BELTERRA

On the economies of nature and society

LAYING THE FOUNDATIONS FOR AGRICULTURE-BASED BIODIVERSITY CREDITS

Title: On the economies of nature and society: laying the foundations for agriculture-based biodiversity credits

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Author: Guilherme A. C. Bircol

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1 World crisis

As we all have seen in the news, the world is currently facing a global crisis that cannot be traced back to a single root cause but to several. War is again a major source of conflict among the world powers, with nuclear war being as close as it was during the Cuban missile crisis (1962), in the Cold War. Diplomacy and Multilateralism are no longer proving to be the way out of international disagreements. Individual interests, isolationism and the unsettling rise of extremist governments are challenging the contemporary notion that Democracy could save us all. Human Rights appear not to be a consensus anymore.

In terms of economic development, despite the obvious improvement in living standards in this past century it has not reached the world population equally, with the poorest nations still struggling to achieve decent living conditions. According to the World Bank [1], 8% of the world population (around 648 million people) were living under extreme poverty[1] in 2019, with roughly half of the world population living under less than US$6,85 per day. It is true that poverty was sharply reduced since 1990, but progress was slowed down after 2014 and even reversed during the COVID-19 pandemic, with 71 million more people projected to be living under extreme poverty.

Added to these aspects is the potential collapse of planetary systems. Climate change and biodiversity loss are global threats that risk disrupting not only ecosystems but entire value chains around the globe – the food systems being the most vulnerable to these changes. Extreme weather events are becoming so frequent that millions of dollars are being directed to climate adaptation in most countries. On the other hand, with the deepening of the climate crisis, in a world still reliant on fossil fuels[2], climate finance is still gaining traction, expected only to produce elusive mid-term outcomes – at least for now.

Biodiversity loss is another side to the same problem. Whilst the word "biodiversity" evokes psychological representations of large mammals peacefully grazing and coexisting in the African

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[1] The World Bank updated its poverty line in 2022, shifting the measure unit from international dollars given in 2011 prices to international dollars given in 2017 prices. Thus, the current poverty line is now set at US$2.15 per day.

[2] Oil companies are still increasing production and making huge profits (https://www.nytimes.com/2024/02/02/business/oil-gas-companies-profits.html).

Savannahs, the role biodiversity plays in sustaining human life is much more critical. It is precisely from biodiversity that humans obtain crucial subsistence conditions (i.e., ecosystem services), such as food resources and climate stability. And despite the impulse to think of only a handful of species that have economic interest, each and every species is part of an intricate web of relationships that sustains the natural capital (e.g., forests, savannahs, fields, mangrove etc.). Remove enough of these species – as least important as they might be perceived – and resilience reaches its breaking point and the entire system collapses. According to WWF [2], there is a 69% average decline in relative abundance of 31.821 wildlife populations monitored – which corresponds to around 5.230 species. If the extinction rate seen in Earth's history were used as reference, the species going extinct in the last century would normally take 800 to 10.000 years to reach the same fate [3]. In other words, we are apparently causing species to go extinct at a higher rate than new species can evolve.

The common denominator in all these aspects is the human factor, as recognized by both UN-backed agencies, IPCC and IPEBES [4]. It is clear that human activity is putting major pressure on global natural systems since at least the Industrial Revolution. Greenhouse gases emission, land conversion and deforestation, pollution, introduction of invasive species are among the main drivers of change. Such a multidimensional crisis needs a solution just as multifaceted, capable of providing creative answers that are both feasible and effective. In this sense, seeking a silver bullet capable of eliminating the threat all at once may not be fruitful – despite recognizing that government leadership is central in any case, if we are to succeed. Instead, combining and coordinating actions at different scales and geographies could prove to be a more productive path.

Among these, nature and climate-related financial incentives are one of the most discussed courses of action. Carbon credits schemes, for example, are currently the most famous incentives of this kind[3], with revenues from carbon taxes and emission trading systems (ETS) reaching about US$95 billion and a voluntary market with an annual value of US$2 billion. [5].

[3] Carbon credits were first defined by the Kyoto Protocol, signed in 1997, but their trade took effect in 2005 with the establishment of a global market.

Another kind is the newly established biodiversity credit scheme, which aims at inducing environmental protection and/or restoration at the most elementary scale: of biodiversity itself. This technical note focuses on discussing this instrument, focusing on agriculture-based biodiversity credits.

2 Biology and Economics

To make things more purposeful, it is important to define the body of knowledge that motivates Belterra to start the debate on what an agriculture-based biodiversity credit scheme should look like. The most basic aspect worth mentioning is the relationship between Ecology and Economics.

Those seemingly different realms, in reality, share the same prefix: “eco”, which comes from Greek word “oikos”, and could mean either “the family”, “the family’s property” or “home”, depending on the context. Whilst Ecology’s suffix comes from “logía” (i.e., the “logic” behind it), Economics’ comes from “nomus” (i.e., the “norm” or “law” that should guide). It becomes clear, then, that both Sciences focus on our planet – our “house” – and its resources: Ecology from a perspective of understanding the relationships that enable the functioning of ecosystems as we know and Economics from a perspective of resource management and stewardship.

However, despite their relationship, these two domains have drifted apart. For one reason, humans like to believe that almost 10.000 years of “civilization development” made them the pinnacle of evolution. A species that discovered the power to bypass the constrains of nature and can now develop society to an unforeseeable future. The only thing that could jeopardize the future of humanity is humanity itself. And even when that happens, humans would always find the solution to their problems. It is no surprise that by this reasoning Economics should deserve a path of its own, preferably separated from everything related to the natural world.

Despite some of these statements being true, it is either naïve or arrogant to believe that our species is no longer constricted by our Biology. Physiologically, Science is still lagging behind nature’s “creative power” to come up with new challenges to our health: cancer is still a major disease to be overcome, HIV is still uncurable, and the risk of a new pandemic is now always a looming ahead. Not only that, but our way of life has made things even worse: our dietary preferences have increased the prevalence of chronic diseases, our CO_2-dependent cities compromise both our lungs and our minds. Ecologically, widespread consumerism has put a strain on natural systems that a few years back had no problem in regulating themselves. Global value chains now connect systems in distinct parts of the globe: the cocoa produced in Africa becomes the chocolate consumed in different countries. An unpredicted increase in cocoa demand could render now economic and ecological consequences: inflation in the commodity market – affecting everyone that depend on it and its byproducts – and the overuse of local natural systems beyond their carrying capacity, affecting populations close to the production sites. Indeed, six of the nine planetary boundaries[4] have already been crossed, adding layers of uncertainty by altering the functioning of Earth's systems [6] (Figure 1).

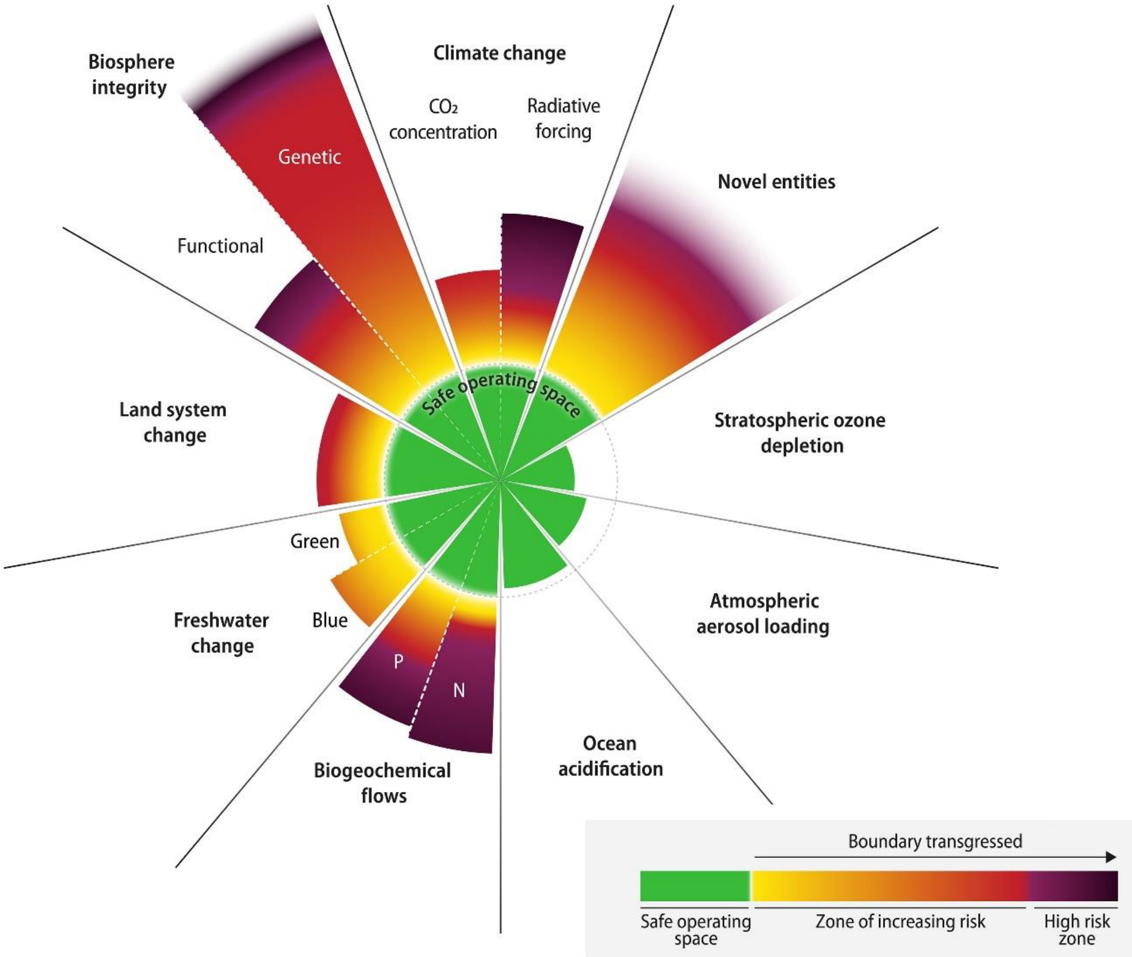


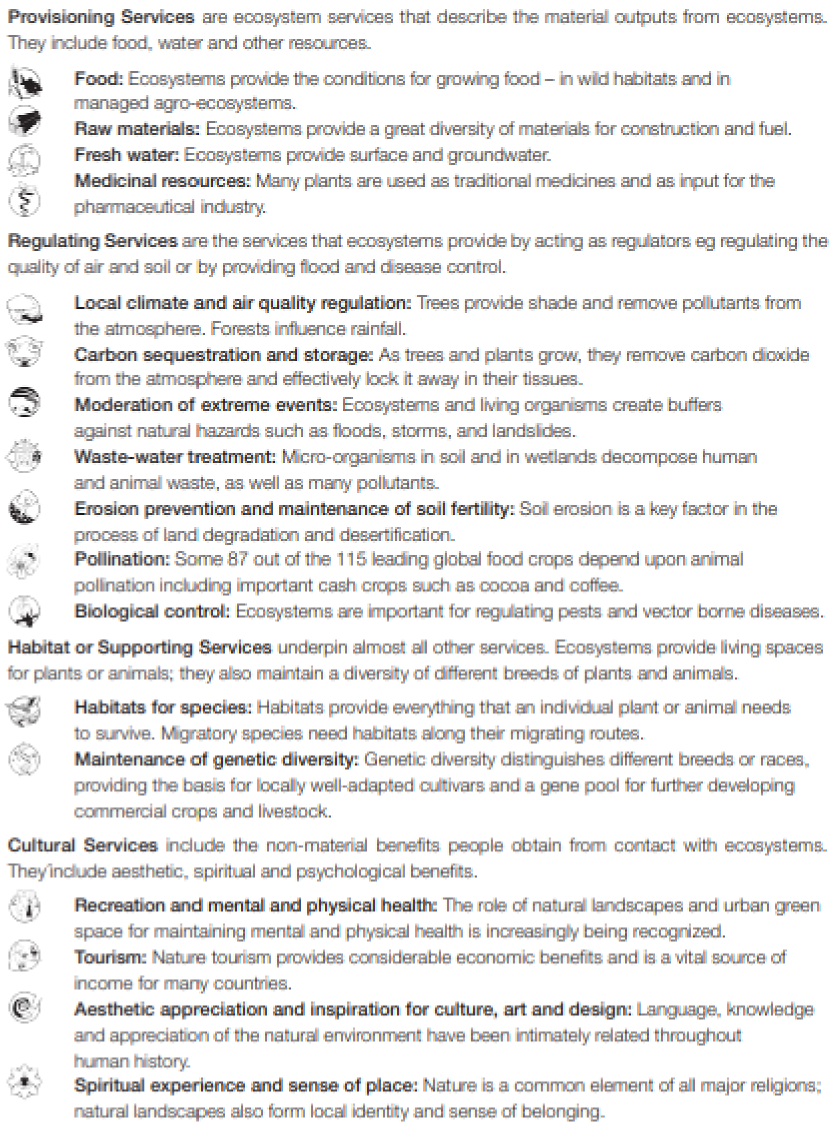
Figure 1. Six of the 9 planetary boundaries have been crossed, indicating that Earth's systems may change to an uncertain space for humanity. Source: [6].

