5 LAND USE CHANGE AND BIODIVERSITY

As we saw in Chapter 2, the main cause of terrestrial ecosystem and biodiversity loss is conversion and degradation of natural habitats, such as forests, wetlands and grasslands. The principal threats are from agriculture, forestry, infrastructure, human settlements and other economic activities.

Land use change by humans has transformed ecosystems across the terrestrial biosphere. This could be potentially catastrophic for both humankind and the environment. The dramatic decline in plant and animal species has been so swift that scientists warn that we may be facing "biological annihilation" in coming decades.[1]

The scale and speed of this loss and its impacts have been immense. Terrestrial ecological communities worldwide have lost more than 20 percent of their original biodiversity.[2] Natural ecosystems have declined by almost half during the past fifty years, and approximately one quarter of all terrestrial species are threatened with extinction.[3] Land use pressures have reduced local biodiversity intactness – the average proportion of natural biodiversity remaining in local ecosystems – beyond safe limits across the majority of the world's land surface.[4] Land use change could be contributing around 15 percent of total global carbon emissions.[5] Even protected areas are not safe. As much as one third of global protected land is under intense human pressure.[6]

Scientists have proposed a number of planetary boundaries that demarcate essential aspects of the ecosystem that we need to preserve, in order to halt destruction of the remaining natural landscape.

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These include measures based on indices of biodiversity intactness; species abundance or richness; net primary productivity; and no net loss of natural ecosystems.[7] However, setting even modest global limits to protect some of the world's remaining natural areas has so far failed. The Convention on Biological Diversity, signed by 196 countries in 1992, made a pledge to conserve 17 percent of the world's terrestrial areas by 2020. But current rates of land use change and ecological decline suggest that this target has not been met (see Chapter 2).

Because of the concern over accelerating losses of ecosystems and biodiversity, some scientists are advocating even more ambitious goals for conserving the Earth's remaining natural areas. One suggestion is to protect 30 percent of the planet's surface for nature and to designate an additional 20 percent as climate stabilization areas to keep global warming below 1.5°C.[8]

But adopting such a limit could come with a high cost. If half of Earth is preserved for nature, the vast majority of current land use expansion would have to stop. The result could be 15–31 percent less global cropland area; 10–45 percent less pastureland; and 23–25 percent less land for feed, biofuel and other nonfood crops.[9] Such potential trade-offs will continue to fuel debates over whether or not to impose limits on human destruction of the terrestrial biosphere – or even if a planetary boundary approach is the most effective way of controlling current threats to natural habitats.

Nonetheless, there is consensus among scientists that we need urgently to "bend the curve" of biodiversity loss and ecosystem destruction. As explained by the biologist Georgina Mace and colleagues:

> The degradation of nature is among the most serious issues that the world faces, but current targets and consequent actions amount, at best, to a managed decline. Required now are bold and well-defined goals and a credible set of actions to restore the abundance of nature to levels that enable both people and nature to thrive.[10]

One indicator used to track "the degradation of nature" is the Living Planet Index (LPI), which covers thousands of populations of mammals, birds, reptiles, amphibians and fish from around the world.[11] The LPI declined by more than two-thirds from 1970 to 2016 (see Figure 5.1). If current trends continue, the index will fall to around 15 percent of its 1970 level by 2050. At a minimum, we must reverse this decline so that

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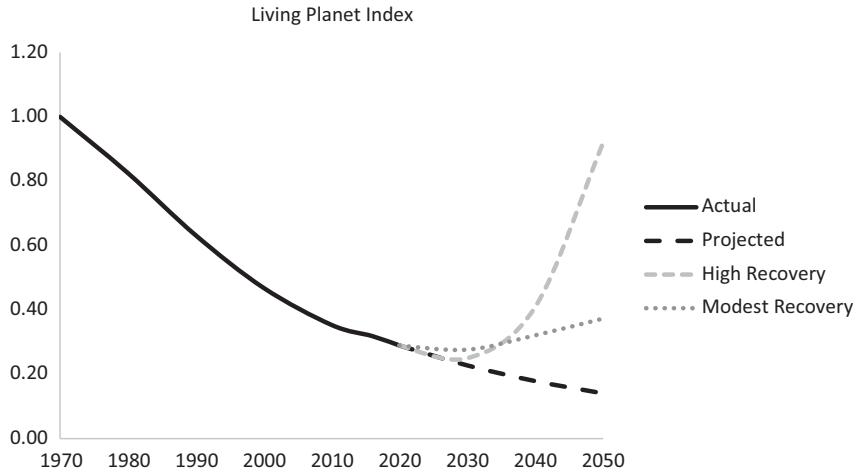

Figure 5.1 Bending the biodiversity loss curve
Notes: The global Living Planet Index (LPI) represents 20,811 populations of 4,392 species of mammals, birds, amphibians, reptiles and fish. The base year for the LPI is 1970 (LPI = 1.00). Actual shows the LPI trend from 1970 to 2016 (solid black line), based on LPI data from WWF (2020), available at WWF/ZSL https://livingplanetindex.org/data_portal. Projected indicates the LPI projections from 2016 onward based on the 2000–2016 annual decline rate (dashed black line). High Recovery shows the LPI projections based on 92 percent recovery of 1970 levels by 2050 (Mace et al. 2018). Modest Recovery indicates the LPI projections based on 90 percent recovery of 2010 levels by 2050 (Leclère et al. 2020).

global populations and species are able to make a modest recovery to nearly their 2010 LPI level by 2050. An even more ambitious goal is to ensure almost full recovery to the 1970 level.

Halting degradation of the terrestrial biosphere will require a major transformation in how economies use land and nature. This chapter will explore different policy initiatives, both globally and within countries, to address this critical problem. First, we explain how addressing the underpricing of nature is essential to creating the incentives, institutions and innovations needed to change humankind's conversion and use of natural landscape. Second, we look at how underpricing also perpetuates rural poverty in many countries. The impacts of land use change are not evenly distributed but borne increasingly by the most vulnerable and poorest human populations. Decoupling development from excessive land use change leading to ecosystem decline is necessary to make our economies both more

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sustainable and inclusive. Third, global biodiversity conservation is also plagued by underfunding, as the international community struggles to compensate developing countries for protecting valuable terrestrial habitats. The rest of this chapter looks at how to end the underpricing of natural landscape and the underfunding of nature. Collective action will require commitments not only by rich countries to assist poorer ones in protection and restoration efforts, but also by the private sector to invest in nature to reduce the risks from biodiversity and ecosystem loss.

Economics for a Fragile Landscape

In Chapter 3, we explained that ecosystems are an important source of "wealth" as they support economies and boost the welfare of people. In addition, many individuals value nature for its own intrinsic worth. The traditions, culture and way of life of many local communities and indigenous people are intimately connected with their surrounding environment. Consequently, ecosystems should be viewed as highly valuable capital assets to humankind, because they produce a very wide range of beneficial ecosystem goods and services – often called *ecosystem services* for short.

These ecological values and benefits may be irreversibly lost when we degrade or convert nature. The fact that we ignore the rising cost of ecosystem loss signals that there is something fundamentally wrong in the economics of managing our increasingly fragile terrestrial landscape.

The main flaw, as we saw in Chapter 3, is the *underpricing of nature* – or more specifically in the case of terrestrial ecosystem and biodiversity decline, the *underpricing of natural landscape*. Modern economies are squandering valuable natural and ecological capital and failing to act on rising global environmental risks. This is because the ecosystem services provided by natural habitats are not routinely reflected in markets. Most of their ecosystem goods and services are available for free. We do not have to pay for them, as healthy ecosystems provide their valuable benefits to us through their natural structure and functioning. This is certainly the problem for much of the world's remaining natural landscape, which is largely ignored by the economic system and whose many valuable services are not routinely exchanged in markets.

But the problem is even worse. Not only do we not pay for the ecological degradation caused by land use change, but often we

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subsidize the economic activities that lead to this destruction. As the economist Partha Dasgupta points out, we are not just pricing ecosystems and their services too cheaply, we are actually giving them a "negative price," which is tantamount to paying some economic activities to destroy nature:

> The current structure of market prices works against our common future; the biosphere is precious but priced cheaply, if it is priced at all. Worse, owing to a wide range of government subsidies, some services come with a negative price.[12]

Consequently, the paramount challenge for decoupling our economies from ecologically destructive land use change is to end the underpricing of natural landscape. Only then will our institutions, incentives and innovations reflect the growing ecological and natural resource scarcity that is caused by continuing land use change. Unless we remove environmentally harmful subsidies that encourage destructive land use practices and correct the cheap cost of converting natural habitats, we cannot begin to address the problem of excessive loss and degradation of our terrestrial ecological capital.

Taking the scarcity of ecosystems and biodiversity into account will induce changes in our use of valuable natural landscapes, and encourage less conversion and more conservation and restoration. Ending underpricing will also encourage the sustainable intensification of existing land uses and the reduction in food and agricultural waste.

