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ILLEGAL WILDLIFE TRADE AND CLIMATE CHANGE

Joining the dots

Acknowledgements

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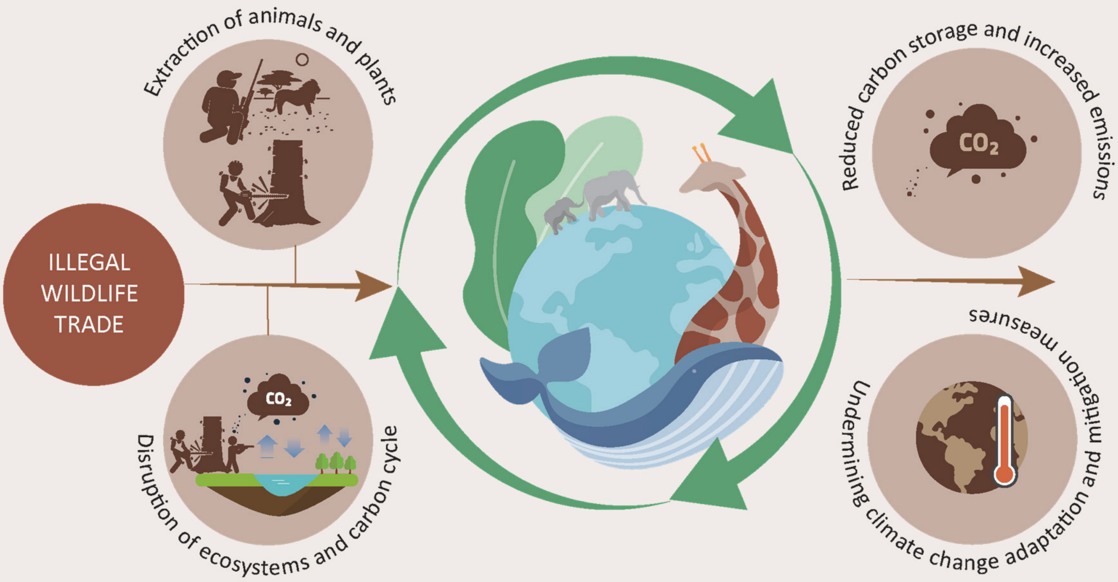
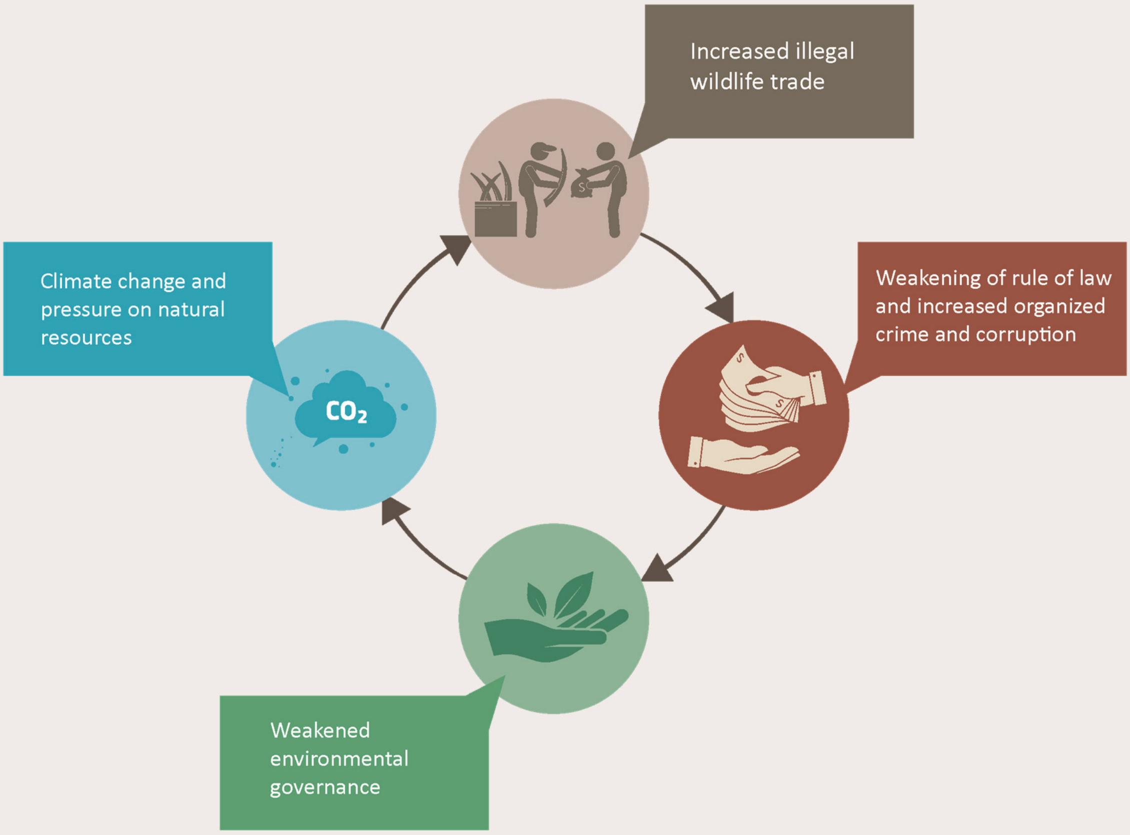
KEY TAKEAWAYS

1. Illegal wildlife trade (IWT) persists in contravention of laws specifically aimed to address negative impacts of over-exploitation of nature, one of the most critical threats to the world's biodiversity.
2. By reducing and otherwise negatively impacting populations of wildlife species, IWT undermines the functioning of ecosystems, with significant potential to harm related natural processes – including those affecting climate.
3. The causal chains that demonstrate and explain these links are diverse, complex, and little researched and they are important to long-term climate stability and mitigation of climate change impacts.
4. Some key pathways linking IWT, ecosystems and climate:



- IWT reduces populations of species such as hardwood trees, which directly and indirectly sequester and store carbon.
- IWT impacts the role of "ecosystem engineers", species that shape fundamental physical processes that are especially important to the long-term storage and persistence of carbon stocks.
- IWT affects species that have unique functional traits, such as pangolins and some predators, meaning that they serve roles in their ecosystems that few other species provide. This uniqueness means that, when populations of these species are impacted, related ecosystem services are likely to be undermined.
- IWT targets species that are often geographically co-located in habitats that provide multiple ecosystem goods and services, including carbon stocks. Moreover, sites affected by IWT are often also impacted by other human activities such as habitat degradation that harm carbon stocks.

