Value wild animals' carbon services to fill the biodiversity financing gap

Incorporating the carbon services of wild animals into financial markets has the potential to benefit both climate and conservation through the development of carbon offsets that are equitable and nature positive. However, for this paradigm to be successful, many challenges regarding science, finance and law still need to be overcome.

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Human-induced climate change and widespread biodiversity loss have been globally recognized as threats to the long-term sustainability of nature and our world. Increased evidence suggests that these two threats are highly intertwined and should be tackled jointly[1]. The Nature-based Solutions (NBS) framework proposes to do so through the restoration and protection of ecosystems while improving socioeconomic conditions. However, the focus of NBS on habitats as a whole (forests, wetlands and so on), and not on the individual components of biodiversity, may miss an opportunity to attract those best able to fund these solutions: private investors.

The involvement of financial markets will be required to successfully implement NBS at a scale that can make a sizable impact on counteracting these global challenges. The importance of financial market participation was one of the key messages and priorities that emerged from the United Nations COP26 and the 2021 International Union for Conservation of Nature World Conservation Congress. We argue that a new generation of NBS including wild animals and their carbon services has the potential to attract substantial investments from financial markets and provide both climate mitigation and biodiversity benefits.

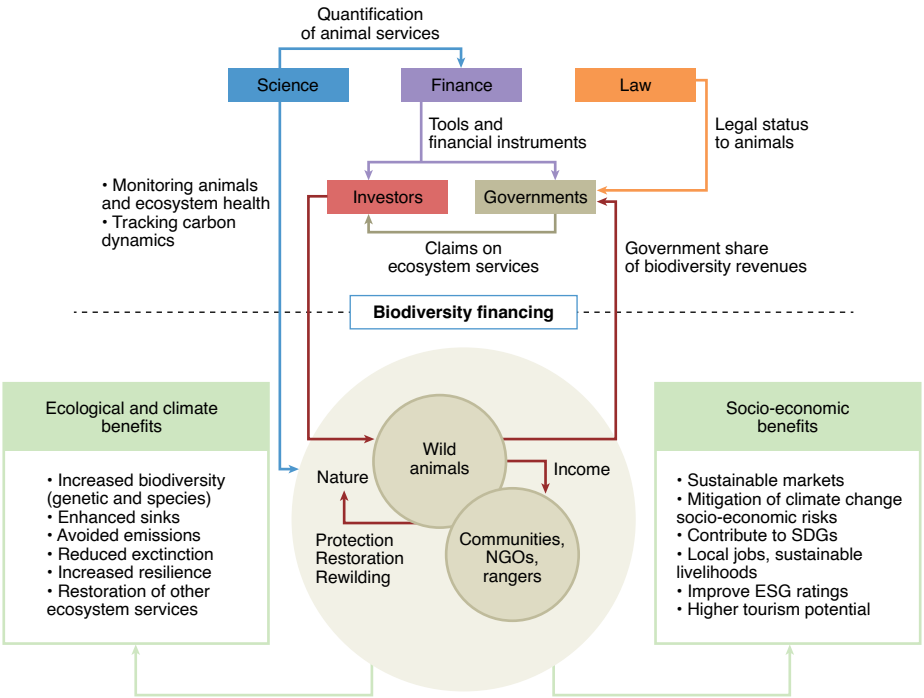

Fig. 1 | Overview of the main components, processes and stakeholders involved in bridging the biodiversity financing gap. The top part shows how knowledge, tools and laws are required for governments and investors to interact. The bottom part shows the benefits of financial investments for nature and people. The dashed line represents the biodiversity financing gap, which could be overcome with the help of private investors. NGOs, non-governmental organizations; SDGs, Sustainable Development Goals.

The biodiversity financing gap

Biodiversity and ecosystem services, when considered at the level of an entire ecosystem, are difficult to measure and hence value. This limits the development of private markets for funding biodiversity protection or NBS because they cannot be compared with other investments. Governments and philanthropists are therefore the primary investors in conservation, but they cannot afford the amounts required to protect and restore biodiversity[2], leading to a 'biodiversity financing gap' estimated at US$100–300 billion annually[2].

