A CONTEXT-BASED BIODIVERSITY METRIC FOR ORGANIZATIONS

A Prototype Developed for Cabot Creamery Cooperative

By Mark W. McElroy (Center for Sustainable Organizations) and Andy Whitman (Manomet)

CENTER FOR SUSTAINABLE ORGANIZATIONS

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Mark W. McElroy, PhD is the Founding Director of the non-profit Center for Sustainable Organizations in the U.S., and creator of the Context-Based Sustainability method. He is a veteran of management consulting having spent many years at Price Waterhouse, KPMG and Deloitte Consulting. Dr. McElroy is co-creator of the MultiCapital Scorecard, the world's first context-based triple bottom line performance accounting method.

Andrew Whitman is Senior Director of Applied Science at Manomet. He is developer of a dozen sustainability frameworks and indicators that address biodiversity including the Leading Harvest Standard for agriculture, the Vital Capital Index for Dairy Agriculture, and the Forest Biodiversity Scorecard for managed forests. His work concentrates on environmental stewardship and sustainability of working lands and seas across the Western Hemisphere.

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Introduction

This paper addresses a long-standing challenge in the field of context-based sustainability, which is whether or not it is possible to devise a context-based metric that can satisfactorily measure the biodiversity performance of organizations – and if so, how?

Including biodiversity in sustainability assessments is challenging, mainly due to its complexity, scaling issues, and the significant difficulty associated with reducing such assessments to a single measure or conservation objective.[1] Biodiversity approaches are also highly sensitive to selected threshold states and assumptions when models are used, not to mention available data.

In what follows below, we begin by calling attention to other relevant initiatives in the field aimed at addressing biodiversity metrics in any way at all (i.e., not necessarily context-based), and then move on to present our own recommendations for a specific way forward. We do this by first acknowledging key initiatives or policy proposals at the global level, and then also at the national level. We then shift to the level of individual organizations, focusing on tools, methods, and metrics that may already be available from others before offering our own.

Here we should also make it clear that we do not claim to be exhaustive at the global or national levels, and that our primary focus is the organizational one. Our treatment of policy proposals and initiatives at the global and national levels, therefore, is cursory at most and is only intended to identify and address some of the more important and illustrative developments as we see them.

The Lay of the Land

The biodiversity space is a crowded one insofar as activities and initiatives are concerned. Rather than attempt to list all that is going on there, we will highlight just a few of the most notable efforts thus far. But before we do that, some sort of organizing framework or typology should be helpful:

1. **Policy Proposals at the Global Level** – These consist of programs and initiatives, mostly by the UN, to define global goals and policies for the maintenance of biodiversity levels in the world and the manner in which they should be managed by member states.
2. **Accounting Proposals at the National Level** – These consist of specific tools, methods and metrics for measuring the inventory of biodiversity assets in the world and their economic value to the human economy. National-level accounting proposals, in particular, are found here.
3. **Accounting Proposals at the Organizational Level** – These consist of specific standards and protocols for measuring the impacts of individual organizations on biodiversity. This is the level at which our own performance accounting proposal for a biodiversity metric is expressed.
4. **Accounting Proposals at the Product Level** – These consist of specific tools designed to address the impacts of products themselves on biodiversity, usually in terms of their lifecycles.

1 Noss, R. (1990) "Indicators for Monitoring Biodiversity: A Hierarchical Approach": https://www.researchgate.net/publication/240046146_Indicators_for_Monitoring_Biodiversity_A_Hierarchical_Approach; Hagan, J.M. and Whitman, A.A. (2006) "Biodiversity indicators for sustainable forestry: simplifying complexity". Journal of Forestry, 104(4), pp.203-210: https://www.researchgate.net/profile/Andrew_Whitman/publication/237494147_Considerations_in_the_Selection_and_Use_of_Indicators_for_Sustaining_Forests/links/54d24c610cf25017917db870.pdf

Policy Proposals at the Global Level

» **Convention on Biological Diversity (CoB)** – This was arguably the seminal event in the arrival of biodiversity as an issue on the global stage. The CoB, a UN (UNEP) initiative, was first introduced at the Rio "Earth Summit" in 1992 and then entered into force on 29 December 1993. It had three main objectives:

1. The conservation of biological diversity
2. The sustainable use of the components of biological diversity
3. The fair and equitable sharing of the benefits arising out of the utilization of genetic resources

The CoB is currently focused on developing a Post-2020 Biodiversity Framework[2] as a stepping stone for achieving its 2050 Vision of Living in Harmony with Nature,[3] using what's known as decision 14/34 as its jumping off point.[4] As set forth in 14/34, this vision, if successful, would specifically call for:

> "… broad societal engagement to achieve accelerated and sustainable transformations to implement the three objectives of the Convention, whereby biodiversity and ecosystems are recognized as the essential infrastructure supporting life on Earth, without which human development and well-being will not be possible. It will place biodiversity, its conservation, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources at the heart of the sustainable development agenda, recognizing the important linkages between biological and cultural diversity;"

Whether or not to adopt the proposed *Post-2020 Biodiversity Framework* will be the subject of the CoB's next (15th) Conference of the Parties (CoP 15) meeting in Kunming, China, in May of this year (2021).

Also within the UN context, and of particular interest to the agricultural sector, is the distinction made by the FAO (Food and Agriculture Organization of the United Nations) between *biodiversity* and *agrobiodiversity* as indicated in Figure 1.

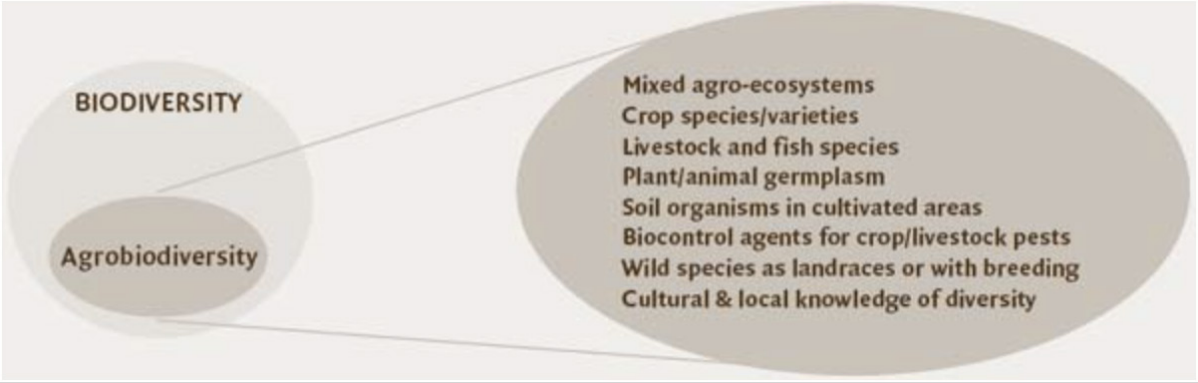

Figure 1 – FAO Distinction Between Biodiversity and Agrobiodiversity

2 https://www.cbd.int/conferences/post2020
3 https://www.unep.org/news-and-stories/story/towards-vision-2050-biodiversity-living-harmony-nature
4 https://www.cbd.int/doc/decisions/cop-14/cop-14-dec-34-en.pdf

The FAO defines agrobiodiversity as follows:[5]

> "The variety and variability of animals, plants, and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry, and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel, and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems."