All these events point to an obvious conclusion: the connection between Economics and Biology needs to be restored. We need to find a way to better account for nature-related benefits – to which we

[4] The planetary boundaries are a framework developed by Rockstrom and colleagues, in 2009, in their seminal work "A safe operating space for humanity", which identify and quantify boundaries that must not be crossed, if humanity is to continue existing in a safe existential space.

depend on – in our economic models. And that is precisely what the Ecosystem Services (ES) approach helps us with.

Definitions vary. According to the Millenium Ecosystem Assessment, an ecosystem is a "dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit" and ES are "the benefits people obtain from ecosystems" [7]. Thus, it is clear that ES are intrinsically related to the human perception of "benefits" (Figure 2).


Provisioning Services are ecosystem services that describe the material outputs from ecosystems. They include food, water and other resources.

- **Food:** Ecosystems provide the conditions for growing food – in wild habitats and in managed agro-ecosystems.
- **Raw materials:** Ecosystems provide a great diversity of materials for construction and fuel.
- **Fresh water:** Ecosystems provide surface and groundwater.
- **Medicinal resources:** Many plants are used as traditional medicines and as input for the pharmaceutical industry.

Regulating Services are the services that ecosystems provide by acting as regulators eg regulating the quality of air and soil or by providing flood and disease control.

- **Local climate and air quality regulation:** Trees provide shade and remove pollutants from the atmosphere. Forests influence rainfall.
- **Carbon sequestration and storage:** As trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues.
- **Moderation of extreme events:** Ecosystems and living organisms create buffers against natural hazards such as floods, storms, and landslides.
- **Waste-water treatment:** Micro-organisms in soil and in wetlands decompose human and animal waste, as well as many pollutants.
- **Erosion prevention and maintenance of soil fertility:** Soil erosion is a key factor in the process of land degradation and desertification.
- **Pollination:** Some 87 out of the 115 leading global food crops depend upon animal pollination including important cash crops such as cocoa and coffee.
- **Biological control:** Ecosystems are important for regulating pests and vector borne diseases.

Habitat or Supporting Services underpin almost all other services. Ecosystems provide living spaces for plants or animals; they also maintain a diversity of different breeds of plants and animals.

- **Habitats for species:** Habitats provide everything that an individual plant or animal needs to survive. Migratory species need habitats along their migrating routes.
- **Maintenance of genetic diversity:** Genetic diversity distinguishes different breeds or races, providing the basis for locally well-adapted cultivars and a gene pool for further developing commercial crops and livestock.

Cultural Services include the non-material benefits people obtain from contact with ecosystems. They include aesthetic, spiritual and psychological benefits.

- **Recreation and mental and physical health:** The role of natural landscapes and urban green space for maintaining mental and physical health is increasingly being recognized.
- **Tourism:** Nature tourism provides considerable economic benefits and is a vital source of income for many countries.
- **Aesthetic appreciation and inspiration for culture, art and design:** Language, knowledge and appreciation of the natural environment have been intimately related throughout human history.
- **Spiritual experience and sense of place:** Nature is a common element of all major religions; natural landscapes also form local identity and sense of belonging.

Figure 2. The different groups of ecosystems services. Source: The Economics of Ecosystems and Biodiversity (TEEB). [8]

Another one is given by Robert Costanza[5] and colleagues in their seminal work "The value of the world's ecosystems services and natural capital" [9]. According to them," ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions". On the other hand, ecosystem functions (EF) are broadly defined as the "habitat, biological or system properties or processes of ecosystems". It is clear, then, that EF refers to the processes that enable ecosystems to continue existing, while ES – just as MEA's definition –, to a more anthropocentric view of nature. Spangerberg and colleagues [10] summarize this view with a very elucidating scheme (Figure 3).

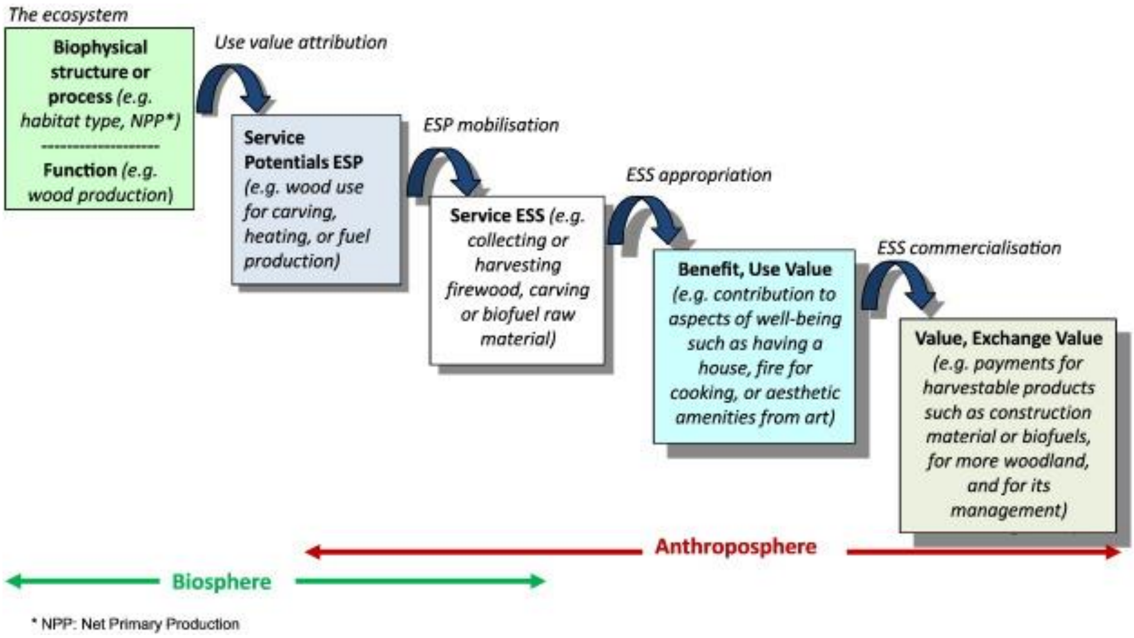


Figure 3. The relationship between a more "biocentric" view of nature ("biosphere") and an anthropocentric one ("anthorposphere"). From the nature's structure, process and functions, society (i) values nature in terms of their potential benefits to be derived; and (ii) deploys others forms of capital (manufactured and human) to access the services themselves. Source: [10]

The conclusion is that, aside from assigning value to ecosystems structures, processes and functions[6], humans need to deploy manufactured capital and human capital to access the ES themselves [9].

[5] There are several other relevant definitions of ES, such as the newly defined Nature's Contribution to People (NCP), used by IPBES, as well as Herman Daly's definition.

[6] Despite being different concepts, for the purpose of clarity, all of them are considered together in this article to represent the "less anthropocentric" aspects of ecosystems.

2.1 Biodiversity and natural capital

And finally, we come to the last relevant concepts to our reasoning: natural capital and biodiversity. From an economic perspective, capital is considered the stock of anything that can be used, combined with other forms of capital, to create flows of services and/or materials that enhance the welfare of humans – and the more these flows enhance welfare, the more valuable they are [9]. Thus, natural capital (NC) can be generally defined as the stocks of capital coming from the environment that can produce ecosystem services. Examples would be trees, minerals, ecosystems, the atmosphere [9], meaning that NC is composed of the complex assemble of (i) the "living" dimension and (ii) the "non-living" or physical dimension (Figure 4).

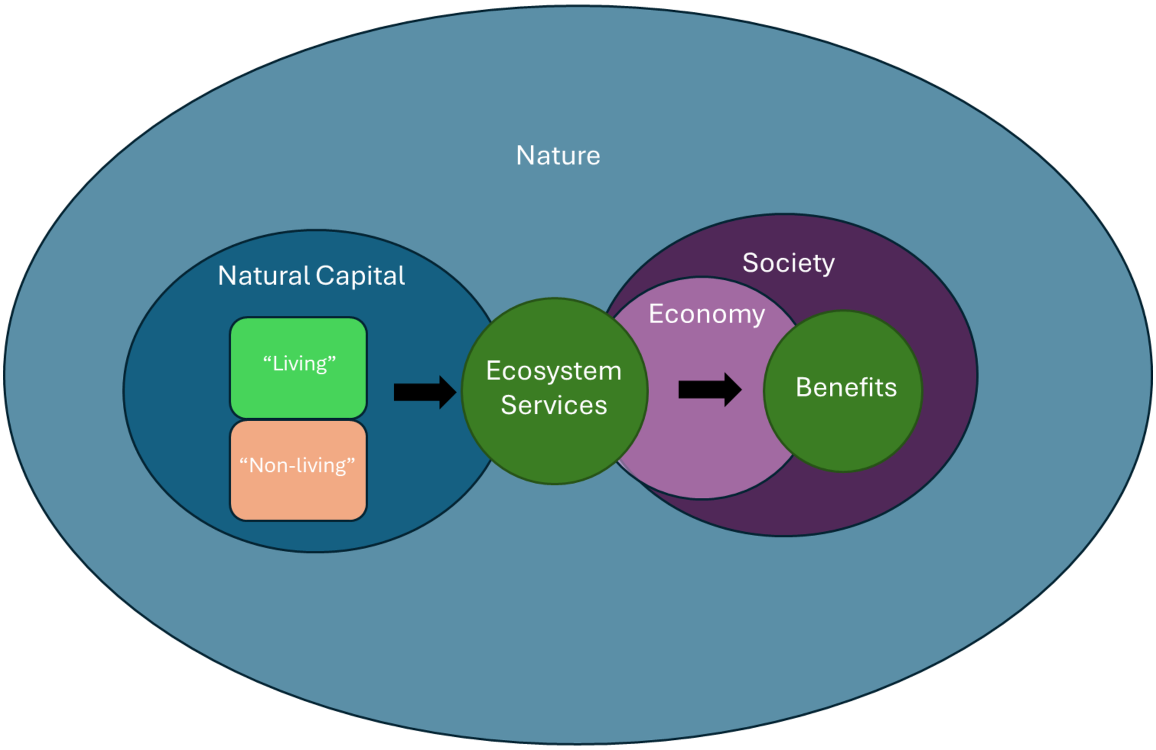


Figure 4. The relationship between nature and society. Nature encompasses all that exists. The part that society can perceive as "potentially" valuable is the natural capital, which in turn is composed of "living" and "non-living" aspects. By deploying other capital forms, via its economic system, society can access ecosystem services and benefit from them. Source: based on the definition used by the Taskforce on Nature-related Financial Disclosure (TNFD) [11].

Ecosystems are generally understood as synonymous to NC but they may mean different things as scale is also relevant. For instance, a single tree may produce food resources for a family (i.e., a provision service), and thus be considered a form of natural capital, but may be unable to be the sole responsible for the climate regulation in a given region. In this sense, both the tree and the ecosystem may be considered different forms (i.e., assets[7]) of NC. Moreover, NC varies according to their specific geographies. A savannah ecosystem produces other services than mangroves do. However, regardless of scales and geographies, the relationship between "living" and "non-living" aspects is always present, as even one single tree depends on nutrients and soil resources to exist.

The question that arises now is: what is the role played by biodiversity in the formation of capital? To answer that question, we must first define biodiversity itself. According to the Convention on Biological Diversity (CBD), "'Biological diversity' means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems" [12]. The World Wide Fund for Nature (WWF) defines it as "all the different kinds of life you'll find in one area—the variety of animals, plants, fungi, and even microorganisms like bacteria that make up our natural world. Each of these species and organisms work together in ecosystems, like an intricate web, to maintain balance and support life. Biodiversity supports everything in nature that we need to survive: food, clean water, medicine, and shelter" [13]. Thus, it becomes clear that (i) biodiversity refers to the "living" aspect of NC; (ii) variability is important because, through evolutionary processes, allows the creation of complex interactions among different species, organisms and the "non-living" aspects of the environment (i.e., complex networks), which in turn confers resilience and a certain kind of stability to the ecosystems that we depend on; and (iii) biodiversity is directly responsible for ES provision (Figure 5).

[7] Assets, here, is defined as any identifiable unit of NC from which a specific ES can be derived. Thus, NC is generally used in a broader sense, encapsulating all the elements, both "living" and "non-living", in a given ecosystem, while assets are more ES-specific concepts.