Focusing on wild animal services could substantially bridge the biodiversity financing gap by attracting investments into the conservation and restoration of individual species that produce significant environmental services such as carbon services. Scientific evidence of how animals influence the carbon cycle is recent, but an increasing number of species have been identified as important contributors to the carbon cycle in marine and terrestrial ecosystems (detailed in Box 1)[3]. Animals influence carbon cycling through interactions with primary consumers (and indirectly via the food web), through nutrient redistribution enhancing primary productivity, or by adding the carbon stored in their bodies to long-term storage pools in the deep sea (Box 1).

The ability to attribute a specific, measurable environmental service flow to an individual animal species forms the foundation of a new asset class that investors can understand, both in terms of how value is created as well as the potential gains to

Box 1 | Contribution of animals to the carbon cycle

Well-established assumptions imply that processes such as climate, hydrology, weathering and microbial activity control the carbon cycle. Because animal biomass is comparatively low in ecosystems, the contribution of animals to carbon pools is considered minimal and the effects on carbon fluxes are considered negligible compared with other processes. In the past decade, these assumptions have been challenged by a growing body of experimental and modelling studies showing that wild animals can influence carbon and nutrient cycling through different pathways[3,15–17]. Animals modify terrestrial and marine carbon dynamics through direct interactions with primary producers (for example, plants, algae and phytoplankton) and nutrient pools, and indirectly through predation on other animals[3]. In the ocean, some of the carbon stored in bodies is captured in deep-sea anaerobic environments after death[16–18]. We know that carbon stored in ecosystems is the result of complex biotic and abiotic processes in which biodiversity plays a role. Animals do not act in a vacuum, so it might be difficult to measure the contribution of single species. However, ecologists have identified certain species or groups that have disproportionate effects on ecosystem functioning and consequently on carbon dynamics. Here we provide a few examples.

A better understanding of the effects of animals on the carbon cycle has been reached in the context of the Late Quaternary extinction of large terrestrial mammals (body mass >45 kg). This global collapse of large mammals probably caused vast changes in vegetation cover and perturbations to biogeochemical cycles and greenhouse gas fluxes, including a global reduction in carbon sequestration capacity of many ecosystems[19]. Research has identified a few animals that in some present-day ecosystems can exert a significant additionality in carbon stored in ecosystems[3]. Mammals are the most studied group, but other taxa have also been examined, including birds and fish. In the Amazon, high mammal diversity has been associated with higher soil and aboveground carbon[3]. In tropical Africa, the presence of elephants increases rainforest carbon stocks by 3–15% because elephants reduce plant density and promote the growth of carbon-dense trees[15]. In the African savannah, large herbivore populations (for example, wildebeest) can increase above- and belowground carbon by reducing wildfires through the removal of combustible biomass[3]. In some coastal systems, sea otters can facilitate the growth of kelp biomass by predating on sea urchins, which consume kelp forests. Whales, once numbered in the millions, perform several carbon-related functions. They increase phytoplankton productivity by bringing nutrients to the surface and their carcasses sequester carbon by sinking to the seafloor[18]. Similarly, large marine fish sequester carbon after death, which could result in carbon sequestered in the deep sea[16]. In some cases, particularly in the colder biomes such as the tundra and boreal forest, certain animal effects resulted in reduced carbon storage, primary productivity or CO_2 uptake. However, some of these carbon-negative effects were associated with the absence of predators such as wolves[3]. Animals can have both positive and negative effects on carbon dynamics and greenhouse gas fluxes. Ideally, we should strive to evaluate the net effect over large spatio-temporal scales based on locally observed mechanisms and in relatively undisturbed ecosystems. The magnitude and direction of these effects probably depend on various factors: the species population size and its ecological functions, the state of the ecosystem, abiotic factors, and the turnover time of carbon pools[20].

be captured from conserving and restoring these wild animal services.

