoration projects involving local communities can be powerful solutions for protecting, buffering and reconnecting areas of natural forest and other natural ecosystems and their associated biodiversity. This promotes the ensuing improvement in integrity, resilience and stability of existing, regenerating and planted forests and the carbon sequestered and stored in them. Examples of large landscape scale restoration projects across land tenures that focus on increasing connectivity and buffering existing natural ecosystems include Gondwana Link in south-west Western Australia (Gondwana Link 2022) and the Great Eastern Ranges along the dividing range in eastern Australia (GER 2022).

Restoration success depends not only on the land area, but on the type of restoration chosen and the quality and permanence of restoration or plantings. Natural regeneration of forests – including assisted natural regeneration – should be prioritized (Shono *et al*., 2007; Lewis *et al*., 2019). In contrast, 45 percent of initiatives for restoration under the Bonn Challenge are accounted for by new plantings (Fagan *et al*., 2022). Unless plantation establishment is directly linked to improving agricultural productivity and/or meeting demand for wood – thereby reducing conversion and logging pressure on primary and other natural forests – it will have extremely limited mitigation benefits. Restoration via tree planting will not have a positive climate mitigation benefit if deforestation and forest degradation continue unchecked.

3.3.4 Policy innovation for effective mitigation

Despite recent updates in international policies (see **Box 4**) that demonstrate progress, significant policy innovation is required at international, national and local levels to support urgent action on climate and the conservation of ecosystems. Closing the gap between supply and demand for land and resources requires strategic approaches that recognize, assess and value the multiple ecosystem services provided by forests and their contribution to human well-being and economies.

A landscape level or holistic approach can assist by incorporating ecosystem integrity and providing the capacities and mechanisms for strong governance and effective planning (Chazdon and Brancalion, 2019; Mackey *et al*., 2020; Morgan *et al*., 2020).

Protecting the remaining primary forests and engaging in large-scale ecological restoration of degraded forests is essential for solving the biodiversity, climate change, social justice and zoonotic disease crises

Encouraging synergistic action in NDCs based on the intent of the Paris Agreement will be critical. Article 5.1 encourages all parties from both developed and developing countries to "make use of the full range of ecosystem-based mitigation options to support integrated climate mitigation and adaptation outcomes". Article 5.2 provides guidance on reducing emissions from deforestation and forest degradation in developing countries (REDD+) and encourages non-market approaches to support the multiple functions of forests through a landscape approach" (Carazo, 2017). Providing greater guidance on priorities for achieving synergistic climate and biodiversity outcomes in NDCs is needed, including by promoting relevant IPCC AR6 decisions and the priority actions identified by IPBES/IPCC (Pörtner *et al*., 2021).

Governance and enforcement structures are needed to combat illegal exploitation of forest resources, which occur in many countries and in many forms. For example, estimates of illegal logging include: one-quarter of wood removal from forests in Europe, which is unaccounted for (Camia *et al*., 2021); more than two-thirds of tropical deforestation (Chatham House, 2022); and 50–90 percent of wood sourced from tropical forests, which accounts for an estimated one-tenth of total timber trade worldwide (Greenpeace, 2022). Schemes for certification, traceability, standards and enforcement need to be strengthened, both by producing countries and importing and consumer countries, as supported by the FAO Forest Law Enforcement, Governance and Trade Programme (FAO FLEGT, 2022).

Improved monitoring and assessment of targets such as the New York Declaration on Forests set a goal of 150 million ha restoration by 2020 and received pledges of 170 million ha. However, only an estimated 18 percent has been realized in terms of increased tree cover through restoration, reforestation and afforestation (NYDF, 2019).

Regulation by governments can create rapid change and incentivize transformation through markets and investment. For example, the Biden administration introduced regulatory measures to protect mature (including old growth and primary) forest on public land in the United States of America. Regulatory measures could also be used to reduce the demand for wood for bioenergy by disallowing combustion of wood to count as zero emissions and as a renewable energy source (Mackey *et al*., 2022b).

Financing mechanisms and incentives are needed to harness the full value of ecosystem services through conservation management of forests to support incomes for the development of local communities, based on just benefit-sharing and without the need for income from exploitation (Morgan *et al*., 2022). Such mechanisms form part of integrated financial solutions being pursued to address national priorities and commitments related to climate change through the drivers of deforestation and degradation, as well as disaster risk reduction and land restoration (UNCCD, 2022). Strong government environmental regulations can be effective in incentivizing private finance for conservation (Davergne and Lister, 2011). Effective financing mechanisms can also be developed by shifting subsidies away from destructive and highly emissive industries to low carbon, protective and restorative activities (IPBES, 2019; White House, 2022).