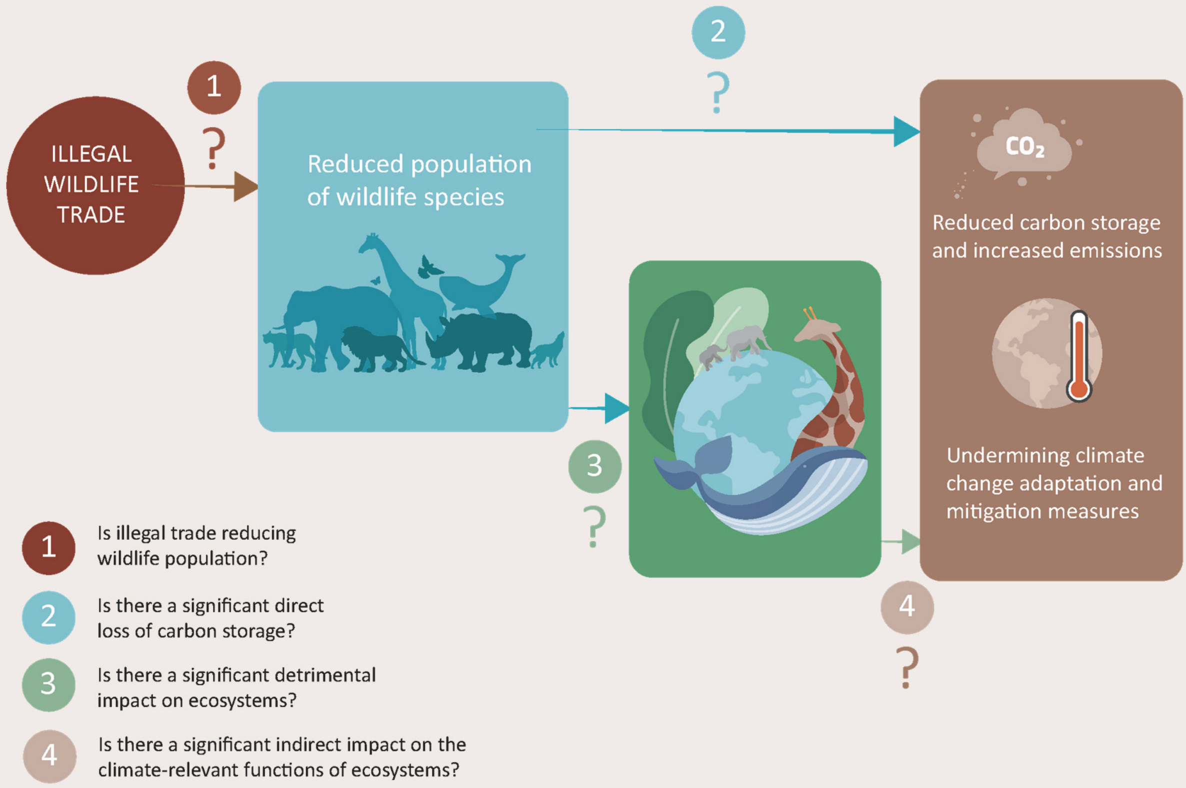
5. IWT is both a reflection of weak environmental governance, and an exacerbating factor to it. It is often associated with ineffective regulation, monitoring and enforcement, and with rule-breaking, corruption and organized crime.



6. Given the importance of climate stability and the long-term persistence of carbon stocks, adopting broader time horizons and a more holistic view that considers biodiversity is important to climate mitigation and stability. Adopting this type of longer, broader view that recognizes the centrality of biodiversity to many ecosystem processes highlights the clear need for improved governance of wildlife resources and recognizes the need for strong justice system responses to environmental crimes.

7. It is critical to keep in mind that this relationship works in both directions. As climate change impacts take shape, natural resource conflicts will worsen as people and wild species adapt to evolving living conditions. It is very likely that this will lead to new incentives for and patterns of illegal wildlife trade, and in turn new interventions to contain the resulting environmental harm.

8. The links between IWT, biodiversity and climate are still under researched and not well understood. This Research Brief is the first effort to frame these linkages, which are important to understand how policies aimed at addressing IWT, biodiversity and climate can be better integrated.



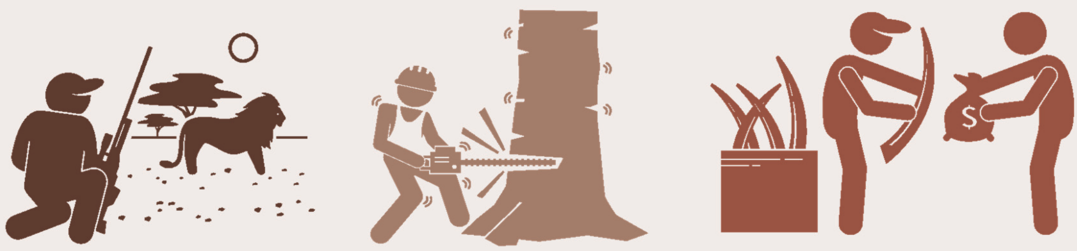
INTRODUCTION

Illegal wildlife trade (IWT) is a leading threat to global biodiversity, endangering not only large charismatic mammals, but many thousands of species of terrestrial and marine flora, fauna and fungi all over the world.[1] This threatens not only species survival, but also degrades the range of functions and processes that these species provide in their ecosystems – including those essential to stable, resilient ecosystems. Especially when exacerbated by other pressures, such as habitat loss, degradation and climate change,[2] overexploitation is widely recognised as a pervasive and targeted driver of biodiversity loss across[3] [4]. Indeed, the IUCN Red List lists overexploitation as the most prevalent threat facing threatened and near-threatened species that have been evaluated (primarily vertebrate species).[5]

Although IWT is traditionally narrowly framed as a conservation problem, it has cascading impacts on ecosystem functions and processes that affect the climate. This Brief considers the complex relationships between biodiversity and climate, and highlights 5 key types of relationships between IWT and climate change. These suggest that, although IWT may *seem* tangential to climate debates, its implications for ecosystem function and resilience, including to the persistence carbon stocks, justifies a more integrated perspective across these policy spheres.

ILLEGAL WILDLIFE TRADE

IWT refers to an incredibly wide range of species, products, geographies, actors and networks.[6] There is no single definition for IWT, or for related "wildlife crime", but it is typically understood as referring to the harvest and trade of wild species contrary to national law,[7] including harvest quotas, protected species lists, protected areas regulations, and obligations to the Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES). It often involves the avoidance of laws and regulations aimed to protect threatened species and limit harvest and trade levels. In some cases, especially for high-value wildlife products and international trade, IWT represents a specialized area of organized crime that requires specific intervention.



[1] Fukushima, C.S., Mammola, S., Cardoso, P., 2020. Global wildlife trade permeates the Tree of Life. *Biological Conservation 247:1*08503.

[2] Brook, B.W., Sodhi, N.S., Bradshaw, C.J., 2008. Synergies among extinction drivers under global change. *Trends in Ecology & Evolution* 23:453-460.

[3] IPBES. 2019. : Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Brondizio,E.S., Settele, J.,Díaz,S., Ngo, H.T. (Eds.). IPBES secretariat, Bonn, Germany. URL: https://doi.org/10.5281/zenodo.3831673.

[4] Hughes, A.C., 2017. Understanding the drivers of Southeast Asian biodiversity loss. *Ecosphere* 8:e01624.

[5] Maxwell, S.L., Fuller, R.A., Brooks, T.M., Watson, J.E., 2016. Biodiversity: The ravages of guns, nets and bulldozers. *Nature* 536:143-145.

