

Bridging the science-business gap: from biodiversity measurement to action

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ABSTRACT

Biodiversity is the living fabric of our planet, and its loss poses growing risks to human well-being, ecological resilience, and business profitability. Yet businesses often lack the information and incentives to align decisions with nature stewardship. We argue that several conditions are essential to sustain biodiversity and a habitable planet. First, monitoring multiple components of biodiversity at scale is critical to understand ecosystem condition and change. Because nature is complex, monitoring requires multiple ecosystem-specific measures across levels of biological organization supported by established methods and emerging technologies that enable scaling. Second, we need to close the gap in translation between scientific measurements and information that businesses, governments, investors, and consumers can use to understand the dependencies and impacts of their activities. Case studies demonstrate how biodiversity monitoring contributes to supporting conservation mechanisms, ecosystem service benefits, and local livelihoods when linked to transparent governance and benefit-sharing. Third, information alone is insufficient where profits remain disconnected from biodiversity loss. Technological advances that enable biodiversity monitoring at large spatial extents will only contribute to biodiversity conservation under a nature-positive business environment. Regulation and public pressure stemming from relational and intrinsic values of nature are thus needed when business incentives conflict with conservation. Incentives for sustaining nature need to be incorporated into businesses and institutions that reward stewardship, protect ecosystems, and equitably benefit Indigenous Peoples and local communities. Aligning business with biodiversity requires locally-relevant, scalable monitoring coupled with policy, finance and governance that enforce stewardship of Earth's life-support systems.

Significance Statement

Biodiversity is integral to ecosystems that sustain human well-being and economic activity, yet it remains poorly integrated into business decisions. A central challenge is that scientific measures of the multiple dimensions of biodiversity are not easily translated into information that businesses can use. This Perspective identifies a critical gap between biodiversity science and business decision-making and outlines how it can be bridged through scalable monitoring, translation of metrics into decision-relevant information, and enabling policies and incentives. Biodiversity information alone, however, is insufficient: aligning economic activity with biodiversity stewardship requires changing business incentives away from extraction and towards reciprocity by combining scientific advances with governance, finance, and societal values to sustain Earth's life-support systems.

INTRODUCTION

Increasing anthropogenic pressures on the Earth's life support systems, and growing recognition of the need to sustain biodiversity has led to a rise in global focus on the role of business in biodiversity conservation and restoration (1). The urgency of conserving biodiversity can be understood from multiple perspectives, including the need to sustain human well-being through intact ecological systems, the value of human cultural relationships with biodiversity, and the intrinsic value of the myriad life forms on Earth (2-5) (Fig. 1). Goals and mechanisms for conserving, supporting and restoring ecosystems have been outlined within the United Nations Conference of the Parties (COP) through the Convention on Biodiversity and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

Biodiversity encompasses the variation in all of life on Earth, at all spatial and temporal scales, and is roughly synonymous with 'nature.' Given its inherent complexity, there is no single measure of biodiversity that can capture the variation in life across scales and biomes. Consequently, proposals to create a single apex metric of biodiversity have been rejected in favor of multifaceted approaches, as exemplified by the many targets within the Kunming-Montreal Global Biodiversity Framework (KMGBF) that focus on ecosystem integrity, connectivity, genetic diversity, restoration of degraded land, and control of invasive species, among others. Moreover, unlike molecules of carbon whose removal from the atmosphere can be traded, biodiversity is largely not fungible. For example, we cannot exchange old growth terra firme forest in the Amazon for intact tundra in the Arctic without extinctions taking place. To preserve current life on Earth, critical components of biodiversity and habitat need to be conserved in every biome and ecosystem type across the globe. In our view, the only acceptable forms of substitutability might be among parcels of land of the same ecosystem type or among species within the same lineage (branch) of the tree of life (6).

Real or perceived trade-offs between biodiversity and business profits can lead to business decisions with short-term benefits that result in irreversible habitat loss and declines in biodiversity with long-term impacts on our life support systems (e.g., 7, 8-10). While businesses recognize a certain level of reliance on nature (11, 12) and face some pressure from stakeholders to disclose

their environmental impacts and adopt “nature-positive” practices (13), they often find it difficult to understand and quantify their direct impact on nature and to identify feasible biodiversity stewardship strategies. Often businesses are not even aware of options that can decrease impact or contribute to reciprocity with nature (14). Moreover, businesses often struggle to discern why biodiversity and nature matter to them or their profits, and are therefore not appropriately incentivized to modify their practices to the benefit of biodiversity. Indeed, there is often a fundamental misalignment between business incentives and biodiversity values in the current business environment, where extractive practices that exacerbate biodiversity loss can be harnessed for short-term profits with limited repercussions.

Despite these challenges, businesses could take actions now that are beneficial for biodiversity without reducing their profits (1). However, a major translation gap exists between how scientists measure biodiversity and what is required for businesses to consider biodiversity in decision-making. Part of this gap stems from differences between what scientists measure and what is material to business (i.e., what affects profits). From a business perspective, it would be easiest to have a single metric (e.g., carbon equivalence) that could be readily measured and traded. The complexity of biodiversity, which prevents measuring it in terms of a single metric, is therefore inconvenient for business.

But even with advanced capability to measure the variation of life across biomes, scientific information only solves part of the problem. Under the current economic system, many profitable actions result in degradation of nature and biodiversity loss because they are not directly material or explicitly valued by business. Businesses often do not pay for biodiversity loss from their actions nor do they benefit financially when they restore biodiversity. This misalignment is evident in proposed mining activities near the Boundary Waters region of the US, where short-term financial gains conflict with long-term ecosystem and economic benefits, and where business incentives alone are insufficient to prevent biodiversity loss (Fig. 2). Government policy and regulatory changes could address this type of market failure and advance biodiversity goals further than what businesses can do alone. In South Africa, for instance, strong environmental regulation has constrained extractive development in response to biodiversity concerns, while shifting political decisions in the Boundary Waters create uncertainty over whether high-value ecosystems

will be protected (Fig. 2). Changes in customer demand and creative and responsible business practices could push the needle towards more sustainable business practices, but these may not be enough. Shifts in mindsets to understand dependence on biodiversity are needed to create the political and cultural will to sustain nature. If consumers, shareholders, and employees do not understand the value of biodiversity they cannot demand it from governments and businesses.