Since the dawn of agriculture over 10,000 years ago, land use intensification has been pivotal in influencing the ecological impacts of humankind. As Erle Ellis and colleagues argue:

> The single most important lesson from assessing changes in land use across the Holocene is that changes in the productivity of land-use systems, and especially productivity per area of land, has likely been the main long-term driver of change in human impact on the terrestrial biosphere. The pace of agricultural intensification is, therefore, also likely to remain a major determinant of future land change and our ability to meet societal demands for food, feed, housing, and energy.[13]

Intensification of agriculture, forestry and other land uses, reducing waste and adopting sustainability practices will be essential to "bending the curve" of global ecological decline and biodiversity loss.[14]

Boosting the productivity and sustainability of land use systems in low- and middle-income countries is especially a priority, if we want to reduce conversion of the world's remaining forests, wetlands and other natural habitat. David Tilman and coauthors estimate that, if current trends of agricultural intensification in wealthier nations and the pattern of land clearing in poorer nations were to continue, one billion additional hectares (ha) of land would be cleared globally for crops by 2050. On the other hand, greater agricultural intensification in all countries would mean only 250,000 million more hectares of land cleared.[15]

Addressing this problem is especially urgent in tropical developing countries, where agricultural land expansion continues to occur at the expense of natural forest (see Figure 5.2). Tropical forests are one of the most biologically rich and ecologically important biomes on Earth. Nearly all the world's tropical natural forest is located in low- and middle-income countries. Since 1990, these countries have lost 15 percent of these forests. Over the same period, land for agricultural production in tropical developing economies has expanded by 13 percent, and land just for cereal production has increased by 27 percent. Additional causes of rapid land use change in developing countries are the expansion of forestry, mining and other extractive activities.[16]

The fact that agricultural and other primary production activities are prevalent in low- and middle-income economies should not be surprising. Most developing economies, and the majority of the populations living within them, depend directly on land and natural resources. For many of these economies, primary product exports account for the vast majority of their export earnings, and one or two primary commodities often make up the bulk of exports.[17] In low-income countries, agricultural value added accounts for an average of 30 percent of GDP, and nearly 70 percent of employment is in natural resource-based sectors, such as agriculture, forestry, fishing or hunting.[18]

But simply because many low- and middle-income economies are highly dependent on their land and natural resources does not mean that they should underprice their economically and ecologically valuable natural landscape. Rather than help their economies develop and end poverty, such underpricing actually works against sustainable and inclusive development.

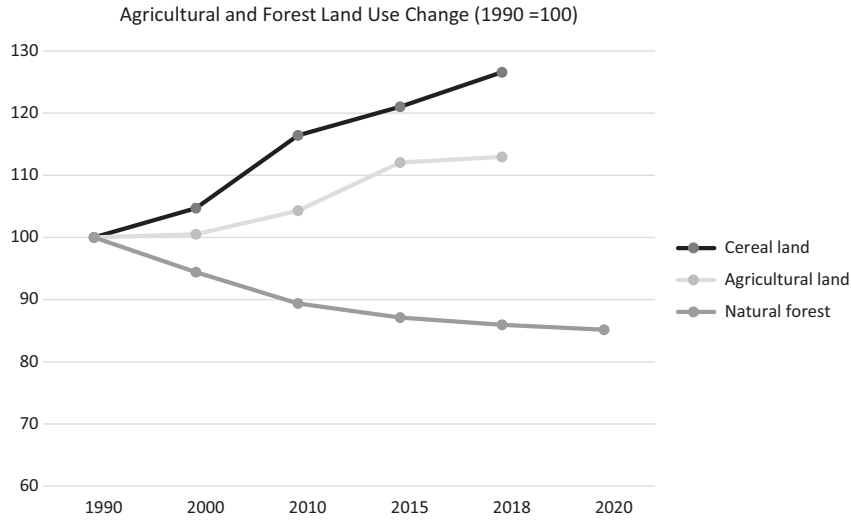

Figure 5.2 Land use in tropical low- and middle-income countries, 1990–2020
Notes: Cereal land refers to a cultivated area of wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat and mixed grains. Agricultural land refers to the share of land area that is arable; under permanent crops; and under permanent pastures. Natural forest is naturally regenerating forest, which is predominantly composed of trees established through natural regeneration. Cereal and agricultural land data are from World Development Indicators, available at https://databank.worldbank.org/source/world-development-indicators. Natural forest data are from the Food and Agriculture Organization of the United Nations (FAO) Global Forest Resources Assessment (FRA) 2020, available at https://fra-data.fao.org/WO/fra2020/home. Low- and middle-income countries are economies with 2019 per capita gross national income (GNI) of US$12,535 or less. Countries are defined as tropical following FAO FRA 2015 domain classification. In 2020, natural forest in tropical low- and middle-income countries comprised 1,710 million hectares (ha), which is 99 percent of all tropical natural forest worldwide and 46 percent of all global natural forest.

Underpricing and Rent Seeking

Underpricing of land and natural resources constrains sustainable economic development in several ways. First, it is inefficient, and may encourage what economists call *rent seeking*. If an economy has abundant resources to exploit, but the natural landscape containing these resources is valued only as a potential reserve to be tapped for valuable agricultural, mineral and other primary products, then the costs of exploitation are considered negligible but the gains in terms of

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commercial profits could be substantial. As long as this is the case, primary product activities will continue to seek more profits – or rents – from converting additional natural landscape. This process will continue until there are no additional profits to be made through converting or exploiting more natural habitats. Worse still, government policies that promote and subsidize agriculture, forestry, mining and other primary production activities encourage further land use conversion and natural resource overexploitation.

This problem may occur in all economies that underprice natural landscape, but it is especially prevalent in low- and middle-income countries because of their economic dependence on land and natural resources. Moreover, underpricing also reinforces poor governance and institutions. If rent-seeking exploitation of land and natural resources is widespread in an economy, then the significant short-term gains often perpetuate inadequate government oversight, poor environmental regulations and management, corruption, land grabbing and other illegal practices. Lack of property rights or their enforcement and other institutional failures also encourage more rent-seeking exploitation of land and natural resources. In turn, weak governance and institutions that fail to control rent-seeking provide further incentives to continue with wasteful and unsustainable management of land and natural resources.

The economists Halvor Mehlum, Karl Moene and Ragnar Torvik explore this potential interaction between resource rent-seeking, institutional quality and long-run economic performance.[19] They argue that, if an economy has good-quality institutions, with low corruption, effective rule of law, well-defined property rights and so on, then resource rent-seeking behavior will be modest. If a "resource bonanza" occurs, such as a rise in commodity prices or a discovery of new land or resources to exploit, the effect of the bonanza will be to raise the profits from productive entrepreneurship in the economy, including from investment to increase productivity from existing land and resource use. Overall economic performance will therefore improve. But if an economy has poor institutions, then resource rent-seeking is encouraged rather than deterred. Any bonanza will expand "resource grabbing" at the expensive of productive entrepreneurship in the economy, and the result is not only overexploitation of land and resources but also less economic development. Mehlum and colleagues found evidence across eighty-seven countries to support this outcome. Institutional quality appears to determine the economic performance of resource-dependent

economies. Those with better institutions had higher economic growth than those economies with poorer institutions.

Given the incentives created by the underpricing of natural landscape, poor institutions and rent seeking, increasingly it is commercially oriented agricultural and extractive activities that are responsible for much of the land use change occurring in developing countries.[20] These activities include plantation agriculture, ranching, forestry, fossil fuels and mining activities. The result is often export-oriented extractive enclaves with little or no forward and backward linkages to the rest of the economy.[21] This means that the gains from extractive activities have few spillover benefits, and do not boost development in other sectors of the economy. In addition, developing countries have been actively promoting these commercial activities as a means to expanding the primary products sector, especially in the land-abundant regions of Asia, Latin America and Africa.[22]

What is more, the gains and losses from underpricing and rent seeking worsen inequality. The benefits from commercial primary production activities derived from land use change and natural landscape decline are often concentrated in the hands of a few wealthy owners. In contrast, the costs of land use change and natural landscape decline are often borne by poor rural households and communities.

Underpricing, Poverty and Inequity

Rural poverty is still pervasive in most low- and middle-income countries. Despite increasing urbanization, the rural population in developing regions is expected to stay above 3.1 billion for the next thirty years, placing continuing pressure on available land and natural resources.[23] In addition, current global poverty trends suggest that the poor are increasingly rural, dependent on agriculture and predominantly young.[24]

As long as the chronic underpricing of natural resources persists, aided and abetted by resource rent-seeking and poor institutions and governance, then rural poverty will remain an ongoing problem. The prospect of quick and easy profits from natural resource exploitation attracts wealthy investors away from manufacturing and other dynamic sectors of the economy. The latter sectors do not develop, and may even decline, thus reinforcing the continued and overwhelming dependence of the economy on land use change and natural resource

exploitation for the majority of its exports and for overall development. In addition, weak political and legal institutions not only encourage rent-seeking by wealthy investors in the resource-based sectors of the economy, but also allow the most valuable natural resources of the economy to be "transferred" to rich and powerful individuals.

There are many ways that this may occur, but the outcome is usually always the same: Poor rural households are unable to compete in existing land and resource markets or to influence policy decisions that determine the allocation of more valuable natural resources, and thus the rural poor continue to be confined to marginal land and resource areas to exploit for their economic livelihoods. Moreover, since these regions are relatively poor, very little public or private investments flow to these locations. Thus the concentration of the rural poor in marginal land and resource areas is perpetuated.