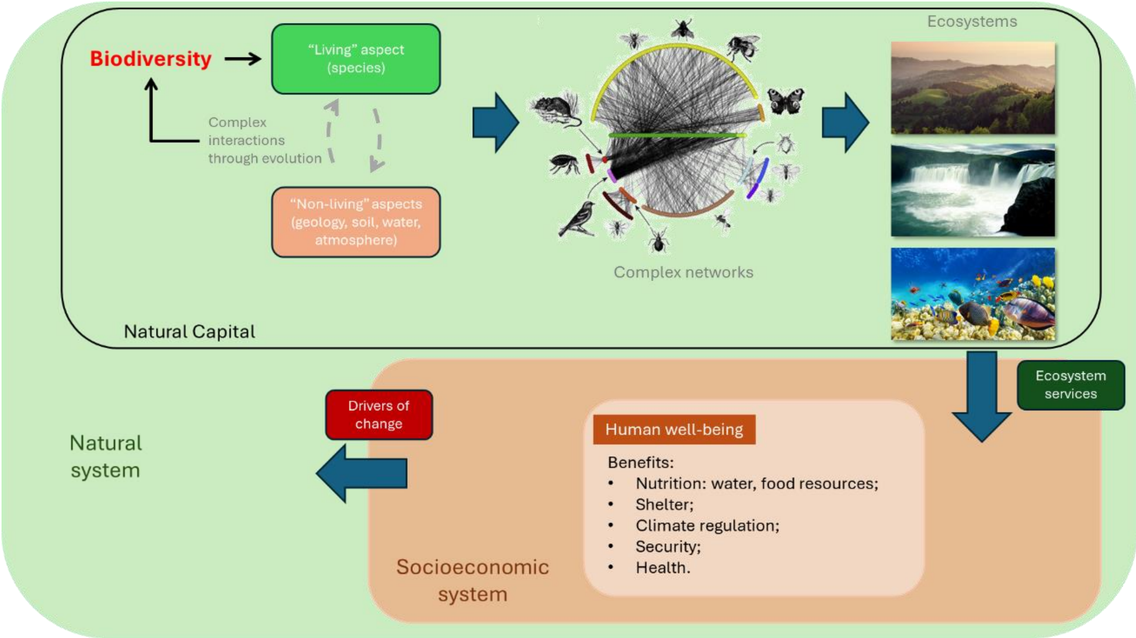


Figure 5. The complex relationship between biodiversity, ecosystem services and society. Biodiversity is what defines the complex relationship between different species. The more "natural" links in the network, the more resilient the ecosystem is and is understood to continue providing ecosystem services to society. These complex iterations, in turn, affect back biodiversity allowing new species and relationships to be formed through time (i.e., evolution). Society also affects the natural system (i.e., drivers of change) both in terms of species evolution (i.e., new selection pressure) and ecosystems change (by removing links from the network and weakening them). Source: layout based on [14], complex network from [15], ecosystem images from [16] [17] [18].

Therefore, the availability of NC is directly linked to how evolutionary processes are allowed to continue happening. Biodiversity, in this sense, becomes both (i) the product of an underlying evolutionary process of geological scale and (ii) the main stabilization force of present ecosystems and their respective ES. Remove enough links from a complex network of a given ecosystem and in a generations time the relationships breakdown, ES cease to be provided and entire civilizations risk collapsing from losing their needed livelihoods. As pointed out by Cheng Zhang and colleagues, "biodiversity is the basis for the formation of ecosystem functions and services, which can have a significant impact on the productivity, material cycle and other ecosystem functions and services and their stability" [19].

2.2 The failures in nature accounting

Giving the importance that biodiversity has to society – keeping the integrity of critical ecosystems, the NC and, thus, the related ES that we depend on – why are species getting extinct at an unprecedented rate? Explanations vary. Some argue that not enough policy efforts are being made to protect nature. To them, stricter regulations could halt biodiversity loss if decision-making bodies are committed to it and enough investment is made in law enforcement. Others argue that not enough economic incentives are being created to catalyze the implementation of more sustainable "nature-friendly" technologies. According to this view, despite recent efforts to mobilize capital to make this transition viable, there is just not enough to reach global scale.

Letting this false dichotomy aside – since they are better seen as complementary rather than mutually exclusive courses of action – what seems to be a common flaw to both is the failure to account for nature's contribution to society. In monetary terms, if nature were to be accounted for properly in our balance sheets, we would see something around US$7,3 trillion of unpriced natural capital costs [20]. According to the initiative The Economics of Ecosystems and Biodiversity (TEEB) this happens because *"those ecosystem services most likely to be priced in markets are the consumptive, direct use values of 'provisioning services,' such as crops or livestock, fish or water, which are directly consumed by people. Non-consumptive use values, such as recreation, or non-use values, which may include the spiritual or cultural importance of a landscape or species, have often been influential in decision making but these benefits are rarely valued in monetary terms"* [8].

Failing to value NC not only disrupts our ability to counter biodiversity loss but also increases our blindness as to how our business practices are preventing future generations of accessing the ES needed to wellbeing. To invest in a sort of "natural gross capital formation" we need first to understand the depths of our impacts, decrease measurement uncertainty and then invest in it. Currently, it is estimated that the financing gap to reverse biodiversity loss is around US$711 billion [21].

That is the space that biodiversity credits, along with other nature-related market instruments, have been developing. Not only they aim at contributing to better account for nature in monetary terms but also to bridge the financing gap. Far from having a standardized approach, biodiversity credits are still in their youth. Multiple methodologies are being developed and there still a long way to go.

3 Biodiversity credits so far: what, who and when?

In this section we briefly describe the "state of the art" of the biodiversity credits ecosystem. It is important to remark that even though effort is always made to use the most recent information it is still possible that by the time of publication they may already be outdated.

According to the Biodiversity Credit Alliance (BCA) a biodiversity credit is "a certificate that represents a measure and evidence-based of positive biodiversity outcome that is durable and additional to what would have otherwise occurred"[8] [22]. Therefore, any initiative that promotes verifiable positive changes to biodiversity is eligible for biodiversity credits issuance. One question that automatically arises is what should we measure then?

The answer depends on the definition of biodiversity being used, the attributes being considered and the methods we choose. Are we talking about the ecosystem as a whole? Genes? Species-level indicators? Or area-based measurements? (Figure 6).

[8] The BCA report is still in press and not publicly available, making it possible that this definition could change.

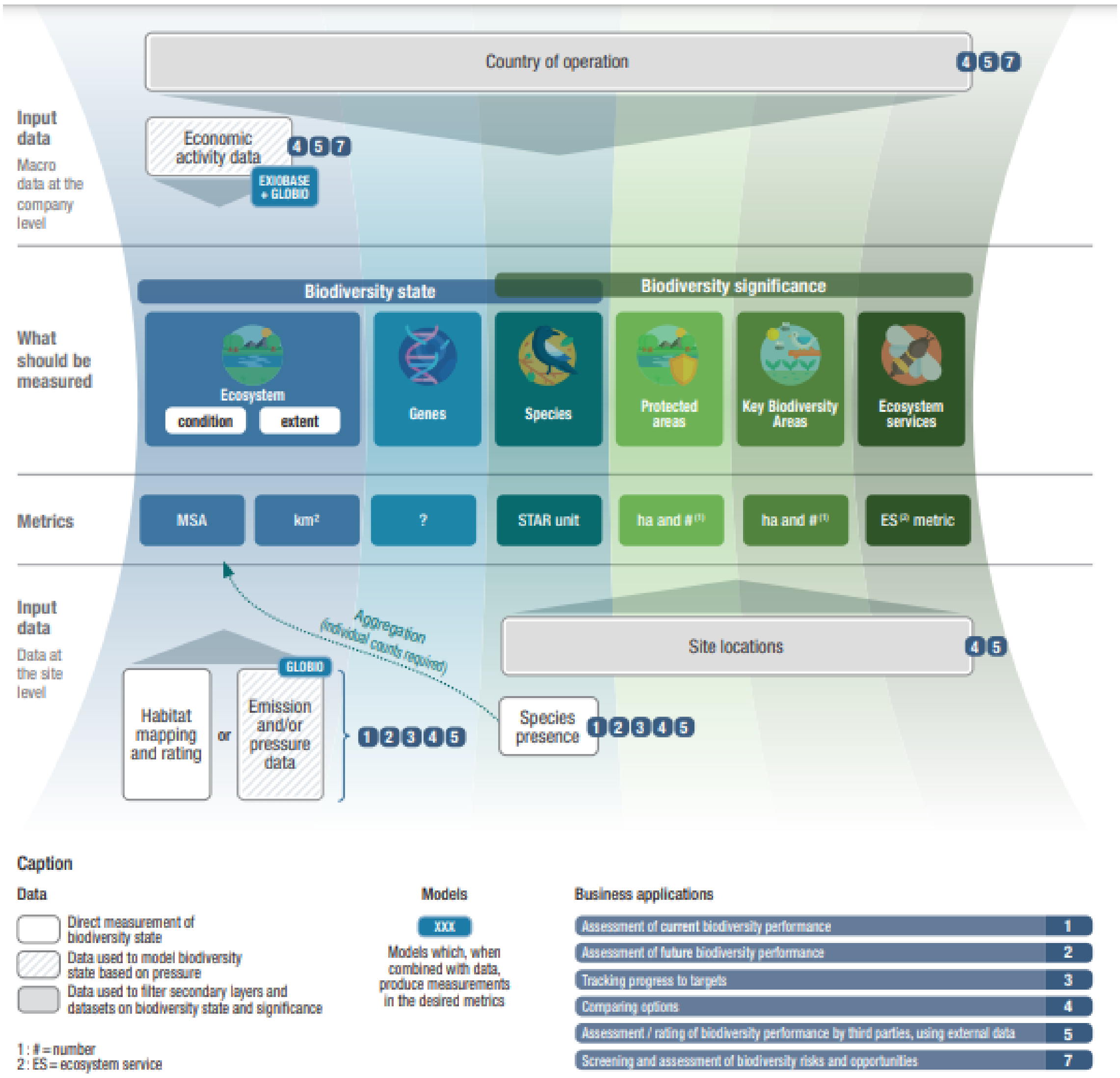


Figure 6. Elements important to be considered when assessing biodiversity in business practices. Source: [23].

Aside from measuring, another question that arises is how to we assign value to those measurements? The classical theory says that the market will be the responsible for determining how much an asset (or service) is worth [24]. The price would be the proxy for the value. Through the normal functioning of the market, supply and demand would regulate flows of materials and services in the most efficient way, avoiding complete depletion by substituting one resource for another. Whenever a natural resource is facing any shortage of supply (e.g., fossil fuels), prices would naturally rise and businesses would invest in cheaper or more efficient substitutes (e.g., clean energy). Other theories, however, challenge this understanding. To them, the market is incapable of apprehending the full value of nature [24]. As seen before, the price of a given natural capital that has spiritual or cultural value will fall short in terms of its price. With no direct business application, that natural capital will almost aways be deemed "cheaper" – and thus, more appealing to be converted – for not having its cultural or spiritual dimensions contemplated in the price. Moreover, according to these converse theories, natural capital cannot be subject to substitution, since one ecosystem is not comparable to another [24] – an issue we will discuss it further in the next section. Figure 7 illustrates the different approaches to valuing natural capital.

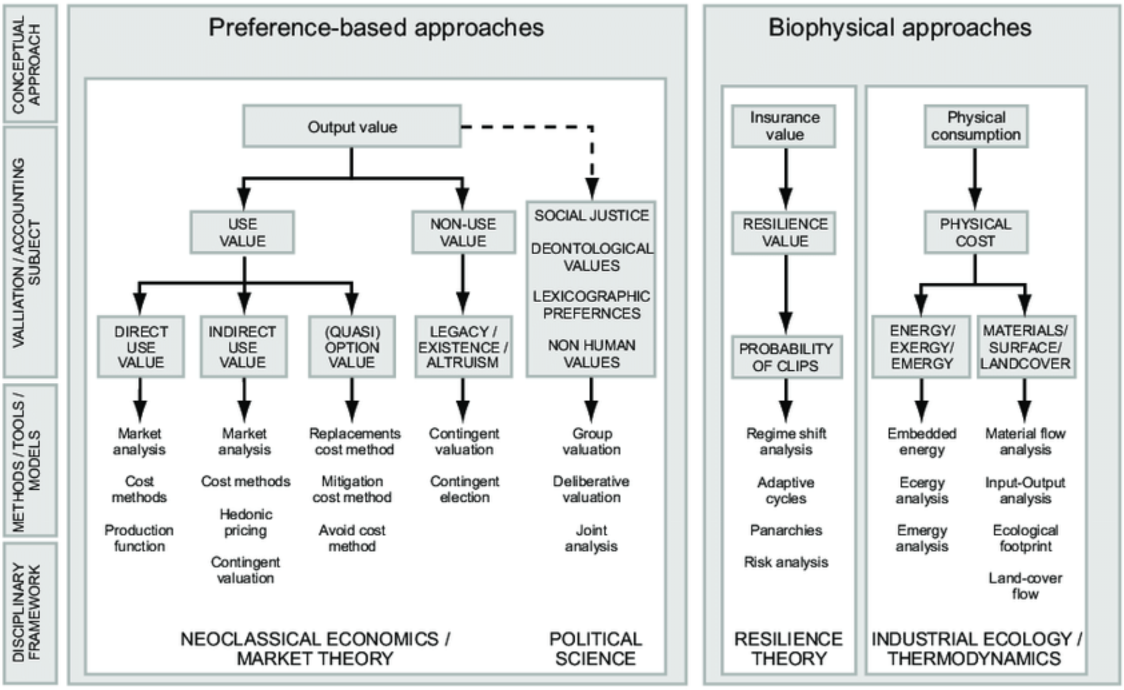


Figure 7. *Valuation methods used for natural capital and ecosystem services. Source: [8].*

Notwithstanding metrics and to value nature, who would be the actors interested in buying these potential credits and why? Starting with the "why", since 2022 the world has agreed to halt biodiversity loss and improve the quality of our ecosystems. The Global Biodiversity Framework (GBF), signed under the UN regime (CBD/UNEP[9]), has four 2050 goals and twenty-three 2030 targets. In the context of business, it is worth highlighting the targets 3 ("conserve 30% of land, waters and seas"[10]),15 ("businesses assess, disclose and reduce biodiversity-related risks and negative impacts") and 19 ("mobilize US$200 billion per year for biodiversity from all sources, including US$30 billion through

[9] United Nations Environmental Program.
[10] Known as "30 by 30", meaning 30% protection of land water and seas by the year 2030.

international finance"). Target 19 specifically mentions biodiversity credits in item "d"[11]. It becomes clear that not only nations will be demanded action but also businesses will have to adapt their models as to decrease their impact and improve biodiversity condition – especially the biodiversity that their value-chain depend upon.