[6] Phelps, J., Biggs, D., Webb, E.L., 2016. Tools and terms for understanding illegal wildlife trade. *Frontiers in Ecology and the Environmen*t, 14:479-489.

[7] United Nations Office on Drugs and Crime (UNODC). 2020. World Wildlife Crime Report 2020: Trafficking in Protected Species. URL: https://www.unodc.org/unodc/en/data-and-analysis/wildlife.html.

Harms from illegal wildlife trade

The environmental impacts of IWT are usually, and appropriately conceptualised in terms of direct harm to species survival. However, this focus has often meant that policy debates have overlooked the cascading impacts IWT has on human wellbeing and ecosystem services–including related to climate. Even where broader impacts are recognized (e.g., the CITES treaty recognizes species' role in ecosystems) these are often treated as separate policy concerns. There is growing recognition that other types of harm need more active recognition,[8] including on ecosystem goods and services; livelihoods; welfare[9] and on State budgets (Table 1).

A fuller accounting of the diverse impacts caused by IWT is central to

- Understand the severity of these crimes;
- Reflect the true relationships of IWT to other policy spheres (e.g., climate, ecosystem services, poverty alleviation)[10], and
- Ensure policy and legal responses meaningfully account for the true costs of IWT.

This more expansive view of IWT harms is important, but presents challenges for those wanting to assess or quantify these types of harm. Many of these forms of harm are difficult to quantify and/or value in monetary terms, involve little-researched relationships, and are felt at different spatial and time-scales. This is especially true of the relationships between biodiversity and ecosystem functions.

Table 1: Key categories of harm caused by IWT [11] and examples Rosewood *Dalbergia* spp. IWT

TYPES OF HARM AND DESCRIPTIONS	EXAMPLE HARMS CAUSED BY ROSEWOOD IWT
Harm to the environment	
Harm to individual plants, fungi or animals affected by the case	• Harm to individual trees, including individuals of great age (although welfare is more commonly associated with fauna)
Harm to species survival	• Reduction in the survival probability of a Critically Endangered species, at level of both local population and overall species survival
Harm to public ecosystem goods and services and to broader human wellbeing	• Lost carbon stock and sequestration • Changes to future forest structure and community • Harm to relational values (e.g., sense of place, bequest, existence values)

[8] Phelps, J., Aravind, S., Cheyne, S., Dabrowski Pedrini, I., Fajrini, R., Jones, C.A., Lees, A.C., Mance, A., Nagara, G., Nugraha, T.P. and Pendergrass, J., 2021. Environmental liability litigation could remedy biodiversity loss. Conservation Letters, 14(6), p.e12821.

[9] Baker, S. E., R. Cain, F. Van Kesteren, Z. A. Zommers, N. D'Cruze, and D. W. Macdonald. 2013. Rough Trade: Animal Welfare in the Global Wildlife Trade. BioScience 63:928-938.

[10] Duffy, R., St John, F.A., Büscher, B. and Brockington, D., 2016. Toward a new understanding of the links between poverty and illegal wildlife hunting. *Conservation Biology*, *30*(1), pp.14-22.

[11] Based on Phelps, J., Aravind, S., Cheyne, S., Dabrowski Pedrini, I., Fajrini, R., Jones, C.A., Lees, A.C., Mance, A., Nagara, G., Nugraha, T.P. and Pendergrass, J., 2021. Environmental liability litigation could remedy biodiversity loss. *Conservation Letters* 14:e12821.

	• Reduced ecotourism revenues and potential tourism • Losses for scientific research potential
Harm to the State	
Loss in revenues	• Reduced tourism and/or national park revenues in affected areas • Reduced taxation from legal timber harvest
Loss in reputation and/or trust	• Domestic and international reputational harm and decreased public trust in government's ability to conserve its protected species, effectively manage protected areas, and maintain control over illegal activities is reduced. This is also associated with harm associated with undermining the rule of law, associated with corruption and money laundering associated with IWT.
Increases in public spending	• Increased public spending on conservation actions to reduce deforestation and IWT • Increased public spending to replace or enhance the ecosystem services that were degraded by IWT, such as erosion control and flooding mitigation.
Harm to private economic interests	
Loss in income or property value	• Reduced local tourism associated with attractive forests including large trees
Increased private costs of accessing goods and services	• Increased costs of finding alternative materials to replace Dalbergia wood • Increase costs for companies to verify the legality of timber value chains
Burdens of enforcement responses	
	• Increased government enforcement efforts to address IWT • Exceptional costs, such as DNA tests for species identification, required fieldwork and, hiring species experts • Legal costs of undertaking court action • Court costs of ensuring court orders are enforced

Why link wildlife to climate?

Illegal wildlife trade may seem distant from climate change mitigation efforts, especially relative to high-emitting sectors such as transport and agriculture. However, there is wide recognition that environmental goals are intimately linked to multiple Sustainable Development Goals; environmental degradation undermines the other goals, while efforts to mitigate degradation can offer many synergies with other policy objectives.[12] Biodiversity conservation has a similar relationship: Neither a warmer climate without biodiversity, nor biodiversity conservation without a stable climate, is viable. These types of synergies are complex, but increasingly apparent as, for example, changing ocean temperatures affect marine habitats and fish population dynamics in ways that are likely to exacerbate the pressures of fisheries IWT.[13] Similarly, changing weather patterns are exacerbating forest fire risks, notably in degraded forests, including those affected by timber IWT.[14]

Moreover, there are efforts to promote alignment among policy priorities across policy instruments (e.g., CBD, CITES, UNFCCC), rather than compete for space and priority. The embrace of overlaps can offer efficiencies, and enable candour about trade-offs.[15] It cannot be **assumed that interventions that help to address one policy priority will necessarily support the other. Similarly, there are important risks in just focusing singly on carbon as a climate-relevant commodity without thinking about the wider system**. A notable example are tree plantations, which can improve carbon sequestration but, unless strategically managed offer comparatively limited biodiversity values.[16]

What are the relationships between IWT and ecosystems?

Although IWT threatens biodiversity,[17] [18] its implications for ecosystem function are often left implicit: The biodiversity affected by IWT underpins all ecosystems[19] as a "regulator of fundamental ecosystem processes", such that there is a compelling argument that "biodiversity and ecosystem services are the same thing".[20] Importantly, however, biodiversity is not only conceptualized in terms of how many species there are in a site (i.e. species richness), but rather the various functional roles in the environment that these species provide. For example, some bird species targeted for IWT, such as toucans and hornbills, have large bills and so provide unique roles in the environment such as dispersing large seeds, which smaller birds cannot provide. This functional diversity is important to understanding the links between biodiversity and ecosystem services.

Yet, biodiversity-ecosystem relationships also are complex, diverse, nonlinear and little understood in most contexts. "The varied and frequently complex relationships between biodiversity and ecosystem services have, however, frustrated our capacity to quantify and predict the vulnerability of those services to species

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[12] Nerini, F., Sovacool, B., Hughes, N., et al. 2019. Connecting climate action with other Sustainable Development Goals. *Nature Sustainability 2*:674-680.