Inequality in access to valuable land and natural resources is therefore an important outcome of many rural areas of poor countries. Wealthier individuals and interests use their social and economic power to secure greater access to valuable environmental resources, including land, minerals, energy, gems, water and even fuelwood. Such problems are exacerbated by government policies that favor wealthier households in markets for these key natural resources, and especially land. As explained by Hans Binswanger and Klaus Deininger, "rural elites" in developing countries are often "able to steer policies and programs meant to increase rural productivity into capital-intensive investment programs for large farms, thus perpetuating inequality and inefficiency."[25]

In addition, poor rural households are affected the most by loss of surrounding natural landscape and ecosystems. In many rural areas, poor households rely on natural resources both as a supplement to consumption needs and income and as part of overall insurance and coping strategies for avoiding the income and subsistence losses associated with natural disasters and other shocks.[26] Ecosystem services such as drinking-water supply, wild foods, fuelwood and other benefits contribute from 20 to 30 percent of the income of the rural poor, and even a larger share for the poorest households.[27]

Indigenous people, too, are under threat from land use change. At least a quarter of the worlds' land surface is managed by 370 million indigenous people, who have created and maintained mosaics of crops, forest and pasture for millennia. These traditional land uses overlap with about 40 percent of all terrestrial protected areas and ecologically

intact landscapes, such as boreal and tropical primary forests, savannas and marshes. Because their livelihoods, society and culture are interconnected with the natural landscape, the land inhabited by indigenous people is better managed and conserved compared to other areas. Yet despite the importance of indigenous lands to global conservation, they are the most vulnerable to and threatened by appropriation for resource exploitation by commercial primary production priorities.[28]

Underfunding of Nature

Ending the underpricing of natural landscape in all countries, including low- and middle-income countries, is vital to reducing global loss of terrestrial ecological capital and biodiversity. The other imperative is to end the *underfunding of nature* worldwide.

Table 5.1 summarizes the extent of the current underfunding problem.

Global financing for nature conservation and protection amounts to around $78–$91 billion each year (see Table 5.1). It includes domestic spending by eighty-one countries ($68 billion) and private expenditure ($6.6–$13.6 billion). The latter comprises biodiversity offsets, sustainable commodities, forest carbon finance, payments for ecosystem services, water quality trading and offsets, philanthropic spending, private contributions to conservation nongovernmental organizations (NGOs) and private finance leveraged by bilateral and multilateral public development finance. International public finance for nature, in the form of bilateral and multilateral assistance to low- and middle-income countries, is $3.9–$9.3 billion each year.

Just under $100 billion a year to fund nature sounds like a lot. But it isn't.[29]

For one, governments spend considerably more on damaging nature (see Table 5.1). Public subsidies to agriculture and fossil fuels that are environmentally harmful amount to almost $500 billion per year. That is more than five times the amount spent globally by the public and private sector on nature conservation and protection. Governments also provide environmentally beneficial subsidies to nature, but they currently average less than $1 billion per year.

In comparison, the economic benefits provided by nature are substantial (see Table 5.1). The World Economic Forum analyzed 163 industry sectors and their supply chains, and found that $44 trillion

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Table 5.1. Global underfunding of nature

Category	Amount per Year	Description and Source
Funding from all sources	**$78.3–$90.7 billion**	OECD (2020a).
Public domestic finance	$67.8 billion	Average annual spending between 2015 and 2017 by eighty-one countries (OECD 2020a).
Public international finance	$3.9–$9.3 billion	Bilateral and multilateral official development assistance and concessional flows (OECD 2020a).
Private sector finance	$6.6–$13.6 billion	Average annual spending between 2015 and 2017 on biodiversity offsets, sustainable commodities, forest carbon finance, payments for ecosystem services, water quality trading and offsets, philanthropic spending, private contributions to conservation NGOs and private finance leveraged by bilateral and multilateral public development finance ($41–$155 million annually).
Subsidies		
Environmentally harmful public subsidies	$482 billion	Fossil fuel subsidies ($370 billion, OECD 2019a) and support to potentially environmentally harmful agricultural production ($112 billion, OECD 2020b).
Environmentally beneficial public subsidies	$0.89 billion	2012–2016 average (OECD 2019a).
Benefits from nature		
Economic production	$44 trillion	Global value added of 163 industry sectors and their supply chains that are moderately or highly dependent on nature and its services (WEF 2020).

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Table 5.1. cont'd

Category	Amount per Year	Description and Source
Funding needs		
Costs of tropical natural climate solutions (NCS)	$618 billion	Author's estimates based on thirty-five tropical countries with cost-effective NCS and median NCS cost of 5.5 percent of GDP (Griscom et al. 2020).
Costs of restoring degraded landscape	$350 billion	Costs of restoring 350 million hectares of degraded forest and agricultural land (Ding et al. 2019).
Costs of reducing pandemic risk	$9.6 billion	Direct forest protection payments to reduce tropical deforestation in areas at highest risk of wildlife–human disease spillover (Dobson et al. 2020).

of global value added is moderately or highly dependent on nature and its services. This amounts to over half of the world's GDP. Even if these benefits are overestimated by a magnitude of ten or even one hundred, they suggest that nature is grossly underpriced and underfunded worldwide.

There are also three additional funding needs for global nature conservation: reducing the greenhouse gas emissions contributed by land use change; restoring degraded landscapes; and reducing the risks of future disease outbreaks caused by wildlife habitat loss.

As we saw in Chapter 4, land use change may contribute close to15 percent of global greenhouse gas emissions, and it may be even a larger share in poorer economies.[30] As the economists Alex Bowen and Sam Fankhauser (2011, p. 157) note, "the most important source of greenhouse gas emissions in low-income countries remains, by some distance, *land-use change and forestry*. Together it accounts for 50% of low-income country emissions."[31] Greenhouse gas emissions from land use change in tropical developing economies can be reduced significantly through natural climate solutions (NCS), which conserve, restore and improve land management to protect biodiversity and ecosystem services. As indicated in Table 5.1, the additional funding needed to implement cost-effective NCS in thirty-five tropical low- and middle-

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income countries that show potential for such approaches could be well over $600 billion per year.

The costs of restoring globally 350 million hectares of degraded forest and agricultural land amounts to around $350 billion annually (see Table 5.1). However, public funding for such activities is only $41 billion per year, and private investment about $10 billion. The annual shortfall in global funding of landscape restoration is therefore about $300 billion. Yet, for every dollar invested in restoring degraded forest, anywhere from $7 to $30 in economic benefits are generated.[32]

Nearly two-thirds of emerging infectious diseases spread from animals to humans, and three quarters of them originate in wildlife.[33] An important cause of this spread is the reduction in natural habitat, which increases the likelihood of disease spillovers between infected animals.[34] If we want to prevent future pandemics from wildlife-borne diseases, such as COVID-19, we must also reduce exploitation and protect our natural habitat. The estimated price tag for reducing deforestation of tropical habitats with highest risk of virus spillover from wildlife to humans is just under $10 billion per year (see Table 5.1).

What is clear from all these estimates of the underfunding of nature is that the largest financing gap occurs in the protection and conservation efforts in low- and middle-income countries.

Most of the world's remaining terrestrial biodiversity and natural landscape is in developing economies. Over three-quarters of species are found in the tropics, which is mainly occupied by low- and middle-income countries.[35] Yet, as noted, the international community spends at most around $9 billion each year to aid these countries in their effort to protect and conserve nature. There may be an additional $500 million contributed through private finance mobilized by international aid agencies (see Table 5.1). Current global funding to support conservation efforts in developing countries, who host the vast majority of biodiversity, is woefully inadequate to prevent habitat loss and overexploitation. This underinvestment is a major reason why the world is not preserving sufficient natural landscape biodiversity.

Figure 5.3 illustrates the economic implications of this underfunding. As the figure shows, the global benefits of nature conservation (gray line) are much greater than the benefits accruing to developing countries (black line). Left on their own to finance protected areas, the latter countries will conserve insufficient natural landscape (Point A). Existing international funding has boosted conservation efforts in

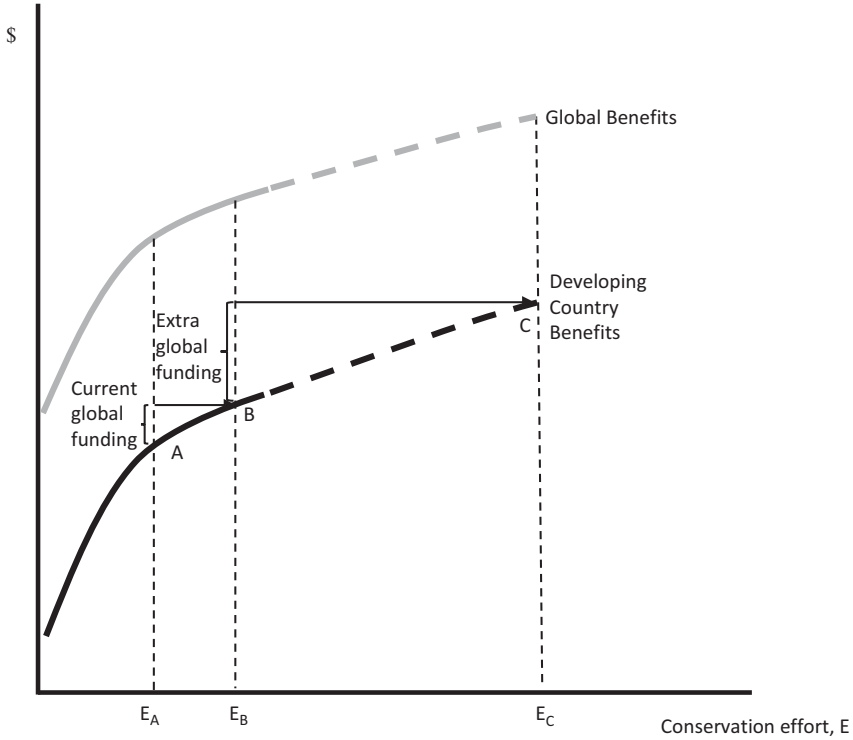

Figure 5.3 Conserving global natural landscape
Notes: Most of the world's remaining terrestrial natural landscape is in developing countries. Its global benefits (gray line) exceed the benefits to developing countries (black line). If this remaining natural landscape is not conserved and protected at high levels, it will disappear due to continued habitat loss and overexploitation (dotted gray and black lines). As it is costly for developing countries to fund nature conservation on their own, they are willing to pay for only so much conservation (Point A). Current international funding boosts conservation efforts in developing countries so some additional natural landscape is saved (Point B). Extra funding is still required to reach safe levels of nature conservation (Point C). Unless this additional funding is forthcoming, the remaining global natural landscape and its benefits are in danger from inadequate conservation and protection and irreversible, and potentially catastrophic, loss (i.e. dotted gray and black lines may eventually disappear).

low- and middle-income economies so some additional nature is saved (Point B), but current global conservation efforts still fall far short of what is need to attain safe levels of nature conservation worldwide (Point C). Unless this additional funding is forthcoming, the remaining global natural landscape and its benefits could eventually disappear.