Aligning themselves with these targets, several business-driven disclosure frameworks have emerged in these past few months, while others have updated their guidelines. The Taskforce on Nature-related Financial Disclosure (TNFD) calls for the investigation and reporting of both impacts and dependencies [25]. The Global Reporting Initiative (GRI) has just recently published the "GRI 101: Biodiversity 2024" with new sets of indicators and recommendations to help companies disclose their impacts on biodiversity more transparently. And the Science-based Targets Network (SBTN) provides a list of science-based targets and indicators that includes biodiversity as a dimension of interest for companies to measure, assess and report.

And who are the actors that already hold positions in the biodiversity credits market? Simas Gradeckas from Bloom Labs has compiled a list with the most important organizations in the landscape at the

[11] "Stimulating innovative schemes such as payment for ecosystem services (PES), green bonds, biodiversity offsets and credits, and benefit-sharing mechanisms, with environmental and social safeguards".

moment (Figure 8).

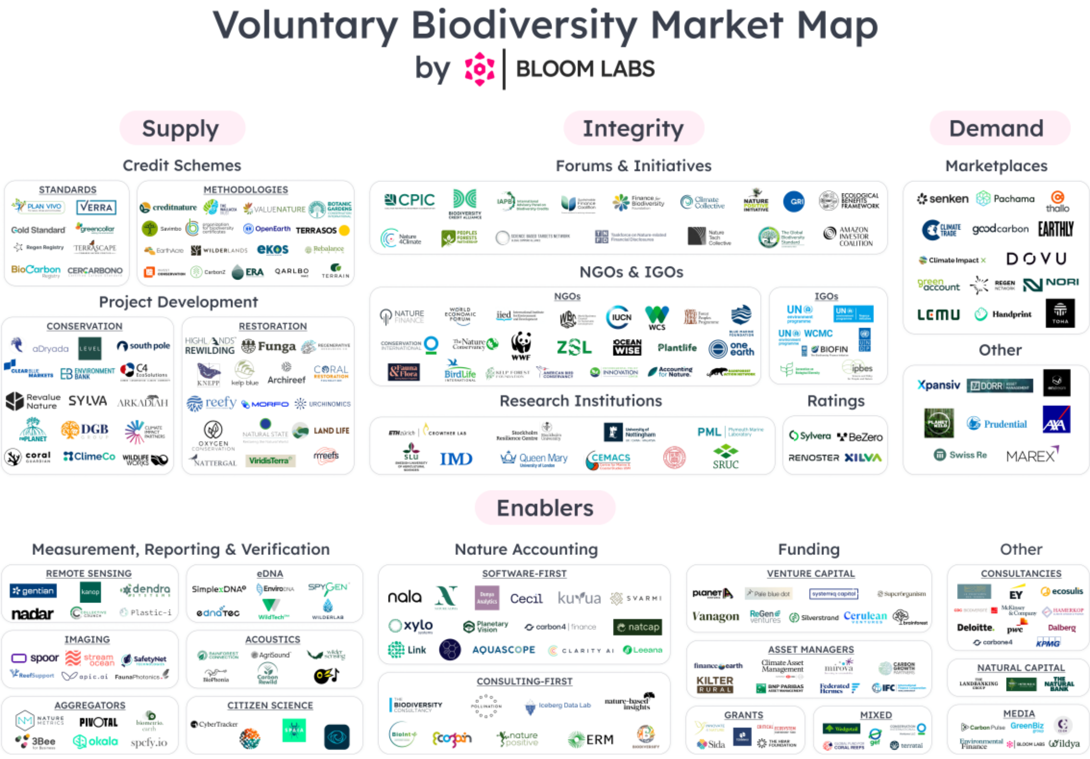


Figure 8. Compilation of players in the voluntary biodiversity credits market (as of February of 2024). Source: [26]

3.1 Market challenges and demand: is there any?

Despite GBF serving as an incentive, the question whether biodiversity markets will thrive or not, especially in terms of the demand for credits, deserves a little more elaboration. Whilst you could always find project developers, the reason why someone would start a project in the first place is a much elusive information. Who is going to buy biodiversity credits? Why would they do that? Is the GBF and other agreements incentive enough? How would they use it? Are there any guarantees that biodiversity credits would be bought at scale? Those are questions that any prospective project developer may be asking themselves right now. After all, how safe it would be to invest in a product that does not have a structured market yet? Novelty always comes with a risk. But sometimes, the risks are too high to be taken. So far, there seems to be an indication that indeed there would be demand for biodiversity credits – as we will see further on. However, uncertainty is also very high.

Much of biodiversity credits efforts builds upon the carbon market experience. Although a global compliance market – detailed in the article 6 of the Paris Agreement – depends on further negotiations, the voluntary market seems to be working properly. The supply side continues to offer a multitude of projects generating emission removals of varying qualities. The demand side continues to buy those credits as means to reduce net emissions, while also making efforts to phase-out all fossil fuel-dependent activities and infrastructure to achieve carbon neutrality by 2050. Both businesses and countries themselves – via the Nationally Determined Contributions (NDC) – contribute to the demand for carbon credits.

Diversely from carbon markets though, biodiversity markets are faced with multiple existential challenges that risk undermining the enterprise from the start. For starters, while carbon markets could agree on a single unit, the metric ton of carbon dioxide equivalent (ton of CO_2eq) – each corresponding to a single carbon credit – biodiversity markets are still in the process of institutionalizing the most accepted units. So far, what seems to be a common understanding is that an area-based approach is needed.

Another problem is an ethical one. Whilst emissions all go to roughly the same place – the atmosphere – and every ton of CO_2eq is comparable ("fungible") to one another, it is easy to propose a market that allows for compensation an offsetting. Indeed, an emission removal made in South America could in theory compensate for an emission made in Asia. Carbon is carbon everywhere in the world and all of it will end up in the atmosphere. Biodiversity, in the other hand, is not as easily fungible. Biodiversity is very site-specific and removal in one place cannot compensate for a restoration in another. While it is possible to put a number on the biodiversity of a place (e.g., Shannon index) or to label ecosystems in terms of biodiversity richness or threat levels (e.g., biodiversity hotspots), it is hardly an indication of equivalence. Some say it is immoral to think that a community of species of a place could compensate for another. Or that species X and Y are worthy more than species W and Z. That is precisely why some deem the biodiversity market to not rely on offsets but rather on nature positive contributions[12].

[12] Biodiversity offsets and biodiversity credits would then be different products to be traded in different markets. Despite being currently very contested, biodiversity offset is slowly garnering momentum in the public debate.

As seen in the previous section, business would then use credits not to offset, but to prove they are positively contributing to nature. It would be more a matter of reputation than to financially benefit from credit trading[13].

Both these emerging characteristics of biodiversity markets – the lack of an agreed unit and the ethical challenge to propose an offset market – risk the scalability of biodiversity credits and the market itself. There is a trade-off to be weighed in between an ethical approach to biodiversity markets and the possibility of risking the market development itself.

In terms of the demand for biodiversity credits, the BCA and the International Advisory Panel on Biodiversity Credits (IAPB) – both multiagent organizations delving into the biodiversity markets – produced technical content on the different profiles of credit buyers.

The BCA published a report [27] that maps the potential sources of demand, which include:

- **voluntary footprint compensation driven by shareholder and stakeholder pressure**: stakeholder and shareholder pressure and the emergence of disclosure frameworks on nature-related issues (e.g., TNFD) could drive companies to enter on biodiversity markets.
- **businesses seeking credit market experience in anticipation of regulatory requirements**: companies may anticipate further regulatory requirements to ensure long-term business sustainability or even to avoid any surprise regulation that might cause disruption in their operations.
- **businesses seeking to comply with supra-national or national regulatory requirements**: these would be the buyers stimulated by the incentives posed, for instance, by the GBF and other global agreements, which eventually may reverb nationally.
- **businesses seeking to mitigate systemic business risk emanating from nature dependencies**: the so-called "insetting", through which companies invest in the safety of their own value chain to avoid any environmental disruption that may jeopardize their operations.

[13] Some even state that biodiversity credits should be a one-off operation: one sold to a buyer, this credit is automatically retired and cannot be resold, preventing any financial speculation on the credits.

- **financial institutions and markets seeking nature positive investments**: financial institutions may want to invest in biodiversity credits as part of their financial portfolio. Even if they are not buyers for credits, they may influence the market by demanding businesses to mitigate environmental risks or make nature-positive contributions by buying credits.
- **government agencies implementing policies, regulatory measures, or official development assistance (ODA)**: governments and other public agencies might want to compensate (or offset) for their policies by buying biodiversity credits. Other possibility is using credits to redirect harmful subsidies from the agricultural sector to protect natural capital as means to increase system resilience.
- **retail and individual consumer-facing companies and brands providing value for consumers**: consumers would be the driving force behind this specific demand source by being willing to pay more for products that have nature-positive outcomes.
- **philanthropists, including foundations**: philanthropic organizations may want to redirect their funds to purchase biodiversity credits to voluntarily fulfill their mission.

Among the factors that could affect demand, the BCA lists the credits' quality and integrity, financial regulations related to disclosures, regulations related to footprint compensation, attributes that may influence buyers[14], and attributes that may influence business[15] [27].

On the other hand, the IAPB has proposed an "archetype" approach[16] to research and discuss biodiversity credits. Each archetype would describe the demand drivers, the potential buyers and sellers, and even case studies for that specific credit type [28]. Figure 9 illustrates these archetypes.

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[14] These include speed and simplicity, reputation, transparency, free prior informed consent (FPIC), liability, evidence, clear rights, geography, relevance, claims, tradability, auditability, and comparability.

[15] These include Enhanced ESG credentials, storytelling, values, real ecological impact, affordability, a way to forestall regulation, and a way to avoid public relations crises.

[16] The proposed framework is still on the consultation phase and changes could happen in the final version.

Motivation / objective	Voluntary[1]	Compliance
Compensation: **Addressing material nature impacts, dependencies, risks and opportunities within own organisation and value-chain.**	1. Addressing nature impacts, dependencies, risks and opportunities in operations (including insetting in value-chains) - this is a model where organisations use biodiversity credits to address nature impacts, dependencies, risks and opportunities in their operations to improve business outcomes in the long-term or reduce ecosystem dependency risks. These can be driven in the short-term through their nature-related financial disclosures or voluntary target setting aligned to e.g. TNFD/SBTN and by shareholder or stakeholder pressure. a. Voluntary Insetting: Insetting nature in value-chains. Organisations could use biodiversity credits to secure or improve access to ecosystem services upon which they and their value-chains rely, and reduce risks of their depletion. In the process, this could support positive outcomes for nature with potential wider benefits. b. Voluntary Offsetting: Compensating residual impacts. Organisations could take responsibility for reducing unmitigated and residual direct or indirect biodiversity impacts, in a context where compliance offset schemes do not exist or only cover certain sectors or part of a company's impact on nature.	2. Compliance offsetting of biodiversity loss – this is a model where organisations must measure and address the impacts of specific activities on nature in one place by providing improved outcomes to nature in another – the most widely used form of biodiversity credits today (also called units or offsets), for example policies like the UK's Biodiversity Net Gain.
Contribution: **Making nature improvements beyond own organisation or value-chain**	3. Corporate Social Responsibility and philanthropic goals – this is a model where organisations use biodiversity credits to claim contributions (including towards wider national or global biodiversity goals) that are separate to addressing their own material nature impacts or risks. These can be driven by considerations including consumer or shareholder / investor preferences. a. Corporate voluntary CSR contributions: Pure contribution to nature separate from one's own impacts: Organisations could make commitments to improve the state of nature in their CSR strategies (i.e. via charitable contributions) that they fulfil with biodiversity credits, which would enable them to claim to have contributed to global nature goals set out by the GBF or to have affected a region's ecosystem restoration/species protection. b. Provision of consumer products / services bundled with nature improvement contributions: Companies could offer products / services bundled with biodiversity credits to give consumers a means to directly support positive nature outcomes through their consumption choices.	4. Regulatory driven requirements/targets for Corporate Social Responsibility – this is a model where governments could require organisations to make evidence-based contributions towards nature which could be fulfilled by biodiversity credits. This could be linked to local, national or global goals for halting and reversing biodiversity loss but not linked to organisations' specific nature impacts/risks. Alternatively regulatory incentives could include levers such as tax reliefs to incentivise purchase of biodiversity credits to achieve national goals.