» **The Sustainable Development Goals (SDGs)** – The issue of biodiversity also figures prominently in the UN's Sustainable Development Goals as adopted in 2015. Also known as the "2030 Agenda," the SDGs consist of 17 global goals for development, one of which (Goal 15 and its underlying targets) deals specifically with human impacts on biodiversity (see Appendix A).

Of particular importance to our own attempt to create a context-based biodiversity metric for organizations is the broad emphasis given in SDG 15 to species protection, habitat conservation, and the avoidance of non-native (invasive) species transfers from one part of the world to another. These ideas will figure prominently in the specific metric we propose below.

» **Planetary Boundaries Program** – Also germane to our project is the Planetary Boundaries Program at the Stockholm Resilience Center (SRC) in Sweden, where since 2009 scientists have been taking steps to identify nine processes that regulate the stability and resilience of the Earth system, as well as boundaries for each that should not be crossed in order to maintain biospheric integrity and conditions fit for life on Earth.[6]

5 http://www.fao.org/3/y5609e/y5609e01.htm

6 https://www.stockholmresilience.org/research/planetary-boundaries.html

Among the tools proposed for use at the global level by the Planetary Boundaries team at SRC is the *Biodiversity Intactness Index*, which may or may not have a role to play in our own work at Cabot.[7] In any case, the policy implications of the SRC project are clear: Crossing planetary boundaries increases the risk of generating large-scale abrupt or irreversible environmental changes. Any attempt to measure, manage or report the biodiversity performance of human social systems must therefore have adherence to planetary ecological limits and boundaries at its heart.

Accounting Proposals at the National Level

Members of the UN, of course, are the sovereign nations of the world, and so whatever happens at the UN/global level must ultimately be adopted and operationalized at the lower national level in order to take hold. Here, there is primarily one and only one initiative to take account of: the System of Environmental Economic Accounting (SEEA).

» **The System of Environmental Economic Accounting (SEEA)** – Because biodiversity is an aspect of the real, material world, any attempt to understand or manage the quantity or quality of it must involve measurement. And because biodiversity is fundamentally found at the local, regional, and continental levels, the measurement of it should ideally include assessments of it at the national level – or at least for global reporting purposes, it should. Measurement tools, methods and metrics for biodiversity at lower levels of analysis can then proceed from there.

Thus, it is important to understand not just what is happening at the global level, but also at the national level. In many respects, this raises all of the same kinds of issues that ultimately led to the development of the so-called national accounts system between the late 'twenties and early 'fifties, which is still in use today:

> "The original motivation for the development of national accounts and the systematic measurement of employment was the need for accurate measures of aggregate economic activity. This was made more pressing by the Great Depression and as a basis for Keynesian macroeconomic stabilisation policy and wartime economic planning. The first efforts to develop such measures were undertaken in the late 1920s and 1930s, notably by Colin Clark and Simon Kuznets. Richard Stone of the U.K. led later contributions during World War II and thereafter. The first formal national accounts were published by the United States in 1947. Many European countries followed shortly thereafter, and the United Nations published *A System of National Accounts and Supporting Tables* in 1952. International standards for national accounting are defined by the United Nations System of National Accounts, with the most recent version released for 2008."[8]

As is so often the case in economics, the international system for measuring and reporting the extent of commercial activities in the world failed from the start to take natural capital into account, not only as a contributing factor to the health of national economies, but also as a resource that is very much diminished by them. Much like financial accounting at the level of individual organizations, national economic accounting, too, has for decades more or less ignored the role played by nature in the human economies, not to mention the damage done by economic activity to the environment, including to biodiversity. As something that has never been measured, the impacts and dependencies of businesses in the world on and to the environment has been a blind spot.

Now that the unwanted effects of human activity (economic) have come home to roost, a significant effort is underway to double back and fill the void of natural capital accounting that has been missing for so long from the national accounting system. Into the breach, in particular, has come the SEEA, which is described as follows:

> "The System of Environmental Economic Accounting (SEEA) is the agreed international standard for organizing and presenting statistics on the environment and its relationship with the economy. It is

7 https://www.nature.com/articles/nature03289

8 https://en.wikipedia.org/wiki/National_accounts#History

produced and released under the auspices of multiple organizations, including the United Nations, the European Commission, the Food and Agriculture Organization of the United Nations, the Organisation for Economic Co-operation and Development and the World Bank."[9]

SEEA is working to provide frameworks for producing accounting in eight thematic areas:

1. Material flows
2. Environmental activities
3. Water
4. Ecosystems and biodiversity
5. Agriculture, forests, and fisheries
6. Land
7. Air emissions
8. Energy

Figure 2 – The Status of SEEA's Published Standards
(Note: SNA = System of National Accounts)

Not all of these areas have been addressed yet in terms of SEEA's development efforts (see Figure 2). Guidance for biodiversity accounting, for example, is still not completed.

As also indicated in Figure 2, SEEA's core *System of Experimental Ecosystem Accounting* (a 315-page document) was still undergoing revision as of late 2020. The *SEEA EA*, as it is known, specifically addresses the ecosystems and ecosystem services side of environmental accounting, a draft of which was currently out for public consultation until November 30, 2020. Figure 3 provides some additional background on the trajectory of that effort.

