Designing and scaling up nature-based markets[1]

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Abstract: This chapter describes a new market mechanism to finance nature-based provision of carbon and biodiversity benefits. In our mechanism, jurisdictions propose nature-positive large-scale projects. Investors buy shares in these projects. Shares do not affect land ownership but produce carbon and biodiversity dividends. Prices in the primary market are used to pin down investor preferences over project attributes and generate conversion rates for different projects in the secondary market, thereby fostering liquidity for investors. Compared to existing credit-based approaches, our mechanism lowers transaction costs, encourages additionality, reduces leakage, and fosters long-term thinking for market participants. We propose several venues to support demand for this new market and discuss options available to adapt the mechanism to pure conservation projects, which are essential but less amenable to be turned into dividend-producing assets because they generate lower climate and biodiversity flow benefits.

1. Setting the stage

The natural carbon cycle provides a critical lever to fight climate change. Overall, the biosphere is a net carbon sink (Rockström et al., 2021). Carbon sequestration in plants and soils currently absorbs around 4.8 Gt of CO_2 annually (Friedlingstein et al., 2023). By some estimates, it could contribute 37% of cost-effective emissions reductions through 2030 (Griscom et al., 2017). This has not landed on death ears: According to Grassi et al. (2017), land use and forests made up a quarter of the emissions reductions planned

[1] We thank Francesco Tripoli for excellent research assistance.

under the nationally determined contributions (NDCs) submitted by signatories of the Paris Agreement.

Nature is also a carbon stock. Natural forests cover 28% of global land cover and non-natural tree cover represents 2%. Carbon stored in all forests (accounting for all carbon pools: living biomass, dead wood, litter, soil organic matter and harvested wood products) is estimated to represent 870±61 Gt of carbon, of which tropical forests represent 54 % (Pan et al. 2024). Preserving these forests is, therefore, essential. Emissions from deforestation are estimated to release around 7 Gt of CO_2 per year, canceling and reversing the carbon absorbed through afforestation and reforestation (Friedlingstein et al., 2023).

But nature's services go well beyond climate change mitigation. Costanza et al. (1997) estimated the value of the ecosystem services the biosphere provides at 1 to 3 times the global GDP. This initial estimate was then updated and refined, with an estimate of the loss of ecosystem services due to land-use changes (Costanza et al, 2014). Forests provide habitat to more than half of the world's land animal and plant species and are a direct source of food, income, and shelter for millions of people.

This chapter explores options to scale up market-based solutions to finance and support the provision and conservation of nature's essential services. It starts by describing the inputs to the problem at hand (Sections 1 and 2) before discussing current credit-based solutions and their shortcomings (Section 3). Section 4 describes our new market design for nature-based provision. Section 5 discusses how it can be adapted to nature conservation.

1.1. What's special about nature?

The services that nature provides differ in many ways from the manufactured products, commodities, and assets traded in most markets. These differences create challenges but also opportunities when it comes to designing markets based on nature.

First, nature comes as a bundle of functionally-linked and interdependent goods and services. Carbon storage and sequestration are just two of these services. Biodiversity is a key attribute of natural ecosystems as it contributes to their resilience and, therefore, supports many of the other services that nature provides.

Relatedly, ecosystems are highly multidimensional. Their description requires a large number of indicators measured at different scales. For example, biodiversity is defined at multiple levels: genetic, species, populations, ecosystems, and functional ecosystems. It is common that nature management interventions improve some metrics of biodiversity or ecosystem service provision but degrade other metrics. Focusing on a simple single indicator – e.g. species abundance for biodiversity – may be misguided and lead to scientifically unsound interventions. Appendix 1 gives an overview of the most popular single indicators.