[13] Birchenough, S.N., 2017. Impacts of climate change on biodiversity in the coastal and marine environments of Caribbean small island developing states. Caribbean Marine Climate Change Report Card: Science Review. pp.40-51.

[14] Cochrane, M.A., Laurance, W.F., 2008. Synergisms among fire, land use, and climate change in the Amazon. *AMBIO: A Journal of the Human Environment* 37:522-527.

[15] Phelps, J., Friess, D.A., Webb, E.L. 2012. Win–win REDD+ approaches belie carbon–biodiversity trade-offs. *Biological Conservation* 154:53-60.

[16] Lindenmayer, D.B., Hulvey, K.B., Hobbs, R.J., et al. 2012. Avoiding bio-perversity from carbon sequestration solutions. *Conservation Letters* 5:28-36.

[17] Morton, O., Scheffers, B.R., Haugaasen, T., Edwards, D.P., 2021. Impacts of wildlife trade on terrestrial biodiversity. *Nature Ecology & Evolution* 5:540-548.

[18] Symes, W.S., Edwards, D.P., Miettinen, et al. 2018. Combined impacts of deforestation and wildlife trade on tropical biodiversity are severely underestimated. *Nature Communications* 9:1-9.

[19] Millennium Ecosystem Assessment. 2005.Washington DC, Island press.

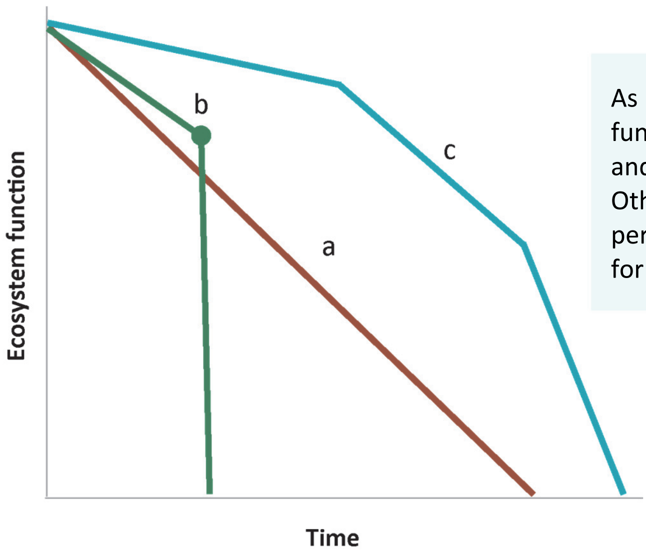
[20] Mace, G.M., Norris, K., Fitter, A.H., 2012. Biodiversity and ecosystem services: a multilayered relationship. *Trends in Ecology & Evolution* 27:19-26.

extinction…consequently, we have only a rudimentary understanding of the vulnerability of many, perhaps all, ecosystem services to species loss."[21]

On one hand, we know there are relationships between biodiversity and ecosystem stability, including a stable climate.[22] When faced with sudden environmental changes, an ecosystem with high species richness is more likely to contain species that are able to survive these disturbances and new conditions, and continuing to provide ecosystem goods and services.[23] Moreover, species-rich environments are more likely to be high in functional diversity, meaning that they include many species that provide different sets of ecosystem services, potentially providing the "insurance" of functional redundancy whereby species losses can be replaced by other species.[24] Research suggests that the converse is also true; a recent review highlights that "less diverse forests may be less effective at mitigating against climate change than diverse forests…(and) that degraded tropical forests often have a reduced ability to store and sequester carbon".[25]

However, in some contexts, some ecosystem services may not require a strong biodiversity basis–because those services are provided by a small number of abundant species, or because the functions provided by some species may be met by other species.[26] For example, studies in different ecosystems have shown that most vegetation cover is provided by a small number of species[27] Even as species richness declines (Fig. 1- a), provision of this key ecosystem attribute – associated with primary productivity and some carbon stocks – is largely preserved. This is part of the reason, for example, that some monoculture tree plantations may offer high above-ground carbon stocks, despite intrinsic low biodiversity.[28]

Figure 1: Example relationships between biodiversity loss from actions such as IWT and changes in ecosystem functions



As biodiversity declines (a), some ecosystem functions and processes may decline quickly and suddenly once they hit tipping points (b). Other ecosystem functions and progress may persist despite declines in biodiversity, at least for some time (c).

[21] Ross, S.R.J., Arnoldi, J.F., Loreau, M. et al., 2021. Universal scaling of robustness of ecosystem services to species loss. *Nature Communications* 12:1-7.

[22] Chapin FS III, Zavaleta ES, Eviner et al. 2000. Consequences of changing biodiversity. *Nature* 405:234–242

[23] Kremen, C. 2005. Managing ecosystem services: what do we need to know about their ecology? *Ecology Letters* 8:468–479.

[24] Naeem, S. 1998. Species redundancy and ecosystem reliability. *Conservation Biology* 12:39–45.

[25] Reviewed in Zhu, L., Hughes, A.C., Zhao, X.Q., et al., 2021. Regional scalable priorities for national biodiversity and carbon conservation planning in Asia. *Science Advances* 7:eabe4261.

[26] See Cooke, R.S., Eigenbrod, F., Bates, A.E., 2020. Ecological distinctiveness of birds and mammals at the global scale. *Global Ecology and Conservation* 22:e00970.

[27] Tilman, D., Wedin, D. & Knops, J. 1996 Productivity and sustainability influenced by biodiversity in grassland ecosystems. Nature 379: 718-720.

[28] See Bremer, L.L., Farley, K.A., 2010. Does plantation forestry restore biodiversity or create green deserts? A synthesis of the effects of land-use transitions on plant species richness. *Biodiversity and Conservation* 19:3893-3915.

Importantly, biodiversity-ecosystem relationships are often nonlinear and change over time (Figure 1). This includes tipping points at which biodiversity loss may suddenly and profoundly impact ecosystem functions and processes (Fig. 1 - b). Although, at local-scales and short-time horizons biodiversity-ecosystem relationships may appear to be stable, systems can hit unexpected tipping points. For example, secondary forests in Singapore have been protected for more than 50 years and are successfully regenerating in ways that, particularly to the casual observer, are very encouraging. Despite this, studies show that those regenerating forests are unlikely to ever resemble the old growth forests that preceded them—likely because many animal species that serve key roles in dispersing forest are locally extinct. The loss of biodiversity has changed long-term ecosystem processes in irreversible ways that are affecting the provision of key ecosystem services, and the resulting secondary forests are unlikely to store as much carbon as their predecessors.

Research to date suggests "there seems to be no universal relationship between species richness and ecosystem functioning, perhaps because processes differ in their sensitivity to species richness." [29] As such, there is strong reason to heed the conclusion of Chapin et al. (2000) that "conserving biodiversity is essential because we rarely know a priori which species are critical to current functioning or provide resilience and resistance to environmental changes".

