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POLICY BRIEF
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Toward a Nature-Based Economy

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Humanity faces a dual threat to its existence: climate change and biodiversity loss. The two risks are linked through human activity and an economic system that promotes growth at the expense of nature. Creating a nature-based economy can mitigate the dual risks and bring sustained, shared prosperity. The article shows how markets can be developed around the protection and regeneration of nature. Policies and actions needed to unleash the resources and innovation of markets to ensure that nature-based economic growth is shared and sustainable are specified. A nature-based economy ensures that conservation is a source of capital for development.

Keywords: nature-based solutions, natural capital, climate change, biodiversity, ecosystem services (ESs), Paris Accord

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INTRODUCTION

Humanity faces the dual threats of climate change and nature-biodiversity loss (Pörtner et al., 2021). Scientific reports warn us that one million species of plants and animals are threatened with extinction, linking this loss to human drivers such as changes in land and sea use, and climate warming (IPBES, 2019). Our current paradigm assumes that nature is limitless, and that economic wealth and human wellbeing can grow irrespective of the impact of our actions on the natural world. With nature treated as "external" to economic life, we have created an economy that extracts and pollutes with no boundaries (**Figure 1**).

The pursuit of growth at all costs to nature is not sustainable. Our world is characterized by Daly's (1996) concept of strong sustainability in which nature is a complement to human-created capital rather than a substitute (weak sustainability), so that natural capital is a limiting factor to growth and has become the main limiting factor. Second, society is consuming natural capital at an alarmingly high rate (Wackernagle and Beyers, 2019). We need to change our relationship with the natural world to one that acknowledges the economy's dependence on natural capital and accepts the bounds that nature places on economic sustainability. Kate Raworth's "doughnut economy" shows the need for upper and lower boundaries to growth, that prevent both deprivation and over-consumption, and the "butterfly economy" that adds "wings" of regeneration and recycling to the standard economic model of "take, make, use, and lose" (Raworth, 2017).

Although such visions establish clear goals for humanity, we also need a concrete, practical and politically feasible plan of action capable of reaching them, starting from the status quo. In this article, we develop a financial and economic framework that can yield significant progress toward a nature-based economy. The center of this framework is a model for nature-based solutions to climate change that protect and regenerate biodiversity while reducing climate change risk. We argue that well designed nature-based solutions can and should play a leading role in mitigating the dual threats to humanity, both because of their potential effectiveness and because they demonstrate that the transition to a new relationship with nature is consistent with shared and sustainable prosperity.

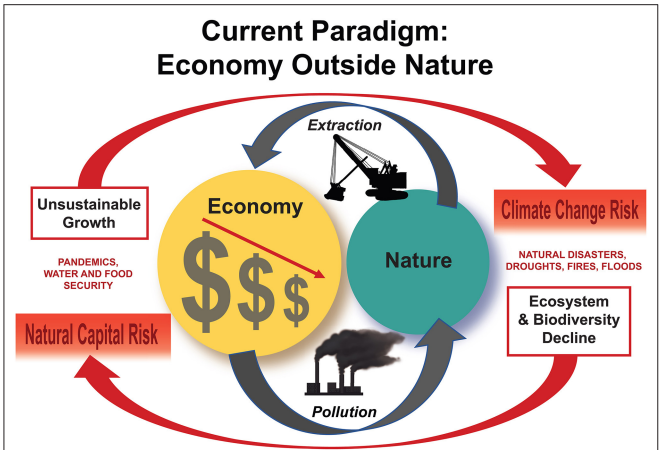

FIGURE 1 | Current paradigm: economy outside nature.

THE RATIONALE FOR FOCUSING ON NATURE-BASED SOLUTIONS

The task of reducing carbon emissions to mitigate climate change is urgent and complex. The TSVCM report estimates that net CO_2 emissions must be reduced by 23 billion metric tons by 2030 as well as remain within the 570 $GtCO_2$ budget for 2018-50 to limit temperature rise to 1.5°C (Carney et al., 2021). Every method of emissions reduction faces challenges and limitations. Hundreds of governmental units and private companies have voluntarily set goals of becoming "NetZero," but mechanisms for monitoring and verifying compliance with these commitments are inadequate, and ambitions are not necessarily being matched by action (Fankhauser et al., 2022). In addition, large-scale industrial decarbonization faces political, cultural, infrastructure, and other obstacles that can dramatically slow (and may prevent) its adoption (Buck, 2021). Negative emissions technologies also constitute a key component of efforts to meet the emissions reduction target, especially bioenergy paired with carbon capture and storage, as well as carbon capture from air. But these technologies have yet to be implemented on a large scale, and in the event that they are, may place demands on land use that reduce biodiversity (Anderson and Peters, 2016).