9 https://seea.un.org/sites/seea.un.org/files/seea_tri-fold_final_nov_18.pdf

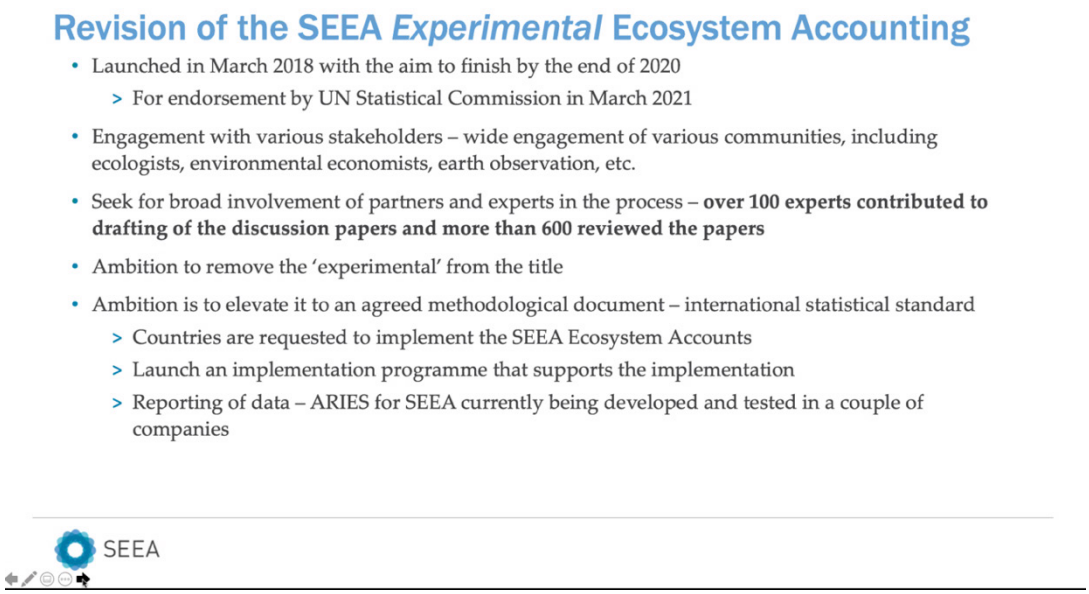

Figure 3 – The Current Revision of SEEA's *Ecosystem Accounting* Standard

One thing that should be clearly understood about SEEA is that it is not a sustainability accounting system in the sense that it assesses impacts on natural resources and ecosystem services relative to norms for maintaining them. Rather, it is an extension of an international economic accounting system, the purpose of which is to measure the degree to which such resources exist and provide value to the human economy. Thus, it is fundamentally an incrementalist accounting system that happens to focus on non-financial assets, all of which are eventually valued and expressed in purely monetary terms.

» **The Economics of Ecosystems and Biodiversity (TEEB) –** The Economics of Ecosystems & Biodiversity (TEEB) initiative was launched in 2007 at the G8+5 Potsdam Meeting of Environment Ministers in order to develop a global analysis of the economic significance of biodiversity, the costs of the loss of biodiversity, and the failure to take protective measures versus the costs of effective conservation.[10]

As explained on its website, TEEB:

> "… is a global initiative focused on 'making nature's values visible'. Its principal objective is to mainstream the values of biodiversity and ecosystem services into decision-making at all levels. It aims to achieve this goal by following a structured approach to valuation that helps decision-makers recognize the wide range of benefits provided by ecosystems and biodiversity, demonstrate their values in economic terms, and, where appropriate, capture those values in decision-making."[11]

With this in mind, TEEB has been an active promoter of national accounting for natural capital, and is a strong supporter of SEEA:

> "The concept of accounting for natural capital has been around for more than 30 years. A major step towards achieving this vision came with the adoption by the UN Statistical Commission of the System for Environmental and Economic Accounts (SEEA) in 2012. This provides an internationally agreed method to account for material natural resources like minerals, timber, and fisheries."[12]

10 http://ens-newswire.com/ens/mar2007/2007-03-16-01.asp
11 http://teebweb.org
12 http://teebweb.org/our-work/nca/understanding-nca/in-a-nutshell/

Of particular interest to us here, perhaps, is a study released by TEEB in 2018 in which "the real costs and benefits—including environmental, health, and social impacts—of our agriculture and food systems" were discussed. Referred to as the *TEEBAgriFood Scientific and Economics Foundations* report, the content was intended to provide "the basis for a major paradigm shift in how we view and manage our agriculture and food systems, demonstrating how to evaluate not just the visible, but also the hidden costs and benefits."[13]

As explained by Joao Campari, World Wildlife Fund (WWF) Food Practice Leader at the time, in the same report, "If we want to bend the curve on biodiversity loss we must understand the true impacts of the food system on our planet. WWF works across the full spectrum of the food system, from production to consumption, loss and waste, and we welcome TEEBAgriFood's research as it assesses a multitude of impacts on both people and planet instead of trying to distill the complexities into one over-simplified metric."

As indicated above, the primary thrust of the TEEB initiative was/is to characterize the impacts of whole sectors, and nations, too, on biodiversity. We see no evidence of any additional attempt on the part of the TEEB program to formulate organization-level metrics that could be used to measure and report the impacts of individual actors on biodiversity in the world. For that we must turn our attention to organization-level biodiversity accounting proposals as such, in hopes that what we find there will also be context-based.

» **The Economics of Biodiversity: The Dasgupta Review –** In February of this year (2021), a 600-page special report was published by Professor Partha Dasgupta of Cambridge University, in which he made the following argument:[14]

> "…that in order to judge whether the path of economic development we choose to follow is sustainable, nations need to adopt a system of economic accounts that records an inclusive measure of their wealth. The qualifier 'inclusive' says that wealth includes Nature as an asset. The contemporary practice of using Gross Domestic Product (GDP) to judge economic performance is based on a faulty application of economics."

13 https://foodtank.com/news/2018/06/teebagrifood-revealing-foods-hidden-costs-new-framework/

14 https://www.gov.uk/government/publications/final-report-the-economics-of-biodiversity-the-dasgupta-review

In making his case, Dasgupta points to notable applications of the UN's SEEA approach discussed above (in New Zealand) and also the Gross Ecosystems Product (GEP) approach in China. All in all, the Dasgupta report makes a powerful case for the need to include assessments of natural capital in national-level accounting.

That said, it should also be clear that because the orientation to biodiversity accounting in the Dasgupta report is mainly concerned with assessing stocks and flows of natural capitals at the national or macro-population level, it does not by itself constitute a methodology for assessing biodiversity performance at the organizational level. In order to do that, it (or any other method) would have to assess the sustainability of discrete *impacts* on natural capitals relative to not only the magnitude of their stocks and flows (thresholds), but to organization-specific *allocations* of them as well.

Assessing the sustainability of organizational impacts on natural capitals would also give rise to consideration of what we call *monetization curves*, which essentially assign higher costs or prices to impacts in cases where they – if broadly generalized – would put the sufficiency or viability of capitals at risk (see Figure 4).[15] Again, this is not something the Dasgupta report explicitly addresses, but it *is* something that *must* be done in order to do a proper job of assessing biodiversity performance at the organizational level.