Currently, there is no commonly agreed measure of biodiversity. The verification community and standard setters are working on establishing a consensus. The emerging consensus seems to be a composite indicator, which combines a matrix of quality attributes with areas, to produce an indicator of "quality hectares." Verra's Nature Framework, for instance, defines nature credits using three dimensions—Extent, Condition, and Significance—to capture both the physical area involved in projects and the ecological quality of habitats (Verra, 2024). By multiplying Extent and Condition, Verra computes quality hectares, a unit designed for comparability across different sites.

Second, natural ecosystems are intrinsically dynamic and subject to shocks and variations. State variables of natural ecosystems vary due to multiple factors, both external and internal. External factors include climate variability. Internal factors include processes such as vegetation successions. Other processes of change, such as wildfires, combine both internal factors, i.e., fuel accumulation, and external factors, such as dry conditions causing increased flammability and sources of ignition (thunderstorms or human activities). These dynamics are non-linear and display threshold and hysteresis effects. Some of these changes may be irreversible, e.g., when species become extinct. Changes in natural ecosystems are also caused by human activities, primarily through land use changes and pollution. Some of these changes are intentional, e.g., forest clearing for agriculture, while others are unintentional and result from spillovers associated with other human activities taking place in other places or sectors.

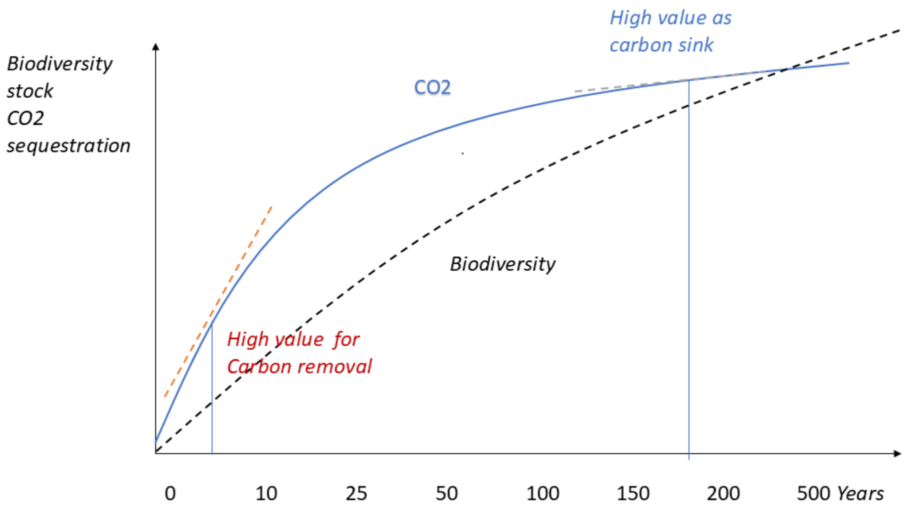
Combined with nature's multifunctional character, these complex dynamics mean that attribution of the causes of change in an ecosystem may be challenging. These causes may be climatic (e.g., drought), biophysical (e.g., wildfires, pests, invasive species, natural successions), related to human intervention, or a combination of all these factors.

Third, the functioning of natural ecosystems differs greatly across geographies and eco-climatic zones. Each geographic region has a specific regime of disturbances to which natural ecosystems are functionally adapted. As a result, ecosystems are not equivalent across geographies. A loss in a lowland tropical forest cannot be compensated by a gain in a highland tropical forest, for example.

Because natural ecosystems are living systems, time plays an important role. The time scale for ecosystem restoration or rewilding is very long. It takes decades to achieve significant biodiversity gains through ecosystem restoration. This restoration time can be somewhat shortened by an active reintroduction of species. Still, the slow biological cycles need to be integrated to avoid negative cascading effects that could result from a program of nature restoration that is rushed and creates transient ecological imbalances, e.g. in prey-predator equilibriums. In contrast, large carbon sequestration can happen quickly following reforestation or afforestation, even if forests and their soils continue to absorb carbon for hundreds of years (Luyssaert et al., 2008).