Nature-based solutions stand out as a necessary component of the emissions-reduction portfolio because they have the potential to make significant contributions toward the abovementioned target when following key attributes as discussed by Fankhauser et al. (2022). According to the IPCC, land and ocean have already sequestered 56% of all human-caused emissions between 1850 and 2019 (IPCC, 2021). The oceans have been absorbing CO_2 at a rate of about 7 $GtCO_2yr^{-1}$ and have taken up 500 $GtCO_2$ from the atmosphere out of 1,300 $GtCO_2$ total anthropogenic emissions (IPCC, 2019). But both land and ocean carbon sink rates are at risk of slowing (IPCC, 2021). In addition, care must be taken to avoid overreliance on specific nature-based solutions such as reforestation, for which global capacity is limited and much of it not easily converted (back) to forest (Cook-Patton et al., 2020). This approach must also focus on restoring ecosystems rather than promoting monocultures, both in order to be more resilient as well as to avoid further harm to biodiversity (Krause and Nielsen, 2019). Nonetheless, if carbon sink ecosystems are protected and restored as part of nature-based solutions, they could provide up to one third of the emissions reductions needed by 2030 (Rockstroem et al., 2021).

Advances in science, moreover, are identifying new opportunities to increase carbon capture through conservation and restoration of species and habitats, enhancing biodiversity. For example, a single great whale can sequester over 33 tons of CO_2 in carbon in its body (Chami et al., 2019). Whales also fertilize phytoplankton, which is thought to be responsible for capturing over 30% of CO_2 due to human activity (SeaWiFS Project, 1997). Restoring whales to their pre-whaling abundance (a five-fold increase), therefore, could contribute significantly to negative carbon emissions. Similarly, coastal marine habitats such as saltmarshes, mangrove forests, and seagrass meadows capture and sequester significant amounts of CO_2 and provide natural defense against floods (Hilmi et al., 2021). Each km^2 of seagrass is estimated to enhance CO_2 capture by 15,000 metric tons over the course of 50 years (Duarte et al., 2013). Because seagrass meadows are estimated to cover <15% of their former range in the early 1900s, their restoration could also add substantially to negative emissions (McKenzie et al., 2020). Also, forest elephants in Africa have been found to increase carbon sequestration in trees by 7%, so that a single forest elephant can capture over 9,500 tons of CO_2 by increasing above-ground forest biomass (Berzaghi et al., 2019). Again, given that forest elephants have been reduced to ten percent of their former numbers, protection and restoration present a potentially important source of additional carbon capture.

In addition, nature-based solutions have special potential to motivate society to change its relationship with nature. This stems from the opportunity to create new markets for environmental services produced by the natural capital being protected and restored by nature-based solutions, which in turn demonstrate that a nature-based economy can offer prosperity to all. As stated in the Dasgupta report (Dasgupta, 2021), most of the benefits of biodiversity remain "silent and invisible" to those making the decisions around the use of natural assets. The policies advocated to achieve needed carbon reduction often focus on taxation, limits on economic activities, and phaseouts of products and possibly entire industries (Buck, 2021). Our approach creates positive incentives for society to move quickly toward a nature-based economy by ensuring the benefits are visible to consumers, policymakers, and the private sector, and expressed in terms of the monetary language these stakeholders can understand.

Developing environmental services markets around nature-based solutions that protect and restore biodiversity can make the benefits of a nature-based economy both concrete and accessible to all members of society under three conditions. First, the owners of natural assets agree to sell environmental services produced by these assets,

under the condition that a substantial majority of the sales revenues are invested in the permanent protection and restoration of the natural assets[1]. Second, local and indigenous communities must be the primary groups employed to protect and restore the natural assets. Third, focusing initial development efforts on ecosystem services for which markets and prices already exist (as in the case of the carbon market) will attract investors to purchase the environmental services and develop financial markets around them (Yoo et al., 2021). In this way, environmental services markets can finance the creation of a conservation and restoration sector within the economy that provides employment and opportunity.

