



CLIMATE AND ENVIRONMENT

Biodiversity - A Key Source of Technological Innovation

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Abstract

Biodiversity - the variety of life on Earth – provides a virtually infinite source of inspiration for technological innovation. Thousands of designs and strategies from thousands of unique species and ecosystems are being uncovered and mimicked for applications as diverse as surgery and space exploration. At the same time, however, unique species and ecosystems with unknown potential are being lost at an unprecedented rate due to human activities. G20 members will benefit from valuing biodiversity as an indispensable resource for technology. By fairly and equitably sharing those benefits among their populace, G20 members also set a global precedent for achieving many of the sustainable development goals.



Challenge

Biodiversity is being lost before we can secure its benefits

The term, “biodiversity” was coined in the 1980s but is still widely misunderstood and sometimes misused. Biodiversity is often considered to mean “life on Earth”, but it is fundamentally more than that - it is the *variety* of life on Earth. One key reason for the importance of that variety to economies, is through the potential it offers for technological innovation.

That potential is vast, with an estimated 8,700,000 species on Earth. Almost 7,500,000 of these have, however, not yet been described by scienceⁱ. Among those that have, only a tiny proportion have been studied sufficiently to reveal some of their potential to inform technological innovation. That tiny proportion, nevertheless, represents an enormous variety of species and ecosystems that have inspired more than 13,000 patented designsⁱⁱ.

Over the past five years alone, more than 10,000 peer-reviewed publications presented examples of biodiversity’s contributions to medicine and other technological innovations: the glue produced by a marine worm to build underwater enclosures solved problems with surgical adhesivesⁱⁱⁱ; the high-voltage discharges of electric eels was the design basis for a biocompatible power source for implanted devices such as pacemakers and prosthetics^{iv}; a low-pressure water purification membrane was inspired by the roots of mangrove trees^v; and nanostructures mimicking the surface of butterfly wings have been embedded into currency, credit cards, and pharmaceuticals to prevent counterfeiting^{vi, vii}. From sea urchin-inspired ground samplers that could one day operate on a Mars rover^{viii}, to frog-inspired anti-icing coatings^{ix}, biodiversity stimulates a myriad of innovations across various industries.

While we are discovering these innovation triggers, we are also rapidly losing the genes, species and ecosystems that produce them^{x, xi, xii, xiii, xiv}. Unlike previous “mass extinctions”, this loss is the result of human or human-induced activities, especially land-use change, climate change, pollution, over-exploitation, and invasive alien species^{x, xi, xii, xiii, xiv}. Policy to maximize the amount of biodiversity conserved, requires specific considerations. Special considerations also need to be applied in order to ensure the fair and equitable sharing of the benefits they



offer^{xv}.

Proposal

Proposal 1: G20 members establish inventories, or support existing inventories, of (a) threatened biodiversity and (b) biodiversity for technological innovation; and integrate these two kinds of inventories

Rationale

- Assessment informs planning and policy. Governments need comprehensive and accessible knowledge of the species in their territory, to inform conservation efforts to optimally limit the loss of species and ecosystems.
- Before species are known to science their level of threat is usually unknowable. Many are, therefore, likely being lost before they can be described or their potential harnessed.

Suggestions for implementation

Two kinds of inventories are needed, preferably at the national level: (a) lists of species' threat status; and (b) lists of species that have already inspired innovations or have been identified as having that potential.

The threat status of any species cannot be definitively known until it is assessed. It is, therefore, generally assumed that, among *undescribed* species, the proportion of threatened species is roughly the same as the proportion of *described* threatened species. Of the species that are on the verge of being lost, only an estimated one per cent are currently being monitored, worldwideⁱ. Once threat status is known, Governments are in a better position to take additional measures to prevent extinction. A number of initiatives have been documenting the threat status of species for decades. G20 members can provide or increase support for efforts such as IUCN's Red List of Threatened Species^{xvi}, as well as establishing or supporting such initiatives in their own countries.