The promise of wild animal services

Carbon services are produced by many natural entities, but valuing and protecting animals may have notable benefits as mitigation initiatives. First, animal conservation inherently involves conserving and restoring natural habitats, with cascading benefits for biodiversity. Ecosystem-wide benefits might be broadened when conservation involves so-called umbrella species, whose conservation indirectly protects many other species. In terrestrial ecosystems, animal conservation might reduce the 'empty forest' effect observed in tree-centred CO_2 emission-reduction schemes[4]. Tree or plant-centred schemes do not offer sufficient protection for animals and lead to defaunation that undermines biodiversity, resilience and, ultimately, carbon storage[4]. Second, once animal species become extinct, their reintroduction from captivity or even de-extinction using DNA poses a series of social, ethical, biological and logistic challenges[5], as opposed to using seed banks and nurseries to replant trees or seagrass. Third, animals might appeal to a broader audience because they include flagship species, which are iconic species with greater potential to engage the general public and political institutions in conservation initiatives and fundraising. Animals may be more relatable and tangible compared with other 'static' contributors to carbon sequestration. Lastly, carbon capture and maintenance have market value, as shown for the African forest elephant, whose services would provide significant funding for conservation even at very low carbon prices[6].

Consequently, there are opportunities to create a win–win model by constructing a financial pathway from investors to local communities through conservation and restoration programmes that protect ecosystems, reduce biodiversity loss, enhance carbon capture and also avoid irreversible animal species extinctions. Financing and empowering local communities will also promote sustainable livelihoods and reduce emerging zoonotic diseases in a future where global changes can trigger political instability and climate migration. Not all these added benefits can be explicitly valued at this time, but they may nonetheless attract private investment because of the growing importance of environmental, social and governance (ESG) investing[7]. Increased public demand for ESG reporting and the negative lessons of the financial crisis have created rising demand for investments with positive outcomes for society and the environment[8]. Valuation of animal carbon services and its related benefits imply high ESG ratings, which are more likely to attract investors.

Possible caveats and risks

The proposed framework of valuing animals' carbon services includes some potential caveats and risks. The main caveat is that over long timescales, ecosystems not perturbed by anthropogenic pressures probably oscillate between being sources and sinks of carbon[9]. This implies that our proposed framework may only work in diminished ecosystems far from their natural steady state. In addition, other processes such as extreme climate events, fires and hypoxic zones might have greater effects on carbon dynamics than wild animals and diminish the importance of their contribution to carbon sequestration.

Table 1 | Challenges and solutions to implement the valuation of wild animals' carbon services

Macro area	Challenge	Solution
Science	Limited knowledge of wild animals' role in carbon cycling, particularly compared with plants and soils	Enhance research through combined modelling and experimental approaches
	Animals' well-being and contributions to carbon cycling are not well measured	Couple carbon measurements in ecosystems with animal monitoring through combined field and remote-sensing techniques
Finance	Lack of global standards for monitoring and accounting of animal carbon services	Build on established standards for trees and soil carbon (for example, gold standard)
	Disbursement of funds opaque and difficult to audit	Adopt new technologies, including distributed ledgers and smartphones, to track payments; such tools have been deployed even in rural or poor areas[12]
Legal	Legal uncertainties regarding ownership of, right to take or kill, and level of protection provided for wild animals	Enact laws to grant legal protection, standing or rights including personhood[13] to wild animals
	Wild animals' ecosystem services missing from the balance sheets of owners	Recognition of wild animals as natural capital and codification of their services as assets
Governments and institutions	Governments hesitant or unable to work with financial markets to loan wild animal services or channel revenues to conservation programmes and local communities	Develop public sector financial capacity and create public–private partnerships
	Lack of coordination in managing transborder animal populations	Build on international area-based and species-specific agreements already in place (for example, the United Nations Convention on the Conservation of Migratory Species of Wild Animals)
Food security and sustainable livelihood	Unmet local demand for wildlife products and cropland	Capacity building for sustainable agricultural practices (for example, integrated farming and agroforestry); design and implement micro-financing schemes to diversify and create sustainable local economies
Implementation	Complexity of designing successful conservation involving multiple stakeholders and motile natural assets	Actively involve local communities in conservation and restoration projects from conception to implementation and provide appropriate payments for their contributions
	Human–wildlife conflicts and land use not well managed	See solutions regarding capacity building and community involvement

Challenges are divided in macro areas matching most of the areas present in Fig. 1.