There are different reasons for valuing biodiversity

Perspectives on why biodiversity matters have changed through time (4). Biologists and conservationists often emphasize the intrinsic value of nature and its evolutionary history, questioning the ethical basis for human-driven biodiversity loss. ‘Nature for itself’ underscores the intrinsic value of nature and was a common framing early in the environmental movement both in the US (e.g.,15, 16-18) and globally, including among early British naturalists and others. Similarly, ‘nature despite people’ is a perspective that focuses on human threats to biodiversity and on strategies for sustaining nature (19). Environmental economists, in contrast, often adopt a utilitarian approach, viewing biodiversity in terms of ecosystem services (the contributions that nature makes to human well-being) and natural capital that provides ecosystem services (20). This perspective emerged in the 1990s with the recognition that human impacts on nature were ubiquitous, large, persistent, and propagated across great distances impacting even remote ecosystems (4). With increasing human domination, there was a need to shine a light on ‘nature for people,’ to show to a much broader audience why nature matters. This emphasis was adopted by the Millennium Ecosystem Assessment (21), which generated an international agenda for the valuation of nature, and led to the IPBES assessment and development of the concept of Nature’s Contributions to People (NCP) (22). Many Indigenous perspectives highlight relational and cultural connections to nature, challenging the conventional human-nature divide and encompassing the myriad relationships between people and nature (23). Reciprocity with nature, as practiced by some Indigenous groups, incorporates a world view that humans are part of nature, depend on it to survive, and need to give back to nature so that it thrives and is sustained, rather than used up (24). This view encompasses an understanding that our living planet has adaptive capacity and resilience in response to change if not overtasked. While these intrinsic, relational

and utilitarian perspectives on biodiversity differ, they are complementary and synergistic (5, 25, 26) (Fig. 1).

Despite broad recognition of these values, we are not living up to them, and the current biodiversity crisis is a result of these shortcomings. All of the components necessary to create a sustainable path for humanity can be found in examples around the world, but they are currently too small and incomplete on their own to reign in the ongoing decline in global biodiversity. How do we create the conditions to live up to the environmental values that can guide us through this perilous moment?

In this perspective, we argue that to align our actions with our articulated biodiversity values, we need to 1) understand and measure biodiversity, using emerging technologies to scale up measurements; 2) translate that information into metrics that can be understood, standardized and used by business, policy and in non-science realms; and 3) examine the ways in which business incentives can be aligned or misaligned with Earth stewardship. In the first section we explain why scalable biodiversity information is needed and how this can be achieved. In the second section, we clarify the disconnect between what science does and what business needs, and explain the issues involved with translating biodiversity information into business and policy relevance. Finally, in the third section, we show that incentives for business can be aligned or misaligned with biodiversity values, and we are realistic about where humanity is in its actions relevant to global biodiversity stewardship. We end by summarizing how better biodiversity measurements can help provide transparency in information to enable and promote better alignment (Fig. 1).

Fig. 1. Conceptual figure showing how values of nature are important for translating biodiversity to metrics relevant to businesses, decisionmakers and the public. Major components of biodiversity (e.g., species, the genetic variation of the populations within them and across the tree of life, interacting species within ecological communities, and ecosystems) are important to measure carefully because they underlie the health, adaptive capacity, and resilience of nature and biodiversity. Scaling up to large spatial extents across ecosystems and biomes globally requires emerging technologies, monitoring inventories, biodiversity repositories, and networks to provide the necessary input for the construction of models based on remote sensing to produce upscaled models of biodiversity and ecosystem services across space and time. However, these biodiversity measurements may have little relevance to business directly. Translating them to the ecosystem services or nature's contributions to people as well as metrics of biodiversity and nature relevant to stakeholders can better inform business operations. Even with translation, biodiversity information, alone, will not ensure nature outcomes consistent with our values if business incentives are not aligned with those values. Aligning business incentives with nature values requires a nature-positive business environment.

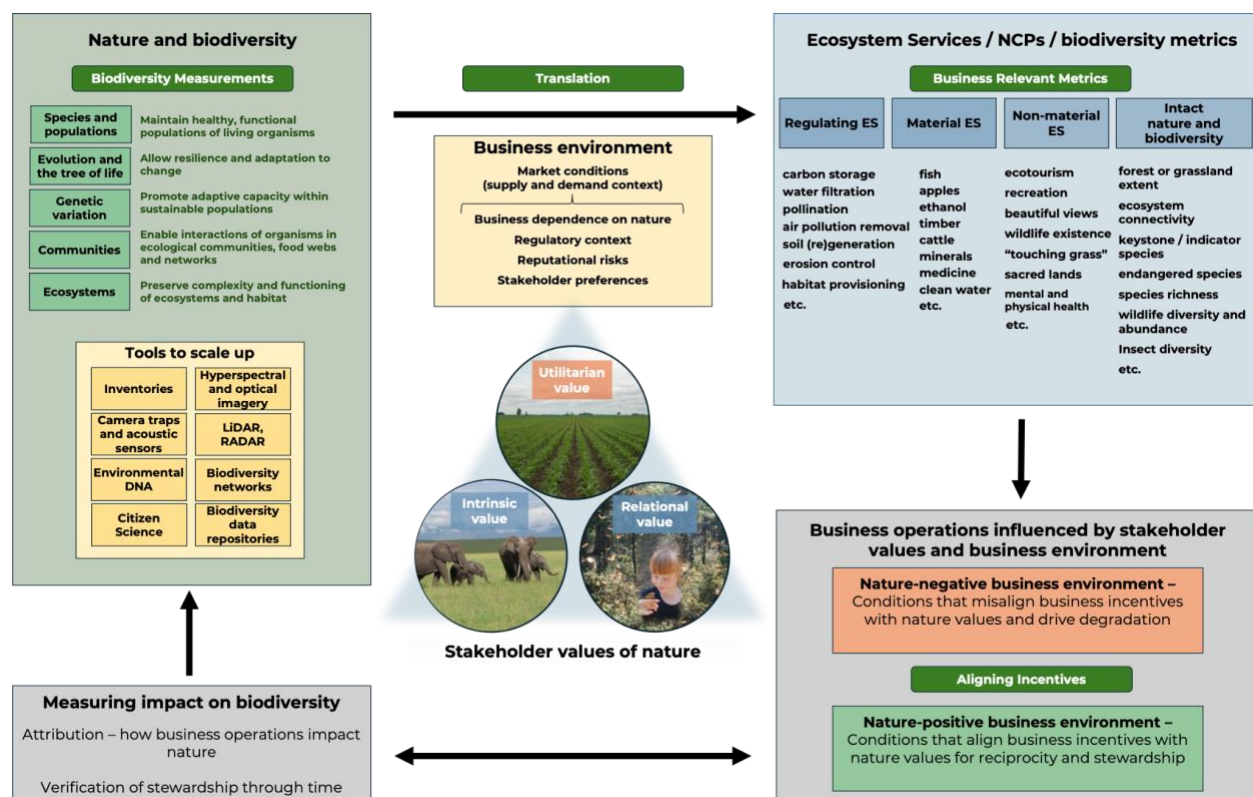


Fig. 2. Case studies that illustrate how biodiversity values can be aligned or misaligned with outcomes and how business can positively or negatively impact biodiversity. These are expanded in the Supplemental Information (SI1).