The rapid rise in the value of carbon credits and the large quantities of carbon capture services produced by natural capital suggest that environmental services markets will be large enough to both attract professional investors, without whom the markets cannot develop, and provide funding sufficient to support effective conservation and restoration efforts. For example, recent work by Chami (2021) estimates that over the last 150 years, carbon sequestration delivered by the biological carbon pump into the deep ocean could be worth trillions of dollars based on today's carbon market prices (Chami, 2021). Chilean blue whales' ecosystem services including carbon sequestration are valued at over $4 million per whale (Chami et al., 2020a). If seagrass meadows were restored to historical levels, the value of their carbon sequestration service alone could be worth over $1.9 trillion (UNEP, forthcoming). Forest elephant carbon sequestration is worth over $1.75 million per elephant (Chami et al., 2020b). These amounts represent a new source of growth that comes from recognizing and rewarding services that had previously been overlooked. Thus, the creation of markets for environmental services could create inclusive economic growth at the cost of relatively small increases in the throughput of the economy.

A final reason why nature-based solutions should be emphasized is they can help achieve the Sustainable Development Goals (SDGs). Recently, Kumagai et al. (2021) investigate the link between natural capital and SDGs for the case of Japan. The nature-based economic paradigm uses market forces to strengthen this link to sustainability. Protection and restoration of nature directly supports several of the 17 SDGs, including SDG13, 14, and 15. Moreover, income from ecosystem services links the wellbeing of nature with the wellbeing of communities living alongside nature and whose livelihoods are derived from stewarding it. This new income source has the potential to reduce poverty (SDG1) and inequality (SDG10) by providing steady income and raising living standards with decent work and local community development (SDG8). Also, a healthy and biodiverse environment produces ecosystem services that lead to healthier living (SDGs 3 and 6).

[1]In order for this market to develop, it is essential that all who participate in the production and sale of the environmental services, including the owner of the natural capital, the financial professionals that create and market the claims on the environmental services, and the administrators of the conservation and restoration programs, among others, also be compensated.

CAREFUL DESIGN OF NATURE MARKETS IS NEEDED

The successful development of environmental services markets that incorporate nature-based solutions as their fundamental source of value-added is far from assured, however. Some are critical of the use of price- and market-based approaches to mitigate climate change and protect biodiversity, especially when such measures are not a part of a comprehensive package of policies that treat the dual threats as a systemic problem (Rosenbloom et al., 2020). Without thoughtful and careful design of both the market and the regulations to govern it, and unless supported by sufficient supervision and enforcement of the rules, the introduction of market-based solutions can create perverse incentives and lead to unforeseen negative consequences. Several key features of environmental services markets must be put in place in order to avoid negative outcomes.

Commitment to the Long-Run Existence of Natural Capital

A distinguishing feature of nature-based solutions is that natural assets physically exist (in contrast to financial assets such as bonds and stocks that only exist in the law) and in many cases are sentient beings (elephants, whales). Thus, the trading of their services, whether carbon capture or other ecosystem services, must respect certain moral and ethical absolutes. Investments in such assets should follow principles and standards (**Figure 2**) that guarantee their existence and wellbeing in the long run, even after their carbon or other service flows have been maximized. Failing to do so would risk future harm since markets for animal products such as ivory continue to exist and thrive, and space occupied by fixed natural capital such as saltmarshes, seagrass, or mangroves is always vulnerable to appropriation by land developers and other users.

Therefore, revenues from environmental services sales that are to be directed to conservation and restoration must flow into endowments charged with funding both short- and long-term stewardship of natural assets. An endowment establishes a long-term commitment that would not only ensure the survival and wellbeing of ecosystems but would also provide for the flow of future ecosystem services from future generations of these natural assets, where ecosystem services would be of continued value to investors and produce revenue for the local governments and communities living around the asset. The management of such endowment funds must be independent of governments but include representatives from it as well as from the local communities and indigenous peoples who operate conservation and restoration programs.

Facilitate Governance *via* Technology

As is the case with every nascent market, governance is an issue. Investors must be confident that the money they spend purchasing the rights to environmental services will reach the conservation and restoration programs that protect the natural assets producing the services. In addition, investors must be confident in the verification of the quantity and quality of environmental service produced. They must also be confident