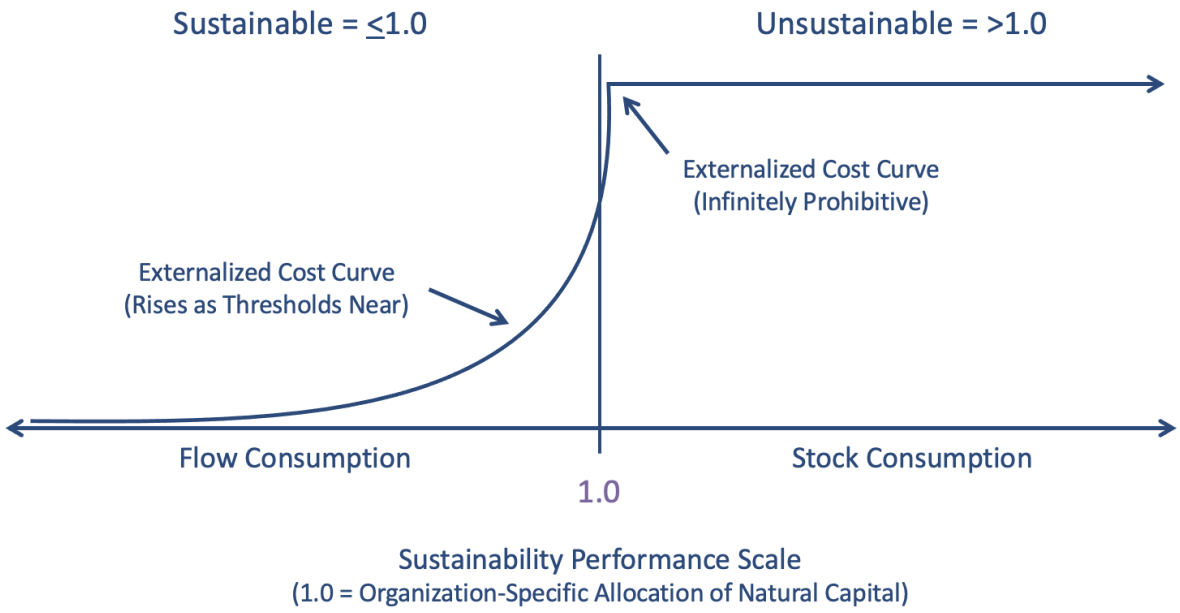

Figure 4 – Context-Based Monetization Curve for Impacts on Natural Capital[16]
(Note: This principle applies whether impacts are being monetized or not.)

15 See here for more information on monetization curves: https://www.sustainableorganizations.org/Context_Based_Monetization_Curves.pdf

16 Source: https://www.sustainableorganizations.org/Context_Based_Monetization_Curves.pdf

Accounting Proposals at the Organizational Level

Next in our tour of biodiversity accounting tools are those intended for use at the organizational level of analysis. Three specific methods come quickly to mind here, as well as a third broad category of initiatives aimed at agricultural organizations:

» **The Natural Capital Protocol (NCC) and SEEA –** As earlier shown in Figure 2 above, multiple efforts are underway to pilot, test, and evaluate SEEA's approach to natural capital accounting in several areas. Separately, SEEA is also collaborating with the Natural Capital Coalition to apply its principles at the level of individual organizations. The nature of this collaboration has been described by the Natural Capital Coalition (creators of the Natural Capital Protocol) as follows:[17]

> "Central to the efficacy of accounting practices is the use of a common framework, standard definitions, shared language, and repeatable processes. While these have been well established for national and business financial accounting, natural capital accounting is relatively recent and its processes are still evolving both in the public and the private sector.
>
> - In the public sector, standard accounting frameworks, structures, and principles for natural capital accounting have been developed through the System of Environmental and Economic Accounts (SEEA) and endorsed by the United Nations Statistical Division in 2012. The SEEA framework provides the means to organise data on natural capital in a consistent and comparable way which enables the economic contribution of natural capital and the environmental impacts of economic activity to be captured and analysed.
> - In the private sector, the Natural Capital Coalition has led on the development of a standard framework to integrate natural capital into business decision-making through natural capital assessments, culminating in the release of the Natural Capital Protocol (the Protocol) in 2016. Natural capital assessments are used to obtain trusted, reliable, and actionable information on any impacts the business has on natural capital, or any dependencies it may be exposed to.
> - While there is currently no global standard for corporate natural capital accounting, methodologies are beginning to emerge from both within the corporate sector and through governments. In 2015 the United Kingdom's Natural Capital Committee produced a framework through which corporations and landowners can use monetary values to quantify natural capital assets and liabilities and present them in the form of a balance sheet. Accounting approaches such as these compliment natural capital assessments and enable quantified monitoring of business decisions made in relation to natural capital."

One such current collaboration between SEEA and the Natural Capital Coalition (NCC) is taking place in Tasmania, where a forest services company there, Forico, has been working with the IDEEA Group to apply natural capital accounting (see Appendix B for a transcript of a recent email exchange about this between one of the authors [McElroy] and Forico's CFO, Rayne van den Berg).

While it is clear that Forico's work with the IDEEA Group, the NCC, SEEA, and natural capital accounting in general is cutting-edge, it should also be clear that in no way are they taking steps to measure, report, or assess the *sustainability* of their impacts on natural capital. Rather, they are talking about the *value* of natural capital to *them* and to the economy in general. Nor do they (or anyone else using SEEA) take steps to assess the carrying capacities of natural capitals. Instead, what SEEA calls for is ultimately no more than simply taking inventory of such capitals and then valuing them – in monetary terms – mainly for their instrumental, economic utility.

17 https://naturalcapitalcoalition.org/wp-content/uploads/2019/02/W1-Accounting-narrative-Final-04-02-2019.pdf

» **The Global Reporting Initiative (GRI)** - The Global Reporting Initiative (GRI) *Guidelines* (now *Standards*) for sustainability reporting have included treatment of biodiversity impacts since at least 2002, when the second edition (G2) of the standard was released. Then and now, however, the indicators proposed have not been context-based and instead have been cast in purely incremental terms. Little has changed, in fact, between 2002 and 2016, when the last and most recent version of the GRI *Standard* was released.

In 2002, the Guidelines called for the following basic disclosures ("Core"):

- Locations of operations in biodiversity-rich habitats
- Major impacts on biodiversity

"Additional" indicators in 2002 were further suggested as follows:

- Total land used for production or extraction
- Amount of impermeable land surface
- Extent of activities in protected and sensitive areas
- Changes to natural habitats resulting from operations and percentage of habitat protected and/or restored
- Programs and targets for protecting and restoring native ecosystems and species in degraded areas
- Number of IUCN Red List species with habitats in areas affected by operations
- Business units currently operating or planning operations in or around protected or sensitive areas

Required biodiversity disclosures in the more recent 2016 *Standards* (known as *GRI 304*) are as follows:

- Locations of operations in biodiversity-rich habitats
- Major impacts on biodiversity
- Habitats protected or restored
- Number of IUCN Red List species with habitats in areas affected by operations

Required disclosures in 2016, that is, are simply a subset of those first put forward in 2002 and are no more context-based (in 2016) than they were in 2002. That said, the second category of disclosure (Major impacts on biodiversity) warrants closer scrutiny (see Figure 5).