Figure 1 illustrates schematically these different stock-flow dynamics for carbon and biodiversity. A young, naturally regrowing forest is highly effective at removing carbon from the atmosphere (CO_2 flow). However, its biodiversity stock is relatively low. In contrast, a mature forest hosts a high stock of biodiversity but is less effective at removing carbon because, in a mature forest, new biomass growth (which sequesters carbon) is increasingly balanced by decomposing biomass (which releases carbon). At the same time, a mature forest serves as a valuable reservoir for long-term carbon storage (CO_2 stock). While an individual tree is not a permanent carbon store, a mature forest ecosystem maintains its carbon stock as dying trees are continuously replaced by new growth. In other words, young forests are valuable for their carbon flow, whereas mature forests are valuable for both their carbon stock and the biodiversity they sustain.

Figure 1: Stylized age profile of carbon and biodiversity stocks in a forest



1.2. Challenges specific to the Global South

The Global South, which hosts a large portion of existing forests and offers great potential for further carbon sequestration and biodiversity conservation, brings further challenges for nature-based markets. A large share of rural populations in the Global South depends directly on farming for their livelihoods. They also directly rely on nature for the provision of a range of essential ecosystem goods and services, such as drinking water, biomass for fuel and wood for construction.

Despite this dependence, rural populations in the Global South often suffer from a lack of secure land rights and unclear rules for land ownership and access to natural resources. It is common to observe overlapping systems of access rights, with conflicting customary, public and private land tenure systems regulating the same agricultural and forest lands.

Some of these countries also suffer from syndromes associated with "weak states". This poses specific challenges for the design of nature markets as, where poor governance and corruption are prevalent, the risk is high that financial resources aimed at promoting nature conservation are seized by intermediate public or private actors before these financial resources reach the local land managers most in need of these resources, typically rural and Indigenous communities.

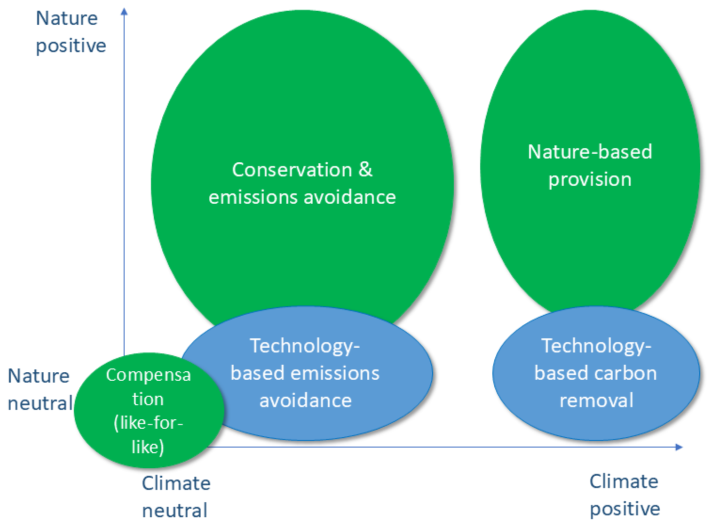
Most countries in the Global South have experienced in their history a colonial regime for extended periods of time, with its associated appropriation and extraction of their natural resources. This history leads to great sensitivity to any form of land or resource "grabbing," even for nature conservation. As a result, some countries have enacted legislation to exclude foreign actors from acquiring land with valuable natural resources. The expression "green colonialism" includes mechanisms to expand nature conservation for the development of projects related to carbon and biodiversity markets. Any market design must account for this sensitivity to avoid being undermined by local regulations and actions.

1.3. The landscape for climate and nature-positive solutions

Nature-based solutions have become a catch-all term for different approaches that rely on nature and seek to foster the provision of climate and/or biodiversity benefits or avoid adverse climate or biodiversity impacts. These approaches differ in the mix of biodiversity and climate benefits they offer and the counterfactual used to assess these benefits. Understanding these differences is essential for sound market design.