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If terrestrial ecosystems and global biodiversity are to be saved, we need to rethink the international framework for cooperation, and at the same time, foster investment by those with the greatest ability and incentive to conserve biodiversity. And, if we want developing countries to conserve more terrestrial natural landscape, ecological capital and biodiversity that yields global benefits, we have to devise more creative and innovative ways for helping them do so.

To summarize, the only way to "bend the curve" of the current rapid loss of ecosystems and biodiversity is to address the two economic ills that are behind this loss: ending the *underpricing of natural landscape* and *the underfunding of nature*. The rest of this chapter explains how this can be done.

Ending the Underpricing of Natural Landscape

A key step in ending the underpricing of natural landscape is to remove environmentally harmful subsidies. In Chapter 4, we argued that the transition to a clean energy economy requires removing subsidies to fossil fuels to curtail their underpricing. To control inefficient and unsustainable land use, we must also curtail environmentally harmful subsidies in agriculture, mining and other activities converting and degrading natural landscape.

As indicated in Table 5.1, such subsidies for agriculture alone amount to more than $100 billion per year. That exceeds global spending on nature conservation from public and private sources. In other words, if we removed all environmentally harmful subsidies in agriculture, and devoted the released funds to natural landscape protection instead, we would double the financing for nature worldwide.

There are concerns that, for low- and middle-income countries, fertilizer and other agricultural input subsidies are necessary to spur intensification of land use, ensure food security and promote exports. This is especially the case in sub-Saharan Africa, where low fertilizer and input use are viewed as constraints on higher agricultural yields and intensification. This in turn contributes to deforestation, shortened fallows and unsustainable land use. Subsidizing inputs has been the primary policy approach for addressing these problems in Africa. Fertilizer subsidies in ten countries containing half of Africa's population are around $1 billion per year and represent as much as a quarter of public expenditure on agriculture in these countries.[36]

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Reviews of input subsidy programs in sub-Saharan Africa indicate that they have largely failed to achieve the objectives of widespread agricultural intensification and more sustainable land use.[37] Universal subsidy programs have benefited mainly large farmers who grow fertilizer-intensive crops, and not poor smallholders. The effect on improving agricultural intensification and land use expansion has been limited. Targeted subsidies to smallholder farmers have had more success, but there is also evidence that fertilizer subsidies have undermined other sustainable management strategies to improve yields. The subsidies have tended to benefit wealthier smallholders, who are more likely to be able to purchase fertilizer at commercial prices. These problems are often compounded by poor design and implementation of targeted subsidy programs. As Stein Holden has pointed out, "The fundamental reason for this is that they have been captured by elites who are able to reap the lion's share of the benefits and at the same time gain political support from the rural masses that hope to benefit from the subsidies."[38]

A better approach to increase agricultural intensification and reduce deforestation in Africa and other developing regions is to remove agricultural input subsidies and invest the savings in targeted investments to enhance sustainable land use among poor rural smallholders. Smallholder agriculture in most remote and marginal agricultural areas of Africa, Asia and Latin America is still a low development priority. Yet, targeting policies and investments to improve smallholder agriculture, land distribution and livelihoods in marginal environments could be a significant catalyst for green transformation in many low- and middle-income economies. In these countries, about 70–80 percent of farms are smaller than 2 ha, and they occupy about 30–40 percent of available agricultural land.[39] Investments and policies that support sustainable smallholder land use and livelihood diversification not only reduce poverty but also encourage environmental protection and land regeneration, especially in remote land-abundant areas.[40]

For example, as Susanna Hecht notes for rural Latin America, "cheap food policies, poverty alleviation programs of conditional cash transfers, and migration coupled to the transformations in tenurial regimes that legalized traditional holdings (and not just of natives) were substantive as drivers of forest maintenance and forest recovery than specifically environmental policies simply because the number of households affected by migration, remittances, cash transfers and tenure

changes was so significant."[41] Similarly, Michael Knudson and Niels Fold find that state regulation of the cocoa sector in Ghana, along with regulation of informal land tenure arrangement and labor contracts, have spurred increased efficiency among private cocoa purchasing companies; reduced the marginalization of farmers with small landholdings; and limited unnecessary land expansion. The overall effect of the policy has been to improve the livelihoods of cocoa-growing smallholders by preserving their access to a vital source of income and facilitating their market integration, which has led in turn to their investing in their existing land and reducing excessive conversion. As Knudson and Fold conclude, "there are strong poverty reduction arguments behind sustaining a landholding structure in which small-scale farmers are able to maintain both their land and a relatively stable income without seriously reducing production and land productivity."[42]

Investments and policies that improve and diversify the livelihoods of smallholders can also have the additional side benefits when smallholders see additional value from protecting and restoring natural areas and from afforestation on their own lands. For example, as pointed out by Hecht, much of the decline in deforestation trends in Latin America can also be attributable to the "woodland green revolution," which has arisen through the cultivation of non-timber forest products, timber and tree-based crops by smallholders and their protection of the surrounding natural landscape.[43]

Removing agricultural subsidies would also help in reducing the enormous waste in the global agricultural system, especially in the production and consumption of food. Any savings from greater efficiency could also be deployed to protect ecosystems and natural landscape, and to invest in climate-resilient farming systems and methods.

Eliminating subsidies and reducing waste will not on their own end the underpricing of natural landscape. It may also be necessary to tax pesticides, fertilizers, forest products and timber harvests that place an additional cost on the use of land and natural resources or on environmentally damaging pollution. Such taxes can help ensure that agriculture, forestry and other land uses are not excessively degrading the environment, overexploiting natural resources and unnecessarily converting ecosystems. In addition, the revenues raised from these taxes can be channeled into the conservation, restoration and sustainable use of natural landscape and ecosystems.

Since 1980, such *biodiversity-relevant taxes* have been rising steadily in fifty-nine countries. However, these taxes are still too small to have a significant impact on the underpricing of nature. They generate only about $7.5 billion a year in revenue, equivalent to around 1 percent of the total revenue from all environmentally relevant taxes.[44] In comparison, environmentally harmful agricultural subsidies are fifteen times greater (see Table 5.1).

Increasing use of biodiversity-relevant taxes to deter excessive loss of ecological capital is clearly a priority. But more innovative policies are also required.

The Group of 20 (G20) countries with substantial tropical areas, such as Australia, Brazil, India, Indonesia and Mexico, should impose a *tropical carbon tax*.[45] This is a levy on fossil fuels that is invested in natural climate solutions (NCS) aimed at conserving, restoring and improving land management to protect biodiversity and ecosystem services. NCS are a relatively inexpensive way of reducing tropical land use change, which is not only a major cause of global biodiversity loss but an important source of greenhouse gas emissions. For example, cost-effective tropical NCS can mitigate 6,560 10^6 tonnes of CO_2e in the coming decades at less than $100 per 10^3 tonnes of CO_2e, which is about one quarter of emissions from all tropical countries.[46]

Costa Rica and Colombia have already adopted a tropical carbon tax strategy. If a policy similar to Colombia's was put in place by India, it could raise $916 million each year to invest in natural habitats that benefit the climate; similarly, Brazil could fund $217 million annually; Mexico $197 million; and Indonesia $190 million.[47] A more ambitious policy of taxation and revenue allocation could yield nearly $6.4 billion each year for natural climate solutions in India; $1.5 billion for Brazil; $1.4 billion for Mexico; and $1.3 billion for Indonesia.

Natural climate solutions, such as reversing deforestation, reforestation, increasing soil carbon levels and enhancing wetlands, are increasingly considered cost-effective investments for mitigating greenhouse gas emissions from land use for temperate G20 economies as well.[48] NCS can provide over one third of the cost-effective climate mitigation needed by 2030 to stabilize warming to below 2°C, with one third of this mitigation costing $10 per 10^3 tonnes of carbon

dioxide-equivalent (CO_2e) emissions or less.[49] At this cost, the United States could abate 299 million tonnes CO_2e of greenhouse gas emissions annually through NCS, which would also provide other benefits, such as air and water filtration, flood control, soil conservation and wildlife habitats.[50] Most importantly, investing in NCS places a value on nature and its services, and sends a market signal that ecological capital is a valuable economic asset that is worth holding onto rather than converting to other land uses.