Several risks must also be carefully managed. First, protecting a few flagship species might shift attention away from other less known or less charismatic species[10]. A one-species approach does not necessarily lead to the protection of all biodiversity, which includes myriad species from microbes to whales. It may also lead to overlooking the contributions of other species to carbon storage (both positive and negative) or other ecosystem services. As a result, some species might be assigned lower values than others because their services are ignored. In addition, widespread protection of biodiversity, particularly involving large species, will require significant expanses of land (and water) and may increase human–wildlife as well as land- and water-use conflicts. However, these conflict issues also affect other initiatives such as the '30-by-30' initiative announced by the US government to conserve 30% of public land by 2030.

Finally, the proposed approach may (further) encourage the commodification of natural capital, land (or water) grabbing, and the view that habitats are fungible and therefore substitutable. Conflicts may arise if wild animals are intentionally 'herded' to different areas or purchased to participate in the framework. Governments may be tempted to resolve land-use conflicts by allowing habitat-destroying development in exchange for 'restoring' habitats elsewhere that are not comparable to those destroyed or 'creating' habitats that are not actually viable[11].

Challenges ahead

A series of interconnected challenges need to be overcome for this framework to be successful (Fig. 1 and Table 1). We list them by macro area and highlight the importance of science, finance and law as the main catalysts for the rest of the framework to be successful (Fig. 1). Although the science has greatly improved in the past decade (Box 1), more experimental and modelling work is needed to understand the functional roles of different species. Monitoring the contribution of animals to the carbon cycle is also important, as now a fraction of carbon stored in ecosystems will have to be attributed to animals and double counting of carbon credits must be avoided. Financial experts in collaboration with ecologists will have to develop standards for animal carbon accounting and for providing transparency and traceability in the investments[12]. This is fundamental to providing confidence to investors that money will be distributed according to agreement. The legal framework of animal rights and status will require important improvements that enable governments to approach investors and loan animal services. In addition, the current paradigm of extractive use of natural resources implies that a dead or destroyed nature is worth more than a living, thriving nature. Some governments are shifting this paradigm by applying legislative changes, such as conferring personhood to natural entities[13], and legislative roadblocks will have to be overcome (Table 1). A series of institutional, food security and implementation challenges also need to be tackled to ensure that local communities become the main beneficiaries of this framework. In Table 1, we propose some possible solutions to each of these challenges based on solutions that have been developed for similar challenges.

Conclusion

We use carbon as an example, but the value of biodiversity includes many other ecosystem services that in the

future could be connected to financial markets as more scientific evidence becomes available. Despite the challenges involved in developing a market for animal carbon services, the demand for reducing and offsetting emissions provides an opportunity to implement NBS involving wild animals. Unlike high-tech approaches, which are not yet developed nor their spillovers well understood[14], 'Earth-tech' could provide, in addition to carbon services, other long-term benefits for nature and society. Nature-based solutions are one of our best tools and opportunities to mitigate both climate change and biodiversity loss, as well as deliver sustainable development benefits. Global markets want to invest in NBS, encouraged by consumer demands to protect nature and to support organizations limiting their ecological footprint. Thus, the time is right to build NBS centred on wild animals as a way to link financial markets to conservation. We need to start now, as global changes are already having major effects on our society. The future of Earth depends on the collective global actions of creating sustainable markets around nature, and developing these markets will be challenging and time consuming. ❐

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Competing interests

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