Figure 9. *Archetype approach proposed by the IAPB to research and discuss biodiversity credits. Source: [28].*

Together, the efforts of BCA and IAPB help draw some limits to a still much elusive market – especially in terms of the demand side. Whether or not these demand projections will become true it remains to be seen.

3.2 Main frameworks: a non-exhaustive analysis

In this section we discuss some the most advertised schemes of biodiversity credits that have been proposed so far. Despite several other schemes worthy of mention in this report, we selected 4 of them based on (i) the reputability of the proposing organization; (ii) the outreach these frameworks have achieved so far; and (iii) the variability between them to try and provide a more solid picture of how diverse the landscape is becoming. For a synthetic analysis of more frameworks, please refer to the report created by the International Institute for environment and development (IIED) on biocredits [29]. For a more science-based overview, although still in preprint phase, the newly available science paper by Wunder and colleagues is an option [30].

We provide a somewhat in-depth analysis of their layout, their main steps, and the specific methods to calculate the amount of biodiversity credits to be issued. Whenever possible, we also provide a general assessment, pointing out the perceived opportunities and challenges to each one.

3.2.1 Verra/The Biodiversity Consultancy

Credit name	Unit	Duration	Calculation	Comment	Offset
Nature credits	Qha	Minimum of 40 years of project longevity. Maximum crediting period of 100 years.	$TA \times Cond$	For example, 1 Qha could mean 1 hectare with the Condition index as 1 or 10 hectares with Condition index as 0,1. Explicit leakage concerns. 20% buffer for reversal concerns on each credit release tranche. Connection to GBF via Significance factor.	No

Legend: TA = total area in hectares; Cond = an index that combines condition indicators, normalized in a scale of 0 to 1, 0 being the worst case-scenario, and 1 the best.

Verra's biodiversity-focused framework, called Nature Framework [31], is part of the Sustainable Development Verified Impact Standard Program (SD VISta) that plans to value different nature assets – in this case, biodiversity. It is not clear whether this method for valuing other assets (e.g. ecosystem services, such as water safety or resource provision) will soon be made available.

The so called "nature credits" are a mechanism that builds up upon the experiences from the carbon market and is somewhat related to the concept of REDD+, as it uses counterfactuals to estimate impact. Verra's method is based on the concept of "quality hectare" (Qha) – the unit that summarizes the overall quality of a given area. To calculate it, one must multiply the area of the project in hectares by a composite index of ecosystem condition (Figure 10A). Verra requires that project proponents use at least 5 condition indicators, being 2 pertaining composition and the other 3, structure (Figure 10B). The aggregation of these condition indicators, after normalization, creates an index that is then multiplied by the area to give the number of potential credits in terms of Qha. These calculations should be done for each biome or ecoregion involved in the project, meaning that for each one there must be a specific baseline and a trend projection.

A

B

Condition Component	Requirement for measurement	Minimum number of indicators required
Composition	Required	2
Structure	Required	3
Function	Not required	-
Pressure	May be substituted for a composition or structure indicator if used as a demonstrated proxy. To be specified in biome-specific modules (to be developed).	-

Figure 10. A) The simplified calculation of the potential nature credits emitted in terms of Qha; it is important to notice that significance measures do not enter in the equation but as attributes in the end of the process. B) Minimum required indicators for any given project, according to Verra's proposed method. Source: [31].

The basic idea of Verra's scheme is described in the following Figure 11. It is worth noting that Verra explicitly differentiates nature credits from offsetting schemes, stating that these credits cannot be applied to offsetting schemes. Also, there is explicit consideration of leakage concerns, aside from the 20% of total credits buffer created for each release period – which may be accessed depending on the non-permanence risk. The required minimum project duration is 40 years.

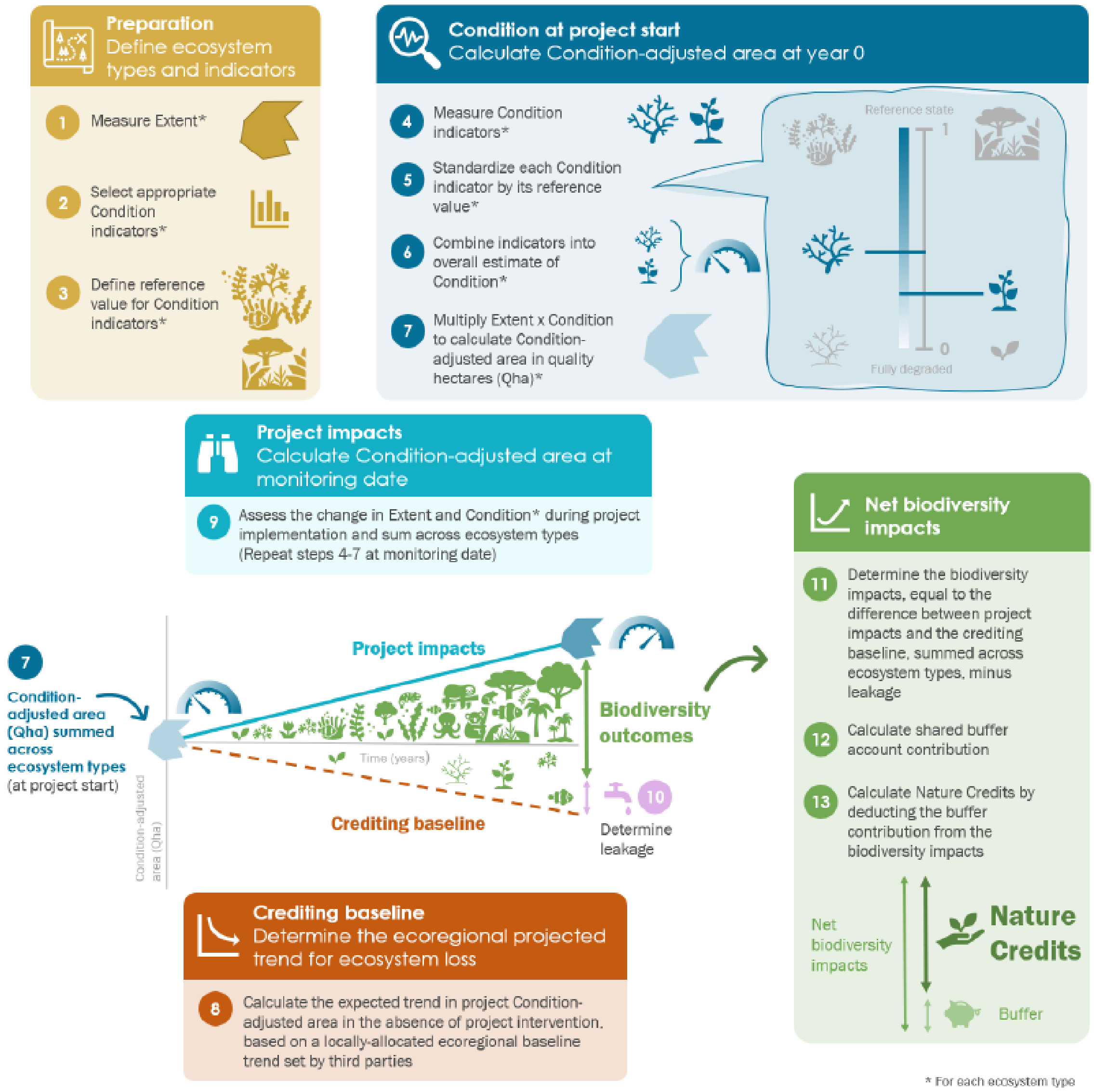


Figure 11. The basic nature credits scheme proposed by Verra. Source: [31].

As shown before in Figure 10A, the process also involves a small assessment on the significance of the project. According to the framework, "significance" is defined as "the importance of the biodiversity present for achieving defined conservation aims (e.g., contribution to the GBF goals and targets)" [31]. Thus, after the calculations are made, projects should report their significance in terms of how they contribute to the achievement of the first 4 targets under goal A of the GBF (Figure 12). It is noticeable then that (i) significance measures do not influence in the amount of nature credits to be issued; and (ii) it serves as a differentiation attribute that could assign more value to those credits coming from projects that contribute the most to GBF targets.

GBF Target (Headline summary and relevant text)	**Project contribution**	**Potential Significance Attribute**	
		Terrestrial (Measurement dataset)	**Marine** (Measurement dataset)
Target 1. Halt loss of ecosystems of high ecological integrity Bring the loss of areas of high biodiversity importance, including ecosystems of high ecological integrity, close to zero by 2030, while respecting the rights of Indigenous Peoples and local communities	Preserving highly intact ecosystems	High ecoregional intactness (Measured via Ecoregion Intactness Index) See illustrative example in Figure 7.	Low human pressures (Measured via Marine Human Pressures Index - requires further development)
Target 2. Effective restoration of degraded ecosystems Ensure that by 2030 at least 30 percent of areas of degraded terrestrial, inland water, and coastal and marine ecosystems are under effective restoration	Restoring degraded ecosystems	Low ecoregional intactness (Measured via Ecoregion Intactness Index) See illustrative example in Figure 7.	High human pressures (Measured via Marine Human Pressures Index - requires further development)
Target 3. Effective conservation of ecologically representative areas Ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed	Conserving under-represented biodiversity	Low percentage of ecoregion protected (Measured via WDPA) See illustrative example in Figure 8	Low percentage of marine region protected (Measured via WDPA)
Target 4. Halt extinctions and reduce extinction risk Ensure urgent management actions to halt human induced extinction of known threatened species and for the recovery and conservation of species	Reducing species extinctions	High potential to reduce extinction risk (Measured via terrestrial STAR) See illustrative example in Figure 9.	High potential to reduce extinction risk (Measured via marine STAR)

Figure 12. Adherence matrix to assess a project's significance in terms of GBF goal A targets. Source: [31].

Aside from nature credits themselves, Verra is studying the creation of “nature stewardship credits”, which are intended to reward indigenous people and local communities (IPLC) that have been keeping the forests where they live in a pristine state of preservation. The idea is that native areas keeping the majority of their condition indicators stable for the past 5 years would be rewarded nature stewardship credits. However, this mechanism was not described nor discussed in depth in the framework.

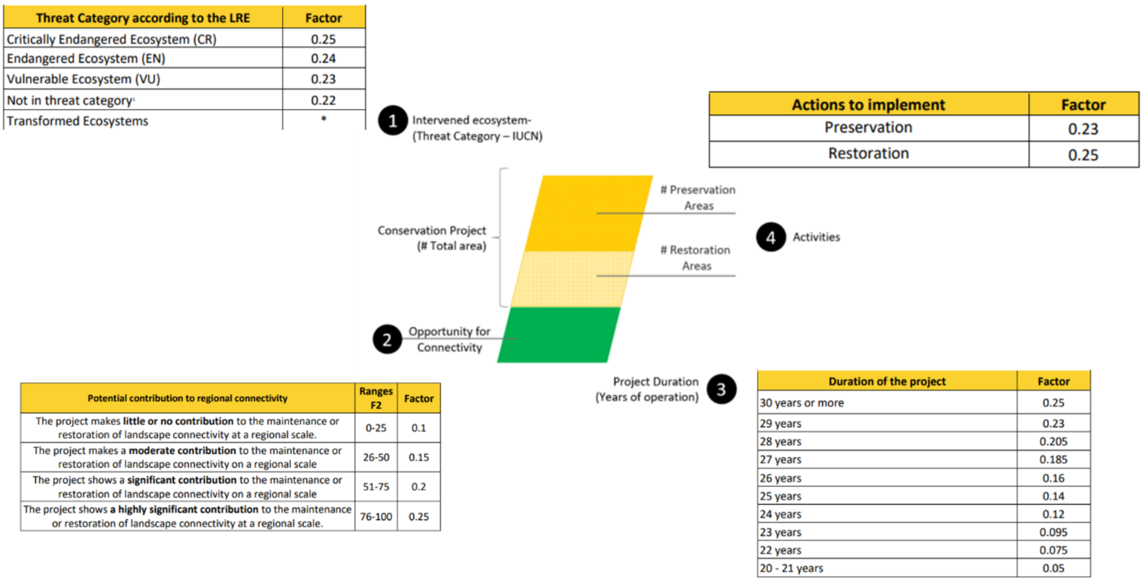
3.2.2 TerraSOS

Credit name	Unit	Duration	Calculation	Comment	Offset
Voluntary biodiversity credit (VBC)	10 m^2	Minimum of 20 years of project longevity. Maximum crediting period not defined but amount of credits will not change after 30 years.	$\frac{TA \times (T + Conn + D) + (ARes \times ResF) + (APre \times PreF)}{10}$	No connection between ecological indicators in the monitoring phase and credit estimation. No leakage concerns. No buffer established but the last 20% is conditioned to overall ecological perfomance.	Yes, but clarification still needed on applicability.