Developing countries other than G20 members should also consider adopting a tropical carbon tax. As noted, two low- and middle-income economies, Costa Rica and Colombia, have already adopted such a strategy. If twelve other megadiverse countries roll out a policy similar to Colombia's, they could raise $1.8 billion each year between them to invest in natural habitats that benefit the climate.[51] A more ambitious policy of taxation and revenue allocation could yield nearly $13 billion each year for natural climate solutions.

Moreover, such a strategy can be "pro-poor." As noted previously, poor rural households and indigenous people are affected the most by loss of natural landscape and ecosystems. Ecosystem services such as drinking-water supply, wild foods, fuelwood and other benefits contribute from 20 to 30 percent of the income of the rural poor, and even a larger share for the poorest households. The benefits to indigenous people are possibly greater, as their livelihoods, society and culture are so closely intertwined with surrounding natural areas.

Increasing the value of natural landscape in policy and market decisions is also critical to two other strategies for low- and middle-income economies: improving the efficiency and sustainability of primary production and decoupling land use change from rural development.

Case study evidence from both successful agricultural and mineral development suggests that improving the efficiency and sustainability of primary production for economy-wide gains will require resource-enhancing technological change in primary production activities; strong forward and backward linkages between the resource-based primary production sector and the rest of the economy; and substantial knowledge spillovers in primary production and across resource-based activities.[52] If guided effectively by public policy, research and extension, country-specific knowledge and technical applications in primary production can effectively expand what appears to be a "fixed" resource

endowment of a country, whether it is mineral resources or agricultural land. As noted by William Maloney, even in Latin America, which has largely underperformed in terms of resource-based innovation and growth, there have been some "success stories" following this model: "Monterrey in Mexico, Medellín in Colombia, and São Paolo in Brazil all grew to become dynamic industrial centers based on mining and, in the latter two cases, coffee."[53]

Resource-enhancing technological change, knowledge spill-overs and strong forward and backward linkages are also critical to structural transformation of agriculture in developing economies, including Africa, which has struggled to emulate the rapid agricultural growth of Asia and other regions.[54] The priority should be to achieve productivity growth through sustainable intensification of agriculture and food systems to increase incomes while strengthening resilience and reducing environmental impact. Productivity growth should also boost expansion of the rural non-farm economy through income and demand effects, and as many households diversify their earnings between the farm and non-farm sectors, gains from the non-farm economy are often reinvested in further agricultural intensification. Many poor economies, especially in Africa, will need agricultural innovations that are more suitable to diverse cropping systems, marginal environments and variable agro-ecological conditions. This will require development and dissemination of drought-tolerant and pest-resistant crop varieties, integrated agro-forestry systems and improved varieties of sorghum, millet, cassava and other secondary crops.

Ending the underpricing of natural landscape is critical to both improving the efficiency and sustainability of primary production and to sustainable intensification of agriculture. As long as natural landscape is underpriced, then there is little economic incentive to invest in increasing the economic returns to existing agricultural land and natural resource exploitation.

Pricing natural landscape appropriately may also be important for decoupling agricultural and rural development from continued land expansion and deforestation. But instead, most countries have attempted to control land use change through more direct policies, such as imposing environmental regulations and limiting forest conversion, with mixed results.[55]

Even though there are signs that environmental restrictions can limit excessive agricultural land expansion, their effectiveness remains

limited as long as forests and other natural landscape are undervalued compared to agricultural uses. For example, in the Brazilian Amazon, appreciation of land values due to soy expansion has contributed to significant deforestation and conversion of other natural habitat, because these areas are treated as if they have no other value. Cattle ranching is still pervasive, and although it is a relatively low-value land use with limited land productivity, rangeland expansion continues to generate substantial deforestation because natural forest is considered worth even less.[56]

In an attempt to control tropical deforestation from primary product industries, in 2011 Indonesia implemented a moratorium on new concessions for oil palm plantations, timber plantations and logging activity on primary forests and peatlands. Jonah Busch and colleagues found that, in the first few years after its implementation, the moratorium has had a significant impact on reducing deforestation, although the effect would be substantially larger if the moratorium was extended to limit forest loss on existing oil palm and timber concessions or deforestation on lands where no concessions officially exist. In addition, the authors conclude that decoupling agricultural and timber developments from deforestation would be even more effective if moratorium controls were combined with price-based instruments, such as carbon payments, payments for ecosystem services, taxes on deforestations or certified environmentally sustainable products, "all of which attempt to raise the private value of maintaining land as forest relative to converting land to agriculture."[57]

Ending the underpricing of nature in market and policy decisions is also vital for any effort to impose global limits, such as *no net loss of ecosystems*, on humankind's destruction of the biosphere.

No Net Loss

As noted in the Introduction, various planetary boundaries for controlling the decline of ecological capital have been proposed. These include measures based on indices of biodiversity intactness, species abundance or richness, net primary productivity and no net loss of natural ecosystems.

Chapter 2 discussed a number of concerns raised about establishing planetary boundaries for biodiversity and other Earth system processes. Some question the relevance of establishing global

boundaries to control land use change and biodiversity loss, as most of the drivers are at the local, regional or country level. Instead, they argue that policies and incentives should be developed nationally, and then most effectively implemented at the local or regional level to limit excessive and destructive impacts on the environment.[58]

A further problem is the difficulty of establishing planetary boundaries based on scientific measures of biodiversity, ecosystem integrity and other key ecological characteristics of natural landscape. As explained by the economists Giannis Vardas and Anastasios Xepapadeas, this challenge is exacerbated by "the complexity of ecosystems and by important and interrelated uncertainties, a number of which include sources such as major gaps in global and national monitoring systems; the lack of a complete inventory of species and their actual distributions; limited modelling capacity and lack of theories to anticipate thresholds; emergence of surprises and unexpected consequences."[59]

Because of these complications, some have argued that specifying global limits to land use change and biodiversity decline should focus on simpler criteria, such as *no net loss of ecosystems*. Sandra Díaz and colleagues argue including this objective in the post-2020 globally biodiversity framework of the Convention on Biological Diversity (CBD). The authors suggest as possible goals no net loss of natural ecosystem area and integrity by 2030 relative to 2020, and by 2050, a net gain of 20 percent of area and integrity of natural ecosystems and a 20 percent gain of integrity of managed ecosystems. There should also be no loss of "critical" ecosystems that are rare, vulnerable, or essential for planetary function, or which cannot be restored.[60]

However, the CBD appears to be moving toward an even more straightforward goal for its post-2020 global biodiversity framework: the "30 by 2030" target. This proposal calls for protection of 30 percent of the planet's land and water surface by 2030, nearly doubling the existing conservation and protected areas globally.[61]

In addition to such "no net loss" and "30 by 2030" targets, planetary boundaries have been proposed for some of the world's critical ecosystems and biomes. One such habitat critical for global biodiversity are natural forests, which are declining especially in tropical regions (see Figure 5.2). These forests are predominantly composed of trees established through natural regeneration, and thus their ecological integrity is compromised if they are converted to agriculture or if they are replaced by plantation forests with a handful of tree species or less.

Two possible planetary boundaries for natural forests have been proposed. Will Steffen and colleagues advocate preserving 75 percent of the original global natural forests and 85 percent of boreal and tropical natural forests. Eric Dinerstein and coauthors recommend protecting half of the terrestrial realm, which includes all natural forest globally.[62] Such conditions suggest that agriculture, forestry, mining and other primary production activities are limited to using or converting only part of the remaining natural forest area. For example, in the case of tropical natural forests, Steffen and colleagues suggest that this "safe operating space" for primary production is only 15 percent of the forest area, whereas for Dinerstein and colleagues these activities may safely operate in 50 percent of the remaining area.

However, establishing a no net ecosystem loss rule, designating how much natural landscape should be protected or designating a planetary boundary for natural forest and other critical global habitats is not the end of the story. As in the case of Indonesia's moratorium on deforestation discussed in the previous section, setting such an absolute limit on destructive land use change is much less effective – and perhaps impossible to achieve – if the underpricing of natural landscape persists.

It all comes down to economic incentives. As we have seen, underpricing natural landscape sends a signal that natural areas are worth less compared to converting them to agriculture, timber forestry, mining and other commercially valuable land uses. The result is that too much natural area will be converted and degraded.

But suppose there is a limit placed on how much a particular ecosystem, such as natural forest, can be converted to agriculture and other commercial uses. This limit means that there is now less remaining natural forest available for these primary production activities to convert. It has become increasingly scare and thus even more valuable. The danger now is that, unless the underpricing of natural landscape is halted, the gap between the value of keeping natural landscape intact and the value of converting it to another land use will grow.

This creates several problems. First, if producers and consumers do not receive signals through market prices that forest land and its resources are valuable and becoming scarce, then they will fail to switch to alternative uses in a timely manner. Constraints in the availability of essential inputs into productions will undermine production of valuable goods and services, and could slow economic growth and development. Furthermore, the failure to receive market signals of scarcity will lead to

the underinvestment in diversification to reduce dependency on key natural resource and environmental benefits. This could make the economy vulnerable to exports shocks and stresses. In addition, in the absence of proper pricing, any remaining natural forest that is safe to convert to agriculture and other land uses will be deforested too quickly. Once that happens, owners of primary production activities will have a strong incentive to ignore the limit on deforestation and to convert illegally natural forest that is supposed to be preserved.

