Supplemental Information

SI1. Case studies that explain how nature may matter to business or be in conflict with it.

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

Elephants in the Maasai Mara draw ecotourism revenues to local communities. Photo: J. Cavender-Bares

Kenya's savanna ecosystems are home to unique interventions and 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 (1). Nature assets have been created through financial mechanisms that support both people and habitat, and represent a new model for nature stewardship. Nature assets are generated by rigorous biodiversity monitoring, 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.

The majority of Kenyan wildlife lives outside of the national park system. Fortunately, Kenya has a large network of conservancies that protect and steward nature beyond the boundaries of national parks. The Kenyan Wildlife Conservancies Association (KWCA) has more than 180 conservancies as members, covering nearly 10 million hectares, equivalent to 16% of Kenya's total landmass. These conservancies are on private/communal land and represent critical habitats and migration corridors for a vast number of species. Landowners have individual title deeds and can sell for development or extractive purposes if household income is not sufficient.
The Maasai community owns many of these conservancy lands, often bordering or adjacent to internationally recognized national parks such as the Maasai Mara, Amboseli, and Tsavo. Ol Kinyei conservancy encompasses approximately 7,300 ha, and is the oldest conservancy (established in 2005) in the Maasai Mara ecosystem. The International Union for Conservation of Nature (IUCN) has awarded Ol Kinyei conservancy Green List status – one of only three sites in Kenya. Ol Kinyei is a keystone corridor for the wildebeest migration from the Maasai Mara to the Loita Plans (Loita migration) and has the highest lion densities in the Mara.

The Maasai are pastoralists and graze cattle alongside wildlife. The local community (over 150 households) in Ol Kinyei receives ecotourism revenue through a long term lease with tourism operator Gamewatchers (90% of their employees are from the local community). Revenue from ecotourism can be volatile, and can be cut off completely due to political instability or global pandemic. Community members may come under economic pressure to sell their land for short term gain, but thereby lose connection to their heritage and culture. Buyers typically convert the land to unsustainable agriculture and/or erect fences, which prevent migratory species from accessing traditional corridors. Unlocking additional payments for ecosystem services is paramount for ongoing conservation of these landscapes, and the biodiversity and human communities they support.

Ol Kinyei Conservancy has partnered with the for-profit company EarthAcre to develop nature assets that generate payments for biodiversity stewardship and restoration. EarthAcre measures the impact of on-the-ground interventions using a combination of LiDAR-based biodiversity capacity assessments, camera traps, acoustic monitoring, and Indigenous-led bird surveys. Interventions include reducing human–wildlife conflict, removing fences, training rangers, and eliminating invasive species. Biodiversity capacity (discussed in Section 2.1) is monitored continuously to track progress in nature stewardship and to provide a shared framework for funders, project developers, and the local community.

Novel and scalable measures of structural complexity have been linked to bird and mammalian diversity (2-4). Movement patterns of large mammals are tracked via camera traps and acoustic monitoring devices enabling modeling of population levels. Measurement data aid in the management of herbivores (via land conservation) for the benefit of the ecotourism industry while maintaining pastoral savannas for cattle grazing. Acoustic monitoring has been used to verify the presence of specific mammalian, bird, and insect species, ensuring pollinator abundance for crops. Monitoring cattle grazing conditions have enabled community-level rotational grazing to avoid desertification from over grazing, unlocking payments for soil carbon sequestration via carbon credits.

Nature assets generated through these measures are issued over a ten-year protection period and are renewable. More than two-thirds (70%) of the revenue from their sale is distributed directly to community members (landowners) and intervention coordinators, with all payments digitally traceable. Buyers of these nature assets include corporations, philanthropies, and individuals seeking to demonstrate leadership in conservation.

LiDAR measurements coupled with ground surveys of biodiversity help ensure payments for ecosystem services to local communities. Photo Andrew Davies

Written by Mark Tracy and Andrew Davies

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

The Fynbos biome, a biodiversity hotspot in the Western Cape of South Africa, included in intensive biodiversity monitoring campaigns aimed at scaling up biodiversity information through hyperspectral remote sensing on aircraft. Photo: J. Cavender-Bares

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 at the time led to a cabinet decision by the newly formed post-apartheid government to block proposed strip mining of St Lucia's dunes and instead protect biodiversity and promote sustainable development and conservation (5). 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 impoverished, forming part of the former Transkei Bantustan, 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 (6) while mining activities cannot begin without the free, full, prior, and informed consent of the local custodians (7, 8). Effectively, the Court recognized the right of local communities to say "no" to exploitive forms of development (9). 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.

Biodiversity monitoring is contributing to nature-positive outcomes. South Africa has invested heavily biodiversity monitoring, including the National Biodiversity Assessment (10, 11), 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 (12). 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 (13). 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.

Written by Andrew Davies and Jeannine Cavender-Bares

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

The Quabbin reservoir in Central Massachusetts, New England, US, provides drinking water to most of the state. Surrounding forests are preserved to safeguard water quality. Photo: J. Cavender-Bares

The recovering forests and waterways of New England are a compelling example of ecological resilience following extensive land-use change, where benefits of nature are locked in by public-private conservation initiatives that align with international biodiversity targets. At the same time, recovering forests are currently threatened by invasive pests, pathogens, and unintended consequences of renewable energy subsidies.

The historical context. At the time of European settlement in the 17th century, New England was largely forested, shaped by Indigenous land management practices that included selective clearing, burning, and cultivation (14-16). Over the next two centuries, settlers cleared most of southern and central New England for agriculture, pasture, fuelwood, and timber, reducing forest cover in some areas below 30–40% (17, 18). Residual forests and woodlots, especially in steep terrain, remained important refugia for biodiversity (19).

Rivers, central to economic development, were heavily modified by mills, logging, pollution, and dam construction, degrading water quality and fragmenting river systems. These changes contributed to the collapse of migratory fish such as Atlantic salmon and river herring (20), impacting local livelihoods.

Recovery. In the mid- to late 1800s, agriculture declined as farmers moved westward and industrialization concentrated populations in cities. Abandoned farmland regenerated naturally due to minimal soil degradation and sufficient intact forests that served as seed sources and wildlife refuges. By the 20th century, forest cover rebounded to roughly 75–80% in some states (21, 22). These secondary forests now provide critical habitat that supports biodiversity, sequester carbon (23, 24), filter water, improve air quality and public health (25), and provide timber, recreation, and other ecosystem services (26, 27).