Figure 2 maps these different approaches according to their climate and biodiversity benefits. In the top right corner are solutions that generate both climate and biodiversity benefits. This category includes natural reforestation, revegetation, mangrove restoration, and regenerative agriculture. These approaches not only remove carbon from the atmosphere but also enhance biodiversity by restoring ecosystems (Ren et al., 2020; Wu et al., 2021; Andres et al., 2022; WWF, 2024). Carbon extraction, however, does not always enhance biodiversity. For example, fast-growing monoculture plantations based on exotic species (often eucalyptus or pine trees) can sequester carbon efficiently but provide limited biodiversity benefits. Figure 2 captures this diversity by the large span of biodiversity benefits associated with nature-based provision of climate and biodiversity benefits. When biodiversity benefits are very low, these nature-based solutions are close to technology-based carbon removal solutions such as direct air capture (in blue in the figure).

Figure 2: An integrated framework for carbon and nature-positive solutions



The second group of approaches seeks to avoid the destruction of existing ecosystems. They are represented in the top left corner of Figure 2. Conservation projects protect existing forests and other ecosystems against destruction, thus preventing massive releases of carbon. Depending on the state of maturity of these ecosystems, they can also generate climate and biodiversity benefits above and beyond their existing stock. For example, a young forest will continue to grow, absorbing carbon and expanding its support for biodiversity. These climate benefits will typically be lower than reforestation / afforestation and restoration projects because their growth rate is lower.

Similarly to conservation projects, nature-based emissions avoidance projects seek to avoid the destruction of existing ecosystems. They do so by providing local communities with viable alternatives to deforestation (such as agroforestry) or by promoting forest management practices (such as fire prevention) that reduce emissions relative to the status quo. As for conservation, the associated biodiversity benefits range from small to large. They are complemented by technology-based emissions avoidance solutions, such as efficient household cookstoves, waste recovery for energy production, or carbon capture and storage (CCS). These technology-based solutions are represented in blue.

A third group of nature-based approaches, which we label compensation, seeks to compensate for unavoidable environmental degradation in one area, due, e.g., to infrastructure development, by restoring nature in another, equivalent, area. They are part of a broader set of measures to mitigate environmental degradation due to land use changes. These schemes typically follow a hierarchy of actions: first, avoiding environmental harm where possible; second, implementing measures to reduce residual impacts; and finally, compensating for any remaining, unavoidable losses (IAPB, 2024). By design, compensation seeks to be at least biodiversity-neutral, meaning that nature is restored in an area sufficiently similar to the area where the environmental degradation takes place (referred to as the like-for-like principle).

Our chapter focuses on nature-based provision and conservation. We deliberately exclude technology-based carbon removals and climate solutions from the scope of our analysis (for a treatment of these solutions, see Edenhofer's chapter in this volume and Edenhofer et al., 2023). We also leave compensation schemes aside and don't cover them because they tend to be local by design and, therefore, are less relevant for scaling up finance for climate action in the Global South.

2. Provision vs. conservation and the rationale for external finance

Nature-based provision and conservation not only differ in their mix of climate and biodiversity benefits and stock-flow dynamics. They also differ in their economics. The main issue with nature-based provision is that only a small share of the benefits generated by reforestation and nature restoration accrue to the owner of the natural resource or the local community. The other benefits are positive externalities. This is a classic public goods problem. In particular, the climate benefit of reforestation and nature restoration is a global public good, given that they absorb CO2, a global pollutant, from the atmosphere. This implies that, without external finance, resource owners and local communities have too little incentive to provide these services. The policy goal for provision, therefore, is to foster the provision of nature-positive carbon sinks.