To overcome these perverse incentives, there should be a tax imposed on deforesting the remaining forest area that is safe to convert. This tax should reflect the value of all the benefits that this forest area provides to everyone in the region or country containing this area. But in addition, the tax should rise over time to reflect the remaining forest's increasing scarcity value as it is depleted. By eliminating the gap between the value of keeping the natural forest intact and converting it to another land use, the tax would now provide an incentive to slow down the rate of deforestation of the remaining natural forest that is allowed to be converted. If necessary, the tax rate could rise over time to extend the lifetime of this forest area indefinitely.

To illustrate how such pricing of natural landscape can support an absolute limit on natural landscape conversion, Joanne Burgess and I explore the two proposals for planetary boundaries on tropical natural forests just discussed.[63] As Will Steffen and colleagues suggest that 85 percent of these forests should be preserved, then the remaining "safe operating space" for possible conversion by agriculture, forestry, mining and other primary production is only 15 percent of the forest area. In comparison, because Dinerstein and colleagues propose that half of tropical natural forests should be protected, primary production may safely operate in 50 percent of the remaining area.

We find that the size of the forest area that is allowed to be deforested – 15 percent versus 50 percent – impacts significantly the lifetime of this remaining area before it is completely depleted. However, irrespective of the initial size of this safe operating space, its lifetime can be significantly extended by imposing a tax on forest conversion that captures all the benefits of the remaining forest, and also rises over time as the forest is depleted. If the safe operating forest is extremely valuable for its ecosystem services, then a very high tax should be imposed to extend the lifetime of the remaining forest indefinitely. Such a tax will signal that the value of conserving the safe

operating space of forest is significantly high, and thus over time much more of the forest will be conserved rather than converted to an alternative use.

For example, in the most stringent case, if the remaining safe operating space is 15 percent of the original tropical natural forest area in 1990, then complete deforestation could occur in 11–21 years from 2015 onward if no tax is imposed to control deforestation. In comparison, imposing a tax that includes the foregone ecosystem benefits and the rising scarcity value from deforestation extends the lifetime of this safe operating space for tropical natural forests to sixty-five years. If the value of ecosystem benefits lost to deforestation is extremely large, then the tax should be even higher, in which case deforestation of the safe operating space may be delayed hundreds of years, or not deforested at all.

The lesson to be learned from this exercise is that simply imposing a limit or boundary on how much natural landscape can be used or converted is important for determining *ecologically* how much of nature we should preserve. But it is not a substitute for ending the underpricing of natural landscape. As we have seen in this chapter, only by ending such underpricing can we determine *economically* how to manage efficiently and sustainably our remaining natural landscape.

Or, as Thomas Sterner and colleagues put it, "keeping within planetary boundaries requires that we make better and more cost-effective use of the finite resources and sinks available to us."[64]

Collective Action

As we discussed previously, if global land use change and biodiversity loss are to be halted, then we must also end the underfunding of nature.

Most of the world's remaining terrestrial ecosystems and biodiversity are found in low- and middle-income countries, yet current global funding to support conservation efforts by these countries is woefully inadequate to prevent habitat loss and overexploitation. Simply put, if we want to "bend the biodiversity curve" we need to find creative and innovative ways to fund more conservation by developing countries.

The global value attributed to remaining natural landscape is significant. As we saw previously, its contribution to the value added of

industries and their supply chains could amount to as much as half of the world's GDP (see Table 5.1). According to the 2020 Global Risks Report, biodiversity loss is one of the five greatest risks faced by humankind, and it is also intertwined with other significant risks, such as climate change.[65]

The consumption pattern and habits of rich countries also bear some responsibility for the rapid decline in terrestrial ecosystems and biodiversity in developing countries. Florence Pendrill and colleagues found that 29–39 percent of deforestation–related greenhouse gas emissions is caused by international trade, mainly in beef and oilseeds. As a result, one sixth of the carbon footprint of the average diet in the European Union is due to tropical deforestation.[66]

However, if the rest of the world does substantially increase its funding of conservation investments in poorer countries, it could have a major impact on saving ecosystems and biodiversity. Even relatively small increases in funding could make a major difference.

For example, fifty-nine tropical developing countries spend nearly $370 million annually on conservation, yet are still experiencing biodiversity decline of 1.9% on average per year (see Table 5.2). If $1 million in additional annual funding was available for these countries, there would be an 18.5% reduction in biodiversity decline. If funding increased by $5 million per year, the rate of biodiversity decline would be reduced by almost 61%. The gains from $5 million extra spending each for some megadiverse countries would also be substantial, such as Peru (54%), Brazil (42%) and Papua New Guinea (33%). With $5 million a year of extra funding, Madagascar would be able to transition from a declining to an improving biodiversity trend.

Given the urgency of "bending" the biodiversity loss curve (see Figure 5.1), the key question is what collective action is needed globally to end the underfunding of nature worldwide.

One avenue is for wealthier countries not only to increase the amount of their own domestic spending on nature conservation but also to devote substantially more bilateral and multilateral assistance to poorer countries (see Table 5.1).

Increasing domestic conservation investments can provide much needed economic benefits, including jobs, which should be an important consideration as major economies recover from the COVID-19 pandemic. For example, ecosystem restoration in the United States provides direct employment for 126,000 workers and generates

Table 5.2. Increasing global conservation funding to developing countries

Country	Average Annual Biodiversity Decline	Average Annual Conservation Spending $ Million	Reduction in Biodiversity Decline from a $1 Million Spending Increase	Reduction in Biodiversity Decline from a $5 Million Spending Increase
Brazil	0.4%	20.85	9.03%	42.18%
Colombia	1.0%	14.83	5.57%	26.96%
Democratic Republic of Congo	0.6%	2.12	6.38%	31.22%
Ecuador	1.3%	3.91	4.81%	23.44%
Indonesia	3.7%	18.69	7.66%	33.85%
Madagascar	0.0%	13.93	30.77%	Recovery
Malaysia	6.7%	9.21	1.64%	8.07%
Papua New Guinea	2.8%	8.83	7.09%	32.84%
Peru	0.3%	16.28	11.25%	54.31%
Philippines	1.5%	6.11	5.02%	24.27%
10 megadiverse countries	**1.8%**	**114.76**	**8.9%**	**30.8%**
59 tropical countries	**1.9%**	**369.05**	**18.5%**	**60.8%**

Notes: Based on Waldron et al. (2017). All countries are low- and middle-income economies, with 2019 per capita gross national income (GNI) of US$12,535 or less. Megadiverse countries identified by Mittermeier et al. (1997). This classification is used to set conservation priorities internationally, see www.worldatlas.com/articles/ecologically-megadiverse-countries-of-the-world.html. Recovery indicates transition to an improving biodiversity trend.

$9.5 billion in economic output annually, while creating a further 95,000 indirect jobs and $15 billion in household spending.[67]

The returns to increased conservation investment in developing countries could be even greater. Based on data from sixteen low- and middle-income countries, Nicoletta Batini and colleagues find that, for every dollar spent in conservation, almost seven dollars more are

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generated in the economy after five years. The authors attribute these high returns to three factors. First, conversation spending sponsored by donors supplement domestic resources in developing countries rather than crowd them out. Second, conservation actions in these countries are highly labor-intensive and create jobs. Finally, as discussed earlier in this chapter, conservation of natural landscape protects ecosystem services that support the economic livelihoods of the rural poor, including water, food, fodder, resource harvests and protection from extreme events.[68]

One way that richer countries could fund more conservation in poorer economies is to step up their investments in biodiversity offsets and payments for ecosystem services.

Biodiversity offsets are conservation actions, such as protecting threatened forests or restoring wetlands, which are intended to compensate for unavoidable losses to natural habitats caused by other investments in the economy. The objective is to ensure at least a no net loss of biodiversity and, where possible, a net gain. Globally, about $5 billion is spent annually on biodiversity offsets.[69] However, much of these offsets occur domestically within wealthier economies. Richer countries and multilateral agencies need to increase their assistance to low- and middle-income countries for funding biodiversity offsets.

Payments for ecosystem services are market transactions, usually direct cash or credit payments, made by those who benefit from ecosystem services to landowners who have agreed to provide these services through specific actions, such as habitat conservation or restoration. The type of ecosystem services generated include watershed protection, carbon sequestration, water quality benefits, biodiversity conservation and wildlife habitat benefits. Ten large, publicly funded payments for ecosystem services programs account for around $10 billion of global funding annually. In addition, private schemes that pay for watershed protection services provide financing of around $15 million each year.[70]

There is plenty of scope to expand public and private payments for ecosystem services, and especially to fund more projects in developing countries. Such schemes should focus on tropical countries where natural climate solutions are most cost-effective and to reduce tropical deforestation in areas at highest risk of wildlife–human disease spillover (see Table 5.1). Tropical countries that benefit most from the extra spending on biodiversity conservation should also be a priority (see Table 5.2).

The pandemic has also caused rising debt levels and budget cuts in low- and middle-income countries. As we have discussed in Chapter 4, there is an opportunity to employ a comprehensive private and public debt relief program, conditional on indebted countries undertaking additional actions or investments in climate adaptation and mitigation. This could potentially be a win-win strategy for addressing the climate and debt crises, provided that the additional climate actions should include a commitment by participating low- and middle-income countries to ending the underpricing of fossil fuels in their economies.