Water quality has also improved since the mid-20th century due to the Clean Water Act and state regulations. Dam removals have accelerated (28),(29), improving connectivity and fish passage (30). While Atlantic salmon remain endangered, species such as striped bass and river herring have locally recovered (20).

Ecosystem service benefits. Protected watersheds like the Quabbin Reservoir maintain drinking water quality for the state, avoiding costly filtration infrastructure (31). Tourism, including fall foliage, generates significant regional revenue (32). Healthy ecosystems help sustain maple trees for syrup production and pollinators for fruit trees that contribute to livelihoods in rural regions. Forest recovery has also restored habitat for many wildlife species and insect populations, critical for pollination. Collectively, these ecosystem services underpin economic activity, reduce public health costs, and contribute to climate mitigation and carbon management strategies (24).

Despite the widespread ecological recovery, it has been uneven and incomplete. Some biodiversity losses are irreversible, including extirpation of species like the passenger pigeon and large carnivores (15). High deer populations now alter regeneration and forest structure (33).

Emerging threats. New challenges continue to emerge. Waves of invasive forest pests and pathogens have eliminated or severely reduced once-dominant tree species such as American Chestnut, American Elm, Ash, American Beech, and Eastern Hemlock (34, 35). Renewable energy policies, including solar subsidies, can incentivize forest clearing, creating tensions between decarbonization, biodiversity conservation, and ecosystem services (36). Land-use decisions increasingly require balancing carbon storage, habitat protection, water quality, and energy production under ongoing global change (37).

Conservation policies. State policy and public-private funding mechanisms like the MassAudubon Catalyst Fund helps to lock in the ecosystem service benefits of forest recovery (38). Massachusetts under Executive Order 618 has developed 30x30 and 40x50 targets to set aside land for conservation. The continued recovery and climate regulation benefits of New England Forests and waterways depend on aligning climate and biodiversity goals, and on combatting the disease and stress threats to forests.

Biodiversity monitoring. Management of forests can be aided by rapid and accurate remote sensing tools in partnership with land managers and government agencies (39). Eddy covariance flux towers at Harvard Forest and across NEON track carbon exchange over decades, telling us whether forests remain net carbon sinks (40-43), while long-term experiments clarify drivers of change (44). Forest inventories and ecosystem monitoring are therefore essential for guiding decisions on carbon management, biodiversity conservation, and siting of renewable energy infrastructure (24, 36). Pollinator surveys help to understand and maintain pollinators, essential to fruit tree production in New England, including crops such as apples, plums, and cherries (45).

The New England case illustrates how biodiversity recovery provides a foundation for economic resilience, where measurement and monitoring aid the alignment of policy and business decisions with human values on nature.

Written by Jeannine Cavender-Bares and Mark Tracy

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 Boundary Waters Canoe Area (BWCA), a vast and pristine wilderness region in northern Minnesota, US. Photo by Raymond Gehman, National Geographic

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. The BWCA is a complex mosaic of pristine boreal forests, bogs, and interconnected glacial lakes. It provides critical habitat for diverse wildlife, including one of the largest populations of gray wolves in the contiguous U.S., Canada lynx, black bears, and moose. The region is a globally important area for birds, hosting over 163 nesting species such as bald eagles, ospreys, loons, and various hawks and owls.

The BWCA and surrounding national forests are of tremendous value for recreation and tourism (46), which supports the jobs of outfitters and guides in addition to jobs in restaurants, hotels, cabins, and campgrounds. Many residents of the Arrowhead region choose to live there because of its natural beauty. These homeowners contribute to property values, the building industry, and related service support sectors. In addition to benefits that can be quantified in terms of market values, there are myriad benefits related to the existence of this pristine wilderness region, spiritual value connected to its beauty, history and indigenous connections, clean water for downstream use, carbon storage in forest trees and soils, complex habitat that supports a wide array of species, including moose, bears, wolves, lynx, and numerous birds, like eagles, hawks, owls.

Benefits of copper-nickel mining result primarily from the value of the mining operation, jobs for people who work in the mines, and the cultural and identity benefits of working in the mine (mining culture). Pro-mining groups assert that mining could be done in ways that are "safe" for the environment and not have a tradeoff with the benefits of the BWCA. However, environmentalists and recreation groups point to evidence from past mining operations asserting that mining inevitably leads to pollution and will cause irreparable harm to the BWCA. Even with environmental damages, it is hard to see how environmental concerns, consumer sentiment or arguments about damages to ecosystem services would convince mining companies or miners to stop mining operations.

Federal policy on whether to allow mining in the watershed of the BWCA has swung back and forth depending on which party controls the Executive Branch and Congress. In 2016, the Obama Administration initiated a temporary mining ban and did not renew mining leases. 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.

The fate of mining in the BWCA watershed rests on government policy. Federal policy is one important element, but the state of Minnesota controls permits for air and water quality and mine operations. Will the state government allow the mine or prohibit the mine? The mining company is strongly in favor of mining with a profit motive not swayed by biodiversity value, and it is hard to see how consumer sentiment or material arguments would hold sway here. Short-term profits from mining would largely benefit offshore financiers and lead to loss of the benefits from biodiversity and pristine nature forever. In a polarized political climate that leads to major swings in policy support, protection of this incredibly high biodiversity region is far from certain.

Written by Stephen Polasky

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

Appalachian landscapes are heterogeneous in their recovery from mining and land-use change from agriculture. Non-timber forest products, like ginseng, golden seal, pawpaws and mushrooms can be sustained in forests with high biodiversity. Local community wellness is supported by resilient ecosystems while the costs of recovering the most damaged areas remain. Photos: S. Davis.

Sustaining biodiversity in Appalachia increasingly depends on benefit sharing that aligns ecosystem recovery with local livelihoods. As the region recovers from a legacy of mining and resource extraction, some communities are 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 and reinforcing cultural ties to the land.

The Appalachian region spans 131 million acres across 13 states and is over 65% forested (47). This ecosystem hosts some of the most biodiverse temperate forests globally and is home to a range of rural human communities. Despite severe degradation from logging, agriculture, and coal mining in the early 20th century, policy interventions such as the Resource Conservation and Recovery Act (RCRA, 1976) and the Surface Mining Control and Reclamation Act (SMCRA, 1977) enabled land reclamation and forest regrowth. The return of functional biodiversity now underpins ecosystem resilience and contributes to improving environmental quality and human health.