Legend: TA = total area in m^2; T = threat factor; Conn = connectivity factor; D = duration factor; ARes = area for restoration; ResF = restoration factor; APre = area for preservation; PreF = preservation factor.

TessaSOS' scheme [32] is one that is already fully functional, being possible to acquire voluntary biodiversity credits (VBC) connected to their Habitat Banks Program, in Colombia. Differently from Verra, however, TerraSOS explicitly focuses on obligatory offsetting schemes, although it is not clear whether offsetting would be allowed outside of the Habitat Banks Program or for companies outside Colombia.

The calculation of the amount of credits involves an area value that is weighted according to factors such as threat category, connectivity, duration and type of the project (Figure 13). According to the framework, 1 VBC is equivalent to 10m^2 of a "preserved and/or restored ecosystem that is technically, financially, and legally managed by the project developer to achieve quantifiable results in terms of biodiversity" [32].



Threat Category according to the LRE	Factor
Critically Endangered Ecosystem (CR)	0.25
Endangered Ecosystem (EN)	0.24
Vulnerable Ecosystem (VU)	0.23
Not in threat category	0.22
Transformed Ecosystems	*

Actions to implement	Factor
Preservation	0.23
Restoration	0.25

Potential contribution to regional connectivity	Ranges F2	Factor
The project makes **little or no contribution** to the maintenance or restoration of landscape connectivity at a regional scale.	0-25	0.1
The project makes a **moderate contribution** to the maintenance or restoration of landscape connectivity on a regional scale	26-50	0.15
The project shows a **significant contribution** to the maintenance or restoration of landscape connectivity on a regional scale	51-75	0.2
The project shows **a highly significant contribution** to the maintenance or restoration of landscape connectivity at a regional scale.	76-100	0.25

Duration of the project	Factor
30 years or more	0.25
29 years	0.23
28 years	0.205
27 years	0.185
26 years	0.16
25 years	0.14
24 years	0.12
23 years	0.095
22 years	0.075
20 - 21 years	0.05

Figure 13. The composing factors used to estimate the amount of available credits, according to TerraSOS scheme. Depending on the characteristics of the projects, the amount of credits could be factored up or down. Source: [32].

Another aspect that deserves to be mentioned is the apparent disconnection between the amount of potential credits and the monitoring phase. In Verra's framework, the indicators used to create the baseline are the same ones that will be monitored throughout the project life cycle. In TerraSOS', however, the indicators used in the monitoring phase are not related to the credit estimation calculations. Each project, during the registration phase, will need to point out exactly what are the projects goals and targets, and which indicator will be used during the monitoring period. It is not clear whether the definition of these goals and targets will be based on counterfactuals or not.

According to TerraSOS, there are 2 main instances that should be monitored, conditioning credit issuance to compliance with them: (i) compliance milestones (both management and ecological), which ensure the issuance of 80% of credits fractioned in tranches; and (ii) ecological performance standards, which at the end of the project verify whether the project achieved the intended goals and makes the 20% left available. Thus, the framework proposed a credit release schedule divided in 5 tranches, the first 4 being verified by compliance milestones, and the last one by ecological performance standards (Figure 14).

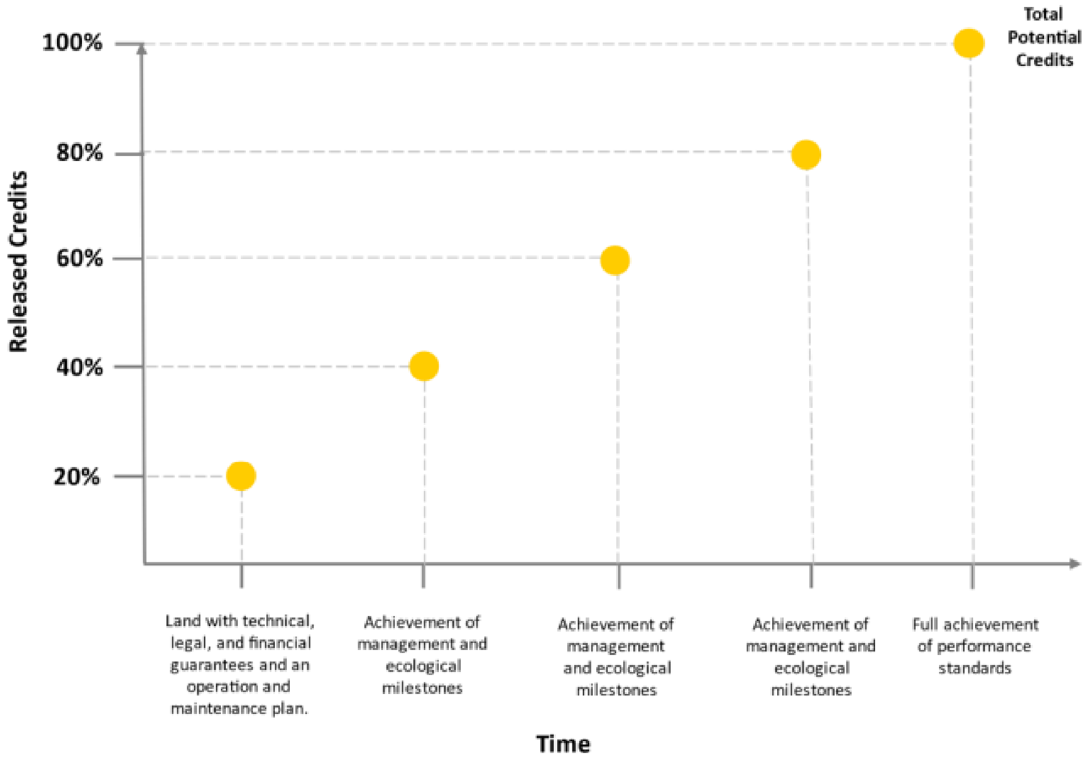


Figure 14. Credit release schedule proposed by TerraSOS framework. Source: [32].

Although there is no buffer calculation, the following 20% release is conditional on achieving the expected results in terms of compliance milestones and ecological performance. In this way, project proponents in theory can access 100% of the credits depending on their implementation performance and overall success. Furthermore, contrary to Verra's, TerraSOS' framework (i) does not include any leakage concerns in the calculations; (ii) does not mention how different biomes/ecoregions should be considered in the same project; (iii) directly considers significance measures in its credit estimation calculations, but fractions in the 4 factors (threat category, connectivity, duration and type); and (iv) sets the minimum project duration as 20 years.

3.2.3 Plan Vivo/Pivot

Credit name	Unit	Duration	Calculation	Comment	Offset
Plan vivo biodiversity certificates (PVBC). Two types: plan vivo biodiversity restoration certificates ($PVBC_{RESTORE}$) and plan vivo biodiversity conservation certificates ($PVBC_{CONSERVE}$)	$PVBC_{RESTORE}$: 1% increase in index per hectare per year. $PVBC_{CONSERVE}$: 5% of the biodiversity baseline (index) conserved per hectare per year.	Minimum of 50 year of project longevity. Maximum crediting period of 50 years.	$TA \times (PCRic + PCDiv + PCDis + PCHH + PCHSS)$	Measurement of the first four factors (PCRic, PCDiv, PCDis, PCHH) must be carried out yearly. The fifth factor (PCHSS) is measured every 5 years. All calculations are to be done by Pivot.	No.

Legend: TA = total area; PCRic = percentual change in species richness; PCDiv = percentual change in species diversity; PCDis = percentual change in taxonomic dissimilarity; PCHH = percentual change in habitat health; PCHSS = percentual change in habitat spatial structure.

Another crediting scheme that has gained attention is the one proposed by Plan Vivo jointly with Pivot [33]. The proposed method builds upon the effort led by The Wallacea Trust, in 2021, whose method proposed a “basket of metrics”, an approach that, according to them, resembles the Retail Price Index[17] comparison method [34]. Any percentual uplift in the composite index would mean a credit that could be emitted. However, in 2023, Plan Vivo partnered with Pivotal to produce the Plan Vivo Biodiversity Standard (PV Nature), launched in December of that year. They still use the concepts of “basket of metrics” and of percentual increase, but they combine the measurements in a so called multimetric index that synthesizes the biodiversity status in a single number. Another important difference is that Plan Vivo refuses to use counterfactuals in its calculations, comparing the biodiversity status of a given area with itself after a period of time. Neither reference sites nor estimated future states via trend analysis are allowed, differing from Wallacea Trust’s initial proposition and from Verra’s Nature Framework.

[17] The Retail Price Index compares the prices of a basket of goods and services to assess the inflation rates across multiple countries. The goods and services assessed vary according to consumer preferences in each country, reflecting what constitutes the overall consumption profile in any country. The same rationale would be applied to biodiversity: different metrics to assess condition over different biomes or ecosystems.

For such a framework to be viable, a great deal of monitoring efforts must be undertaken. And that is precisely what Plan Vivo advocates for: yearly monitoring the 5 different metrics (called "pillars") and calculating a final cumulative multimetric, representing a percentual change in biodiversity status (Figure 15). The metrics used are representative of species richness (pillar 1), species diversity (pillar 2), taxonomic dissimilarity (pillar 3), habitat health (pillar 4) and habitat spatial structure (pillar 5). The data pertaining pillars 1, 2 and 3 are to be obtained on the ground at site level by the project proponent – on the other hand, the calculations of the metrics themselves will be done by Pivotal. Data gathering and calculations for pillars 4 and 5 will be done exclusively by Pivotal. Furthermore, the monitoring frequency of these pillar also differ: pillars 1, 2, 3 and 4 should be calculated yearly, whilst pillar 5, every 5 years.

The multimetric is calculated by summing up the percentual change in each pillar – aside from pillar 5, which will be added up only every 5 years –, rendering a final index that is both cumulative and comparable to its previous state (Figure 16).

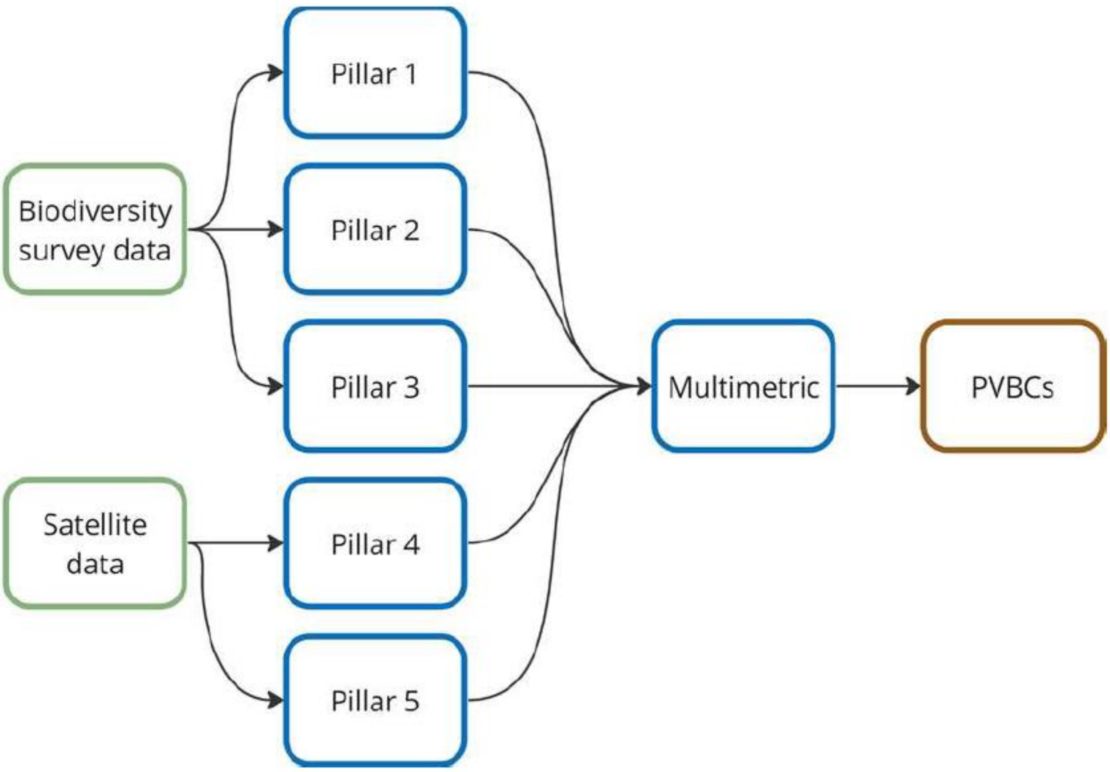


Figure 15. Plan Vivo's framework (PV Nature) basic design: 5 different metrics ("pillars") that add-up to a single multimetric representing a cumulative percentual change in biodiversity status. Source: [33].