Conservation of existing natural resources is different. The main issue here is that the benefits that owners and local communities derive from existing forests and land may be smaller for them than the economic benefits of reallocating the land to other uses, such as mining, agriculture, or animal rearing. This benefit constitutes an opportunity cost for landowners and local communities and implies that, without external finance, they are tempted to harvest the natural resource and convert the land to another use. The policy goal for conservation is to ensure that existing ecosystems are preserved to avoid massive carbon releases and the destruction of biodiversity.

The cost structure of these two activities is also different (Table 1). Reforestation and nature restoration require an upfront investment, with most of the climate and biodiversity benefits accruing over the following decades. By contrast, conservation involves recurring costs in the form of maintenance, protection against illegal harvesting and possibly compensation to landowners. As illustrated in Figure 1, the flow benefits from conservation depend on the area that is preserved and, in particular, its level of maturity.

Table 1: Comparison between the economics of nature-based provision and conservation

	Provision	Conservation
Policy goal	Encourage the provision of nature-based carbon sinks	Avoid the destruction of existing ecosystems
Rationale for external finance	Carbon sinks are global public goods (positive externality)	Conservation represents an opportunity cost but deforestation generates a global public bad
Structure of costs and benefits	Investment precedes the benefits that accrue over a long period	Recurring costs, limited flow benefits

3. Challenges with existing market solutions[2]

Existing nature-based markets find their origins in the clean development mechanisms (CDM) and Joint Implementation (JI) projects introduced by the Kyoto Protocol. CDMs involve investments in emissions reduction or carbon removal projects in developing countries. JIs are their equivalent for projects in developed countries. Both mechanisms are project-based and lead to the issuance of a credit recognizing the emissions reduction or carbon removal associated with the project. Signatory countries could use them to meet their emissions reduction commitment under the Kyoto Protocol.[3]

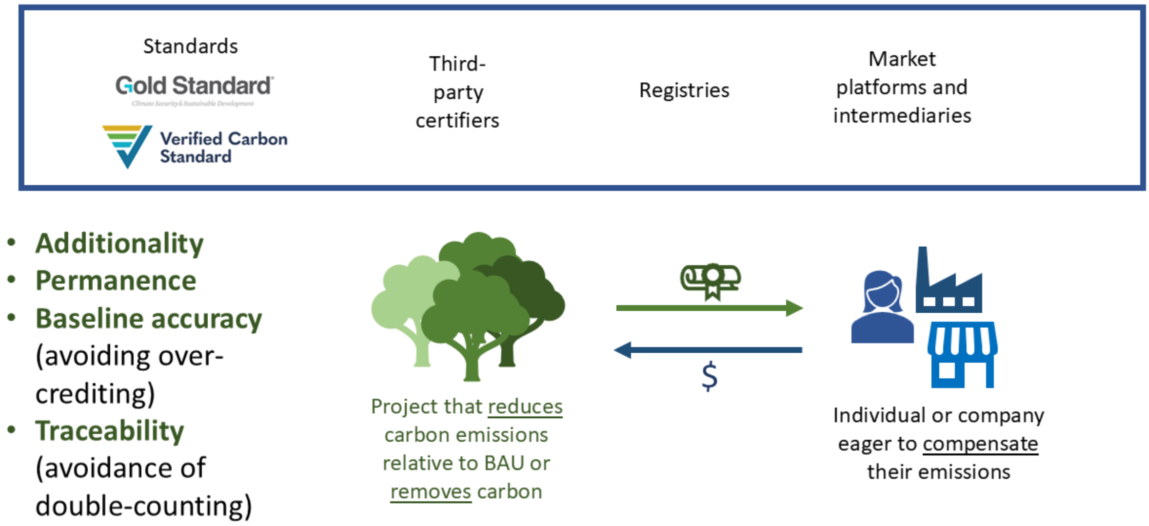
Current carbon and biodiversity markets build on the template set by the CDMs and JI mechanisms. They are also project-based. Several independent organizations have profiled themselves to set standards for what counts as eligible projects and how carbon and biodiversity benefits are computed. They coexist alongside public international, national, and regional crediting mechanisms.