In some cases, aquatic systems that once supported little or no life due to a lack of dissolved oxygen and acid mine drainage now host a greater diversity of organisms, from benthic macroinvertebrates to fish and amphibians. Soil systems are also recovering, with biodiverse microorganisms supporting nutrient cycling and water filtration, while wetland restoration under the Clean Water Act enhances functional diversity across the landscape. These improvements in water and soil systems provide direct benefits for communities and reduce environmental remediation costs in the future. In other cases, the impacts of mining are still evident and ecosystems remain impaired with costly reclamation still required. The value of maintaining biodiversity for reducing the cost of ongoing remediation cannot be understated.

Ecological recovery coincides with a transition away from extractive economies. Following declines in coal and timber, both community partnership and recent federal investments (e.g., Inflation Reduction Act) supported diversified rural development and networks of small businesses (48, 49). These emerging economies depend on healthy ecosystems, with sectors such as recreation, tourism, and non-timber forest products (NTFPs) relying directly on biodiversity. However, tensions remain, as proposals for renewed large-scale logging, including plans affecting over 112 million acres of National Forest land, threaten biodiversity and the ecosystem services that underpin these new economic pathways.

Forests in Appalachia are therefore both ecological and economic assets, supporting recreation, biodiversity, and a range of market and non-market benefits. Nontimber forest products such as ginseng, maple syrup, elderberries, chanterelle mushrooms, ramps, and pawpaws are most abundant in biodiverse, mature forests (50). While individual yields are relatively low compared to monoculture crops, their aggregate value supports local livelihoods and small businesses, particularly in place-based and seasonal economies often underrepresented in conventional market assessments.

The Appalachian region is an overlooked biodiversity hotspot (51), particularly for amphibians and birds (52), with significant untapped value in plant diversity and provisioning services. Realizing the full value of biodiversity in these systems depends on improved measurement and valuation. Traditional metrics often overlook dispersed ecosystem services and low-volume, high-diversity products.

Long-term species inventories by NatureServe and the Division of Natural Areas and Preserves in Ohio, for example at Crane Hollow Preserve (804.5 ha), have documented 12,516 species, including 229 plant species across fourteen communities, providing a foundation for linking biodiversity to ecosystem services and local economies. This kind of thriving ecosystem starkly contrasts with the many unreclaimed areas in the surrounding Appalachian Ohio where the ongoing cost to reclaim abandoned mine sites was estimated to be approximately $1.3 billion, adjusted for inflation (53). Scalable and feasible measurement approaches that can help quantify biodiversity at landscape scales and connect it to ecosystem services and economic benefits (54) are critical for informing management, guiding investment and conservation priorities, and enabling more equitable benefit sharing.

As mentioned in the main text, legislation has been critical to the ongoing ecosystem recovery from mining impacts in Appalachia. The Surface Mining Control and Reclamation Act (SMCRA) of 1977 required mining companies to be accountable for damages, and enforcement was made robust through the Office of Surface Mining Reclamation, which set minimum standards for compliance. States have the option to establish more rigorous standards (these vary across the Appalachian region). Prior to this law, mining companies had no responsibility for damage to ecosystems that were destroyed in order to extract coal and other minerals. Permitting and regulations are accomplished by state agencies in most cases with federal oversight. Under the law, mining companies are required to post financial bonds for land reclamation prior to starting a mining operation (55). 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 in some cases (56), the realization of the costs associated with loss and damage of ecosystems led to a decline in mining activity that allowed for some ecosystem recovery over the five decades since SMCRA.

Written by Sarah Davis

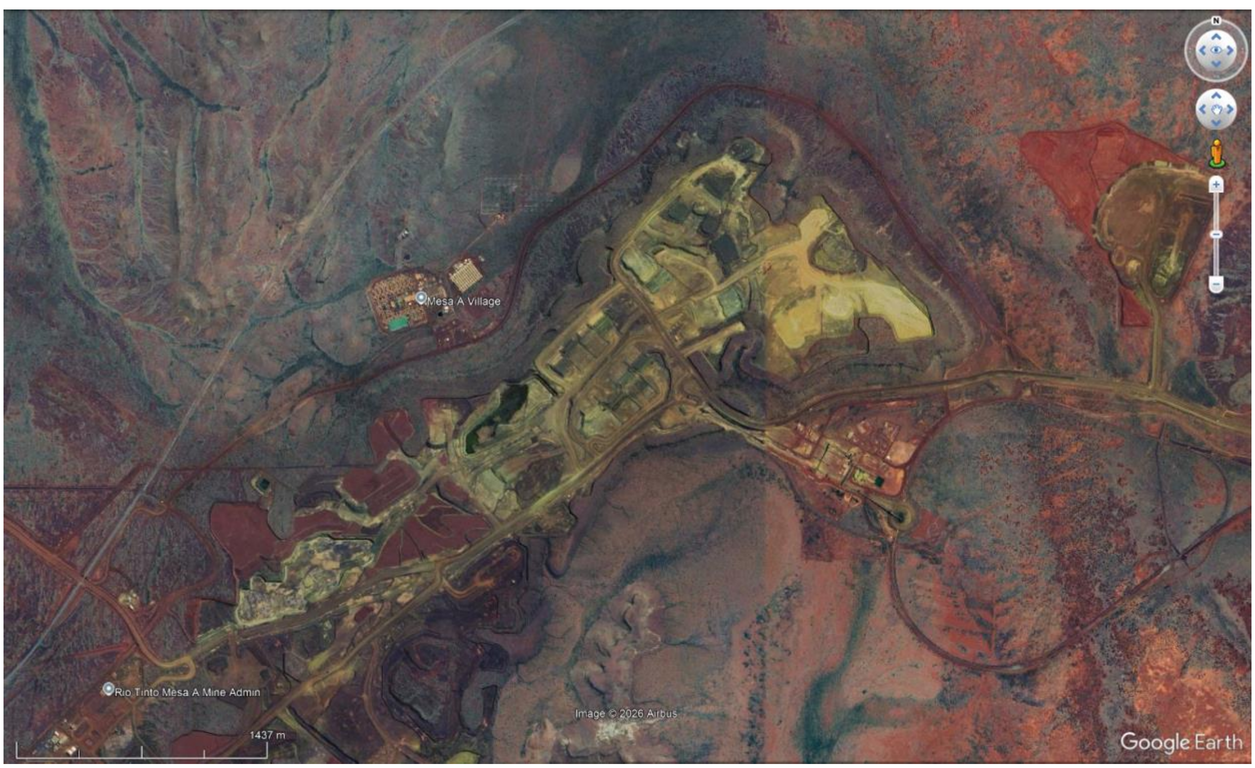
Translating cultural identity with nature to policy in Australia