Kenya



South Africa



Appalachia



Boundary Waters



New England



Linking biodiversity values and knowledge to action

Despite ongoing poaching, and major losses of large mammals due to humans, Kenya is embracing its rich natural heritage. Biodiversity measurements at scale can be converted into standardized metrics that attract private capital and channel conditional payments to local communities for biodiversity stewardship.

One of the most biodiverse countries in the world, South Africa has faced centuries of colonial resource extraction and land-use change. With the transition to democratic rule, participatory and co-management conservation efforts are increasing. Legal reforms that directly encode intrinsic and relational values of nature into the constitution provide a strong legal foundation for nature and biodiversity protection.

Long-term ecological and public-health costs of intensive extraction (coal, minerals, oil) continue. Reclamation statutes have improved landscape recovery and human health outcomes, but recovery trajectories are slow and incomplete, and ongoing shale gas development continues to affect water quality.

A vast, pristine landscape along the US-Canada border hangs in the balance where decisions on mineral extraction and regulatory enforcement will determine whether it follows a high-degradation pathway similar to Appalachia or maintains high ecosystem integrity.

After extensive historical deforestation, land use shifted as logging and agriculture became economically nonviable, leading to large-scale forest regrowth and recovery of water bodies, driven primarily by changing economic incentives. More recent legislation now targets biodiversity protection explicitly; the region avoided the most severe, irreversible mining impacts.

Case Studies

Five case studies from Africa and North America illustrate the connections between nature and business (Fig. 2). An additional case study on Australia is in the Supplementary Information (SI1).

They represent different stages of nature degradation, protection or recovery, and demonstrate how different philosophical perspectives and approaches to biodiversity conservation can align land-use with biodiversity conservation or imperil it. We use each case to illustrate a particular aspect of the relationships between nature and business, the role of biodiversity monitoring, and who has benefitted from actions taken. We examine Indigenous pastoral systems in East Africa, the translation of wide-spread cultural values of nature encoded in South Africa's Constitution that are changing its business environment, the human history and legislation that underpins recovering forests and water bodies of New England and in the Appalachian region of the eastern US, and mining tensions in the Boundary Waters Canoe Area Wilderness of the Upper US Midwest. These examples highlight how biodiversity matters to different sectors of society, illustrate the role of biodiversity monitoring, and contrast the financial and governmental mechanisms involved. Ultimately, they collectively demonstrate the importance of strong policy for protecting biodiversity to help align business interests with nature values.

Tracking nature outcomes while delivering financial benefits to individual community members: Conservation and Maasai pastoral communities in East Africa

Kenya's savanna ecosystems are home to unique management interventions, enabling conditions that align conservation and sustainable livelihoods. This progress comes despite significant wildlife losses, including the elephant "holocaust" driven by the ivory trade at its peak in the 1980s, and ongoing human-wildlife conflict linked to agricultural practices (27). Nature assets have been created through financial mechanisms, developed by private companies, that support both people and habitat, and represent a new model for nature stewardship. Rigorous biodiversity monitoring via tools such as LiDAR, camera traps, acoustic sensors, and community-led surveys track species diversity, habitat quality, and wildlife movements (28-30). Nature assets are paired with payments for ecosystem services that are directed (and traceable) to individual community members who have a unique and historic connection to at-risk land outside of protected areas. Because these payments are directly tied to measured biodiversity outcomes and are transparently distributed to local landowners, they create strong financial incentives to maintain habitats, protect migration corridors, and sustain traditional land uses. In this way, biodiversity monitoring enables ecotourism revenue and additional conservation finance to flow to communities, aligning economic benefits with long-term ecosystem stewardship.

Civil society relies on constitutional law for biodiversity protections in South Africa

South Africa is one of the most biodiverse countries on Earth and has strong environmental protections, which safeguard the right to a safe environment for both present and future generations, enshrined in its constitution. It is also rich in natural resources. Despite a long history of resource extraction exploiting local communities and ecosystems for the benefit of the few, recent examples show how civil society can use existing legislation to safeguard biodiversity and the cultural values of nature. A prominent example is the 1996 ruling permanently blocking mining along the eastern shores of Lake St Lucia, the largest estuary in Africa and now a World Heritage Site within the Isimangaliso Wetland Park. Immense public pressure led to a cabinet decision by the newly formed post-apartheid government to block proposed strip mining of St Lucia's dunes and instead promote sustainable development and biodiversity conservation (31). More recently, global mining and energy companies have sought to exploit titanium-rich sands and offshore oil and gas deposits in the Xolobeni region of the Wild Coast in the Eastern Cape province. This region is historically low income, and the short-term gains of resource extraction can be seemingly optimal for development and social upliftment. However, local communities opposed the industrial development, leveraging biodiversity monitoring data, cultural values, and environmental legislation to argue that the projects would permanently disrupt traditional livelihoods and cause irreparable damage to a highly biodiverse coastal ecosystem. Instead, local stakeholders promoted ecotourism as an alternative form of development to support sustainable employment and biodiversity protection. Despite intense political pressure, local communities prevailed, and offshore seismic surveys have been permanently prohibited by South Africa's Constitutional Court (32) while mining activities cannot begin without the free, full, prior, and informed consent of the local custodians (33, 34). Effectively, the Court recognized the right of local communities to say "no" to exploitive forms of development (35). These rulings represent a significant milestone in the country's environmental legislation and set a precedent for prioritizing environmental and cultural values of nature over short-term business profits.

Forest and watershed recovery following major land use change in New England, US, sustained by conservation policies and public-private partnerships

The recovering forests and waterways of New England are a compelling example of ecological resilience following extensive land-use change, the ecosystem service benefits of which are locked in by conservation efforts through public-private sector partnerships. At the time of European colonization in the 17th century, New England was largely forested, shaped by Indigenous land management practices that included selective clearing, burning, and cultivation (36-38). Over the next two centuries, colonialists cleared most of southern and central New England for agriculture, pasture, fuelwood, and timber, reducing forest cover in some areas to below 30% (39, 40). Residual forests and woodlots, especially in steep terrain, remained important refugia for biodiversity (41). Regenerating forest cover, water quality, and services such as carbon storage, recreation, and pollination contribute to human well-being and business interests. Collectively, these ecosystem services underpin economic activity, reduce public health costs, and contribute to climate mitigation and carbon management strategies (42). Sustaining these ecosystem services, as well as biodiversity itself, have become targets of state-level legislation (e.g., Commonwealth of Massachusetts 2023; Mass. Gen. Laws ch. 21A, § 4C; Mass. Gen. Laws ch. 10, § 35D½), even as the gains in nature recovery are increasingly threatened by invasive pests, high herbivore pressure, and policy trade-offs such as forest clearing for renewable energy. The region highlights the importance of balancing climate, biodiversity, and economic goals through continued conservation investment, careful land-use decisions, and robust ecological monitoring to sustain long-term resilience.