The socioeconomic and business case for action on ecosystem protection has been made by the Organisation for Economic Co-operation and Development (OECD) to the G7 Environment Ministers (OECD, 2019b). Despite these high-level agreements, financing to incentivize climate action by protecting ecosystems remains very small, accounting for approximately 8.5 percent of the subsides given to fossil fuels or 6.3 percent of global GDP (CBD, 2012; OECD, 2019a; Coady *et al*., 2019). Possible sources of financing for forest conservation management include international environmental funds, REDD+, aid, national budgets, private sources, carbon markets, and payment for ecosystem services, such as results-based payments for reduced carbon emissions from deforestation and degradation (FAO and UNEP, 2020). Each of these sources raises different issues for governance, human rights and conservation. For example, REDD+ projects have been initiated in 50 countries, but only 9 countries have as yet reported emissions reductions. Moreover, the effectiveness for conservation management of primary forests is mixed; some positive lessons are being gained about land-use policy reforms linked to sustainable supply chains and the importance of land tenure, but have been criticised by IPs and LCs (Duchelle *et al*., 2019; FAO and UNEP, 2020). The economic case for securing land rights for indigenous peoples has been demonstrated, representing a low-cost, high-benefit investment; for example, the cost of securing forest tenure can be just 1 percent of the total net benefit of the ecosystem services (Ding *et al*., 2016; Garnett *et al*., 2018). Non-market mechanisms should also be considered as playing a crucial role and there are opportunities for harnessing these through Article 6.8 of the Paris Agreement (UNFCCC, 2015).

Supply and demand of wood products require a transformational change based on re-evaluation in terms of: (i) the efficiency of supply of wood from different forest types; (ii) the loss and damage to key ecosystem services caused by timber harvesting; and (iii) markets and patterns of consumption that dictate the balance between supply and demand. Supply of wood products is increasing in response to market forces driving growing demand, particularly by large chain retailers and for bioenergy (see **Figure 3.6**). This relationship between supply and demand needs to be corrected, so that supply pays the full price of the environmental impacts, and demand is reallocated by increasing the use of recycling, substitution and longer product lifetimes.

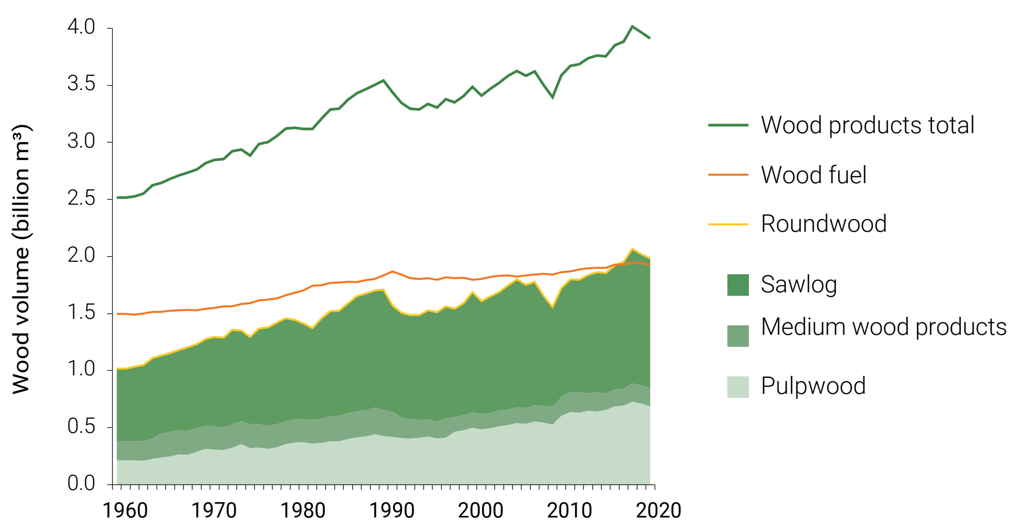
More than half the global supply of wood products is derived from natural forests, even though these are far less cost-effective or efficient in terms of producing and extracting timber, and have greater ecological impacts over a far greater land area than wood production from plantations. Plantations represent 3 percent of all forest area (FAO and UNEP, 2020), but produce 46 percent of global industrial roundwood, although the relative proportions of production vary across biomes (see **Figure 3.7**). (Payn *et al*., 2015; Jurgensen *et al*., 2014). Production from planted forests is predicted to be capable of meeting increased demand to 2030, based on scenarios of increases in planted area plus increases in productivity (Carle and Holmgren 2008; Payn *et al*., 2015). However, any increase in plantation area must follow the key principles that they: (i) are not established by clearing natural forests or other natural ecosystems; (ii) do not violate the rights of landowners or custodians; and (iii) do not exploit, pollute or deplete resources such as water, soil or biodiversity (Turner *et al*., 2006). Increased productive capacity of plantations on existing land needs to incorporate strategies for climate adaptation that focus on forest health, so as to reduce the risks from extreme climatic events, pests and diseases (Payn *et al*., 2015).