Resources such as "AskNature"^{xvii} and "Earth Bank of Codes"^{xviii} have already begun to catalogue the extraordinary breadth of nature's wealth. G20 members



can improve the rate of technological learning from biodiversity by establishing or improving national inventories of genes and species with proven or high potential. This would also encourage the protection of species and ecosystems that harbor such resources as well as opportunities for innovation and access and benefit-sharing agreements.

Proposal 2: G20 members accelerate the mainstreaming of biodiversity across sectors of Government

Rationale

- Policies to protect biodiversity must extend beyond agencies that are dedicated to conservation, in order to be effective, because a variety of sectors have an impact on biodiversity through the way their business is conducted.
- Globally, the United Nations goal of addressing the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society by 2020 is unlikely to be reached^{xix}, despite an increased emphasis on mainstreaming biodiversity across sectors.
- As illustrated in the “challenge” section of this policy brief, various sectors stand to benefit from treating biodiversity as a precious, shared resource that is unique from one country to the next.

Suggestions for implementation

All sectors of Government need to be aware of the value of biodiversity, as illustrated in this policy brief, in addition to existing reports on the status and trends of biodiversity, as presented in reports of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)^{xi,xii,xiii,xiv}. In order to translate that knowledge into practice all sectors, where appropriate, need to integrate biodiversity values into strategies and planning processes, national accounting, and reporting systems; remove or reform incentives harmful to biodiversity and develop positive incentives for the conservation and sustainable use of biodiversity; and keep the impacts of



use of natural resources well within safe ecological limits^{xx}.

The IPBES assessment for Europe and Central Asia^{xiv} suggests a similar set of steps to mainstream biodiversity conservation across sectors: awareness raising of human dependence on biodiversity; the definition of policy objectives; and the creation and implementation of governance approaches and policy mixes.

Proposal 3: G20 members prioritize biodiversity as a criterion for area-based conservation

Rationale

- Protection of species is usually best achieved by conserving the areas inhabited by them.
- Protected areas are expanding worldwide^{xi,xii,xiii,xiv}, yet they still cover only about 15% of the world's land surface, 14% of national waters and 6% of the global ocean^{xxi}. The location and design of protected areas will partly determine the diversity of species and ecosystems that are conserved.
- The majority of the Earth's surface is unlikely to be formally protected. Increased attention, therefore, needs to be paid also to "other effective area-based conservation measures" (OECMs) - geographically defined spaces not recognized as protected areas, which are governed and managed over the long-term in ways that deliver the effective and enduring in-situ conservation of biodiversity, with associated ecosystem services and cultural and spiritual values^{xxii}.

Suggestions for implementation

G20 members are well positioned to set an example through strategic conservation planning that sets biodiversity targets to conserve a minimum set of species and ecosystems within an area. Spatial planning, for whatever purpose, should routinely include information layers on species richness and ecosystem diversity. Some G20 members are already leaders in strategic conservation planning and offer the opportunity for others to take shortcuts to



success in this regard^{xxiii}.

G20 members are encouraged to follow the CBD voluntary guidance on integration of protected areas and other effective area-based conservation measures (OECMs) into land- and seascapes^{xxiv}. These measures include: reviewing national visions, goals and targets; identifying key species, ecosystems and ecological processes; identifying and prioritizing important areas to improve connectivity; conducting a national review of the status and trends of landscape and seascape habitat fragmentation and connectivity for key species, ecosystems and ecological processes; identifying and prioritizing the sectors most responsible for habitat fragmentation; reviewing and adapting landscape and seascape plans and frameworks (both within and across sectors); and prioritizing and implementing measures to decrease habitat fragmentation within landscapes and seascapes and to increase connectivity.

Protected areas and OECMs are frequently inhabited by local communities who may also play a key role in the management and custodianship of those areas and the species that inhabit them. G20 members are urged to pay continued attention to these communities' rights of access to these resources and their rights to share in the benefits provided by them. Furthermore, by considering the degree to which other countries respect these rights as a condition for trade, G20 members are in a position to influence access and benefit sharing in those countries.

References

ⁱ Mora C, Tittensor DP, Adl S, Simpson AGB, Worm B. 2011. How Many Species Are There on Earth and in the Ocean? *PLoS Biology* 9(8): e1001127.