In a similar way, lender countries could offer lower interest rates and principal repayments in return for increasing biodiversity and natural area protection in borrowing countries, in exchange for the latter delivering on additional conservation actions and investments. The basic idea of such *debt-for-nature swaps* involves restructuring or canceling some of a nation's foreign debt in exchange for investment in greater conservation of natural areas. Such deals have existed since the late 1980s. Since 1990, debt-for-nature swaps by the United States canceled approximately $1.8 billion owed by twenty-one low- and middle-income countries. The swaps generated $400 million for conservation. Debt-for-nature swaps carried out by all other high-income countries totaled $1 billion of debt canceled and generated about $500 million for conservation. Evidence suggests that the US bilateral debt-for-nature deals have been associated with lower rates of forest loss in borrowing countries.[71]

If debt-for-nature swaps are to be effective in closing the funding gap for global nature conservation, clearly more deals need to be made and key shortcomings addressed. One option is to expand the range of conservation actions to include a commitment by participating low- and middle-income countries to ending the underpricing of natural landscape. By undertaking subsidy reforms and pricing land conversion in exchange for debt relief, these countries will be reestablishing their credit worthiness with financial investors and markets. This could potentially be a win-win strategy for addressing both the debt crisis and underfunding of nature faced by many developing countries.

Another way to close the funding gap is to expand the use of *green bonds* for biodiversity and sustainable land use investments. These are debt instruments where the proceeds are used exclusively to finance or refinance projects with environmental benefits. First issued in

by the European Investment Bank in 2007 and the World Bank in 2008, green bonds reached a market value of $258 billion in 2019. The Luxembourg Stock Exchange established the first dedicated Green Exchange (LGX) that includes trading in green bonds in 2016.[72] The issuers of green bonds are typically local and national governments, corporations and multilateral development agencies and banks.

While the global market for green bonds is growing, their focus is mainly on renewable energy, energy efficiency, green transport and other climate change mitigation investments. Green bonds are rarely used to finance biodiversity conservation and sustainable land use. Climate change, energy and transport have accounted for around 80 percent of green bonds; land use projects only 3 percent.[73]

The main issuer of green bonds for investments in low- and middle-income economies is the World Bank. Since 2008, the bank has issued green bonds to raise $17 billion for eligible projects worldwide. Of these commitments, nearly $12 billion in green bond proceeds have been disbursed to support 106 projects in thirty-one developing countries. But 66 percent of the projects funded have been for renewable energy, energy efficiency and clean transportation. Only 17 percent have been allocated to agriculture, land use, forests and ecological resources, with a total allocation of just over $1.3 billion.[74]

If greens bonds are to catalyze more biodiversity and sustainable land use investments, especially in developing countries, several limitations need to be overcome. Two key challenges are the relatively small scale of many conservation projects compared to clean energy and transport investments, and as a result, the perceived relative low returns and significant risk of investing in biodiversity and sustainable land use. The average value of issued green bonds is $150 million, but individual conservation projects in low- and middle-income countries are unlikely to reach such a scale, unless they are bundled into larger investment opportunities.[75]

There are creative ways of doing this. The first is that developing country governments, working with aid agencies issuing green bonds such as the World Bank, local governments and NGOS could identify and combine individual natural landscape projects from various localities and regions into a single nationwide investment portfolio. A green bond could then be issued for the entire portfolio of projects, and then disbursed to individual regional and local investments.

Green bonds could also be issued to support other scalable conservation actions, such as a countrywide program of payments for

ecosystem services, biodiversity offsets, ecological restoration or for expanding protected areas, their policing and monitoring. A good example is Mexico's recently completed $350 million Forests and Climate Change program, which was partially funded by the issuance of a World Bank green bond. The project supported rural communities' sustainable management of forests, generated additional income for these communities from forest products and services and significantly reduced greenhouse gas emissions from deforestation and forest degradation.[76]

But if we really want to end the underfunding of global biodiversity, the corporate world needs to step up.

As noted previously in this chapter, $44 trillion of global value added across 163 global industrial sectors and their supply is moderately or highly dependent on nature and its services. This is more than half of the world's GDP (see Table 5.1). The dependence on terrestrial natural landscape is possibly even higher for key sectors, such as forestry and agricultural industries.

Along with Joanne Burgess and Thomas Dean, I examined the benefits from greater participation and investments in global biodiversity conservation by these two sectors.[77] By spending $15–$30 billion annually to protect natural forests worldwide, the forest products industry would attain its own industry sustainable forest management goals. Agriculture also has an incentive to protect habitats of wild pollinators, who along with managed populations enhance global crop production by $235–$577 billion each year.

We go on to argue that, to capitalize on these incentives for business to conserve nature, the world needs a new type of global biodiversity agreement that goes beyond simply establishing targets designating how much of the planet to protect but finds new ways to end the global funding gap. One way is for such an agreement to allow formal participation by leading corporations in forestry, agricultural and other sectors that benefit from conservation. In exchange for committing to the agreement, the corporations would have to commit funding to conserve natural areas and sustainable land use globally. We estimate that the resulting increase in industry revenues and profits could provide $25–$50 billion annually for global conservation, which would help close the funding gap.

In sum, we have to scale up and align finance for biodiversity and natural landscape conservation from all sources, public and private. For example, it is estimated that we need at least three if not four times

the amount of current annual spending on natural-based solutions, if the world is to meet its climate change, biodiversity and land degradation targets.[78] Actions by individual governments and businesses are important, but this must be a collective effort. As many businesses worldwide are the main beneficiaries from nature and its services, it is time that they step up to do their part. In Chapters 8 and 9, we will explore further the main ways in which both business and the government can contribute to the economics of a fragile planet.

Conclusion

There are two principle causes of the current rapid loss of global terrestrial ecosystems and biodiversity: the *underpricing of natural landscape* and *the underfunding of nature*.

If natural areas are priced too cheaply, then we will find it cheaper to convert them to agriculture, forestry and other land uses than to protect or preserve them. By underfunding nature, we provide little incentives for conserving or restoring ecosystems and habitats.

Decoupling development from excessive land use change and ecosystem loss is necessary to make our economies both more sustainable and inclusive. This outcome is crucial if we want to generate the incentives, innovations and governance necessary to transition to sustainable intensification of agriculture, forestry and other land uses; reduce food and waste; and ultimately, "bend the curve" of ecological and biodiversity decline.

Such a transition is also more inclusive than the current pattern of development that undervalues ecological benefits. As long as the chronic underpricing of natural landscapes persists, aided and abetted by resource rent-seeking and poor institutions and governance, then rural poverty will remain a chronic problem in much of the developing world. In addition, poor rural households and indigenous people benefit the most from nature and its services, and have the most to lose from declining ecosystems and biodiversity.

Most of the world's remaining terrestrial biodiversity and natural landscape is in low- and middle-income countries. Yet current global funding to support conservation efforts in these countries is woefully inadequate to prevent habitat loss and overexploitation. This underinvestment is another reason why the world is not preserving sufficient natural areas.

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If catastrophic global biodiversity decline is to be avoided, we need to rethink the international framework for cooperation, and at the same time, foster investment by those with the greatest ability and incentive to conserve biodiversity. And, if we want developing countries to conserve more natural areas, ecological capital and biodiversity that yield global benefits, then we have to devise more creative and innovative ways for helping them do so.

The good news is that we have at our disposal a growing number of financial instruments and mechanisms to spur collective action by rich countries to assist poorer ones in protection and restoration efforts, and by the private sector to invest in nature to reduce the risks posed by biodiversity and ecosystem loss. These include biodiversity offsets, payments for ecosystem services, debt-for-nature swaps, green bonds and international environmental agreements. There are creative ways of to scale up and align finance for biodiversity and natural landscape conservation from all sources, public and private. Moreover, these mechanism should be used in conjunction with demonstrable policy reforms that end the underpricing of natural landscape.

In a nutshell, we can establish all the global targets we want – protecting 30 percent of the Earth's surface by 2030, no net loss of natural ecosystems or planetary boundaries on ecological loss – but until we tackle the perverse incentives caused by the underpricing of natural landscape and the underfunding of nature, we will continue to fall short of any global goals to halt ecosystem decline and biodiversity loss. Corporate leaders, policy experts and even some world leaders are increasingly acknowledging that declining ecological capital is one of the greatest risks faced by humankind. It is time we recognize that managing our remaining fragile natural landscape is just as much an economic challenge as an ecological one.

Notes

1 See Ceballos et al. (2017). Other global assessments that illustrate how land use change is leading to unprecedented loss of biodiversity and ecosystem services include Bar-On et al. (2018); Díaz et al. (2019); Dinerstein et al. (2017); Elhacham et al. (2020); IPBES (2019); Leclère et al. (2020); Mace et al. (2018); and Newbold et al. (2016).
2 Díaz et al. (2019).
3 IPBES (2019).
4 From Newbold et al. (2016), who estimate that natural biodiversity remaining in local ecosystems exceeds safe limits across 58.1 percent of the world's land surface.