Five key relationships between IWT and carbon

Despite the complex, often uncertain biodiversity-ecosystem relationships, there are nevertheless significant links between IWT and significant carbon stocks. This section highlights five such relationships, each illustrated with examples of biodiversity detected in IWT seizures and reported in the UNODC World-WISE Database (Annex 1).

1. Large-bodied species storing carbon

The World-WISE Database highlights the importance of large-bodied species affected by IWT. Notably, timber represents the great amount of wildlife, by weight, documented in seizures database (Annex 1), overwhelmingly hardwood species in the genus *Dalbergia* found across the tropics, and *Pterocarpus* species found in Asia and Africa. The removal of these hardwood species from the wild stops long-term sequestration, affects soil carbon, and limits forest regeneration in ways that that last decades.[30]

Importantly, reported timber seizures captured in the database reflect only a small proportion of actual illegal trade, most of which goes undetected. Moreover, illegal deforestation – to clear land and also often combined with timber IWT [31] [32] – is a leading source of greenhouse gas emissions, biodiversity loss and ecosystem degradation.[33] The resulting forest degradation is known to exacerbate forest fires in some ecosystems, including important parts of the Amazon Basin. [34]

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[29] Chapin FS III, Zavaleta ES, Eviner et al. 2000. Consequences of changing biodiversity. *Nature* 405:234–242

[30] Huang, M., Asner, G.P., 2010. Long-term carbon loss and recovery following selective logging in Amazon forests. *Global Biogeochemical Cycles*, 24(3).

[31] Wilcove, D.S., Giam, X., Edwards, D.P., et al. 2013. Navjot's nightmare revisited: logging, agriculture, and biodiversity in Southeast Asia. *Trends in Ecology & Evolution* 28:531-540.

[32] Rudianto, R., Bengen, D.G., Kurniawan, F., 2020. Causes and effects of mangrove ecosystem damage on carbon stocks and absorption in East Java, Indonesia. *Sustainability* 12:10319.

[33] For example, Rodrigues, A.A., Macedo, M.N., Silvério,et al., 2022. Cerrado deforestation threatens regional climate and water availability for agriculture and ecosystems. *Global Change Biology*.

[34] Barni, P.E., Rego, A.C.M., Silva, F.D.C.F., et al. 2021. Logging Amazon forest increased the severity and spread of fires during the 2015–2016 El Niño. *Forest Ecology and Management* 500:119652.

BOX 1. DALBERGIA AND CARBON STOCKS

Trees in the genus Dalbergia include species known commercially as cocobolo, Indian rosewood, Brazilian Rosewood and Sissoo. These species are protected in many countries and regulated under CITES, but are trafficked globally for use in furniture[35] and instruments.[36]

They have some of the highest wood densities of all commercial trees, which is part of what makes them commercially attractive. However, their high wood density is also part of the reason that these species are especially important to long-term carbon sequestration and storage. Removing slow-growing, high-density species has outsized impacts on forest carbon stocks.

2. Ecosystem engineers

Many of the animal species targeted by IWT are also ecosystem engineers. Like all species, ecosystem engineer species impact biotic factors, like the abundances of other species, through interactions such as predation and competition. Importantly, engineers also shape fundamental abiotic processes such as disturbance, in ways that are significant enough to note alongside other physical processes.[37]

Engineers can shape carbon-rich ecosystems significant to climate mitigation efforts (Box 2, Box 3). They affect not only tropical forests and peatlands that are typically the focus of biodiversity-climate policy debates, but also overlooked systems such as grasslands, savannahs and mangroves that can contain equivalent amounts of sequestered carbon in their soils.[38]

[35] Nhung, N.P., Chi, N.M., Thu, P.Q., et al. 2020. Market and policy setting for the trade in *Dalbergia tonkinensis*, a rare and valuable rosewood, in Vietnam. *Trees, Forests and People* 1:100002.

[36] Taylor, V., Kecse-Nagy, K., Osborn, T., 2013. Trade in Dalbergia nigra and the European Union/ TRAFFIC.

[37] Wright, J.P., Jones, C.G. 2006. The concept of organisms as ecosystem engineers ten years on: progress, limitations, and challenges. *BioScience* 56:203-209.

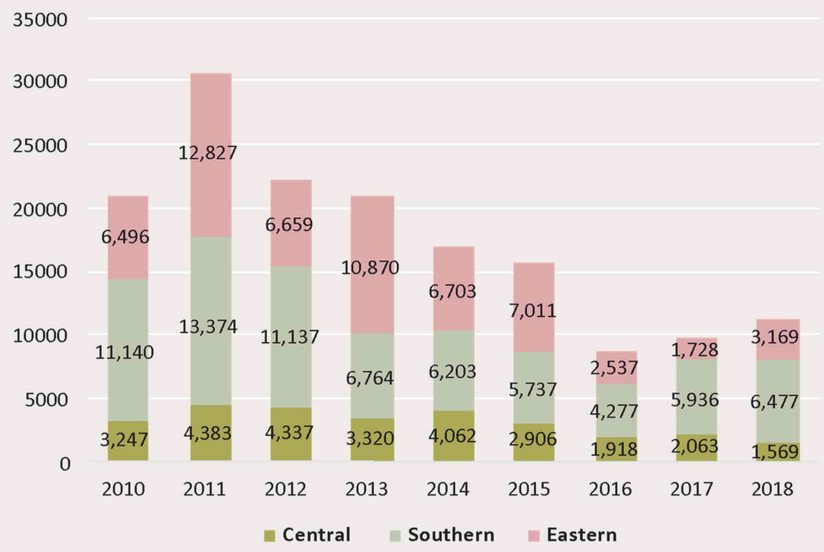
[38] Dobson, A., Hopcraft, G., Mduma, S., et al., 2022. Savannas are vital but overlooked carbon sinks. Science, 375:392-392.

BOX 2. AFRICAN FOREST ELEPHANTS AND ABOVEGROUND CARBON

African forest elephants, *Loxodonta cyclotis*, were upgraded in 2021 to 'Critically Endangered' status on the IUCN Red List following declines of 86% over the last three decades.[39] Their decline is driven not only by habitat loss, but also targeted IWT pressures for their ivory.

Megaherbivores such as elephants have disproportionate impacts on their ecosystems. They reduce above-ground carbon through grazing and disturbance, although over a decadal scale such reductions may actually be neutral. In fact, these engineers greatly influence nutrient transport and plant communities in ways that shape entire ecosystems and can increase carbon stocks. A recent study on African forest elephants found that the species reduced primary productivity through herbivory, but also led to a forest structure that has fewer trees, but more of the larger, high wood density trees, which "increases the long-term equilibrium of aboveground biomass". The researchers estimated that removing the population of forest elephants – one of the species abundant in seizures reported in the UNODC World-WISE Database – "would result in a 7% decrease in the aboveground biomass in Central African rainforests." These forests include the Congo Basin, one of the largest contiguous forests in the world with significant old growth forest, and thus a globally significant above-ground carbon stock.