A

$$M(T) = \sum_{t=1}^{T} (P_1(t) + P_2(t) + P_3(t) + P_4(t)) \quad \text{(Yearly)}$$

$$M(T) = \sum_{t=1}^{T} (P_1(t) + P_2(t) + P_3(t) + P_4(t) + P_5(t)) \quad \text{(Every 5 years)}$$

B

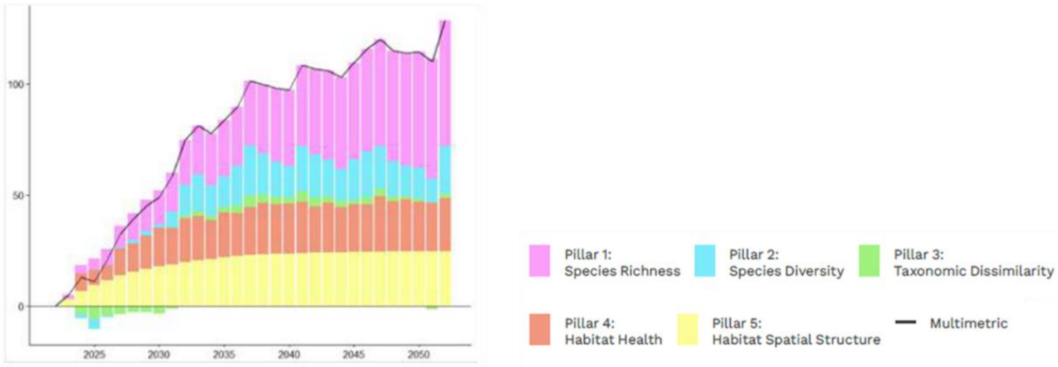


Figure 16. How the multimetric is calculated. A) The different equations that should be used to include pillar 5 (every 5 years) or not (every year); B) The cumulative change in biodiversity status that arise by calculating the multimetric. Source: [33].

Just as TerraSOS' method, the distinction between conservation and restoration projects is contemplated in the calculations. In Plan Vivo's framework, however, they are not used as factors but rather as entirely different approaches, giving rise to two types of Plan Vivo Biodiversity Certificates (PVBC): plan vivo biodiversity restoration certificates ($PVBC_{RESTORE}$) and plan vivo biodiversity conservation certificates ($PVBC_{CONSERVE}$). Each $PVBC_{RESTORE}$ represents a 1% increase the in multimetric per hectare per year. To avoid double counting, the previous measurement should be subtracted from the current calculation, in a way that only actual percentual increases are accounted for.

The case of $PVBC_{CONSERVE}$ is a bit different. Each one represents 5% of the biodiversity baseline (proxied by the multimetric monitoring) conserved per hectare per year. If the multimetric is statistically similar over the years – meaning 100% of biodiversity condition remains the same – then each hectare could emit 20 $PVBC_{CONSERVE}$ per year. If the multimetric fluctuates between 100% and 90%, then the number of certificates allowed to be emitted decreases to 18 per hectare per year – while still representing 5%. If the fluctuation reaches below 90% of the baseline, then no certificates are allowed to be emitted.

In either case, be it $PVBC_{RESTOR}$ or $PVBC_{CONSERVE}$, credit emission can be made after 3 measurements (baseline plus 2 other yearly measurements), meaning that emission would start at least after 2 years from the baseline measurement.

It is noticeable that similar to Verra's, this scheme multiplies a composite index of "condition" by the total area of the project (in hectares) to calculate the number of credits. The difference is that Verra uses the standardized measurement of the metric itself whilst Plan Vivo uses a percentual increase in them.

It is also worth noting that rePLANET is currently applying the Wallacea Trust's method in its biodiversity credits scheme [35]. The main difference between the rePLANET's and Plan Vivo's frameworks is that rePLANET does not combine the "basket of metrics" in a composite index (as Plan Vivo does), instead choosing to monitor the variability of all metrics separately but at the same time. They also use the median of the metrics rather than the mean value. In other words, when there is 1% increase in the median value of the metrics then a biodiversity credit could be emitted.

3.2.4 Savimbo

Credit name	Unit	Duration	Calculation	Comment	Offset
Biodiversity credits (certified) and impact credits (uncertified)	1 hectare of 100% conserved biodiversity in a biodiversity hotspot for 1 month	Preferably Minimum of 30 years but credits are emitted based on unit calculation.	$TA \times D \times I$	Method based on the presence of target species; Credit framework created by IPLC representatives to allow customary right holders to directly access the market.	No.

Legend: TA = total area (fixed in hectares); D = duration (in months); I = integrity (from 0 to 1, with 0 being fully degraded and 1, fully conserved); V = value (qualitative measure based on the importance of a given ecosystem).

Somewhat differently from other biodiversity credit schemes, Savimbo's is created - according to them – by and for indigenous people [36]. In their own words, they "help Indigenous Peoples and local communities sell the positive byproducts of healthy forests with no strings attached. We reverse economic colonialism in climate industries and provide a green economy that transacts fairly with the people who do the most for the intact planet" [36]. On their portfolio of products, they offer not only biodiversity credits but also other so-called "fair-trade climate products": B&E (biodiversity + equity), tree credits, water credits, and carbon credits.

Their biodiversity credits scheme is called Savimbo Indicator Species Methodology (ISBM) and, as the name suggests, it is based on the presence of indicator ("target") species. However, it is important to differentiate between the "unit" – proposed as a way to standardize the market – and Savimbo's method itself (i.e., ISBM). According to them, they were devised concurrently, but have recently taken divergent paths, meaning that although the general formula is the same, specific methods may use slightly different calculation approaches.

A unit of biodiversity credits is fixed as 1 hectare, with a given level of integrity delta, that lasts for 1 month and is differentiated according to the level of importance of a given area. Projects could be focused either on restoration or conservation, with integrity levels increasing in the first case and not changing in the second. To calculate the amount of credits (Figure 17) in a project a simple multiplication of area, duration ("time") and integrity delta would render the final number, which would then be differentiated by the level of importance ("value") – which are based on 12 reputable approaches of categorizing ecosystem importance (Figure 18).

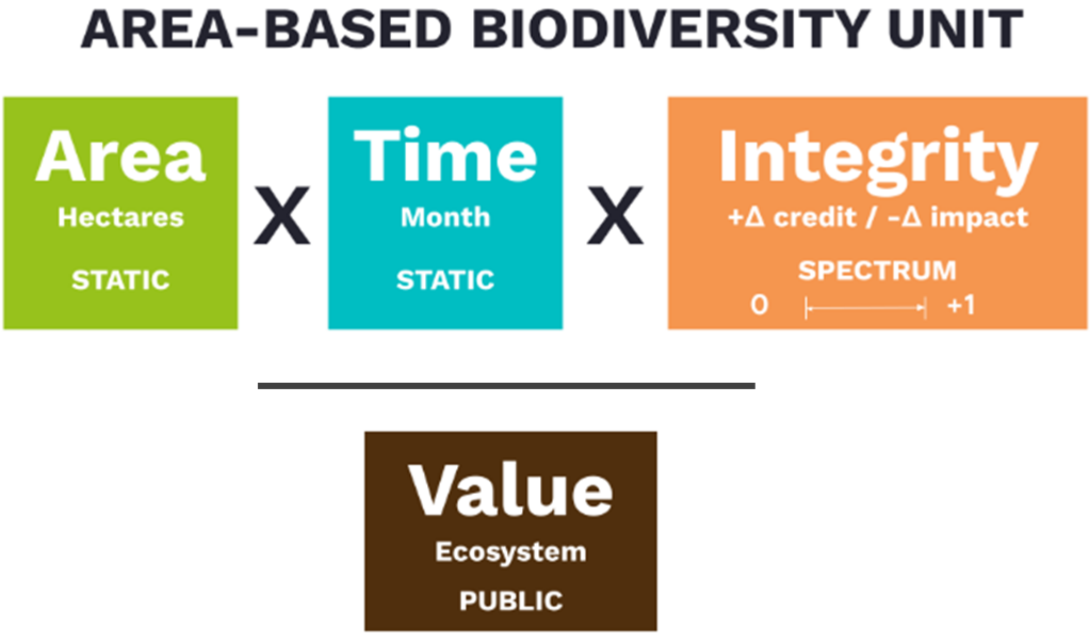


Figure 17. Calculation of the proposed biodiversity credit unit. Area (1 hectare) and time (1 month) are fixes parameters, while integrity delta can vary from 0 (fully degraded) to 1 (fully preserved). Afterwards, the amount of credits would be differentiated according to an ecosystem importance measure. Source: [36].

	Platinum	Gold	Silver	Bronze
IUCN Red List of Ecosystems	Critically endangered	Endangered	Vulnerable	Near threatened
Biodiversity hotspots	Priority target	Recognized hotspot	Within 50km	Within 100km
CBD National targets	Deforestation region 2020 - 2030	Deforestation region 2030 - 2050	Within 50km	Within 100km
IUCN Global Ecosystem Typology	50% probability of collapse within 50 years	20% probability of ecosystem collapse in within 50 years	10% probability of ecosystem collapse within 100 years	Threatened category in the near future
UN-FAO Land cover classification system (LCCS)	n/a	n/a	n/a	No intrinsic ranking
Holdridge	n/a	n/a	n/a	No intrinsic ranking
Terrestrial Ecoregions of the World	Global 200	Within 50km	Within 100km	Within 150km
UNEP Forest Biodiversity Intactness Index	100% completely intact forest ecosystem with minimal human disturbance	75% intact forest ecosystem with moderate human disturbance	50% intact forest ecosystem with high human disturbance	25% intact forest ecosystem with very high human disturbance
IUCN Habitats Classification Scheme	n/a	n/a	n/a	No intrinsic ranking
WWF for Nature Ecoregions	35 global priority places	Within 50km	Within 100km	Within 150km
Ramsar Wetland Classification	Ramsar Category I	Ramsar Category II	Ramsar Category III	Threatened wetlands without Ramsar category
World Heritage List UNESCO	Natural assets	Mixed assets	Cultural assets	n/a

Figure 18. The differentiation levels according to 12 well-known categorization approaches. Levels could be assigned as platinum, gold, silver and bronze, depending on the importance of a given ecosystem. Source: [36].

The ISBM, on the other hand, is a method that focuses primarily on conservation efforts, verified by the presence of indicator species – approach that has specific ways of calculating the parameters needed to estimate credits. For starters, the area parameter is estimated based (i) on the home range of a chosen indicator species (standardized as a circle with a radius equal to its home range) and (ii) the overlapping with the project boundaries (Figure 19). To avoid double counting, whenever circles overlap – meaning that different observations happened close to each other – only the "extra" area is added in the overall calculation.

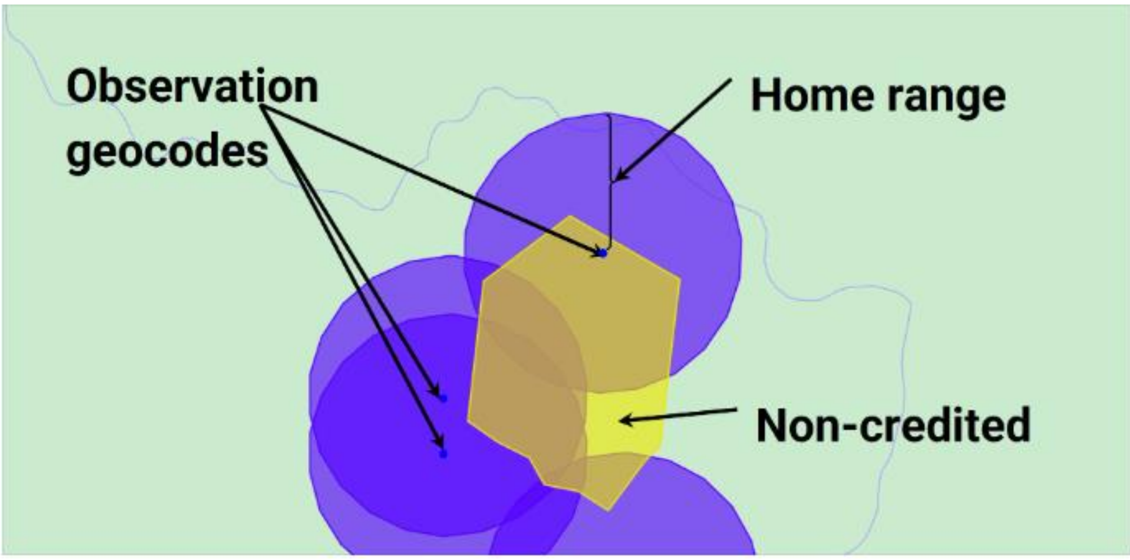


Figure 19. The calculation of the crediting area. Blue circles identify the home ranges of a given indicator species (e.g., jaguar), based on single observations (observation geocodes). The yellow polygon denotes the project area. Only the overlapping areas of the circles and the polygons will be considered as crediting areas. Source: [36].