ⁱⁱ Lenau, T. A., A-L. Metze, and T. Hesselberg. "Paradigms for biologically inspired design." *Bioinspiration, Biomimetics, and Bioreplication VIII*. Vol. 10593. International Society for Optics and Photonics, 2018.

ⁱⁱⁱ Costa RR, da Costa DS, Reis RL, Pashkuleva I. *In press*. Bioinspired Baroplastic Glycosaminoglycan Sealants for Soft Tissues. *Acta Biomaterialia*.

^{iv} Schroeder TBH, Guha A, Lamoureux A, VanRenterghem G, Sept D, Shtein M, Yang J, Mayer M. 2017. An electric-eel-inspired soft power source from stacked hydrogels. *Nature* 552, 214-218.



- v Wah, TY. 2016. Nature-inspired membrane set to reduce purification costs. *Membrane Technology 2016*, 7.
- vi Kolle, Mathias, et al. 2010. Mimicking the colourful wing scale structure of the *Papilio blumei* butterfly. *Nature nanotechnology* 5.7: 511.
- vii Nanotech. 2019. Retrieved from <https://www.nanosecurity.ca/>
- viii Frank MB, Naleway SE, Wirth TS, Jung JY, Cheung CL, Loera FB, Medina S, Sato KN, Taylor JR, McKittrick J. 2016. A Protocol for Bioinspired Design: A Ground Sampler Based on Sea Urchin Jaws. *JoVE*, 110: e53554.
- ix Sun X, Damle VG, Liu S, Rykaczewski K. 2015. Bioinspired stimuli-responsive and antifreeze-secreting anti-icing coatings. *Advanced Materials* 2: 1400479
- x MEA. 2005. *Ecosystems and human well-being: Current state and trends, Volume 1*. Washington DC, USA: Island Press.
- xi IPBES. 2018(a). The IPBES regional assessment report on biodiversity and ecosystem services for Africa. Archer, E. Dziba, L., Mulongoy, K. J., Maoela, M. A., and Walters, M. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 492 pages.
- xii IPBES. 2018(b). The IPBES regional assessment report on biodiversity and ecosystem services for the Americas. Rice, J., Seixas, C. S., Zaccagnini, M. E., Bedoya-Gaitán, M., and Valderrama N. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 656 pages.
- xiii IPBES. 2018(c). The IPBES regional assessment report on biodiversity and ecosystem services for Asia and the Pacific. Karki, M., Senaratna Sellamuttu, S., Okayasu, S., and Suzuki, W. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 612 pages.
- xiv IPBES. 2018(d). The IPBES regional assessment report on biodiversity and ecosystem services for Europe and Central Asia. Rounsevell, M., Fischer, M., Torre-Marín Rando, A. and Mader, A. (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 892 pages.
- xv CBD. 2011. Nayoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity
- xvi IUCN. (2017). *The IUCN Red List of Threatened Species. Version 2018-2*. Retrieved March 2, 2019, from <http://www.iucnredlist.org>
- xvii The Biomimicry Institute. 2018. Asknature. Retrieved from <https://asknature.org/>
- xviii Earth Bank of Codes. 2018. Earth Bank of Codes and Amazon Bank of Codes. Retrieved from <https://www.earthbankofcodes.org/>
- xix CBD/SBSTTA/22/INF/10
- xx CBD. 2010. The Strategic Plan for Biodiversity
- xxi CBD. 2019. Protected areas: global implementation. <https://www.cbd.int/protected/implementation/>
- xxii Smallhorn-West P, Govan H. 2018. Towards reducing misrepresentation of national achievements in marine protected area targets. *Marine Policy* 97, 127-129. <https://doi.org/10.1016/j.marpol.2018.05.031>
- xxiii Balmford A. 2003. Conservation planning in the real world: South Africa shows the way. *Trends in Ecology and Evolution* 18(9), 435-438.
- xxiv CBD. 2018. Decision XIV/8: Protected areas and other effective area-based conservation measures