Image: Stirling Range National Park, Western Australia, shows the characteristic landscape of this floristic and faunistic region, rich in short-range endemics and therefore of conservation importance. These were the hunting grounds of various groups of Indigenous Australians. Photo: G. Giribet

Australia's strong cultural and relational values toward biodiversity, which are rooted in national identity, First Nations heritage, and economic reliance on natural systems, have coexisted with extensive land clearing, agricultural degradation, salinity, invasive species and habitat loss. Nature values are embedded in robust legal frameworks like the Environmental Protection and Biodiversity Conservation Act of 1999 (EPBC), implemented in 2000, and various State-based legislations that require strict environmental assessments, particularly for extractive industries (57). These comprehensive legal frameworks have helped position the country to have comparatively strong environmental institutions, extensive protected-area networks and internationally significant Indigenous-led conservation programs (58), despite a history of land degradation and biodiversity loss. Scientific surveys of biodiversity conducted under these policies have helped to identify areas where mining should not be allowed and have led to practices that involve negotiation among governments, industry, scientists, Traditional Owners, conservation groups and local communities to identify acceptable mining sites and conditions. Paradoxically, mining-related surveys have driven important scientific discoveries, especially in overlooked ecosystems like groundwater habitats difficult to access yet rich in unique biodiversity (59).

The EPBC Act and regulations are Australia's main national environmental legislation (60). They provide a way to protect and manage nationally and internationally important plants, animals, habitats and places (https://www.dcceew.gov.au/environment/epbc). These regulations have provided invaluable resources to study the groundwater environment (e.g.,61), especially in areas with extensive sampling of fractured rock and pisolites associated with mining surveys revealing high troglofaunal diversity (62). Despite being the largest unfrozen freshwater resource, in a period of depletion by extraction and pollution, groundwater environments have been repeatedly overlooked in global biodiversity conservation agendas (63), but paradoxically, this fauna is best known in Australia in areas where mining surveys have allowed access to such groundwaters. Discovery of this diversity is nonetheless posing challenging issues for proponents and regulators of mineral development (59).

This reached the international scene in 2007, when Western Australia's Environmental Protection Authority (EPA) rejected the proposal by Robe River, a unit of mining giant Rio Tinto, to develop an iron ore mine near Pannawonica in the Pilbara region due to the presence of new endemic troglobitic arachnids. The rejection made news headlines with phrases such as this "blind spider-like animal has stopped development of a multi-billion-dollar iron ore mine". Outcomes that favor biodiversity suggest that public pressure can influence the balance between extractive uses of nature and intrinsic or relational perspectives, and can shape political decisions that support environmental protection, affecting companies' social license to operate and long-term access to natural resources.



The 2007 dispute centered on Mesa A in the Robe River valley near Pannawonica. The WA EPA rejected an application by Robe River Mining Company (at the time a subsidiary of RioTinto) to mine the bulk of Mesa A citing biodiversity values (endemic troglofaunal species) and heritage values (from memory, various artefacts from First Nations people). Robe River Mining Company *submitted revised plans which reduced the amount of the mesa to be mined, with a greater proportion left for biodiversity and cultural conservation. This is what it looked like in March 2024 taken from Google Earth. Most of the mesa has been mined.*

Written by Gonzalo Giribet (edited by Jeannine Cavender-Bares)

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SI2. Measuring biodiversity

Phylogenetic measures of biodiversity

In an era where we are rapidly losing species–sometimes right before our eyes–safeguarding Earth's evolutionary heritage requires a focus on maintaining all branches of the tree of life (64). As we lose individual species, is it still possible to maintain the lineage (or branch) that includes their close relatives? Doing so may allow us to save most of the genomic innovations that have been generated through 3.9 billions of years of evolution. Considering the breadth of species across the tree of life provides a means to account for our evolutionary heritage (65-67).

Phylogenetic measures of biodiversity report the evolutionary distance between species in an area. Given two ecosystems with the same total area and the same number of species, phylogenetic diversity (PD) will be higher in the one with greater evolutionary distances among species. The concept was proposed in the context of making choices for protecting biodiversity, and later for quantifying biodiversity (68, 69). PD metrics have been applied to conservation planning in the Cape Floristic Region, where taxon richness is decoupled from PD (70).

Functional measures of biodiversity

Functional diversity captures variation related to how organisms use resources, tolerate stress and interact with each other, with vast consequences for how ecosystems function (e.g., 71, 72). For example, some plants form partnerships with bacteria that can fix nitrogen from the atmosphere and thereby increase nitrogen inputs into the soil; others have deep roots that can access groundwater and maintain water movement through the ecosystem during drought. Greater functional variation within ecological communities enhances the capture of resources and cycling through ecosystems, often resulting in higher productivity and greater ecosystem stability and resilience in the face of disturbance. Diversity of functional traits is correlated with sustained provisioning, regulating, and cultural ecosystem services (e.g.,73). Diversity of trophic guilds–organisms that use environmental resources in a similar way–determines energetic balances and nutrient cycling dynamics. Characteristics that define functional guilds or functional groups and their relevance to overall ecosystem health have been defined for plant (e.g.,73)), animal (e.g.,74), and microbial communities (e.g.,75, 76). Indicator species that play key functional roles can also be monitored to assess ecosystem health (77).

Abundance and biomass

Within an ecosystem, some species dominate while others are rare, tiny, and/or difficult to spot. For example, a massive collecting effort focusing on molluscs (the second largest animal phylum) involving 400 person-days at 42 discrete stations on a 295-km^2 site on the west coast of New Caledonia, revealed 2,738 species of marine molluscs, several times more species than had previously been recorded from any area of comparable extent anywhere in the world. Habitat heterogeneity was pronounced, with 32% of the species collected at a single station and 20% represented by a single specimen, demonstrating that rare species make up a considerable proportion of the sampled fauna (78). Counting the abundance, or relative number of each species, in an ecosystem or biome is important to understanding the evenness of diversity (79, 80).

Measuring the mass of living organisms is a related measure. A mass-based approach essentially quantifies the proportion of the sun's energy that is fixed from the sun through photosynthesis in carbon molecules that make up about half of the dry biomass of every organism. At the global scale, approaches that emphasize biomass reveal how human activity has disproportionately harnessed carbon for humans and domesticated species at the expense of wild biodiversity (81). Strikingly, only 5% of total mammalian biomass on Earth is composed of wild animals; the remaining 95% is attributed to humans, their livestock and their pets (82, 83). Such approaches also reveal that the total mass of human-made materials now exceeds the total biomass of all living organisms on Earth (84).