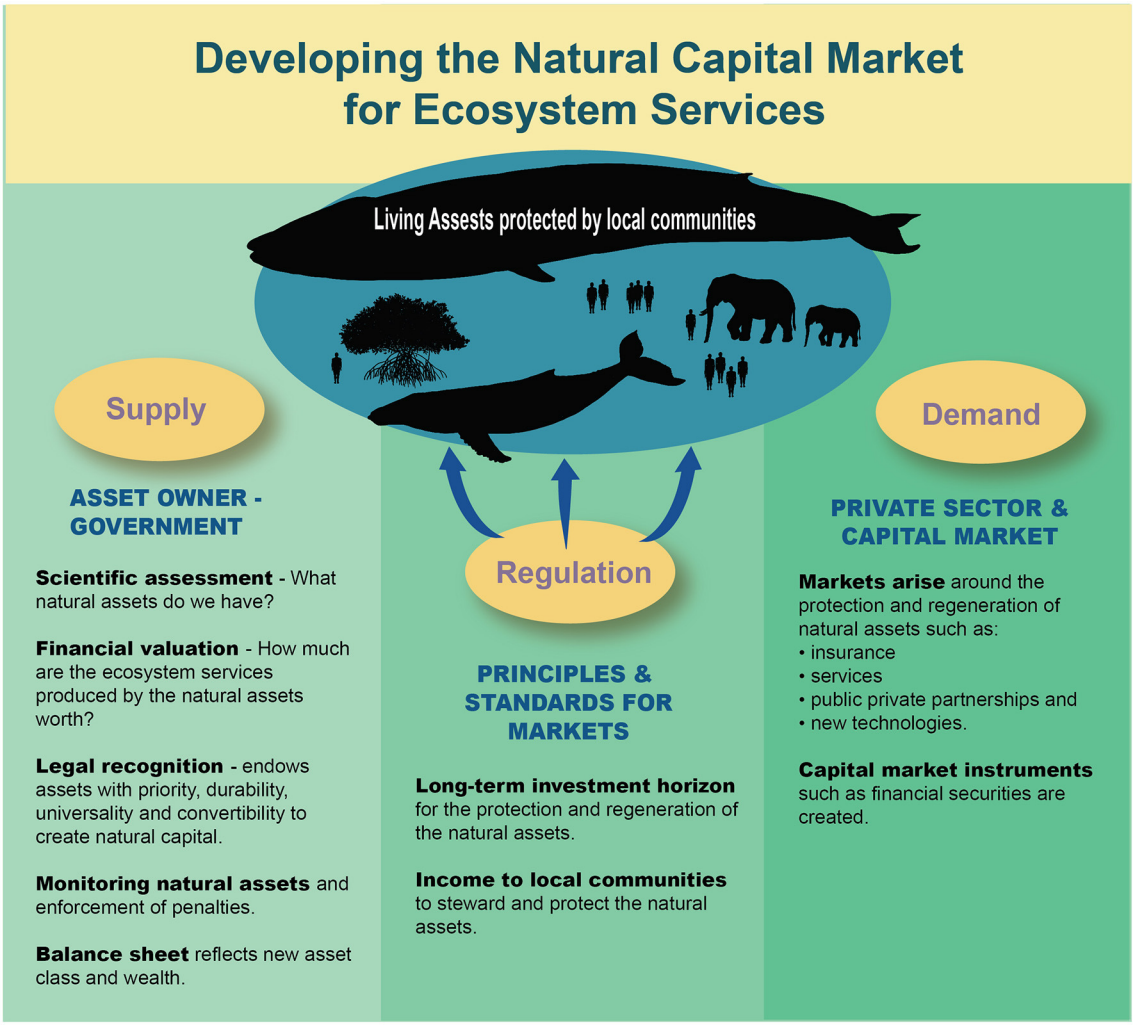

FIGURE 2 | Developing the natural capital market.

that the environmental services they are purchasing have not also been sold to other investors. A significant doubt regarding any of these concerns could cause investors to avoid or flee the market, precluding it from developing.

Recent advances in technology, however, can mitigate governance weaknesses by facilitating monitoring and preventing misuse of both information and money. Distributed ledger technologies like blockchain that create tamper-resistant, publicly viewable records should be used to document and track money, services, and information as they flow through these markets. Such technology makes it much easier to verify that conservation and restoration programs, as well as the local community members they claim to employ, actually receive the proceeds from carbon or other environmental services sales. It would also lend transparency to the data reported on environmental services production, for example by identifying the sources of all data entered into the services verification system and preventing data tampering. It would also alleviate the issue of double counting of services so that the same service flow could not be sold to multiple purchasers. Care must be taken, however, to implement energy efficient ledger technologies that focus on the limited goal of information disclosure (Howson, 2019).