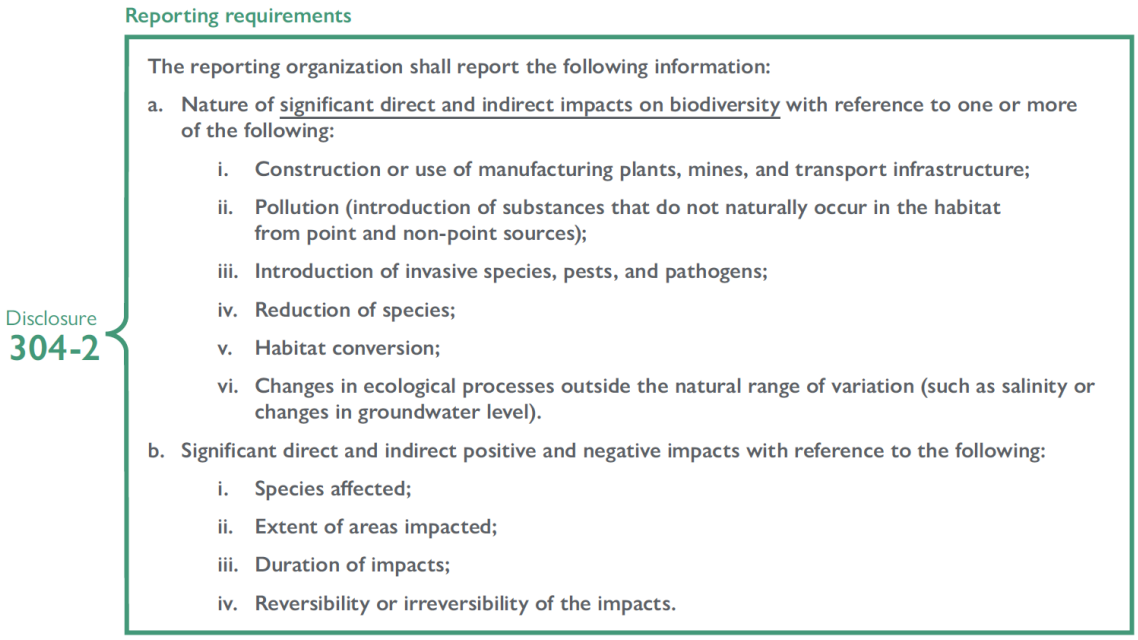

Figure 5 – Disclosure Requirements for Major Impacts on Biodiversity in *GRI 304*

Several of the disclosures shown in Figure 5 arguably pertain to both direct and indirect impacts on biodiversity that are clearly relevant to the biodiversity performance of organizations. As already discussed above (and again further below), for example, the introduction or transplantation of non-native, invasive species from one part of the world to another is a known cause of species loss and is unsustainable. Still, GRI fails to require reporting in such context-based terms, and thereby makes it possible to fully comply with their guidance without making any sustainability performance disclosures at all.

» **Science-Based Targets Network (SBTN) –** SBTN is a relatively new entrant in the field of sustainability accounting having just arrived on the scene in early 2020. Inspired in part by the success of the Science-Based Targets initiative (SBTi) for setting GHG targets, SBTN was launched with the intent of helping to "enable companies and cities operate in environmentally sustainable ways to restore balance to the Earth's interrelated systems of freshwater, biodiversity, land, and ocean alongside climate."[18]

With regard to specific tools, methods or metrics for assessing the biodiversity performance of organizations, SBTN's position right now is still very much in the aspirational stage. Thus, there are no specific SBTN-based biodiversity tools to point to as of yet. Still, the positioning of SBTN in this space is noteworthy, as is its expression of intent to in fact put forward a solution for use by organizations to help measure, manage, and report their biodiversity performance:

> "As targets related to the CBD [Convention on Biological Diversity] Post-2020 Global Biodiversity Framework emerge over the coming months, we will identify relevant indicators for tracking these, including targets on biodiversity and nature's contributions to people."[19]

> "By the end of 2022, SBTN aims to have secured significant public- and private-sector commitments that will have the potential to transform and contribute measurable progress to the SDGs across the climate, development, and nature agendas. By 2025, we aim to have widespread adoption of SBTs for nature (water, land, ocean, and biodiversity)."[20]

18 SBTN news release on 1.17.21: https://sciencebasedtargetsnetwork.org/news/business/erin-billman-leads-sbtn/

19 Science-Based Targets for Nature – Initial Guidance for Business: https://sciencebasedtargetsnetwork.org/wp-content/uploads/2020/11/Science-Based-Targets-for-Nature-Initial-Guidance-for-Business.pdf

20 Ibid.

» **Methodologies for Agricultural Organizations** – It is worth noting accounting proposals for agricultural operations separately, because it is one of the few organization-level accounting arenas where biodiversity metrics have received considerable attention.[21] Key topics for farm biodiversity include: conservation of rare species (including rare, threatened, endangered, at-risk, and G1 and G2[22] species) and rare habitats (e.g., at-risk, G1 and G2, natural communities or ecosystems); conservation of natural (plant) communities; application of habitat enhancement practices and management plans for agricultural lands and areas not in production; avoided conversion of natural habitats, especially forest (e.g., deforestation protocols); and crop diversity (e.g., within-year species and variety diversity and between-year diversity [e.g., crop rotation, cover crops]).[23]

Widely used indicators focus on quantitative metrics for species diversity, indicator species, and habitat diversity, including non-production areas and qualitative metrics for measuring use of practices to enhance habitats for biodiversity and wildlife. Soil biodiversity has been largely ignored until recently because there is a lack of soil ecologists and a large uncatalogued diversity of soil organisms. Soil systems vary widely over short intervals, too, which makes accurate soil monitoring difficult and expensive.

Conceptually, the connections within agro-ecosystems including nutrient cycling are well known but largely not included in farming biodiversity metrics. Indicators of some biodiversity components such as nutrient cycling (e.g., indicators of N and P cycling) and water quality (e.g., habitat quality of aquatic habitats) are often used, but conceptually not integrated with a broader notion of biodiversity. Many of these indicators are useful, but typically suites of biodiversity indicators are selected haphazardly, including an assortment of condition, pressure, impact, and policy/practice indicators.[24] Hence they do not always include pressure indicators which are necessary for measuring areas of impact. However, they often scale well, revealing useful information at multiple levels.

21 Herzog, Felix & Balázs, Katalin & Dennis, Peter & Friedel, Jürgen & Geijzendorffer, I.R. & Jeanneret, Philippe & Kainz, Maximilian & Pointereau, Philippe. (2012). Biodiversity Indicators for European Farming Systems – A Guidebook. ART Schriftenreihe 17Publisher: Agroscope ART.

22 G1 and G2 refer to a global ranking scheme by NatureServe and serve as conservation ranks for species and natural communities. See: Regan, T.J., Master, L.L. and Hammerson, G.A. (2004) "Capturing expert knowledge for threatened species assessments: a case study using NatureServe conservation status ranks". Acta Oecologica, 26(2): 95-107.

23 Kok, A., de Olde, E.M., de Boer, I.J.M. and Ripoll-Bosch, R. (2020) European biodiversity assessments in livestock science: A review of research characteristics and indicators. Ecological Indicators, 112, p.105902.

24 Gabrielsen, P., & Bosch, P. (2003). Environmental indicators: typology and use in reporting. EEA, Copenhagen.

Accounting Proposals at the Product Level

It is worth noting product-level biodiversity metrics as well, because it provides a model for determining how organizational-level biodiversity metrics might be used across scales to accomplish product-level accounting.[25] They allow consideration of upstream and downstream impacts, including impacts from inputs such as fertilizer, pesticides, and fuel, from purchased feed. This approach allows the development of generic metrics that have the advantage of being globally applicable, but risk being unable to be locally relevant.

Common metrics for biodiversity include land species richness, species abundance models which may be sensitive to subtle shifts in community composition, various measures of ecosystem naturalness, human appropriation of Net Primary Productivity, and Characterization Factors (CF). Of these, CFs appear to be the most promising.