5 Friedlingstein et al. (2020) estimate that between 2010 and 2019, 86 percent of total carbon emissions were from fossil fuel CO_2 emissions and 14 percent were from land use change.
6 Jones et al. (2018).
7 See, for example, Díaz et al. (2020); Lade et al. (2020); Mace et al. (2014); Newbold et al. (2016); Running (2012); and Steffen et al. (2015).
8 Dinerstein et al. (2019). The main proponent of this global conservation goal of preserving half of the Earth is the biologist Edward O. Wilson. See Wilson (2016) and also Dinerstein et al. (2017).
9 Mehrabi et al. (2018).
10 Mace et al. (2018), p. 448.
11 Species richness and relative abundance are often the two factors that are considered when measuring species diversity, which is the most common interpretation of biological diversity. Species richness refers to the number of species in an area, community or ecosystem, and relative species abundance measures how common a species is relative to the other species found in an area, community or ecosystem. The Living Planet Index (LPI) is a measure of the state of the world's biological diversity based on population trends of vertebrate species from terrestrial, freshwater and marine habitats. The current LPI comprises 4,801 species and 27,580 populations. All indices are weighted by species richness, giving species-rich taxonomic groups in terrestrial, marine and freshwater systems more weight than groups with fewer species. For more details, see WWF (2020) and WWF/ZSL. https://livingplanetindex.org/data_portal.
12 Dasgupta (2021), p. 234.
13 Ellis et al. (2013), p. 7985
14 Allott et al. (2020); Leclère et al. (2020); Mehrabi et al. (2018); Springmann et al. (2018); and Tilman et al. (2011).
15 Tilman et al. (2011).
16 Barbier (2019a) and (2020b); Busch and Ferretti-Gallon (2017); Carrasco et al. (2017); Gibbs et al. (2014); Hosonuma et al. (2012); Laurence et al. (2014); Leblois et al. (2018); Meyfroidt et al. (2014); and UNCCD (2017).
17 Barbier (2019a) and Venables (2016).
18 From the World Development Indicators, available at https://databank.worldbank.org/source/world-development-indicators.
19 Mehlum et al. (2006). Since this study, there has been a growing economics literature examining this interaction; for example, for reviews, see Badeeb et al. (2017); Barbier (2019a); Havranek et al. (2016); Kolstad (2009); Papyrikis (2017); and van der Ploeg (2011).
20 See, for example, Barbier (2019a) and (2020b); Busch and Ferretti-Gallon (2017); Carrasco et al. (2017); Chomitz et al. (2007); DeFries et al. (2010); Deininger and Byerlee (2012); Gibbs et al. (2010); Hosonuma et al. (2012); Lambin and Meyfroidt (2011); Laurence et al. (2014); Leblois et al. (2018); and Meyfroidt et al. (2014).
21 Barbier (2019a); van der Ploeg (2011); and Venables (2016).
22 Barbier (2019a); Chomitz et al. (2007); Deininger and Byerlee (2012); Hosonuma et al. (2012); and Meyfroidt et al. (2014).
23 United Nations (2014).
24 Castañeda et al. (2018).
25 Binswanger and Deininger (1997), p. 1996.
26 Angelsen and Dokken (2018); Angelsen et al. (2014); Barbier (2019a); Barbier and Hochard (2018); Debela et al. (2012); Delacote (2009); Díaz et al. (2019); Garnett et al. (2018); Hallegatte et al. (2015); López-Feldman (2014); McSweeney (2005);

Narain et al. (2008); Narloch and Bangalore (2018); Noack et al. (2019); Robinson (2016); Takasaki et al. (2004); Vedeld et al. (2007); and Wunder et al. (2014).

27 Angelsen et al. (2014) and Vedeld et al. (2007).

28 Díaz et al. (2019) and Garnett et al. (2018).

29 As a comparison, UNEP (2021) finds that approximately $133 billion per year is invested in *nature-based solutions*, which are broadly defined as actions to protect, sustainably manage and restore natural or modified ecosystems, while also addressing societal challenges, such as food security, climate change, water security, human health, disaster risk and social and economic development. UNEP (2021) assesses that 86 percent ($115 billion) of the annual funding for nature-based solutions is from public sources, and 14 percent ($18 billion) from private sources. The report excludes investments in the marine environment but does include mangroves. UNEP (2021) maintains that, if the world is to meet its climate change and biodiversity targets, annual funding for nature-based solutions needs to increase threefold by 2030 and fourfold by 2050, or around $536 billion per year.

30 Friedlingstein et al. (2020) estimate that between 2010 and 2019, 86 percent of total carbon emissions were from fossil fuel CO_2 emissions and 14 percent were from land use change.

31 Bowen and Sam Fankhauser (2011), p. 157.

32 Ding et al. (2019) and Verdone and Seidl (2017).

33 Cunningham et al. (2017) and Jones et al. (2008).

34 Cunningham et al. (2017); Faust et al. (2018); Gibb et al. (2020); Johnson et al. (2020); and Shah et al. (2019).

35 Barlow et al. (2018).

36 Jayne et al. (2018).

37 Holden (2019) and Jayne et al. (2018).

38 Holden (2019), p. 516.

39 Lowder et al. (2016).

40 See, for example, the many case studies and examples from low- and middle-income countries cited in Bachewe et al. (2018); Barbier (2019a) and (2020b); Barbier and Hochard (2018) and (2019); Barrett et al. (2017); Fan and Chan-Kang (2004); Hecht (2014); Holden (2019); Huang (2018); Larson et al. (2016); and Pingali (2012).

41 Hecht (2014), p. 899.

42 Knudson and Fold (2011), p. 386.

43 Hecht (2014).

44 OECD (2020c).

45 Barbier et al. (2020).

46 Griscom et al. (2020).

47 Barbier et al. (2020).

48 EASAC (2019); Fargione et al. (2018); and Griscom et al. (2017).

49 Griscom et al. (2017).

50 Fargione et al. (2018).

51 Barbier et al. (2020).

52 For reviews of this evidence, see Barbier (2019a) and (2020b); Maloney (2002); Nülle and Davis (2018); and Wright and Czelusta (2004).

53 Maloney (2002), p. 112.

54 Bachewe et al. (2018); Barrett et al. (2017); and Pingali (2012).

55 From 2000 to 2015, there were encouraging signs that the combination of improved environmental regulations to control deforestation and regional economic development policies in the Brazilian Amazon may have had some success in decoupling agricultural development from land expansion (Barbier 2019b; Cardoso da Silva

et al. 2017; Caviglia-Harris et al. 2016; Fekete et al. 2021, Macedo et al. 2012; Tritsch and Arvor 2016). Thus, over this period, increasing commercial production activities, wider socioeconomic gains and reduced land expansion and deforestation may have occurred in some locations. This was largely attributed to land use policies that promoted efficient use of already cleared land through intensification while restricting deforestation, combined with regional policies that encouraged agglomeration economies that spurred innovation, supply chain diversification and reduced market access for commercial primary producers in existing agricultural areas. Similar policy strategies may have also been effective in decoupling commercial crop expansion and deforestation in other tropical regions (Busch et al. 2015; Carrasco et al. 2017; Knudsen and Fold 2011; Meyfroidt et al. 2014; Newton et al. 2013). Unfortunately, policy changes in Brazil after 2015 loosened environmental regulations on deforestation and failed to control land clearing, which have set back the overall strategy of decoupling development and widespread land use change, especially in Amazonia.

56 Cardoso da Silva et al. (2017); Holland et al. (2016); Richards (2015); Richards et al. (2014); and Walker et al. (2009).

57 Busch et al. (2015), p. 1331.

58 See Brook et al. (2013); Montoya et al. (2018); and Randall (2021).

59 Vardas and Xepapadeas (2010), p. 380.

60 Díaz et al. (2020). The authors also propose specific goals for species, genetic diversity and nature's contribution to people.

61 See www.cbd.int/doc/c/3064/749a/0f65ac7f9def86707f4eaefa/post2020-prep-02-01-en.pdf. The suggestion of this target is based on the "Global Deal for Nature" proposed by Dinerstein et al. (2019), who suggest increasing global conservation and protected areas to 30 percent of the world's surface by 2030.

62 Dinerstein et al. (2017) and Steffen et al. (2015).

63 Barbier and Burgess (2019).

64 Sterner et al. (2019), p. 19.

65 WEF (2020).

66 Pendrill et al. (2019).

67 BenDor et al. (2015) and OECD (2020c).

68 Batini et al. (2021). The sixteen countries are Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Ghana, Guatemala, Madagascar, Malawi, Mozambique, Niger, Senegal, Sierra Leone, Tanzania and Uganda.

69 OECD (2020c).

70 OECD (2020a) and (2020c).

71 Sommer et al. (2019). However, Cassimon et al. (2011) find that debt-for-nature swaps have also typically displayed a number of shortcomings: They often fail to deliver additional resources to the debtor country or to the government budget; often fail to deliver more resources for conservation purposes; often have a negligible effect on overall debt burdens; and are often in conflict with principles of alignment with government policy and institutions. As the authors find, some of these shortcomings are present in the specific case of a debt-for-nature swap between the United States and Indonesia.

72 Chahine and Liagre (2020) and World Bank (2019a). Note that, as traded assets, the market valuation of green bonds does not necessarily reflect the amount of money raised by issuers of green bonds to finance environmental projects. As Chahine and Liagre (2020, p. 1) comment about the rapid expansion in the market value of green bonds in recent years: "A lot of this growth has been captured by different stock exchanges where Green Bonds are listed."

73 Chahine and Liagre (2020).
74 World Bank (2019a).
75 Chahine and Liagre (2020).
76 World Bank (2019a).
77 Barbier et al. (2018).
78 UNEP (2021).