Sustaining biodiversity and supporting livelihoods through benefit sharing in fragmented landscapes of Appalachia

As the Appalachian region recovers from a legacy of mining and resource extraction, some communities are now developing place-based economic models that distribute the benefits of biodiversity through small-scale enterprises tied to ecosystem services and nature's contributions to people (NCPs). These approaches support ecological resilience while generating income that reinforces cultural ties to the land, even while costs for continued reclamation remain. Regulation and enforcement have been critical to recovery from mining impacts. The primary law that triggered mining businesses to confront the costs to nature in Appalachia was the Surface Mining Control and Reclamation Act (SMCRA) of 1977. Prior to this law, mining companies had no responsibility for damage to ecosystems that were destroyed in order to extract coal and other

minerals. Enforcement of the law was made robust with the Office of Surface Mining Reclamation and Enforcement, which set minimum standards for compliance. States have the option to establish more rigorous standards, and these vary across the Appalachian region. Under the law, mining companies are required to post financial bonds for land reclamation prior to starting a mining operation (43). The Abandoned Mine Land program established under the law also allocated funding to recover lands that were degraded prior to the establishment of SMCRA. Even though the funds are insufficient to recover all mining areas where land was degraded and biodiversity eliminated (44), the legal requirement to pay the costs of ecosystem damages led to a decline in mining activity that has allowed for some ecosystem recovery over the five decades since.

Pressure to mine the Boundary Waters in northern Minnesota: pristine wilderness could be lost forever for short-term financial benefits in a volatile political climate

The iconic wilderness of the Boundary Waters Canoe Area (BWCA) and the surrounding watershed in northern Minnesota, US, is under threat from proposed copper-nickel mining. Under current economic systems, business incentives conflict directly with nature conservation, making strong policy protections essential. While the region provides substantial ecological, cultural, and economic benefits through tourism, recreation, biodiversity, and ecosystem services, proposed copper-nickel mining offers financial gains and jobs that are largely decoupled from long-term environmental costs (45). Because mining profits are not constrained by the value of intact ecosystems and are unlikely to be deterred by public sentiment or environmental arguments alone, the fate of this high-biodiversity landscape depends heavily on government intervention. Repeated reversals in federal policy highlight how political decisions, rather than ecosystem service benefits, ultimately determine whether such ecosystems are protected or exposed to irreversible damage as seen in Appalachia.

Monitoring biodiversity: No single metric of biodiversity can capture the complexity of nature

Sustaining biodiversity and functional natural systems requires the ability to monitor them and understand how they are changing across spatial and temporal scales from local ecosystems to the global biosphere (46-50). However, there are no standardized or universally adopted measures,

despite important efforts in that direction (51, 52). The lack of uniformity is a consequence of variation in the nature of biodiversity itself across biomes, heterogeneity in resources or capacity to measure it, and contrasting goals. Importantly, there is no single metric that can capture the complexity of nature and biodiversity.

A major challenge in biodiversity monitoring is determining which metrics best capture nature's complexity at different levels of biological organization. Major components of biodiversity include the richness and abundance of *species*, essential units of life; *genetic variation* of populations within species, critical to their viability and ability to adapt to change; the evolutionary breadth across *the tree of life*, critical to the resilience and adaptive capacity of living systems; the interactions among organisms within *communities* and networks that are essential to food webs; and *ecosystems* that encompass communities of organisms and their environment, fundamental to the cycling of energy, carbon, water, and nutrients (Fig. 1). Frameworks such as the Essential Biodiversity Variables (EBVs) (53) capture attributes of life, with the goal of providing a basis for global biodiversity monitoring systems (49, 54, 55). EBVs emphasize major classes of variables, including species, genetic diversity, communities, and ecosystems, with many subclasses of variables within them, although they often miss variation resulting from long-term evolution across the tree of life. Core EBV metrics are frequently measured in local and regional inventories of biodiversity.

Which metrics to use?

Much has been written about the myriad metrics for measuring biodiversity and how to prioritize them (e.g., 51, 56, 57-59, SI2). These metrics capture dimensions of identity, composition, structure, and function within and among species, ecosystems, and biomes and are relevant to physiological, ecological, and both micro- and macro-evolutionary processes. Often the *number of species* in an ecosystem or area is chosen as a straightforward metric of biodiversity (60-62). However, this measure is rife with challenges, such as deciding which groups of species to count. Biodiversity assessments frequently focus on vertebrates and large plants, overlooking the vast diversity of less conspicuous groups. Consequently, estimates of species richness for many groups remain sparse and inaccurate, with notable exceptions for some taxa, such as birds, monitoring of

which has been greatly advanced by citizen science (e.g., eBird,63). While species richness is important, species abundances reveal patterns of dominance and rarity, and determine how and which species function in an ecosystem and meaningfully contribute to ecosystem services (64). Functional diversity captures the different roles organisms play in ecosystems and is critical to ecosystem functioning (65, 66).

Phylogenetic diversity metrics capture the variety of life that has evolved on Earth and the breadth of evolution in an area (67-70). In an era of rapid species loss, safeguarding our evolutionary heritage requires maintaining branches of the tree of life, and it might become critical to treat lineages as conservation units (71). Even if species are lost, preserving other species within the same lineages may retain much of the genomic innovation accumulated over 3.9 billion years. Both environmental DNA and hyperspectral remote sensing (see below) may lend themselves better to detecting branches of the tree of life and estimation of phylogenetic diversity than to detecting species and species richness, particularly in megadiverse ecosystems.

The diversity of life, its adaptive capacity, and the life support functions it provides depend fundamentally on the complexity of ecosystems, their extent, and their intactness. The contiguous area of an ecosystem, and the degree of connectivity among intact ecosystems, are critical for movement and migration of organisms and the maintenance of sustainable populations (57). The structural complexity of ecosystems is tightly linked to habitat for birds, insects, mammals and other organisms and is broadly predictive of biodiversity (72), while productivity (annual growth increment measured as biomass) is a critical measure of the functioning of an ecosystem. The functioning of healthy ecosystems is, in turn, dependent on the biodiversity within them (73-76). Capturing ecosystem intactness often depends on comparison to a baseline state and measurement of the health of organisms within the ecosystem (77, 78) and includes functional redundancy. These measures are related to the capacity of ecosystems to support complex species interactions, resilience, and to maintain critical ecosystem functions (SI2).

Approaches for measuring and monitoring biodiversity range from species checklists and field surveys to remote sensing strategies that aim to increase the ability to quantify biodiversity consistently over large spatial extents (47, 50, 79, 80). Where sufficient financial and technical

resources exist, comprehensive quantification of biodiversity metrics can be feasible (52). However, in more biodiverse regions of the globe, where monitoring infrastructure is also often limited, lower cost methods for measuring ecosystem attributes that support biodiversity are needed. Which metrics to use ultimately depends on context.