Population size and genetic diversity

Population size, or the number of individuals in a species—whose distribution may include multiple populations that span many ecosystems—is a key determinant of population persistence through time. It is an indicator of reproductive potential linked to the ability to find mates and is associated with genetic diversity (85, 86, but see 87). Genetic diversity arises from mutation and is maintained and reshuffled within interbreeding populations through recombination, generating further variation. This diversity represents the adaptive capacity of populations to evolve in response to novel conditions and changing environments. The population size of species provides a useful, if imperfect, proxy to capture potential genetic diversity. Additional measures that directly quantify molecular variation within and among geographically distributed populations (88, 89), or assess genetically-based functional trait variation in common gardens of individuals drawn from different populations (90), can reveal whether populations harbor sufficient genetic variation to avoid inbreeding depression and to adapt to change (91). Given that species are comprised of multiple, often locally adapted populations (92), local abundances are also relevant to understanding persistence and adaptive capacity.

Ecosystem attributes—extent, structure, function, and connectivity

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. The structural complexity of ecosystems is tightly linked to habitat for birds, insects, mammals and other organisms and is broadly predictive of biodiversity (93), 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 (94-97). Capturing ecosystem intactness often depends on comparison to a baseline state and measurement of the health of organisms within the ecosystem (98, 99). These measures are related to the capacity of ecosystems to support complex species interactions and to maintain critical ecosystem functions.

SI3 The relevance of Indigenous peoples and local communities (IPLC's)

Interventions that benefit, and are equitable toward indigenous peoples and local communities (IPLC's) are likely to be more enduring and effective over the long term than those that ignore these considerations (100, 101). The discussion that follows highlights some of the issues and concerns. In the right type of nature preservation project, there is a potential double bottom line for enlightened companies that wish to protect nature while also benefitting IPLC's for a project with potential environmental justice benefits.

Communities that are most intimately dependent on biodiversity often lack the financial and political influence that communities in urban and low-biodiversity geographies enjoy. This is due, in part, to population density, but it is also a result of differences in cultural valuation. For some communities residing in biodiversity hotspots, culture is closely related to their native ecosystem. In other cases, these communities may have a wide range of perspectives on the value of biodiversity versus other forms of wealth.

Many places with high biodiversity, including the Appalachian region of the eastern US and the Boundary Waters Canoe Area in northern Minnesota, US, have communities that formed from historical diasporas. While there is a period of relearning and reconnecting with nature that occurs following diaspora, over many generations the perceived value of biodiversity changes. There is intermingling of cultural values due to immigration to these regions that varies over time.

The private sector, philanthropists, governments, indigenous and local communities, landholders of all backgrounds, and taxpayers will have contrasting perspectives on whether and why nature and biodiversity matter. Both Indigenous philosophies of reciprocity and corporate perspectives on stewardship suggest a responsibility for humans, as a keystone species, to restore and protect biodiversity. Redirecting financial resources to support land stewards engaged in biodiversity-friendly livelihoods, such as sustainable pastoralism or non-timber forest product harvesting holds promise.

Stewardship depends on the context of cultural heritage and diaspora. A culture rooted in place will have rich traditional knowledge about the value of biodiversity and how to steward it, while cultures reformed after war/migration/displacement may have a mixture of incentives and understanding about biodiversity values.

Working with local communities

A range of values may exist within any given community. Land use legacies, migration, land ownership and rights, prior economic development, and capacity to monitor ecosystem health all influence the efficacy of a financial market for biodiversity. Local community stakeholders are usually in the best position to define the factors that will lead to success of biodiversity efforts, identify challenges, and prioritize opportunities. While outside investment may be necessary to establish a financial market, distant investors that become key stakeholders are often not cognizant of the local dynamics that are most important for their success. Financial valuation of biodiversity will be more effective if it incorporates social metrics that can be flexibly defined with input from the communities themselves.

Working with indigenous peoples and local communities (IPLC's) to steward, protect, and restore biodiversity is critical, and comes with unique opportunities and challenges. IPLC's have an intimate understanding of the environment they have come to inhabit, in some cases, for thousands of years, making IPLC representation critical to the measurement, conservation, and stewardship of ecosystem services. Though there is debate over the amount of the world's remaining biodiversity found on IPLC lands (102), it is unquestionably significant, and often located in regions most vulnerable to development.

Initiatives such as Guyana's Low Carbon Development Strategy (LCDS)—in a country that is over 90% forested and ranks among the highest globally in forest cover—demonstrate a people-first approach by directing a share of carbon credit revenues to Indigenous and local communities, including through direct transfers to villages (103). According to the Minister of Amerindian Affairs, in 2023, 15% of revenues earned from the sale of carbon credits were transferred directly to Indigenous and hinterland villages (104).

IPLC's frequently hold land communally which further complicates biodiversity stewardship. In some cases (Kenyan case study) community members hold individual title to their own parcel(s) of land that is recognized and documented through national authority. However in other geographies there may be limited or no documentation for communal land ownership. Alternatively IPLC's may hold a single title deed, but no additional documentation for how ecosystem services or other revenue generating activities (like ecotourism) are shared with community members.

Given the challenges of documenting land ownership, the sharing of benefits deserves particular attention when discussing valuing ecosystem services provided by nature. As new measurements of biodiversity potentially unlock new revenue streams for IPLC's, it is critical that the supermajority of those benefits reach the individuals in that community equitably. The voluntary carbon market has provided a number of examples of alleged IPLC benefits, but upon further inspection, these benefits have often stopped with a single community leader, or development of community wide assets without consultation of actual need (101).

Finally, as part of any IPLC engagement, parties should conduct a diligent, free, prior, and informed consent (FPIC) process (105). FPIC should be documented through multiple mediums, conducted both in written and oral form, and in clear and appropriate language(s) for the communities in question. The FPIC documentation should be auditable, and document recognizable evidence of consent. A rigorous FPIC process sets the stage for ongoing communication and builds trust and understanding to allow for equitable benefit sharing and the long term permanence of stewardship programs.