Estimated annual numbers of illegally killed elephants in Central, Eastern and Southern Africa (median figures)



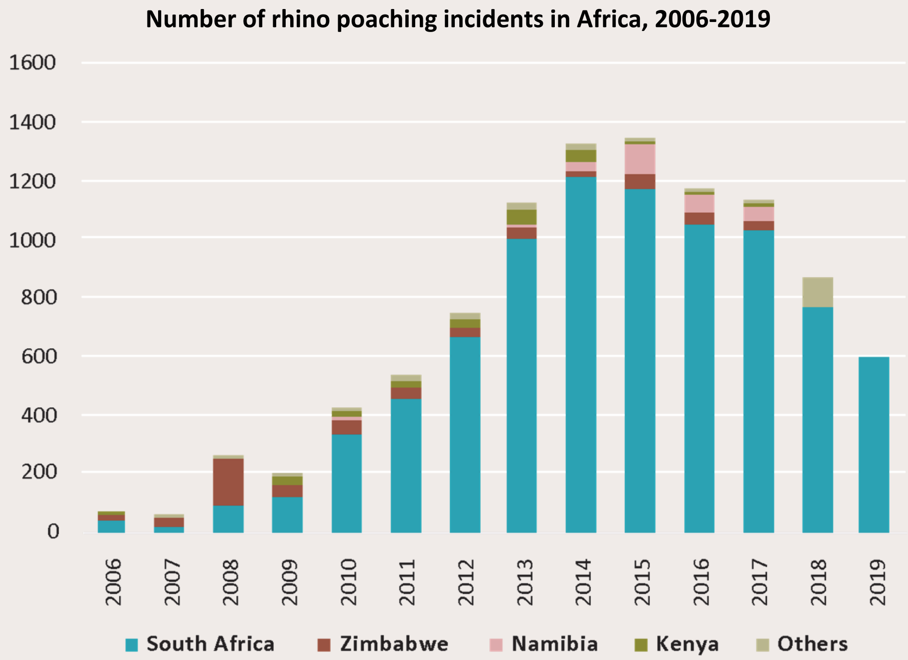
Source: UNODC, World Wildlife Crime Report, 2020

[39] IUCN. 2021. African elephant species now Endangered and Critically Endangered - IUCN Red List. URL: https://www.iucn.org/news/species/202103/african-elephant-species-now-endangered-and-critically-endangered-iucn-red-list.

BOX 3. RHINOS, FIRES AND BELOWGROUND CARBON

White rhinoceros, *Ceratotherium simum,* are heavily targeted by IWT, often involving organized criminal groups poaching and trading the species for their valuable horns. The species has attracted significant investment to reduce poaching, but remains listed as 'Near Threatened' on the IUCN Red List, with most of the remaining populations found in South Africa, where IWT threats remain high.[40]

Rhinoceros can reduce carbon stocks through herbivory, but also affect the carbon cycle through soil compaction and disturbance (bioturbation). In grassland ecosystems, these factors are likely key controls on fires[41] – themselves an important cause of emissions.[42] A recent review highlighted that increasing populations of White rhinoceros and other grazing species in Southern Africa help to engineer more heterogeneous habitats that both benefit other species and reduce fire risks.[43] Conversely, the historical loss of vertebrate grazers was associated with increases in the frequency, severity and extent of fires. This is important because there is growing recognition that habitat such as grasslands can host significant belowground stocks that are crucial to global climate. Moreover, these belowground stocks can persist over the long-term better than above-ground stocks because they are less impacted by herbivory, human activity and stochastic weather.[44]



Source: IUCN (Emslie and Knight) and South African Department of Environment, Forestry, and Fisheries.

[40] Emslie, R. 2012. Ceratotherium simum. The IUCN Red List of Threatened Species 2012: e.T4185A16980466. Source: UNODC World WISE Database

http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T4185A16980466.en

[41] Johnson, C.N., Prior, L.D., Archibald, S., et al. 2018. Can trophic rewilding reduce the impact of fire in a more flammable world?. *Philosophical Transactions of the Royal Society B: Biological Sciences 373:*20170443.

[42] Zheng, B., Ciais, P., Chevallier, et al. 2021. Increasing forest fire emissions despite the decline in global burned area. *Science Advances 7*:e2646.

[43] Johnson, C.N., Prior, L.D., Archibald, et al. 2018. Can trophic rewilding reduce the impact of fire in a more flammable world?. *Philosophical Transactions of the Royal Society B: Biological Sciences 373:*20170443.

[44] Kristensen, J.A., Svenning, J.C., Georgiou, K., Malhi, Y., 2021. Can large herbivores enhance ecosystem carbon persistence?. *Trends in Ecology & Evolution* 37:117-128.

3. Species with unique functional traits

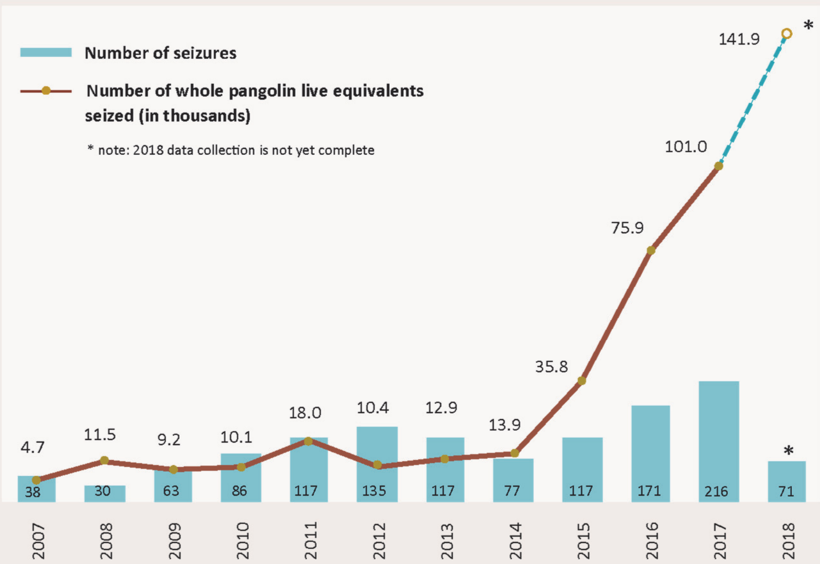
Some species targeted by IWT play diverse other, key functional roles that can shape ecosystem dynamics. While some of these functional roles may be replaceable by other species, many of the species affected by IWT are unique and functionally irreplaceable (Box 4). Species with "multiple uncommon traits will likely lead to more rapid collapse of ecosystem service supply…and increasing the uncertainty surrounding predictions of ecosystem service loss in the face of uncertain species extinction scenarios."[45] Although there is limited understanding of how the removal of unique functional traits will affect ecosystems over the long-term, it is likely that these could have outside impacts on overall system dynamics, including the stability of carbon stocks.