Making biodiversity metrics feasible and scalable, harnessing emerging technologies

Emerging technologies coupled with computational and modeling advances are enhancing biodiversity monitoring and our ability to scale up measurements. Earth observation techniques, such as satellite imaging, airborne sensors, as well as networks of camera traps, acoustic monitoring devices, eDNA, forest inventories, and citizen science observations linked to taxonomic data from biodiversity repositories and coupled with modeling approaches increasingly promise scalable and precise biodiversity assessments (81-84). Approaches that link surface measurements and remote sensing provide critical tools for scaling to spatial extents relevant for informing business and government about impacts of human actions.

Satellite and airborne remotely sensed imagery captures reflected light from the Earth's surface with an increasing array of sensors and capabilities for monitoring aspects of biodiversity, particularly for plants. Specific applications depend on sensor type, spatial and spectral resolution, and repeat frequency. The public availability of imagery from U.S. and European space agencies since the 1970s, combined with a rapid increase in satellite launches and major advances in computational and storage capacity, has greatly expanded the application of remote sensing for land use and biodiversity assessment (85). Multispectral imagery, with a limited number of broad spectral bands, is widely used to classify land cover types, map forest extent, and delineate ecosystem types. It also enables the monitoring of vegetation phenology, such as seasonal greenup and senescence, and the detection of land-use and land-cover change over time. Spectral heterogeneity derived from multispectral imagery has been shown to correlate with species richness and functional diversity, providing a scalable proxy for biodiversity patterns across large spatial extents (49) and detection of disease or other forms of stress (86). Imaging spectroscopy using hyperspectral sensors measures reflected photons across hundreds of narrow wavelength bands (typically between 400–2500 nm), greatly expanding the portion and resolution of the

electromagnetic spectrum that is “seen,” enabling detection of functional and phylogenetic dimensions of biodiversity at large spatial extents (87-89). Plant biochemical and biophysical properties (traits) measured on the ground can be scaled up using spectroscopic imagery and modeling methods (90, 91) to detect ecosystem traits such as leaf nitrogen, water content, and pigments, directly linked to ecosystem function and habitat quality(92-95). Airborne systems, such as those deployed by the U.S. National Ecological Observatory Network (NEON), typically provide very high spatial resolution (pixel sizes < 1 m) and are powerful for resolving individual tree crowns and linking spectral signatures to species or phylogenetic lineages (96, 97) or fine-scale variation in functional and phylogenetic diversity within ecosystems (89, 98-101).

Light Detection And Ranging (LiDAR) and Radio Detection And Ranging (RaDAR) are promising remote sensing techniques that provide structural information of the Earth’s vegetation and terrain with high precision and accuracy. The structure and spatial patterning of vegetation is a key feature of almost all terrestrial ecosystems, with strong impacts on biodiversity. Structurally complex plant communities are associated with higher plant diversity than structurally simpler ones (72) and vegetation structure can be more influential for animal diversity than plant species composition (28, 102-104). Structurally complex habitats promote biodiversity due, in part, to their greater abundance and diversity of ecological niches, providing increased habitat for a wider range of species (28, 72). Measurements of vegetation structure can therefore provide an efficient means to predict biodiversity and, when coupled with expanding remote sensing technologies, provide consistent information over large spatial extents.

Both LiDAR and RaDAR have been used to predict biodiversity across a range of taxonomic groups, including plants (105, 106), insects (107), birds (108-110) and mammals (111, 112), among other groups (28, 113), based on predictable structure-biodiversity relationships. Given the increasing availability of both technologies, they serve as promising means to predict biodiversity over large areas and in a repeated manner, especially as spaceborne instruments, such as GEDI, continue to improve and provide near-global measures of vegetation structure. In hard-to-reach locations, such as the Congo Basin, the world’s second largest yet least studied rainforest region, remote mapping of structural complexity could be especially valuable for indirectly monitoring biodiversity.

Nevertheless, since LiDAR and RaDAR do not directly measure biodiversity, but rather provide a reliable proxy through measuring structural complexity, these approaches need to be combined with direct measures of biodiversity, at least initially, to establish scaling relationships between structure and biodiversity metrics (e.g., biomass cover, species richness or diversity indices). However, once such relationships are quantified and can be reliably inferred, structural measurement from LiDAR and/or RaDAR can be used to make large-scale predictions of biodiversity (e.g., 114) and to track changes in structure that will likely lead to increased or decreased biodiversity.

Sequencing of environmental DNA (eDNA) is increasingly used to detect aquatic organisms, as well as terrestrial organisms, especially those hard to see or hear. This technology has been used to document the presence of rare species (e.g.,115), for early detection of invasive species (e.g.,116), and for discovering new biodiversity (e.g.,117). Scalability of eDNA sensing has tremendous possibilities, especially given the steady decline in short-read DNA sequencing costs, and the adoption of these technologies by private companies that enable citizen scientists to monitor water health.

Citizen science is now a rapidly growing component of biodiversity monitoring and is increasingly used to detect ecological change. For centuries, scientists have led the discovery, naming, and monitoring of biodiversity, resulting in extensive natural history collections housed in institutions worldwide to preserve this knowledge, anchoring species names and informing taxonomic relationships. However, technological and sociological changes increasingly recognize and amplify the role of citizen scientists, particularly through digital photography, GPS-enabled devices (mostly smartphones) and image recognition algorithms for species identification. These advances have driven a dramatic increase in biodiversity records. For example, GBIF contained nearly 109 million bird records by 2000, including historical museum data (over 6.5 million specimens digitized by February 2026) and nearly 99 million human observations. By February 2026, bird records exceeded 2.179 billion, with preserved specimens increasing by ~800,000 and human observations by over 2 billion. Much of this growth comes from citizen science platforms such as eBird and iNaturalist, which provide georeferenced, crowd-sourced biodiversity data.

However, known biases in data collection—such as concentration near roads, cities, and accessible areas—require careful interpretation (118) and comparison with specimen-based data from established collections (119, 120).

Increasing efforts are being made to derive relevant variables using eDNA (121), remote sensing technologies (49, 80), and citizen science (118) that incorporate multiple dimensions of biodiversity. However, while these approaches enable scaling up, they often do not detect the presence or absence of expected species (e.g., satellite imaging) or the abundance of organisms (e.g., eDNA), or they have known biases (e.g., citizen science) necessitating verification methods through complementary approaches. These often require extensive ground monitoring data, including networks of acoustic sensors and camera traps, ground inventories such as the US Forest Service Forest Inventory Analysis, and other data obtained using more conventional measures of biodiversity (50, 84, 122, 123). The Group on Earth Observations Biodiversity Observation Network (GEO BON) is collectively developing tools to make biodiversity monitoring accessible to diverse stakeholders (47) contributing towards these coordinated efforts.

The translation gap: Providing businesses and their stakeholders with relevant biodiversity information

Translating components of biodiversity into metrics that are relevant to businesses and their stakeholders is a necessary additional complex step for metrics to be used by businesses. Metrics relevant to business need to encompass variables that are linked to ecosystem services, and to biodiversity directly, that can be readily understood and monitored for decision support relevant to unique contexts, scales, and priorities (51, 124). The translation requires targeting variables that businesses care about given a particular business context.