Supplement Literature Cited

1. K. Bakker, *The Sounds of Life: How Digital Technology Is Bringing Us Closer to the Worlds of Animals and Plants* (Princeton University Press, Princeton, USA, 2022), pp. 368
2. A. B. Davies, G. P. Asner, Advances in animal ecology from 3D-LiDAR ecosystem mapping. *Trends in Ecology & Evolution* **29**, 681-691 (2014).
3. D. Luther *et al.*, Satellite-based forest structure metrics as a predictive tool for biodiversity in hyperdiverse tropical forests: A test of the habitat heterogeneity hypothesis in the tropics. *Environmental and Sustainability Indicators* **30**, 101212 (2026).
4. A. St Rose, K. Naithani, Unraveling the Influence of Structural Complexity, Environmental, and Geographic Factors on Multi-Trophic Biodiversity in Forested Landscapes. *Ecol Evol* **15**, e70907 (2025).
5. F. I. V. W. B. W. W. A. v. B. Kruger, T. G. T.****, Sustainable development and the environment: lessons from the St Lucia Environmental Impact Assessment. *South African Journal of Science* **93**, 23-33 (1997).
6. S. Bega (2026) 'People over profits': Constitutional Court deals blow to Shell's Wild Coast plans. in *Mail & Guardian: Africa's Better Future* (NewsTeam, Johannesburg, South Africa), pp https://mg.co.za/the-green-guardian/2026-2008-2014-people-over-profits-constitutional-court-deals-blow-to-shell-s-wild-coast-plans/.
7. T. Maphanga, K. Shale, B. Gqomfa, V. M. Zungu, The state of public participation in the EIA process and its role in South Africa: a case of Xolobeni. *South African Geographical Journal* **105**, 277-305 (2023).
8. H. Healy, Struggle for the sands of Xolobeni – From post-colonial environmental injustice to crisis of democracy. *Geoforum* **133**, 128-139 (2022).
9. D. Huizenga, Governing territory in conditions of legal pluralism: Living law and free, prior, and informed consent (FPIC) in Xolobeni, South Africa. *The Extractive Industries and Society* **6**, 711-721 (2019).
10. South African National Biodiversity Institute (SANBI) (2025) National Biodiversity Assessment 2025: The status of South Africa's biodiversity - Website. . (Pretoria).
11. A. L. Skowno *et al.* (2025) National Biodiversity Assessment 2025: The status of South Africa's biodiversity. Summary of Findings and Key Messages. (Pretoria).
12. S. Holness *et al.*, Bridging the research–implementation gap: Mainstreaming biodiversity into the South African mining sector. *Bothalia* **48** (2018).
13. A. W. Cardoso *et al.*, BioSCape combines local knowledge and remote-sensing technology for inclusive biodiversity science. *Nature Reviews Biodiversity* **1**, 2-4 (2025).
14. J. L. Fuller, D. R. Foster, J. S. McLachlan, N. Drake, Impact of Human Activity on Regional Forest Composition and Dynamics in Central New England. *Ecosystems* **1**, 76-95 (1998).
15. W. Cronon, *Changes in the Land: Indians, Colonists, and the Ecology of New England* (Hill and Wang, New York, 1983).
16. D. R. Foster, *Wildlands in New England: Past, present, and future* (Harvard Forest, 2023).
17. D. R. Foster, Land-Use History (1730-1990) and Vegetation Dynamics in Central New England, USA. *Journal of Ecology* **80**, 753–771 (1992).
18. B. Hall, G. Motzkin, D. R. Foster, M. Syfert, J. Burk, Three hundred years of forest and land-use change in Massachusetts, USA. *Journal of Biogeography* **29**, 1319-1335 (2002).
19. D. R. Foster, Thoreau's country: a historical–ecological perspective on conservation in the New England landscape. *Journal of Biogeography* **29**, 1537-1555 (2002).
20. K. E. Limburg, J. R. Waldman, Dramatic Declines in North Atlantic Diadromous Fishes. *BioScience* **59**, 955-965 (2009).

21. D. Foster *et al.*, "The environmental and human history of New England" in Forests in time. (Yale University Press, New Haven, 2004), pp. 43-100.
22. J. Thompson, D. Carpenter, C. Cogbill, D. Foster, Four centuries of change in northeastern United States forests. *PLoS ONE* **8** (2013).
23. W. S. Keeton, A. A. Whitman, G. C. McGee, C. L. Goodale, Late-Successional Biomass Development in Northern Hardwood-Conifer Forests of the Northeastern United States. *Forest Science* **57**, 489-505 (2011).
24. o. R. Thompson *et al.* (2025) Forest Carbon Study: The Impact of Alternative Land-Use Scenarios on Terrestrial Carbon Storage and Sequestration in Massachusetts. (Massachusetts Executive Office of Energy and Environmental Affairs, Massachusetts).
25. D. J. Nowak, S. Hirabayashi, A. Bodine, E. Greenfield, Tree and forest effects on air quality and human health in the United States. *Environmental pollution (Barking, Essex : 1987)* **193**, 119-129 (2014).
26. D. Foster *et al.*, The importance of land-use legacies to ecology and conservation. *BioScience* **53**, 77-88 (2003).
27. A. W. D'Amato, D. A. Orwig, D. R. Foster, The influence of succesional processes and disturbance on the structure of Tsuga canadensis forests. *Ecological Applications* **18**, 1182-1199 (2008).
28. J. R. Waldman, T. P. Quinn, North American diadromous fishes: Drivers of decline and potential for recovery in the Anthropocene. *Science Advances* **8**, eabl5486 (2022).
29. T. Guilfoos, J. Walsh, A hedonic study of New England dam removals. *Ecological Economics* **203**, 107624 (2023).
30. F. J. Magilligan *et al.*, River restoration by dam removal: Enhancing connectivity at watershed scales. *Elementa* **4**, 000108 (2016).
31. E. Elias *et al.*, The public water supply protection value of forests: A watershed-scale ecosystem services analysis based upon total organic carbon. *Open Journal of Ecology* **4**, 517-531 (2014).
32. S. Tannenbaum (2024) Fall foliage is a big boost for the New England Economy: By the numbers. in *Boston Globe* (Boston Globe, Boston, Massachusetts).
33. S. D. Côté, T. P. Rooney, J.-P. Tremblay, C. Dussault, D. M. Waller, Ecological Impacts of Deer Overabundance. *Annual Review of Ecology, Evolution, and Systematics* **35**, 113-147 (2004).
34. D. A. Orwig, D. R. Foster, Forest Response to the Introduced Hemlock Woolly Adelgid in Southern New England, USA. *Journal of the Torrey Botanical Society* **125**, 60-73 (1998).
35. A. M. Ellison *et al.*, Loss of foundation species: consequences for the structure and dynamics of forested ecosystems. *Frontiers in Ecology and the Environment* **3**, 479-486 (2005).
36. M. Manion *et al.* (2023) Growing Solar, Protecting Nature Mass Audubon and Harvard Forest
37. W. J. Wang, H. S. He, F. R. Thompson, J. S. Fraser, W. D. Dijak, Changes in forest biomass and tree species distribution under climate change in the northeastern United States. *Landscape Ecology* **32**, 1399-1413 (2017).
38. Mass Audubon (2025) One Year Later: 30x30 Catalyst Fund. (Mass Audubon).
39. J. A. Guzmán *et al.*, Mapping oak wilt disease from space using land surface phenology. *Remote Sensing of Environment* **298**, 113794 (2023).
40. J. Xiao *et al.*, Estimation of net ecosystem carbon exchange for the conterminous United States by combining MODIS and AmeriFlux data. *Agricultural and Forest Meteorology* **148**, 1827-1847 (2008).
41. M. A. Giasson *et al.*, Soil respiration in a northeastern US temperate forest: a 22-year synthesis. *Ecosphere* **4**, art140 (2013).
42. M. Graham MacLean *et al.*, Forest carbon trajectories: Consequences of alternative land-use scenarios in New England. *Global Environmental Change* **69**, 102310 (2021).
43. A. C. Finzi *et al.*, Carbon budget of the Harvard Forest Long-Term Ecological Research site: pattern, process, and response to global change. *Ecological Monographs* **90**, e01423 (2020).
44. C. A. Bahlai *et al.*, Cascading effects: insights from the U.S. Long Term Ecological Research Network. *Ecosphere* **12**, e03430 (2021).