Damage to other ecosystem services caused by logging needs to be included in the price of wood, such that prices are not based solely on the costs of production. Such an evaluation would greatly increase the cost of harvesting wood from natural forests, further incentivize sourcing wood from well managed plantations, and discourage use for bioenergy and other low-cost, short-lifetime and high-volume commodities.

Figure 3.6 **Global trends in wood volume production 1960–2020**

Wood production is divided into wood fuel and roundwood, with the roundwood divided into subcategories according to longevity of the products. Highest longevity is sawlogs and veneer logs (half-life 35 years), short longevity is pulpwood (half-life 2 years), and all other products are included in medium longevity, such as wood-based panels and composites, plywood, particle board and fibreboard (half-life of 25 years according to IPCC, 2019a

Source: FAO, 2020.



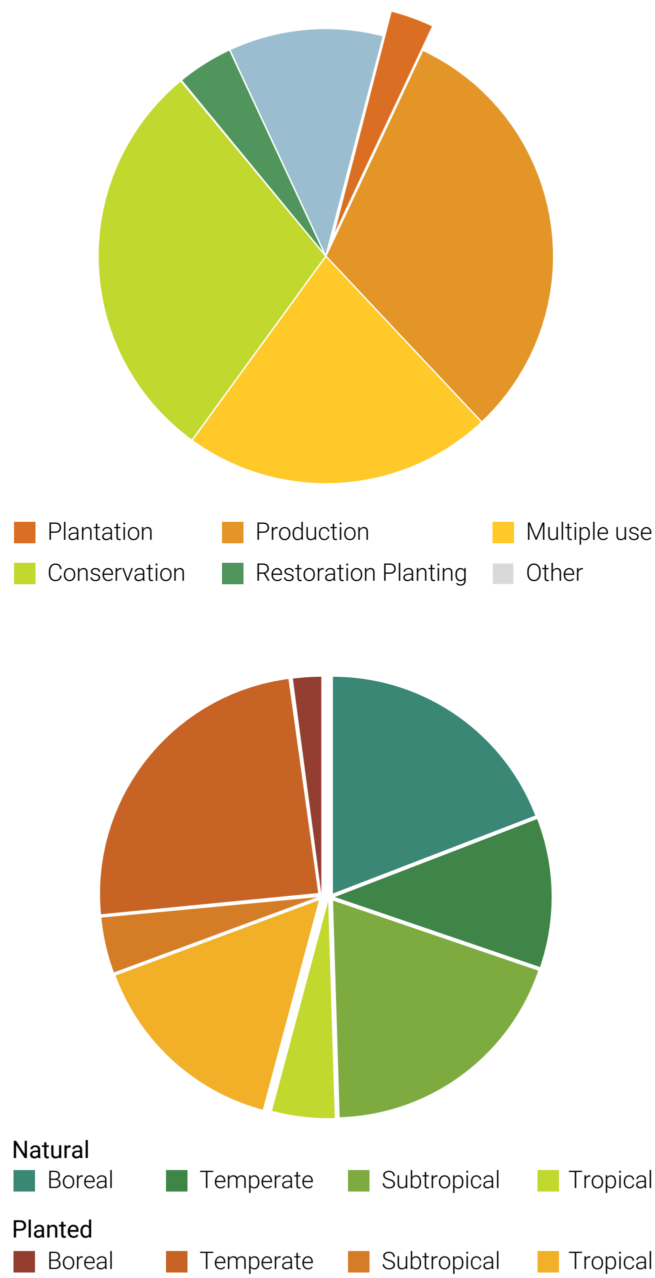
Markets need to be reformed to reduce demand for wood products and shift patterns of consumption. Demand-side measures such as improved regulation and certification could help to counter corporate models of maximizing volume and minimizing costs of wood production, and so reduce reliance on low-cost, high-volume commodities. Responses to changes in wood supply are many and varied, including increasing productivity, increasing efficiency of wood recovery, fostering fuelwood planting to assist local communities, encouraging agroecological farm forestry, and substitution with alternative products derived from clean, renewable and sustainable sources. Reduced consumption is being incentivized by using voluntary and mandatory actions for environmental labelling, sustainability reporting, due diligence, sustainable investment and finance, supply chain transparency, public procurement and corporate social responsibility (EC, 2019).