BOX 4. PANGOLINS

Pangolins (*Manis* spp.) are scaly, nocturnal, burrowing mammals. Of the eight species found across Asia and Africa, four are Critically Endangered accordingly to the IUCN Red List. Their decline is heavily driven by targeted IWT, for their meat and scales, which are used in traditional medicine.[46]

The ecological impact of their precipitous decline has been little researched. However, pangolins play unique roles in the habitats where they are found–notably their diet consists heavily of social insect such as termites and ants, and they are likely important regulators of insect populations[47] They likely regulate these insect populations, which impact a wide range of ecosystem processes. Notably, termites are vital decomposers, but that process also results in an estimated 1-3% of natural global annual emissions.[48]

Number of whole pangolin equivalents seized and number of seizures annually, 2007-2018



Source: UNODC, World Wildlife Crime Report, 2020

[45] Ross, S.R.J., Arnoldi, J.F., Loreau, M., et al. 2021. Universal scaling of robustness of ecosystem services to species loss. *Nature communications* 12:1-7.

[46] Challender, D.W., Nash, H., Waterman, C., (Eds.) 2019. Pangolins: Science, society and conservation. Academic Press.

[47] Chao, J.T., Li, H.F., Lin, C.C. 2020. The role of pangolins in ecosystems. In *Pangolins*, pp. 43-48. Academic Press.

[48] Saunois, M., Stavert, A. R., Poulter, B., et al. 2020. The global methane budget 2000–2017. *Earth System Science Data* 12:1561–1623.

4. Co-location of biodiversity and ecosystem services

Habitats heavily affected by IWT can geographically overlap with sites that offer important ecosystem services, including carbon stocks. For example, a recent study in Northern China's Baiyangdian Watershed found that areas of high biodiversity geographically co-occurred with sites that provide services such as water yield, soil retention and carbon sequestration, though not with nutrient retention or pollination.[49] Numerous studies have explored overlaps between biodiversity conservation priority areas and high-carbon ecosystems—and have shown some overlaps that suggest that efforts to protect carbon could also benefit biodiversity, though ensuring such overlaps requires active policy choices, rather than an assumption that these will happen automatically.[50] [51] [52] To the contrary, efforts that focus narrowly on specific ecosystem service (e.g., tree plantations to increase forest carbon) may harm biodiversity and cause unintended impacts. [53] Moreover, sites that are impacted by IWT are often also subject to other types of harm, such as deforestation and degradation.[54]

BOX 5. SOUTHEAST ASIA CARBON-BIODIVERSITY OVERLAPS

Southeast Asia, a globally significant source of IWT[55] – including tigers, pangolins, Asian elephants, and several rosewood tree species detected in the UNODC World-WISE Database – is notable for its carbon-biodiversity geographic overlaps.[56] Such overlaps are not found everywhere: Across Asia, for example, hotspots of vertebrate species richness only overlapped geographically in some regions, notably parts of SE Asia.[57] Indeed, according to a recent analysis, the world's strongest carbon-biodiversity overlaps are in montane rainforests of Peninsular Malaysia, northern Borneo and West Sumatra, and in the Kinabalu montane alpine meadows.[58] This highlights specific geographic opportunities where there are natural links among policy spheres, including to protect biodiversity from deforestation and IWT, and mitigate climate change.

[49] Bai, Y., Zhuang, C., Ouyang, et al. 2011. Spatial characteristics between biodiversity and ecosystem services in a human-dominated watershed. *Ecological Complexity* 8:177-183.

[50] Phelps, J., Friess, D.A., Webb, E.L., 2012. Win–win REDD+ approaches belie carbon–biodiversity trade-offs. *Biological Conservation* 154:53-60.

[51] Ferreira, J., Lennox, G.D., Gardner, et al. 2018. Carbon-focused conservation may fail to protect the most biodiverse tropical forests. *Nature Climate Change* 8:744-749.

[52] Venter, O., Laurance, W.F., Iwamura, T., et al. 2009. Harnessing carbon payments to protect biodiversity. *Science* 326:1368-1368.

[53] Onaindia, M., de Manuel, B.F., Madariaga, I., et al. 2013. Co-benefits and trade-offs between biodiversity, carbon storage and water flow regulation. *Forest Ecology and Management* 289:1-9.

[54] Laurance, W.F., Goosem, M., Laurance, S.G., 2009. Impacts of roads and linear clearings on tropical forests. *Trends in Ecology & Evolution* 24:659-669.

[55] Nijman, V., 2010. An overview of international wildlife trade from Southeast Asia. *Biodiversity and Conservation* 19:101-1114.

[56] Di Marco, M., Watson, J.E., Currie, D.J., et al. 2018. The extent and predictability of the biodiversity–carbon correlation. *Ecology Letters* 21:365-375.

[57] Zheng, B., Ciais, P., Chevallier, F., Chuvieco, E., et al. 2021. Increasing forest fire emissions despite the decline in global burned area. *Science Advances* 7:e2646.

[58] Soto-Navarro, C., Ravilious, C., Arnell, A.,et al. 2020. Mapping co-benefits for carbon storage and biodiversity to inform conservation policy and action. *Philosophical Transactions of the Royal Society B* 375:20190128.

5. Governance overlaps

IWT is both a reflection of weak environmental governance, and an exacerbating factor to it. It is often associated with weak monitoring and enforcement, rule-breaking, corruption and, in some cases — organized crime.[59] The UNODC World Wildlife Crime Report specifically highlights that size and scale of many of the illegal shipments documented in the World-WISE Database require complex logistics and strong networks, suggesting the organized nature of many of these crimes. In particular, the large-scale trade of highly-protected species of great economic value has attracted the involvement of transnational organized criminal syndicates across contexts.[60] [61] Some of these IWT cases can be tied to parallel trafficking of other goods such as drugs, and to enabling crimes such as laundering and corruption.[62] [63] For example, organized IWT groups often make use of complex networks of illegal harvesters, intermediaries and government contacts to access and smuggle protected species, [64] including the use of sophisticated transportation and finance networks.[65] Corruption exists across all stages of the wildlife supply chain and can facilitate the illegal trade of wildlife, including act such as bribes, abuse of office and embezzlement.[66]

The same factors associated with organized criminal IWT are also responsible for undermining ecosystems globally, and destroy and degrade blue and tree carbon sinks across contexts. Moreover, weak environmental governance resulting in poor management decisions are often linked to IWT: timber IWT is often linked to land-clearing for agriculture [67] and wildlife poaching is tied to road development into new habitats.[68] Equally, IWT is often associated with underlying, historical challenges of uneven development and inequitable resource distribution that can fuel resource degradation.[69] [70]

[59] The UNODC defines organised crime as a groups that serves to "generate profit; organised criminal groups involve three or more people working together for a period of time, with the aim of committing one or more serious crimes in order to generate financial or material benefits, often by providing illicit goods and services." United Nations Office on Drugs and Crime (UNODC). 2020. World Wildlife Crime Report 2020: Trafficking in Protected Species. URL: https://www.unodc.org/documents/data-and-analysis/wildlife/2020/World_Wildlife_Report_2020_9July.pdf

[60] See van Uhm, D. and Siegel, D., 2021. Organised crime and animals. *Trends in Organized Crime*, pp.1-6.