45. D. Vasiliev, S. Greenwood, Pollinator biodiversity and crop pollination in temperate ecosystems, implications for national pollinator conservation strategies: Mini review. *Science of The Total Environment* **744**, 140880 (2020).
46. T. P. Holmes *et al.*, A Synthesis of the Economic Values of Wilderness. *Journal of Forestry* **114**, 320-328 (2016).
47. A. Appalachian Regional Commission (2014) An Assessment of Natural Assets in the Appalachian Region: Forest Resources. . (Report prepared by Downstream Strategies, West Virginia University, and the National Network of Forest Practitioners, Washington D.C.), p 88.
48. A. L. Ricket, F. B. Knutsen, G. J. Jolley, S. C. Davis, Appalachian social entrepreneurship ecosystem: A framework for rural development. *Community Development* **54**, 315-336 (2023).
49. A. L. Ricket, G. J. Jolley, F. B. Knutsen, S. C. Davis, Rural Sustainable Prosperity: Social Enterprise Ecosystems as a Framework for Sustainable Rural Development. http://dx.doi.org/10.3390/su151411339.
50. G. E. Frey *et al.*, Markets and Market Values of Nontimber Forest Products in the United States: A Review, Synthesis, and Identification of Future Research Needs. *Journal of Forestry* **117**, 613-631 (2019).
51. S. P. Graham, D. A. Steen, K. T. Nelson, A. M. Durso, J. C. Maerz, An Overlooked Hotspot? Rapid Biodiversity Assessment Reveals a Region of Exceptional Herpetofaunal Richness in the Southeastern United States. *Southeastern Naturalist* **9**, 19-34 (2010).
52. R. T. Belote *et al.*, Options for prioritizing sites for biodiversity conservation with implications for "30 by 30". *Biological Conservation* **264**, 109378 (2021).
53. S. K. Mishra, F. J. Hitzhusen, B. L. Sohngen, J. M. Guldmann, Costs of abandoned coal mine reclamation and associated recreation benefits in Ohio. *J Environ Manage* **100**, 52-58 (2012).
54. J. Cavender-Bares *et al.*, Spectral biology across scales in changing environments. *Ecology* **106**, e70078 (2025).
55. J. Skousen, C. E. Zipper, Post-mining policies and practices in the Eastern USA coal region. *International Journal of Coal Science & Technology* **1**, 135-151 (2014).
56. R. M. Yonk, J. T. Smith, A. R. Wardle, Exploring the Policy Implications of the Surface Mining Control and Reclamation Act. http://dx.doi.org/10.3390/resources8010025.
57. G. Bates, Environmental Assessment Australia's New Outlook under the Environment Protection and Biodiversity Conservation Act 1999 (Cth). *Environmental Law Review* **4**, 203-224 (2002).
58. D. o. C. C. Australian Government, Energy, the Environment and Water, Collaborative Australian Protected Areas Database (CAPAD). Australian Government. https://www.dcceew.gov.au/environment/land/nrs/science/capad/2024?utm_source=openai.
59. W. Humphreys, Rising from Down Under: developments in subterranean biodiversity in Australia from a groundwater fauna perspective. *Invertebrate Systematics* **22**, 85-101 (2008).
60. Australian Government (2026) Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). (Department of Climate Change, Energy, the Environment and Water, Canberra, Australia).
61. R. J. Smith *et al.*, Southern South Australian groundwater microbe diversity. *FEMS Microbiol Ecol* **94** (2018).
62. M. T. Guzik *et al.*, Is the Australian subterranean fauna uniquely diverse? *Invertebrate Systematics* **24**, 407-418 (2011).
63. M. Saccò *et al.*, Groundwater is a hidden global keystone ecosystem. *Global Change Biology* **30**, e17066 (2024).
64. J. N. Pinto-Ledezma, S. Díaz, B. S. Halpern, C. Khoury, J. Cavender-Bares, No branch left behind: tracking terrestrial biodiversity from a phylogenetic completeness perspective. *Frontiers in Ecology and the Environment* **22**, e2696 (2024).
65. D. W. Redding, A. Mooers, Incorporating evolutionary measures into conservation prioritization. *Conserv Biol* **20**, 1670-1678 (2006).