CFs are an estimate of management impacts to species richness.[26] CF models can reflect potential regional or global species extinction risk for different taxa. It uses species-areas relationship (SAR) models to estimate species richness and species loss at large scale. An important drawback of this approach is that CF models have limited ability to reflect positive impacts on biodiversity. CFs are only able to assess the impact on a single indicator of biodiversity (e.g., species richness) at the eco-regional, country, or global level, but not at the local/landscape level.

The SAR approach has its limitations, too, for it fails to account for the effects of habitat fragmentation that usually accompanies habitat loss.[27] CF can be highly variable depending on how threshold states are selected, assumptions when models are used, and the availability of data. Hence the CFs do not scale well to detect change at the smallest scales, the scales at which most organizations operate. They can be used for impact assessment, but not to guide local decision making.

It is also worth noting the large suite of environmental indicators used in Life-Cycle Assessments (LCA)[28] because they help identify metrics relevant to areas of impact on biodiversity.[29] Product LCA environmental indicators also include a number of pressure indicators, which may be relevant to measuring impacts to biodiversity. These include:

- Resource impacts
  - Climate System:
    - Global Warming Potential (net emissions in kilograms carbon dioxide equivalents)
  - Ecosystem Impacts to fresh and marine waters:
    - Eutrophication Potential - enrichment of an ecosystem with nutrients that accelerate biological productivity. Eutrophication is characterized separately for freshwater and marine ecosystems as freshwater ecosystems are more frequently phosphorus-limited while marine ecosystems are more frequently nitrogen-limited. Calculated in terms of the nitrogen or phosphorous content of releases available to ecosystems and measured in kilograms nitrogen equivalents or kilograms phosphorus equivalents.
    - Ecosystem Toxicity - potential of chemicals to cause toxic effects on aquatic species. The models used to estimate ecosystem toxicity typically consider chemical fate, transport, and exposure of organisms. Measured in terms of common toxic units or toxic chemical equivalency.

25 Kazemi, H., Klug, H. and Kamkar, B. (2018) "New services and roles of biodiversity in modern agroecosystems: A review". Ecological Indicators, 93:1126-1135.

26 Chaudhary, A. and Brooks, T.M. (2018) "Land use intensity-specific global characterization factors to assess product biodiversity footprints". Environmental Science & Technology, 52(9): 5094-5104.

27 Hanski, I., Zurita, G.A., Bellocq, M.I. and Rybicki, J. (2013) "Species–fragmented area relationship". Proceedings of the National Academy of Sciences, 110(31): 12715-12720.

28 https://en.wikipedia.org/wiki/Life-cycle_assessment

29 Curran, M. A., Ed. (2012) Life Cycle Assessment Handbook: A Guide for Environmentally Sustainable Products; Wiley/Scrivener: Hoboken, N.J, 2012.

- Acidification Potential - the acidifying potential resulting from acid rain caused by inorganic air emissions measured in sulfur dioxide equivalents.

- Air Quality:
  - Particulate Matter Formation Potential - emissions with potential to form particulate matter leading to animal respiratory effects.
  - Smog Formation Potential - the relative reactivity of substances that produce ground level ozone in the presence of sunlight measured in kilograms ground-level ozone equivalents.
- Radiation:
  - Ionizing Radiation - the damage to ecosystems that is linked to the emissions of radionuclides throughout a product or building life cycle. Most commonly linked to the use of nuclear power in an electricity mix. Measured in kg of uranium-235 (U235) equivalents or DALY.

» Resource depletion

- Land Use/Occupation - area of land occupied over time, characterized in terms of biological productivity. Measured in terms of area equivalent to an area of land of specified biological productivity.
- Water Consumption - water withdrawals less water returned to the same watershed, measured by volume.

Our Proposal: The Biodiversity Performance Index (BPI)

The Theory We Rely On

We take as our point of departure the view that biodiversity as an issue boils down to the problem of species and ecosystems loss or extinction and how to avoid it. We do so on the basis of the following argument:

1. That biodiversity refers to "the diversity of life", and that it not only means "the diversity of genes and species, it also means the diversity of ecosystems";[30]
2. That "*Biodiversity* is the variety of life in all its forms, which is why it is not uncommon to regard biodiversity to be the number of species of organisms that inhabit Earth ... But biodiversity has several dimensions, including the diversity and abundance of living organisms, the genes they contain and the ecosystems in which they live";[31]
3. That species loss directly contributes to biodiversity loss, since genetic and species diversity is fundamentally bound up in species themselves; and ecosystems diversity, too, is contingent upon the diversity of species that inhabit them;
4. That because species loss directly contributes to declines in biodiversity, key indicators for impacts on biodiversity should include measures of impacts that contribute to or directly cause species loss;[32]
5. That because biodiversity is also an attribute of ecosystems, indicators for biodiversity should include measures of impacts that contribute to, or directly cause, ecosystems loss or degradation, not just species per se. The biospheric climate system on Earth, for example, is an ecosystem, the biodiversity makeup of which matters greatly to climate regulation. Indeed, ecosystems are themselves life-like and very much akin to organisms, the existence and diversity of which are the source of ecosystem services and habitats that humans and other species rely on for their well-being.[33]

The specific issue of interest in the business community, then, is whether or not individual organizations might be contributing to species and/or ecosystems loss or degradation, and how to assess their performance in those terms in a way that is intentionally context-based.[34]

In developing our own response to this challenge, we predicate our thinking by recognizing the scientific community's long-held understanding of what causes species/ecosystems loss or extinctions in the first instance. As explained by the U.S. National Research Council in 1995, there are three such (anthropogenic) causes:

> "Species endangerment and extinction have three major anthropogenic causes—overhunting or overharvesting; introduction of nonnative species, including the spread of disease; and habitat degradation or loss."[35]

30 Dasgupta, P. (2021) The Economics of Biodiversity: The Dasgupta Review, p. 51: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/962785/The_Economics_of_Biodiversity_The_Dasgupta_Review_Full_Report.pdf

31 Ibid., pp.51-52

32 Mace, G. et al (2018) "Aiming higher to bend the curve of biodiversity loss", Nature, Vol. 1, 448-451.

33 See, for example, Lovelock, J. (1979) Gaia – A New Look at Life on Earth.

34 See "Context-Based Sustainability": https://en.wikipedia.org/wiki/Context-Based_Sustainability

35 National Research Council (US) Committee on Scientific Issues in the Endangered Species Act (1995) *Science and the Endangered Species Act*, National Academies Press.