Ecosystem service variables have strong grounding in the MEA (21), IPBES (125) and the Essential Ecosystem Services Variables (EESV) frameworks (126) and include material services (e.g., timber, fish); regulating services (e.g., carbon storage, pollination, air and water purification); and non-material ecosystem services (e.g., beautiful views, recreation) (Fig. 1). Measuring biodiversity and regulating ecosystem services (e.g., carbon sequestration, water purification,

nutrient retention, and adaptive capacity) or non-material ecosystem services (e.g., aesthetics, vistas, accessibility of charismatic megafauna or sacred organisms) and communicating to businesses why it matters is challenging. In contrast, material ecosystem services (e.g., agricultural and timber production, fish landings) tend to be relatively well-measured and readily understood by business because of their direct link to markets and human consumption. There is a growing need to articulate and justify metrics that are interpretable across sectors of society, scaled to large spatial extents, and can be feasibly tracked over time.

Businesses may care about biodiversity for many reasons: i) biodiversity directly affects their profits because of their dependency on nature, ii) to comply with policies and regulations, and iii) business leadership, local communities in which they operate, customers, investors, or employees care (Table 1). The most direct reason that some businesses care about biodiversity is because it directly affects profitability. For example, when ecosystem services contribute directly to business operations, such as pollination or soil fertility for agricultural crops, protection from coastal storms or inland flooding that reduces potential damages to facilities, or the provision of inputs into production such as fish, timber, or other materials, businesses have a clear profit motive to conserve the ecological systems that generate these services. Biodiversity loss thus can pose operational and financial risks to businesses (127-129).

Businesses may need to alter their operations to reduce negative impacts on biodiversity to be in compliance with laws and regulations. For example, under the US Endangered Species Act, wind energy turbine operations in Appalachia and the Midwest have modified operations to reduce harm to the endangered Indiana Bat and the Northern Long-Eared Bat (130). In the UK, the Biodiversity Net Gain regulation requires land developers to increase the Statutory Biodiversity Metric by 10% relative to the baseline before development (131).

Adopting biodiversity positive actions can also improve relationships with customers, local communities, employees, or shareholders (132, 133). If customers value biodiversity and align their purchasing decisions with their ethical commitments, businesses will have market incentives to adopt biodiversity-friendly practices (134). Businesses can respond by changing sourcing and packaging standards, adopting certification schemes, or investing in conservation or

restoration(135). Attracting and retaining talented employees is also vital for business, and some job seekers and employees increasingly prioritize companies that reflect their own values on nature (136). Some shareholders value biodiversity and may be more willing to invest in businesses that commit to ambitious biodiversity policies. Businesses may also wish to take action to conserve and restore biodiversity because of long-term reputational considerations.

Table 1. Connecting perspectives on why people value biodiversity with how we measure it, how these measures are related to benefits to people, and why businesses might care. Blue colors in the “Reasons to care” column indicate intrinsic or relational values of biodiversity, while orange indicates utilitarian values.

Reasons to care about biodiversity	Biological measurement	Business reasons to care about biodiversity
Intrinsic value: biodiversity for biodiversity’s sake (“nature for nature”) (26, 137)	Biophysical measurements of the spatial and temporal variation and abundance of life in different ecosystems—such as the genetic diversity and population sizes of endangered species, the presence of keystone or indicator species that point to ecosystem integrity, ecosystem connectivity that enables migration of wildlife, the health or intactness of ecosystems important for maintaining the cycling of water and nutrients.	Consumer preferences: customers may care about intrinsic value, ethical considerations. They may pay a premium for green goods or boycott brown goods Business leadership: leaders may care about biodiversity and business relationships to nature and communities, as well as their reputation in this regard (138).
Relational values: people and nature are part of an intertwined system. We have feelings of care, respect, responsibility, and belonging in nature (“people as part of nature”) (23)	Measures that capture relational values of biodiversity—such as desirable and just human-nature relationships, identity (cultural, individual, and collective) as shaped through connections with nature, sense of place and interconnections among cultural and sacred landscapes, care for specific places and human and nonhuman beings, or nature’s role in fostering social cohesion and community networks.	Investors (shareholders): activist investors may require companies disclose dependencies on nature and/or potential financial impacts from climate change. Employees: employees (and potential future employees) may have an expectation that companies be responsible corporate citizens which includes taking an active role in reducing their emissions footprint and their overall impacts on nature (139).
Utilitarian values: biodiversity has instrumental value because it generates ecosystem services that benefit people (“nature’s	Quantities or values of the provision of ecosystem services, often calculated as outputs from ecological production functions that rely on biophysical measures. Some biophysical measures directly relate to ecosystem services such as harvestable	Private goods: ecosystem services directly matter to the profits of the business (“materiality”), e.g., business depends on clean water, soil fertility, pollination services, fish stocks, timber, hazard mitigation to reduce property damage, etc.

contributions to people," NCPs) (125, 140).	production of fish or timber, or tons of carbon sequestered in ecosystems. Other biophysical measures must be combined with other data to estimate provision of ecosystem services, e.g., mental or physical health benefits, ecotourism benefits, or air pollution removal. Non-material ecosystem services, such as the existence value of wildlife or "touching grass" as an antidote to an increasingly virtual world, can be difficult to quantify (141).	Public goods and externalities: government regulations may require businesses to protect or restore biodiversity or government policy may provide incentives such as Payments for Ecosystem Services. Policies and regulations can provide powerful incentives for businesses to act even when biodiversity does not directly contribute to profitability.
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Regardless of their motives, businesses and their stakeholders need biodiversity information to inform their decisions. However, a large gap persists between how scientists measure biodiversity to capture the complex fabric of life's variation, and information that is accessible, understandable, and relevant to businesses. Measurements of the variation within and across species, species interactions in complex food webs, and the connectivity and function of ecosystems that sustain populations, are generally published in the scientific literature and aimed at a scientific audience. This body of work is largely inaccessible to the business world, and its relevance is often not immediately apparent to businesses.

Therefore, there is an urgent need for translational material to explain important scientific literature on biodiversity in business-friendly language that makes it clear how biodiversity conservation and restoration can directly affect profits, allow more efficient compliance with existing laws and regulations, or improve relations with important stakeholders. Prominent examples of efforts attempting to bridge the gap between the worlds of science and business include the IPBES Business and Biodiversity Assessment (139), the Taskforce on Nature Related Financial Disclosure (TNFD) (142, 143), Science-Based Targets Network (144), the Capitals Coalition (145), and the World Business Council for Sustainable Development (146). While these efforts are making progress, large gaps remain between setting out principles and frameworks and providing actionable guidance to business operations in specific locations. Since the integrity of biodiversity needs to be evaluated locally, our view is that site-specific assessment is preferable to corporate-level or portfolio-level assessments. Further, because different economic sectors have different impacts on biodiversity, sector-specific guidance on biodiversity metrics is preferable to

universal metrics. Finally, mandatory standards are superior to voluntary guidelines, because they are more inclusive of all businesses and can be more readily enforced. Within legal mechanisms, robust legal tools, like Constitutional provisions, are more durable than executive orders, as evidenced by the South African vs the Boundary Waters cases.