66. N. J. B. Isaac, S. T. Turvey, B. Collen, C. Waterman, J. E. M. Baillie, Mammals on the EDGE: Conservation Priorities Based on Threat and Phylogeny. *PLOS ONE* **2**, e296 (2007).
67. D. P. Faith, EDGE of existence and phylogenetic diversity. *Animal Conservation* **22**, 537-538 (2019).
68. D. P. Faith, Conservation evaluation and phylogenetic diversity. *Biological Conservation* **61**, 1 - 10 (1992).
69. D. P. Faith, C. A. M. Reid, J. Hunter, Integrating phylogenetic diversity, complementarity, and endemism for conservation assessment. *Conservation Biology* **18**, 255-261 (2004).
70. F. Forest *et al.*, Preserving the evolutionary potential of floras in biodiversity hotspots. *Nature* **445**, 757-760 (2007).
71. E. Laliberté, P. Legendre, A distance-based framework for measuring functional diversity from multiple traits. *Ecology* **91**, 299-305 (2010).
72. M. M. Mayfield, M. E. Boni, G. C. Daily, D. Ackerly, Species and functional diversity of native and human-dominated plant communities. *Ecology* **86**, 2365-2372 (2005).
73. E. Waldén, C. Queiroz, J. Plue, R. Lindborg, Biodiversity mitigates trade-offs among species functional traits underpinning multiple ecosystem services. *Ecology Letters* **26**, 929-941 (2023).
74. N. Blaum, E. Mosner, M. Schwager, F. Jeltsch, How functional is functional? Ecological groupings in terrestrial animal ecology: towards an animal functional type approach. *Biodiversity and Conservation* **20**, 2333-2345 (2011).
75. M. Alvarez, A. W. Schrey, C. L. Richards, Ten years of transcriptomics in wild populations: what have we learned about their ecology and evolution? *Molecular Ecology* **24**, 710-725 (2015).
76. C. León-Sobrino, J. B. Ramond, G. Maggs-Kölling, D. A. Cowan, Nutrient Acquisition, Rather Than Stress Response Over Diel Cycles, Drives Microbial Transcription in a Hyper-Arid Namib Desert Soil. *Front Microbiol* **10**, 1054 (2019).
77. V. Carignan, M.-A. Villard, Selecting Indicator Species to Monitor Ecological Integrity: A Review. *Environmental Monitoring and Assessment* **78**, 45-61 (2002).
78. P. Bouchet, P. Lozouet, P. Maestrati, V. Heros, Assessing the magnitude of species richness in tropical marine environments: exceptionally high numbers of molluscs at a New Caledonia site. *Biological Journal of the Linnean Society* **75**, 421-436 (2002).
79. C. E. Shannon, A Mathematical Theory of Communication. *The Bell System Technical Journal* **27**, 379-423 (1948).
80. E. H. Simpson, Measurement of Diversity. *Nature* **163,**, 688 (1949).
81. Y. M. Bar-On, R. Phillips, R. Milo, The biomass distribution on Earth. *Proceedings of the National Academy of Sciences* **115**, 6506-6511 (2018).
82. A. D. Barnosky, Megafauna biomass tradeoff as a driver of Quaternary and future extinctions. *Proceedings of the National Academy of Sciences* **105**, 11543-11548 (2008).
83. L. Greenspoon *et al.*, The global biomass of mammals since 1850. *Nature Communications* **16**, 8338 (2025).
84. E. Elhacham, L. Ben-Uri, J. Grozovski, Y. M. Bar-On, R. Milo, Global human-made mass exceeds all living biomass. *Nature* **588**, 442-444 (2020).
85. R. Frankham, Relationship of Genetic Variation to Population Size in Wildlife. *Conservation Biology* **10**, 1500-1508 (1996).
86. M. T. J. Hague, E. J. Routman, Does population size affect genetic diversity? A test with sympatric lizard species. *Heredity* **116**, 92-98 (2016).
87. B. Charlesworth, J. D. Jensen, How Can We Resolve Lewontin's Paradox? *Genome Biology and Evolution* **14**, evac096 (2022).
88. S. Wright, Genetical Structure of Populations. *Nature* **166**, 247-249 (1950).
89. K. E. Holsinger, B. S. Weir, Genetics in geographically structured populations: defining, estimating and interpreting FST. *Nature Reviews Genetics* **10**, 639-650 (2009).

90. J. R. Etterson, Evolutionary potential of *Chamaecrista fasciculata* in relation to climate change I. Clinal patterns of selection along an environmental gradient in the Great Plains. *Evolution* **58**, 1446-1458 (2004).
91. L. Rea *et al.*, Greater climate change adaptation potential in populations of Quercus macrocarpa at edges of latitudinal gradient. *New Phytologist* **250**, 1313-1329 (2026).
92. J. Hereford, A Quantitative Survey of Local Adaptation and Fitness Trade-Offs. *The American Naturalist* **173**, 579-588 (2009).
93. T. C. Coverdale, A. B. Davies, Unravelling the relationship between plant diversity and vegetation structural complexity: A review and theoretical framework. *Journal of Ecology* **111**, 1378-1395 (2023).
94. D. Tilman, F. Isbell, J. M. Cowles, "Biodiversity and Ecosystem Functioning" in Annual Review of Ecology, Evolution, and Systematics, Vol 45*,* D. J. Futuyma, Ed. (2014), vol. 45, pp. 471-493.
95. M. Jochum *et al.*, The results of biodiversity–ecosystem functioning experiments are realistic. *Nature Ecology & Evolution* **4**, 1485-1494 (2020).
96. P. Hong *et al.*, Biodiversity promotes ecosystem functioning despite environmental change. *Ecology Letters* **25**, 555-569 (2022).
97. X. Liu *et al.*, Ecological insights from three decades of forest biodiversity experiments. *Nature Reviews Biodiversity* **2**, 9-23 (2026).
98. T. Gullison, J. Hardner, S. Anstee, M. Meyer (2015) Good Practices for the Collection of Biodiversity Baseline Data p69.
99. W. Jetz *et al.*, Essential biodiversity variables for mapping and monitoring species populations. *Nature Ecology & Evolution* **3**, 539-551 (2019).
100. IPBES (2019) Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. eds E. Brondizio, S. Diaz, J. Settele, H. T. Ngo (Bonn, Germany).
101. R. J. Howard, A. Tallontire, L. Stringer, R. Marchant, Unraveling the Notion of "Fair Carbon": Key Challenges for Standards Development. *World Development* **70**, 343-356 (2015).
102. Á. Fernández-Llamazares *et al.*, No basis for claim that 80% of biodiversity is found in Indigenous territories. *Nature* **633**, 32-35 (2024).
103. B. Shafeah Oosman (2026) Carbon credit revenues 'putting people first' in hinterland communities —Minister Browne says. in *Guyana Chronicle* (Guyana Chronicle, Guyana).
104. Guyana Department of Public Information, Indigenous Communities to receive GYD $4.725 Billion from Carbon Credit Sales. https://dpi.gov.gy/indigenous-communities-to-receive-gyd-4-725-billion-from-carbon-credit-sales (2023).
105. UN-REDD (2018) Guidelines on Free, Prior and Informed Consent. eds U.-R. Programme, F. a. A. O. o. t. U. Nations, U. E. Programme (UN-REDD Programme, Geneva, Switzerland).