That same year, the paleoanthropologist Richard Leakey made essentially the same argument in his book, *The Sixth Extinction*, where he wrote:[36]

> "Humans endanger the existence of species in three principal ways. The first is through direct exploitation, such as hunting … Second is the biological havoc that is occasionally wreaked following the introduction of alien species to new ecosystems … The third, and by far the most important mode of human-driven extinction is the destruction of habitat, especially the inexorable cutting of tropical rainforests." (p. 234)

Other scholars, too, had earlier expressed the same understanding, including Paul and Anne Ehrlich in their 1981 book, *Extinction*, in which they wrote:[37]

> "Direct pressures against other species [i.e.., by human hunting or harvesting] thus are obviously an important factor in extinctions. In many cases, however, such as the big cats, elephants, and rhinos, the direct hunting pressure has been augmented by damage or destruction of the ecosystem in which the animal lives – its habitat. Indeed, the indirect method of habitat destruction is by far the deadliest means by which humanity has pushed other organisms to extinction." (p. 128)

They further added:

> "One of the [other] human activities that [has] often led to species extinctions is the transporting of organisms. Moving plants and animals from the ecosystems in which they evolved to other places where the native plants and animals have had no evolutionary experience with them has often had catastrophic effects on the recipient community." (p. 164) "The number of populations and species they have been responsible for obliterating can never be estimated, but it is clearly enormous." (p. 167)

This triadic classification of what triggers human-caused extinctions provides us with precisely the kind of organizing principle we need in order to formulate a metric for assessing the biodiversity impacts of organizations. What it tells us is that no such metric will be complete unless it adequately addresses the impacts of organizations on: (1) excessive harvesting or predation, (2) introduction of non-native species to specific areas, and (3) habitat loss.[38]

36 Leakey, R. (1995) The Sixth Extinction – Patterns of Life and the Future of Humankind.

37 Erlich, Paul and Anne (1981) Extinction – The Causes and Consequences of the Disappearance of Species.

38 Earlier foreshadowed, as well, in our review of SDG Goal 15.

The Solution We Propose

Armed with this insight, the metric we propose for assessing the biodiversity impacts of organizations is actually a *composite metric* with three dimensions to it that we call the 'Biodiversity Performance Index' (or BPI). The three principal areas of impact in the BPI are as follows:

1. **Habitat Loss** – A series of context-based metrics that address the separate environmental impacts of organizations on *habitats and ecosystems* relative to sustainability norms in two broad areas:
    a. **Abiotic impacts** – Impacts that affect the geophysical attributes of habitats as follows:
        i. Air – Impacts that affect air quality (e.g., due to emissions of toxic gases, particulates, odors, etc.) *relative to fair, just and proportionate allocations of shared responsibilities to abide by standards of air quality*;
        ii. Land (Cover)[39] – Impacts that affect the stocks and geographic distribution of land types and quality relative to *local or regional conservation standards or target*s, using a standardized classification system:[40]

Artificial surfaces	Shrub covered areas
Herbaceous crops	Shrubs/herbaceous vegetation, aquatic/flooded
Woody crops	Sparsely natural vegetated areas
Multi/layered crops	Terrestrial barren land
Grassland	Permanent snow and glaciers
Tree covered areas	Inland water bodies
Mangroves	Coastal water bodies and inter-tidal areas

        iii. Water – Impacts that affect the quantity and/or quality of stocks of water (e.g., because of consumption or contamination) *relative to fair, just, and proportionate allocations of available renewable supplies*.
    b. **Ecosystem impacts –** Impacts that affect ecosystems per se, above and beyond an organization's separate impacts on their underlying abiotic, geophysical features:
        i. Climate System – Impacts that affect the functioning of the biospheric climate system on Earth *relative to science/context-based climate change mitigation targets*;
        ii. Terrestrial (e.g., tundra, forests, grasslands, and deserts, including soil health) *relative to science-based conservation targets*;
        iii. Freshwater (e.g., lentic, lotic, wetlands) *relative to science/context-based conservation targets*;
        iv. Marine (e.g., open ocean, continental shelf, estuaries) *relative to science/context-based conservation targets*.
2. **Non-Native Species** – A context-based metric that measures the degree to which non-native species are introduced and/or transplanted by an organization into specific areas *relative to a sustainability norm of zero such introductions or transplantations*.[41]

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39 See this FAO publication page for the important distinction we are relying on between 'land cover' and 'land use' in our choice of 'land cover' as the variable of interest here: http://www.fao.org/3/x0596e/x0596e01e.htm

40 Taken from the SEEA Technical Note: Land Accounting report (Table 1, p. 6) for illustrative purposes only: https://seea.un.org/sites/seea.un.org/files/seea_technical_note_-_land_jan_2017_draft.pdf

41 While it is not clear that landowners have obligations to avoid creating conditions favorable for non-native species or for controlling their populations (or if so, to what extent they do), clearly some non-native species negatively impact native species, and their populations can grow out of control; thus, landowners do have an obligation to refrain from engaging in activities that foster the introduction and growth of populations of these sorts of species.

3. **Harvesting/Predation** – A context-based metric that measures the extent of hunting, harvesting, and/or eradication of wildlife (flora and fauna) by an organization *relative to a sustainability norm of no more than fair, just and proportionate shares of available renewable supplies (populations) within the limits of their carrying capacities*.[42]

In practice, the application of the BPI metric would take the form of multiple sub-metrics, some of which are already in use at Cabot. As shown below in Figure 6, at least ten such metrics are envisioned, the use of which would produce individual scores in their corresponding areas of impact, and also a composite score or *index* (again, see Figure 6 for an illustration of how the BPI might be configured in a context-based model, with sample scores included).

Biodiversity Performance Index (BPI)

Biodiversity Areas of Impact	Sub-Areas of Impact and Their Individual Context-Based Metrics			Individual Metric Scores[1]		Biodiversity Performance Scores[2]
Habitat Loss	*Abiotic Impacts*	*Air*		1.20		50%
		Land (Cover)		0.10		
		Water	*Quantity*	1.35	1.18	
			Quality	1.00		
	Ecosystem Impacts	*Climate System*		1.65		
		Terrestrial		0.95		
		Freshwater		1.25		
		Marine		0.34		
Non-Native Species	*Non-Native Species Introduction*			1.10		0%
Harvesting/ Predation	*Harvesting/Predation*			0.00		100%
[1]All scores of ≤1.0 signify conformance to sustainability norms. [2]Proportion of individual scores that conform to sustainability norms.				Overall BPI Score[2]		50%

Figure 6 – Biodiversity Performance Index (BPI) with Sample Scores included

42 Species listed as Threatened or Endangered by the US ESA or IUCN should not be hunted. Other species which are desired as game, and which are sufficiently abundant for hunting, will ideally have well-established science-based hunting or harvesting rules to allow hunting and harvesting of them without unduly diminishing the population or viability of the species in the long-term.

Discussion and Recommendations

The degradation of biodiversity throughout the world has rightly caught the attention of policymakers at the global level just as it should have, and is now well on its way to precipitating a new set of national accounting standards for natural capitals. We applaud these efforts, but worry that the translation of biodiversity concerns into national-level guidance may, like so many things, do nothing but pander to the purely economic and pecuniary interests of commerce, while leaving sustainability considerations, as such, behind. Our concerns are justified, we think, by what we see happening in the leading national accounting frameworks currently being developed (e.g., SEEA), in which the very purpose of those programs is to take inventories of, and monetize, natural resources and ecosystem services for their economic value, as opposed to either their intrinsic value or for the sake of ensuring that human impacts upon them are sustainable.