Biodiversity monitoring can contribute to sustainable outcomes, particularly when government institutions or third parties are involved in using this information to mediate business interests and nature impacts. South Africa has invested heavily in biodiversity monitoring, including the National Biodiversity Assessment (147, 148), which assesses biodiversity status, threats and protection levels, and land-use decision support tools for conservation planning and the expansion of protected areas, implemented by the National Protected Area Expansion Strategy (149). The government has also partnered with international efforts to scale up biodiversity monitoring, including through NASA's BioSCape mission using hyperspectral remote sensing connected to local knowledge (150). The Chamber of Mines of South Africa helps to mediate between biodiversity and mining sectors through The Mining and Biodiversity Guideline, a collaborative process between both sectors that rejects environmental authorizations, preventing mining projects at the application stage, to safeguard vulnerable biomes like the Succulent Karoo and Fynbos hotspots. These collaborative efforts grounded in science and monitoring help to bridge the gap between biodiversity measurement and relevance to business aimed at nature stewardship.

In New England states in the US, forests are carefully monitored using ecological information, remote sensing, and field inspections to maintain multiple uses and enforce legal protections through conservation easements. The New England Forestry Foundation (NEFF), founded in 1944 to promote sustainable forestry and prevent excessive logging, holds conservation easements on > 450,000 ha of working forests that prevent land conversion for development but allow carefully managed forestry (151, 152). NEFF works with forest-management companies, including Seven Islands Land Company and LandVest, on sustainable management in which timber products are generated under conservation restrictions that protect wildlife habitat, water quality, recreation, and long-term forest health. Monitoring is required to enforce the easements, and protocols have been developed that include satellite imagery and field inspections capable of verifying sustainable management at fine spatial scales and detecting potential infractions (153).

In addition to providing information to businesses, there is a need for businesses to provide information about their impacts on biodiversity to governments, customers, shareholders, and others, which is vital to allow these parties to evaluate businesses and make informed decisions about policies and regulations (governments), purchases (consumers), and investments (shareholders). The EU's recent Corporate Sustainability Reporting Directive (CSRD) requires firms operating in the EU to regularly report on the social and environmental risks facing the company, and on how the company's activities impact people and the environment (154). The goal is to promote better environmental performance through mandatory and audited reporting that reduces the ability to selectively report findings and engage in greenwashing (155, 156). Verification by independent third parties is critical to high integrity reporting to address these valid concerns. Measurement technology is maturing to the point where data transparency in nature-related disclosures and actions can be verified.

Aligning our actions with our values: Changing business incentives

Under existing conditions, many businesses lack incentives to conserve and restore biodiversity. Many profitable business actions, including many business operations in mining, agricultural, energy and industrial production, harm biodiversity. Further, many actions to conserve or restore biodiversity are not profitable for an individual business to undertake. Filtering air and water pollutants, sequestering and storing carbon, and providing habitat for endangered species, provide value to society, but generate little or no direct financial return to most businesses (129, 135). While society as a whole would benefit from conserving biodiversity, no individual business has an incentive to do so, creating a collective action problem akin to the tragedy of the commons. Governments can address the collective action problem through policies and regulations that reshape the profit calculus that businesses face creating a business case for nature-positive action.

Protecting biodiversity at ecosystem scales can make certain business sectors profitable. For example, ecotourism businesses in Kenya are dependent on maintaining wildlife populations that draw tourists. Similarly, protecting the watershed of the Boundary Water in Minnesota supports

economic activity based on outdoor recreation and vacation homes. In Appalachia, emerging economies based on non-timber forest products and recreation depend on ecosystem recovery.

Internationally established goals provide a critical foundation for coordinated action globally. The UN Kunming-Montreal Global Biodiversity Framework (KMGBF) provides a global vision with targets for nations and subnational entities. Negotiated policy goals, such as the 30x30 target (preserving 30% of biodiversity by 2030) shape regulations and voluntary commitments globally. These targets can trickle down to subnational levels, even in countries like the US, which is not a signatory to the CBD. Target 15 of the KMGBF encourages governments to enable businesses to assess and disclose their risks, dependencies and impacts on biodiversity, provide information to consumers, and comply with benefits sharing regulations, to reduce negative impacts on biodiversity and ensure sustainable production.

Many government incentive policies and regulations have an impact on businesses and some countries have adopted policies that specifically target biodiversity related outcomes. In South Africa, for instance, strong public and cultural values for nature and biodiversity protection have translated into Constitutional rights and regulatory constraints on extractive industries, shaping business operating conditions (149)(SI1). In some cases, business leadership may act even without evidence about profitability or regulatory constraints. Business leaders can choose to embed biodiversity protection into corporate strategy because of internal ethical commitments even when the financial returns are uncertain or indirect (11).

In the United Kingdom, the Agricultural Act 2020 shifted agricultural policy towards “public money for public goods,” giving financial assistance for managing land or water that protects or improves the environment, mitigates or adapts to climate change, reduces environmental hazards, and improves soil quality among other benefits (157). The UK also developed a biodiversity net gain regulation requiring project developers to increase biodiversity by 10% managed for a minimum of 30 years. China has implemented Ecological Conservation Red Line and National Key Ecological Function Areas policies that prioritize ecosystem protection over growth in key areas and provide strict protection in designated areas (158, 159). China has also introduced Gross Ecosystem Product (GEP) to measure the contribution of ecosystems to the economy with policies

that include giving preferential loans to businesses that improve GEP (160, 161). Costa Rica has developed policies to establish a large protected area network that encompasses 25–28% of the country’s land and pioneered policies on Payment for Ecosystem Services (PES) (162, 163). Colombia similarly has a series of comprehensive regulations regarding nature and enshrined biodiversity protection in the Constitution of 1991 (164), as has the Republic of South Africa, where the Constitution of 1996 (Section 24(a)) stipulates the right to an environment that is not harmful to health or well-being.