[61] e.g., timber, Wyatt, T., 2014. The Russian Far East's illegal timber trade: an organized crime?. *Crime, Law and Social Change* 61:15-35.

[62] Anagnostou, M., Doberstein, B., 2021. Illegal wildlife trade and other organised crime: a scoping review. *Ambio* 51:1615–1631

[63] Feltham, J., Stoner, S., Swaak-Goldman, O., Carmody, S., 2021. Convergence of wildlife crime with other forms of organised crime. Wildlife Justice Commission. URL: https://wildlifejustice.org/wp-content/uploads/2021/05/Crime-Convergence-Report-SPREADS-V07.pdf

[64] e.g., for ivory, Titeca, K., 2019. Illegal ivory trade as transnational organized crime? An empirical study into ivory traders in Uganda. *The British Journal of Criminology* 59:24-44.

[65] See Viollaz, J., Graham, J., Lantsman, L., 2018. Using script analysis to understand the financial crimes involved in wildlife trafficking. *Crime, Law and Social Change* 69:595-614.

[66] United Nations Office on Drugs and Crime (UNODC). 2020. World Wildlife Crime Report 2020: Trafficking in Protected Species. URL: https://www.unodc.org/documents/data-and-analysis/wildlife/2020/World_Wildlife_Report_2020_9July.pdf

[67] Dohong, A., Aziz, A.A., Dargusch, P., 2017. A review of the drivers of tropical peatland degradation in South-East Asia. *Land Use Policy* 69:349-360.

[68] Laurance, W.F., Goosem, M., Laurance, S.G., 2009. Impacts of roads and linear clearings on tropical forests. *Trends in Ecology & Evolution* 24:659-669.

[69] Lunstrum, E., Givá, N., 2020. What drives commercial poaching? From poverty to economic inequality. *Biological Conservation* 245:108505.

[70] Paudel, K., Potter, G.R., Phelps, J., 2020. Conservation enforcement: Insights from people incarcerated for wildlife crimes in Nepal. *Conservation Science and Practice 2*:e137.

CONCLUSION

The relationships between biodiversity and ecosystem functions–and thus between efforts to curb IWT and mitigate climate change–are diverse, complex, affected by scale, and not fully documented. However, decoupling biodiversity from ecosystems and climate, notably by treating related environmental challenges as separate policy spheres, is likely misguided.

Climate mitigation undoubtedly needs near-term, rapid interventions. As a result, in the short-term and local scale, reducing IWT is unlikely to emerge as a leading strategy to reduce greenhouse gas emissions or store carbon. However, there is growing awareness that successfully mitigating climate change will rely on the long-term persistence of carbon stocks–including in peatlands, soils, forests, grasslands and biodiversity itself (Box 1).[71] Across systems, persistent carbon stocks are associated with historical environmental conditions, long-term resource management, and system complexity, themselves linked to biodiversity, ranging from microbial[72] to herbivore communities (Box 2).[73]

Thinking about climate mitigation in terms of dynamic ecosystems and long-term persistence of carbon stocks changes the lens through which we see policy trade-offs.[74] Longer-term views of the regulating ecosystems services that shape global climate highlight that many biotic and abiotic processes are shaped by species heavily targeted by IWT: Carbon persistence relies on diverse and resilient ecosystems that include ecosystem engineers (Box 2), can withstand the shocks of new diseases and changing climates (Fig. 1), and include the distinct species that may provide unique functional roles (Box 4). Long-term carbon dynamics requires an interest in future ecosystem structure and function, which are shaped by the biodiversity that constitute those ecosystems, ranging from herbivores and tree communities to decomposers and seed dispersers.

Adopting this type of longer, broader view that recognizes the centrality of biodiversity to many ecosystem processes highlights the clear need for improved governance of wildlife resources and this includes efforts to address the relationships between human behaviour – including organized criminal activities – and various types of environmental degradation. The UN Common Approach to Biodiversity recognizes the need for strong justice system responses to environmental crimes. [75] However, improved governance relies not only on strengthened monitoring and enforcement, but on the diverse institutions, structures and processes that enable more equitable, efficient, robust and effective governance outcomes.[76] Related reforms would benefit not only efforts to reduce IWT, but are core to improving overall environmental and social outcomes, and are cross-cutting themes that affect carbon and biodiversity.[77] Indeed, efforts to reduce IWT are not only a nature conservation issue, but an important part of both mitigating climate change and ensuring a more stable and resilient future climate.

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[71] Kristensen, J.A., Svenning, J.C., Georgiou, K., et al. 2021. Can large herbivores enhance ecosystem carbon persistence?. *Trends in Ecology & Evolution* 37:117-128.

[72] Lehmann, J., Hansel, C.M., Kaiser, et al. 2020. Persistence of soil organic carbon caused by functional complexity. *Nature Geoscience* 13:.529-534.

[73] Kristensen, J.A., Svenning, J.C., Georgiou, K., et al. 2021. Can large herbivores enhance ecosystem carbon persistence?. *Trends in Ecology & Evolution* 37:117-128.

[74] See Phelps, J., Webb, E.L., Adams, W.M., 2012. Biodiversity co-benefits of policies to reduce forest-carbon emissions. *Nature Climate Change* 2:497-503.

[75] UN Common Approach to Biodiversity. 202. URL: https://unsceb.org/un-common-approach-biodiversity

[76] Bennett, N.J., Satterfield, T., 2018. Environmental governance: A practical framework to guide design, evaluation, and analysis. *Conservation Letters* 11:e12600.

[77] See Evans, J.P., 2012. *Environmental governance*. Routledge.

ANNEX 1

Top 15 wildlife species in UNODC seizure data as reported by weight and by quantity (of various specimen types), (2014-2018)[78] (World-WISE database).

Species (reported by weight)	Description
Dalbergia	Rosewood
Pterocarpus erinaceus	Rosewood
Pterocarpus santalinus	Rosewood
Manis	Pangolin
Anguilla anguilla	European eel
Calamus	Rattan
Scleractinia	Stony corals
Strombus gigas	Queen conch
Loxodonta africana	African elephant
Elephantidae	Elephant (unspecified)
Dalbergia cochinchinensis	Rosewood
Macaranga	Tree
Arapaima gigas	Freshwater fish
Aquilaria	Agarwood
Equus africanus	African wild ass

[78] Weight refers to the volume of seizures, though there are other possible approaches to ranking species, including frequency of seizures and number of individuals (data on the latter is often not recorded).

UNODC. 2022. The World Wildlife Seizures (World WISE) Database.

Species (reported by quantity)	Description
Prunus africana	African cherry tree
Pavo cristatus	Indian peafowl
Saussurea costus	Plant
Hoodia gordonii	Cactus
Orchidaceae	Orchid
Gonystylus	Ramin (tree)
Mammillaria	Cactus
Aloe	Plant
Cactaceae	Cactus
Aloe ferox	Plant
Panulirus	Lobster
Gastrodia elata	Plant
Acipenser baerii	Sturgeon
Anguilla anguilla	European eel
Hippocampus	Seahorses