We also note that as of this writing, there appears to be only two formalized attempts to codify biodiversity performance accounting for use by organizations (*GRI 304 and NCC/SEEA*) albeit with a third promised (SBTN), which such metrics are themselves not context-based at all. And while we do agree with GRI, in particular, in terms of many of the impact disclosures it calls for, we do not agree that such disclosures should be context free, or that by disclosing them as GRI requires, the biodiversity performance of organizations will be revealed at all. Instead, we take the position that in order to be meaningful, a biodiversity metric must be both organization-specific and context-based.

And while a sharp distinction can be made between national-level accounting protocols (such as SEEA) and organization-level protocols, a degree of overlap between them is perhaps desirable. We can, for example, choose to align with a framework like SEEA insofar as the ontology of, say, land types is concerned, just as we did in the examples we provided for 'Land Cover' in the 'Habitat Loss – Abiotic Impacts' sub-category of our *Biodiversity Performance Index* above. By taking such a position, we might at least be availing ourselves of datasets in the future that can be used to help set sustainability norms or targets, even though the sources of data to which we are turning might not themselves be doing so.

We have also taken the position that in order to be meaningful, a biodiversity metric must use as its starting point an understanding of the specific types of impacts that actually cause species and/or ecosystems loss or degradation: excessive harvesting/predation, non-native species introduction, and habitat loss. It is imperative, therefore, that biodiversity metrics include treatment of all three types of impacts, otherwise it may be possible to score 'well' with a metric, even as deleterious impacts on biodiversity are taking place.

With the above in mind, the solution we propose can be compared with other initiatives as follows:

1. As with the GRI, NCC, and agricultural indicators, ours (the BPI) is explicitly organization-based in scope;
2. Unlike the NCC indicator, however, neither ours nor the others (GRI or agricultural) set out to assess the effects of impacts on the extent or value of available natural capital. Rather, they seek to assess the sustainability of the impacts themselves – and by extension, the activities that produce them;
3. Contrary to all the indicators, however, ours is context-based in the sense that it assesses impacts relative to sustainability norms or thresholds for what they (the impacts) would have to be in order to be sustainable. The others, by contrast, are incrementalist in their orientation and therefore do not assess sustainability performance at all;
4. And whereas we arguably share a causal theory with all of the other methods, both in terms of how human activities can affect and undermine biodiversity in the world, we take steps to make that theory explicit in terms of the three principal causes of anthropogenic biodiversity loss or degradation, which we then use to specify indicators in our composite BPI metric.
5. Importantly, we also take steps to include ecosystems impacts in our framework and not just species per se, since ecosystems, too, are (1) life-like, (2) generative of ecosystems services, (3) functionally dependent upon biodiversity both within and between them, and (4) habitats unto themselves upon which species per se depend for their existence.

Our own final recommendation, then, is that Cabot take steps to further develop and deploy the BPI metric we have proposed, recognizing that at least some of the underlying sub-areas of impact are already being measured there. By taking this approach, Cabot can avail itself of a biodiversity metric that is (a) organizational in scope, (b) context-based, and (c) explicitly reflective of the factors known to cause degradations of biodiversity.

Here we hasten to add that all we have said and proposed on these pages is preliminary and largely directional. More work is needed to further develop, test, evaluate, and refine the measurement model we have proposed, not to mention the details of the metrics we have identified and the norms and standards they call for. Still, we believe the approach we have proposed is not only viable, but is the most promising solution for assessing the biodiversity performance of organizations, if only because it is the only context-based one we know of.

APPENDIX A

UN SDG 15

Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

15.1 - By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.

15.2 - By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.

15.3 - By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

15.4 - By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.

15.5 - Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.

15.6 - Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.

15.7 - Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products.

15.8 - By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.

15.9 - By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.

15.a - Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.

15.b - Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.

15.c - Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities.

APPENDIX B

PARTIAL TRANSCRIPT OF DISCUSSION WITH FORICO'S CFO

APPENDIX B – Partial Transcript of Discussion with Forico's CFO[43]

Rayne van den Berg, Forico's CFO, describes her company's experience with SEEA and the NCC as follows:

> "Forico has responsibility for the management of over 172,000 hectares (ha) of land in Tasmania, Australia, of which, 77,000 ha are managed for conservation and biodiversity values, and ~89,000 ha being productive plantation land.
>
> Forico's journey with Natural Capital Accounting started in 2014, when Forico commenced its Natural Forest Assessment Program and then engaged the IDEEA Group and ecological specialists in conjunction with Forico's own internal teams to measure and spatially map ecosystem services by conducting extensive field research to obtain a visual representation and proof of concept of the extent and condition of material ecosystem services on their Estate under the SEEA framework.
>
> Forico has since expanded on this foundational work to adopt a more commercial approach using the framework provided by the Capital Coalition's Natural Capital Protocol (NCP). The NCP framework and the specific guidance also provided in the accompanying Natural Capital Protocol – Forest Products Sector Guide is providing the basis for Forico to prepare an illustrative Natural Capital Report for the year ended 30 June 2020, focusing on measuring, valuing and presenting Natural Capital values in a manner consistent with existing Financial Reporting Frameworks and Standards.
>
> Integrating Natural Capital into Financial Accounting requires the use of a common monetary language with both financial and quantitative metrics showing movements and balances for ecosystem flows and stocks respectively, as well as segmenting values between Natural Capital values to and from society and to and from business.
>
> NCP's principle-based approach also aims to embed all six capitals (Financial, Manufacturing, Intellectual, Human, Social, and Natural) into business decision-making, processes, strategies, and reporting.
>
> In Forico's first illustrative Natural Capital Report, currently under development, they have focused on measuring, valuing, and presenting the following ecosystem services which were determined to be among the most material to their present-day business and industry:
>
> - Provisioning - Wood fibre from sustainable plantations to be converted to renewable sawlogs and wood fibre products;
> - Provisioning and Regulating – Carbon sequestration from plantation and natural forests offset by carbon emissions produced by business operations;
> - Provisioning and Regulating – Water usage and impact on both high and low downstream flows, and water quality impacts principally regarding natural forest riparian corridors utilised to control erosion and sediment release within the managed estate; and
> - Provisioning and regulating – natural forest vegetation to provide habitat and biodiversity and where identified, undertaking habitat restoration and rehabilitation programs to improve or maintain habitat condition.
>
> Forico has also partnered with KPMG, a global Big 4 Accounting firm, to independently peer review Forico's valuation methodologies and to test their disclosures to obtain a public limited assurance opinion across their Natural Capital Report.
>
> We are looking to make the report available early in Calendar Year 2021, so let's keep in touch and share knowledge and thoughts in this emerging field."

43 From personal communications with M. McElroy on Nov. 4, 2020.

P.O. Box 705
Woodstock, VT 05091
sustainableorganizations.org

125 Manomet Point Road
Plymouth, MA 02360
manomet.org