Even without government policy action, voluntary private sector mechanisms can mobilize business actions and finance for biodiversity conservation. A prominent mechanism in this vein is the development of biodiversity credits (165). The Biodiversity Credit Alliance, a UNDP-supported effort to develop a high integrity and equitable market for “nature-positive” crediting, defines a biodiversity credit as “a certificate that represents a measured and evidence-based unit of positive biodiversity outcome that is durable and additional to what would have otherwise occurred” (166). These credits are typically measured in hectares of land protected for a term of 10–30 years. A credit can be generated through either restoration or stewardship. Restoration assets are intended to incentivize payments for improvements in biodiversity at a given project site made through active interventions. Stewardship credits are intended for continued protection of existing rich biodiversity ecosystems. Biodiversity credits face the same issues of additionality, permanence, buffers, monitoring, reporting and verification that have been experienced in the voluntary carbon market (167, 168). In addition, biodiversity credits have an additional serious challenge: “Unlike CO₂ emissions, biodiversity loss in one area cannot be mitigated by improvement in another, so progress must be treated as inherently local” (169). Biodiversity credit markets must define limits on what can be traded (167, 170). Forests, grasslands, wetlands are not substitutable with each other, nor are tropical, temperate and boreal habitats. We suggest that the only parcels of land of the same ecosystem type within the same ecoregion or among species within the same lineage (branch) of the tree of life should be considered adequate substitutes and therefore tradeable (6). However, defining narrow limits on allowable trades makes for “thin markets” without many buyers and sellers that fail to achieve the benefits of using a market. There are also concerns about equity for local communities, scientific rigor, and data transparency (165). The case study below on Kenya details some examples.

Important limitations

Each of the pathways connecting biodiversity to business have important limitations. The ecosystem services pathway is constrained because most components of biodiversity do not have a direct or easily measurable link to a firm's profitability, meaning they lack financial materiality from a business perspective. Even when there is a business case for biodiversity, businesses may be unaware of it because they lack the understanding and data to show it. Customer-driven change may be weak because many customers are unwilling to pay a meaningful premium for biodiversity-friendly products. There is often a gap between stated concern and actual purchasing behavior. Even consumers who say they care about biodiversity may not consistently reward responsible companies or penalize harmful ones (171). In addition, customers frequently lack reliable, accessible information about corporate impacts on biodiversity, making informed decision-making difficult (172). Similar arguments can also be applied to other stakeholders (local communities, employees and shareholders).

Government policy and regulation, while potentially powerful, require governments to act. Biodiversity protection may rank low among competing political priorities such as providing for economic growth, better healthcare, or education, especially in the low-income countries where social and economic pressures are often higher. In polling of public opinion, environmental concerns (including air and water quality, climate change, and biodiversity loss) consistently ranks well down the list of priorities behind the economy, jobs, government spending, taxes, corruption, and safety concerns about crimes, violence, war, and drugs (172). Even when governments express commitment to conservation, they may lack the institutional capacity, resources, or political will to effectively enforce environmental laws. Weak governance and lack of resources can result in "paper parks," continued poaching, or widespread noncompliance, undermining the intended regulatory incentives for businesses to conserve biodiversity (173, 174). Government policy and regulation can also be volatile and unreliable in polarized and shifting political landscapes as repeated changes in direction under different US Administrations has shown. For example, in 2016 the Obama Administration initiated a temporary mining ban in the Boundary Waters watershed. These actions were overturned in the first Trump Administration. The Biden Administration

instituted a 20 year mining moratorium in the BWCA watershed. In 2026, Republicans in Congress passed a law reversing the mining moratorium, which President Trump signed. However, the governor of Minnesota issued an executive order halting permitting and called for a law permanently banning non-ferrous mining in the watershed.

Biodiversity governance and finance will fail without equitable benefit-sharing and rigorous connection to Indigenous Peoples and local communities (IPLC's)

Interventions that fail to benefit, and are not equitable toward, Indigenous Peoples and local communities (IPLCs) are unlikely to endure or succeed (57, 175) (SI3). IPLCs hold deep, intergenerational ecological knowledge, making their participation critical. Although estimates vary on how much global biodiversity occurs on IPLC lands (176), it is substantial and often concentrated in areas vulnerable to development, as illustrated in our East Africa case study (SI1). Stewardship is shaped by cultural heritage and historical diasporas: place-based cultures often retain strong ecological knowledge, while those shaped by war, migration, or displacement may have more mixed incentives and understanding. Local stakeholders are typically best positioned to define success factors, identify challenges, and prioritize opportunities, while distant investors often overlook critical local dynamics. Equitable benefit-sharing is critical. In Kenyan conservancies (SI3), payments linked to measured biodiversity outcomes are distributed directly to landowners, providing a model for equitable benefit-sharing tied to conservation outcomes. As biodiversity valuation creates new revenue streams, the majority of benefits need to reach community members directly. Experiences in voluntary carbon markets show that benefits may be captured by leaders or allocated to community assets without adequate consultation (175). Guyana's Low Carbon Development Strategy (LCDS) illustrates a people-first approach, directing carbon credit revenues to Indigenous and local communities; in 2023, 15% of revenues were transferred directly to villages (177, 178). Finally, engagement must include a rigorous, free, prior and informed consent (FPIC) process (179) to build trust, enable equitable benefit-sharing, and support the long-term success of stewardship initiatives. Ultimately, a critical disconnect remains, and solutions are falling short. Saving the critical dimensions of biodiversity requires new thinking.

CONCLUSIONS

Biodiversity loss poses growing risks to human well-being, ecological resilience, and business prosperity. Positive examples that provide templates for solutions exist somewhere on Earth, they just have not been consolidated or scaled sufficiently to create a nature-positive future. Three steps are critical to bend the curve in biodiversity loss:

First, accurate biodiversity monitoring at appropriate scales is a prerequisite to nature-positive action. As a consequence of major technological advances in biodiversity monitoring, we are on the verge of being able to scale up biodiversity measurements to large spatial extents. While monitoring biodiversity across scales is feasible and can provide critical information to help businesses and improve policy, no single metric of biodiversity can capture the complexity of nature, such that multiple context-specific measures are needed. Second, there is a need to close the gap between what scientists measure and what is accessible and relevant to the metrics businesses need. Third, it is critical to align business profitability and nature values, which can be fostered by creating a nature-positive business environment. While biodiversity credits are a much-discussed topic, our view is that they will only work within narrow confines, i.e., trading parcels of the same ecosystem type within an ecoregion or among species of the same narrow branch of the tree of life in a given locality. Stewardship requires changes in policy, pressures and incentives. Our case studies highlight positive cases, but also show that aligning business actions with nature will likely require robust and durable regulations. Creative but different mechanisms may be possible in different places to maintain sufficient habitat (e.g., 180) across the globe. We will need to go “beyond panaceas” to sustain our life support systems (181). If societies recognize their inherent dependence on biodiversity and nature and agree to act, irrespective of their political beliefs, it will require a range of policy and regulatory mechanisms to safeguard land for biodiversity and implement rigorous standards for restoration.

In short, these changes require a collective effort to communicate why biodiversity matters, not just for its utilitarian value, but for its intrinsic and relational value as well. Stakeholders and business leaders alike can help change internal business policies of massive companies to reduce impact. There are many avenues, and the more paths we follow the greater nature-positive impact there will likely be. All of these require information. Aligning business with biodiversity will

require integrating multidimensional biodiversity measurements across biomes, information translation, responsible decision-making within business, and governance, and policy capable of sustaining Earth's life-support systems.

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