Moreover, indicator species also influence the integrity parameter. Knowing that the ISBM method focuses only on conservation species, the observation of a given indicator species, depending on their characteristics, can serve as proxy to the integrity of the whole crediting area. For instance, identifying a jaguar, given its specialized nature, can indicate that the whole crediting area has an integrity equal to 1 – the highest measure. On the other hand, if only more generalist species are observed during a monitoring period, then a value of 0.5 could be assigned to the integrity level.

The duration parameter ("time") renders the calculation more complex because of the premises assumed. One of them refers to the duration of an observation: each one guarantees that the species is indeed present on site for at least 60 days, 30 days prior to the observation and 30 days after. Since biodiversity units are based on months, the crediting area could be multiplied by a factor of 2 (one for each 30 day-period, before and after the observation). The tricky part happens when observations, in the same monitoring period, overlap. To help calculations, the duration is fractioned in days, with each observation rendering a 60-day period. If observations overlap, then during the overlapping period, only the "extra" area is used, as mentioned above. When the areas cease to overlap, the full circle is again considered in the calculation until the end of the 60-day period – or until another overlapping observation happens. After the monitoring period, the total credits area calculated based on the numbers of days – each one representing 1/30 of a credit –, multiplied by area considered in each of these days, and then finally multiplied by the integrity measure (Figure 20).

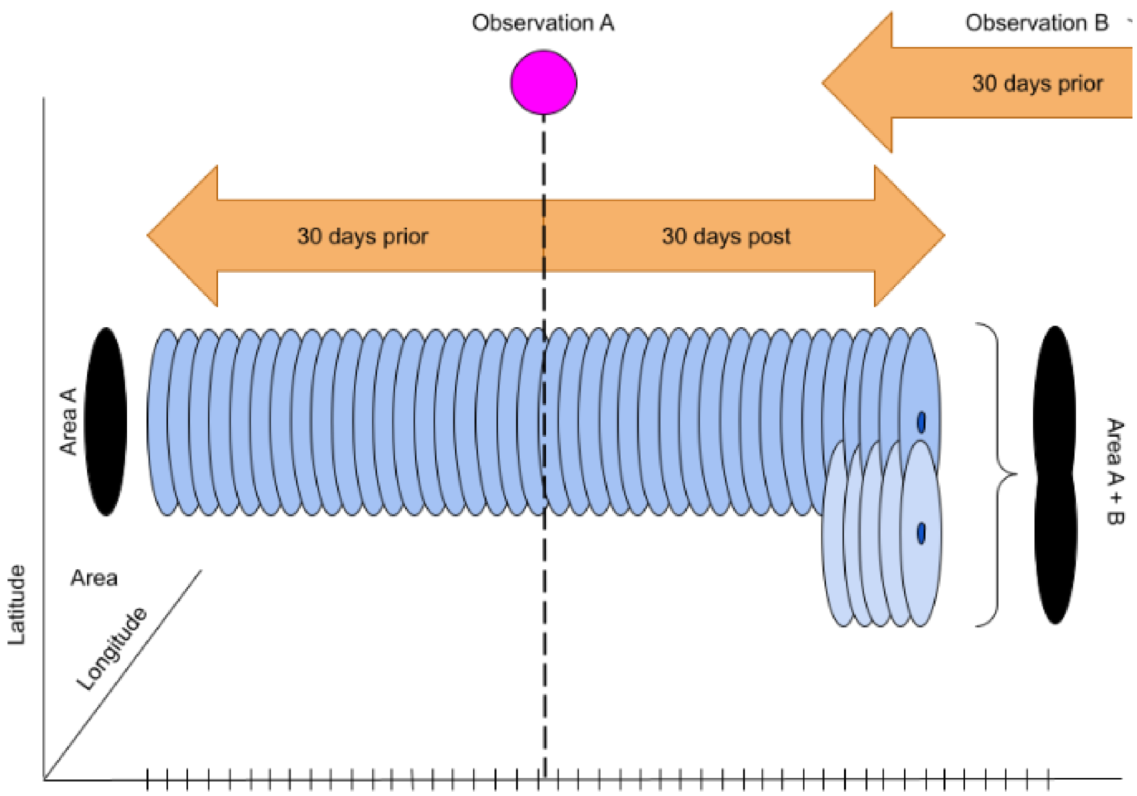


Figure 20. Credit calculation based on overlapping observations. Both area and time are relevant. By the end of the period, the 1/30 fractions of each area considered in these days are summed up and then multiplied by the integrity level to estimate the number of credits. Source: [36].

The measure of importance comes after the calculations, based on the same 12 approaches to categorizing ecosystems (Figure 18).

Aside from the calculations themselves, there are other premises that should be noted. For instance: a minimum of 3 species of 2 different kingdoms should be used, the monitoring frequency can vary according to the project's specification, and the biodiversity baseline (e.g., richness or diversity) is not mandatory, as credits area based on species observations of monthly durations.

4 Regenerative agriculture and biodiversity credits

As it was possible to see in the last section, there is a multitude of schemes and methods being created and, although there are common elements between them, there is also very divergent aspects that remain to be appraised by the biodiversity credit community.

One of the things that comes to mind when researching those different methods is the attention – or the lack of it – that has been paid to regenerative practices such as agroforestry. It is well known that any agroforestry, although mimicking a native forest structure, will never reach a fully native state. It is only logical to assume, then, that the restored ecosystem services coming from it will not be as fully restored as possible. There is no question of their benefits compared to traditional practices (e.g., monoculture). But how do we differentiate biodiversity credits coming from agroforestry from those coming from native environments? Are there any differences in biodiversity measures? For all groups? How do we account for those differences in credit calculations? And in case there is no statistical difference, is it fair to differentiate between them anyway? Are we valuing biodiversity per se or other benefits as well (e.g., ES related to food security)?

Those are questions we hope to answer in coming reports. For now, we propose some initial principles to guide the creation of agriculture-based biodiversity credits (i.e., agrobiodiversity credits). They are not at all final and depending on the feedback they can be modified, excluded and new ones could be added.

4.1 Principles for agriculture-based biodiversity credits

Here are some principles we think can help design high-integrity agriculture-based biodiversity credits.

4.1.1 The main focus should still be on biodiversity

Regardless of having a different approach from native environment-based biodiversity credits, agriculture-based biodiversity credits should still focus on increasing biodiversity status. That is not to completely prevent the addition of other subjects relevant to agricultural practices – as the following proposed principles make it clear – but biodiversity, as the central pillar of all natural capital and ES provision, should remain the focal interest. Species richness, abundance, diversity and functionality should be taken the main measures of positive impact.

4.1.2 It must follow the same integrity principles as other credit frameworks

As a consequence of having the same focus on biodiversity, despite differences with native environment-based biodiversity credits, they all should follow the same integrity principles. Several recommendations have arisen in 2022 and 2022. Organizations such as The Biodiversity Consultancy (TBC) [37], World Economic Forum (WEF) [38] [39], Plan Vivo, Fauna & Flora International, and Carbontanzania [40], and Nature Finance and Carbone4 [41] have all proposed integrity principles to avoid misappropriation of biodiversity by financial markets.

4.1.3 The end goal must be on fostering change to regenerative practices

Giving the fact that traditional practices of agriculture, the final goal must be on fostering behavioral change to regenerative practices. To that end, incentives must be created to influence producers to adopt mora nature-based production approaches. In this sense, biodiversity credits could serve as an important financial stimulus for galvanizing change. Yes creating these mechanisms opens new possibilities for financial markets to explore profit-making but we should never lose sight of the change intended in the first place. As such, valuation methods applied to agriculture-based biodiversity credits should include the opportunity costs for producers in their calculations. If the minimum value is not met, regardless of a credit market being fully operational or not, then change will not take place.

4.1.4 Native environment-based credits should be differentiated from agriculture-based credits

Agriculture-based biodiversity credits should be differentiated from native environment-based ones. To some taxa, biodiversity should be similar in both environments, but specialist species certainly will have different distributions. Therefore, they should be qualitatively different from other credits. Maybe focusing on a specific market niche (e.g., industries dependent on raw materials willing to invest in insetting practices) could be a proposition.

Agriculture-based credits will also intermittently impact biodiversity because of implementation and maintenance practices. The use of fertilizers, pesticides and harvesting methods will certainly impact biodiversity and should be taken into account when calculations are made. Moreover, agriculture-based biodiversity credits should only be commercialized as regeneration credits, never as conservation credits, since that would reward “artificial” environments in the same way as native ones.

4.1.5 The more diversity in plant structure the better

Native environments (e.g., forests), aside from a component of biodiversity themselves, also function as habitat for other biodiversity groups. Thus, when measuring biodiversity condition indicators, it is important that diversity in plant structure be as high as possible. Not only to resemble more a native environment, but also to allow for crop variability to be included in the framework. It is common knowledge that crop variability is decreasing at a faster rate, which can cause disruptions in food production in the future. Therefore, to reward high-variability systems can, at the same time, increase habitat quality and allow for different crop streams to be preserved.

4.1.6 Landscape approach

Aside from the structure, landscape is also relevant when talking about agroforestry. A major reason for advocating in favor of it is that, at the same time they promote socioeconomic outcomes, they improve ecological indicators. Connectivity is one of the most important ecological aspects, especially in high-pressure environments. Fragmentation usually leads to a decreased gene flow among vegetation patcher, which in turn can cause a decline in species populations and, thus, in biodiversity itself. Other biodiversity credit schemes also advocate for connectivity but here we expect that regional biodiversity (beta) should also be monitored. Different agroforestry arrangements may have different implications for biodiversity. It is important to ensure that (i) connectivity is indeed increasing, and (ii) regional biodiversity is being benefited.

4.1.7 Double baseline approach: against native environments and against initial conditions

Trend calculations for agriculture-based biodiversity credit should be compared against two distinct baselines: (i) against reference areas, to understand how different the biodiversity in the system is compared to native areas; and (ii) against its initial condition, to account for biodiversity variations, especially when controlled for implementation and maintenance practices – which will certainly impact biodiversity over a period of time.

4.1.8 Measures of significance should include ES, social aspects, and value-chain aspects

As seen in other credit frameworks, significance is a measure used to differentiate between different qualities of credits. In other words, credits with more positive impact ("significance") have a differentiation label assigned to them, which may increase market value. In terms of agriculture-based biodiversity credits, we claim that significance should include not only positive biodiversity impacts but also other categories of attributes. For instance, agroforestry increases ES (e.g., food resources), which in turn can also increase nutritional safety for a given population – a social aspect not captured in the ES approach. Moreover, we also understand that value chain aspects may also be relevant to some demand sources. A proven increase in production resilience or productivity of some commodities may interest industries that depend on these raw materials.

5 The way forward

This technical note on the connection between Economics and Biology/Ecology, and on the experience of some biodiversity credit frameworks, sought to lay the theoretical grounds on which agriculture-based biodiversity credits that are really aligned to regenerative practices could be built upon. There is no point in creating yet another framework if the intended goal is not connected to an increase in environmental/ecological "health". As idealistic as it may seem, to understand that society is not separated from the environment – but rather part of it and dependent on it – is the first step to creating nature-based financial instruments that are more than just mere speculative market instruments.

In the next months, we expect to propose a framework for biodiversity credits based on regenerative practices – especially agroforestry systems. Thus, another technical note will be published with the desire to hear back from the community its impressions. At this stage, with a multitude of instruments being created every week, it is important to ensure that, aside from scientific soundness, it also considers different points of view. Only then any proposed framework could be on the road to become institutionalized.

We will also take stock of the different discussions being held regarding biodiversity credits, both in favor and against its creation. Not only biodiversity itself but discussions on any ecosystem services or environmental assets are relevant in this case. After all, these are all different aspects of the same environmental crisis. At the international level, discussions on the biodiversity COP 16 will be extremely important to understanding how the operationalization of GBF's targets will be carried out. At the national level, the discussions on new Brazilian policy instruments, such as the creation of a carbon compliance market and the creation of a PES framework, will also be closely monitored.

We hope the proposed framework will contribute, even if marginally, to a better future.

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