Community participation is increasing, with growing public awareness of the interlinkages between the climate and biodiversity crises, scrutiny of global supply chains, claims of sustainability and impacts on IPs and LCs. This increased participation in environmental issues has the potential to impact decision-makers in both governments and company boardrooms. A case in point is growing public alarm witnessed in Europe over the impact on forests as a result of demand for bioenergy. Increasingly, misrepresentations, inaccuracies and falsehoods about climate mitigation actions are being challenged in the courts, and coming under increasing scrutiny from scientists, agencies and organizations, including the OECD (PFPI, 2019).

Human rights are a core component of policies for mitigation action. Just, fair and equitable land tenure and social systems enable commitments to be made to the conservation of forests and the ecosystem services that they provide. This is a complex issue that involves far more than simply land ownership and varies in different places and communities, and may, for example, cover customary rights, legal rights, community ownership, cultural values and motivation (Buckwell *et al*., 2022). This is exemplified by the Kayapo – indigenous peoples who have managed to sustain their territory of primary forest based on their land rights, cultural aspiration to defend their territory, and sufficient external support to enable them to do so (see **Box 3**). Local communities in developing or developed countries may have varying degrees of affinity with natural ecosystems and motivation for their conservation to support the common good. Where local communities are dependent on industrial-scale forestry, numerous examples exist in developed countries of how to support change and deliver a just transition to facilitate improved forest conservation-based outcomes.

Figure 3.7 **The proportions of forest management categories in the global forest area**

Consisting of 3% commercial plantations, 7% planted forests and 93% naturally regenerated forests (b) Global wood production (roundwood by volume m3) with 46% sourced from plantations and 54% sourced from naturally regenerating forests, and the proportions by biome within each category.



Data source: (a) FAO and UNEP, 2020; FAO FRA 2020 (b) Jurgensen *et al*., 2014; Payn *et al*., 2015

3.4 Conclusions

Forest ecosystems are a finite resource and the urgent need for climate mitigation necessitates protecting and restoring the carbon stocks in the remaining forests. The healthy functioning of the planet's life support systems depends on protecting primary forests and restoring significant areas of degraded forests. No further loss and damage of forests is warranted, and logging in primary and many other natural forests should therefore cease. The practice of clearing forest for other land uses and consumption of wood products cannot be allowed to continue.

Protection and restoration afford the benefits of multiple ecosystem services, in combination with climate mitigation. In contrast, tree planting for the sole purpose of mitigation appropriates vast areas of currently non-forested lands for carbon sequestration through afforestation or planted trees for bioenergy, which may displace land uses for food production or settlements. Management of forest land is more efficient when it supports the provision of those multiple ecosystem services that are synergistic with maximizing the ecosystem's carbon retention value (Keith *et al*., 2021; Taye *et al*., 2021). The opportunity exists for improved conservation management of primary and other natural forests to meet multiple objectives without industrial-scale planting of new trees. In this regard, Chapter 6 provides a list of **recommended actions**.

Transformation is required for both supply and demand for wood. Forests need to be valued for their full suite of ecosystem services, not just wood supply. The price of products manufactured from harvested wood should reflect the full environmental costs, including the value of other foregone ecosystem services. Growing demand should be met, not by increasing use of natural forests to supply wood, but by increasing supply through improved resilience, productivity, management and design of the plantation estate. Demand for wood can be reduced by using alternative construction materials and energy sources that are truly renewable and non-carbon emitting.

Climate mitigation requires both (1) rapid and deep reductions in emissions from fossil fuels; and (2) maximizing the mitigation benefit from the carbon stored in natural forests by avoiding emissions through improved forest conservation management, and increasing removals through ecologically-based forest restoration. Protecting and restoring forests is therefore an essential climate mitigation strategy and should be used as an additional action to meet climate mitigation goals. However, it must not be used to offset fossil fuel emissions in national GHG accounts, nor to delay the need to decarbonize the energy, manufacturing and transport sectors.