Partnering With Local Communities and Indigenous People

Safeguarding indigenous people and local communities (IPLCs) are key principles of Nature-Based Solutions, as defined by many groups including the IUCN Gold Standard (IUCN, 2020). Indigenous peoples are noted to already be stewarding nearly 1/5th of the carbon sequestered by tropical and subtropical forests (218 $GtCO_2$) and their territories comprise 40% of protected areas globally (Townsend et al., 2020). IPs make up <5% of the world population yet they protect over 80% of biodiversity (Xie, 2021). The best way to realize these

principles is to ensure IPLCs are full partners in the design and operation of the conservation and restoration projects funded by environmental services sales from the inception. IPLCs are not only on the front lines of climate change, but also the keepers of knowledge about how best to manage biodiversity, which enhances the resilience of the ecosystem. For example, indigenous knowledge regarding forest management to reduce fire risk is being applied in Australia (Gaspers et al., 2022) and California (Begay, 2021). Studies also show that forests tended by indigenous tribes store more carbon (FAO and FILAC, 2021). Responsibility for managing resources must also extend to the financial resources generated from the sales of environmental services, which implies that IPLCs must be represented in the entities that make decisions about the amounts and timing of sales of environmental services, as well as the management of the endowments discussed above.

POLICY RECOMMENDATIONS

Fund Research and Innovation That Supports Environmental Services Markets

Additional research is needed to support nature-based solutions in two essential areas. The first is research into environmental services production by natural assets. Measurement of environmental services is still in its early stages, especially for those services that depend on interspecies interaction such as the whale-phytoplankton relationship. Research into the discovery of other natural cycles and relationships that yield environmental services should also be supported. The development of environmental services markets will also require reliable and affordable monitoring and verification of services production. Public funding of these efforts is needed to support the establishment of markets for environmental services in the short run. As the economic and financial benefits of these markets are realized, the private sector will have incentives to fund more of this research and technology.

Establish Natural Assets as Legally Recognized Capital

It is well understood that legal actions of various kinds, such as defining the molestation or destruction of natural assets as crimes, are needed to protect the natural world. Policy action that codifies natural assets in terms of property rights is also key to converting natural assets into capital with legal standing. This legal recognition allows the value of the asset to be recognized and reported on balance sheets of their owners, including the national accounts and balance sheets of sovereigns (Pistor, 2019).

Given the urgent need to reduce carbon emissions and prevent further biodiversity loss, the length of time required to make substantive changes in environmental laws, and the lack of political momentum for making such changes, this is not the time to attempt wholesale or fundamental changes in environmental law (MacLean, 2020). Instead, policymakers must use the "untapped adaptive and transformative capacity" within existing laws to create the legal infrastructure to support nature-based solutions and related nature markets (Garmestani et al., 2019). In addition, they need to authorize the transfer of claims on environmental services such as carbon capture to the entities who will manage the sale of these claims to the private sector.

ACTIONABLE RECOMMENDATIONS

- Fund research into measuring environmental services and monitoring the natural assets that produce them.
- Undertake national accounting of natural assets and biodiversity.
- Value ecosystem services.
- Extend legal recognition to natural assets.
- Establish endowments to fund protection and regeneration of natural assets in perpetuity.
- Partner with IPLCs in design and operation of conservation and restoration programs for natural assets.
- Require the use of transparent mechanisms to validate the flows of environmental services, information, and money between the buyers of environmental services, those who steward the natural assets, and the entities that organize and oversee the conduit consisting of a sale of environmental services.

CONCLUSION

Reframing humanity's relationship with nature and moving society toward a sustainable, nature-based economy is critical. This transition must happen quickly if we are to prevent the dual threats of climate change and biodiversity loss from reaching calamitous levels. By giving the services of living nature a monetary value, market mechanisms can accelerate this transition, while also providing benefits for all key social stakeholders: citizens, policymakers, and businesses. It offers widely distributed benefits and a positive vision for the future rather than one that imposes high costs and limits human aspirations. Most importantly, it is a concrete step that can be taken immediately and has a high likelihood of being politically feasible.

The question of whether truly sustainable economic growth is possible in the long run remains open. The answer depends, among many other considerations, on whether, and how much, resource usage may be decoupled from the production of goods and services valued by society (Raworth, 2017). But nature-based solutions have the capacity to contribute to sustainable growth in two ways. First, by demonstrating the value of living nature, they provide new incentives for individuals, businesses, and governments to work to decouple economic growth from resource usage that damages or threatens nature. Second, they place market values on environmental services, which then become counted as part of economic activity and necessarily contribute to measures of output and wellbeing such as GDP. This is a new source of economic growth and one that may be enhanced by decreased resource use. To the extent that sustainable

growth is possible, the path to this goal runs through nature-based solutions.

AUTHOR CONTRIBUTIONS

RC, CF, TC, and DN contributed to the economic framework and policy recommendations. RC, CF, and DN contributed to the writing and manuscript revisions. RC, TC, and CF contributed to the financial valuation method and computations leading to the policy recommendations. All authors contributed to the article and approved the submitted version.

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