Additionality, permanence, baseline accuracy, and traceability are central criteria in all standards. Additionality means that the project would not have happened absent external funding. Permanence requires that the benefits from the project are permanent. This condition is especially demanding for nature-based projects given the risks of wildfires, pests and other hazards impacting any natural resource. Baseline accuracy refers to the correct estimation of the counterfactual outcome absent the project. It ensures that the benefits of the project are properly quantified. This includes accounting for any leakage whereby the project displaces, but does not prevent, nature-harming activities. Finally, traceability ensures that the benefits generated by a project are not claimed twice. This is done through registries that record credits, verified benefits generated, and retirement (the use of the credits for compliance or offsetting).

[2] This section draws from Cantillon and Slechten (2024a).
[3] See https://unfccc.int/process/the-kyoto-protocol/mechanisms for more details (accessed February 2, 2025).

Projects are diverse: some are based on nature and others on technology. Nature-based projects can focus on climate benefits, biodiversity benefits, other ecosystem services (e.g. water cycling, soil protection), or any combination thereof. Some reduce emissions relative to a business-as-usual situation (avoided emissions), others physically remove carbon from the atmosphere (carbon removal). Reforestation and nature restoration are examples of nature-based carbon removal projects. Conservation can count as a nature-based emissions avoidance project if the case is made that the forest would likely be converted or degraded without funding.

Figure 3: The ecosystem of voluntary carbon markets



Credits are sold directly by project developers, standard-setting organizations, or independently-run trading platforms. Buyers include companies, organizations, and individuals eager to offset their emissions. Additionally, some carbon credits are eligible for carbon emissions compliance schemes such as CORSIA or California's cap-and-trade scheme. Figure 3 illustrates.

The voluntary carbon market makes up for the bulk of the issuance and trading. Liquidity and transparency are low. Prices vary largely according to projects, reflecting both the quality of the credits issued and the co-benefits of the projects. For example, carbon removal credits tend to trade at a higher price than carbon avoidance projects because the baseline is more certain and over-crediting less likely. Likewise, credits offering co-benefits beyond carbon and recent vintages trade at a premium (World Bank, 2024). Total transaction costs, including certification, monitoring, reporting, and trading, are large and are absorbed by intermediaries that are only service providers. Total transaction costs of the order of 40% of the sale price are common, leaving little for the local project developers.

Several scandals have shattered buyers' confidence in the voluntary carbon market. Researchers have documented the absence of additionality of projects (Schneider, 2009; Calel et al., 2021), large and systematic over-crediting of the benefits generated

(Haya et al., 2020; West et al., 2020; Badgley et al., 2022; Gill-Wiehl et al., 2023) and leakage (Heilmayr et al., 2020). These concerns were further publicized when a syndicate of investigative journalists reported in January 2023 that more than 90% of rainforest carbon offsets certified by Verra, one of the largest standard setters, did not represent genuine carbon reductions.[4] If this was not enough, a number of large-scale forest fires in 2023 and 2024 destroyed forests planted through carbon offset projects, canceling all the claimed (and sold) climate benefits. In 2024, the Science-Based Target Initiative carried out a stock-taking exercise on the use and effectiveness of carbon credits. They concluded that the existing evidence pointed to their ineffectiveness in delivering their intended mitigation outcome (SBTi, 2024).

These concerns about credit quality and integrity have led to large drops in prices, especially for nature-based credits. Several initiatives are underway to promote and rebuild trust, including a revision of certification standards and government-sponsored crediting mechanisms (World Bank, 2024). These initiatives tend to raise standards for project qualification and governance. Some also address concerns about greenwashing on the demand side by developing guidelines for when using credits is legitimate as part of an organization's environmental strategy.

4. A new market design for nature-based provision

4.1. Overview

Our proposal rests on four building blocks: (1) a jurisdictional approach on the supply side, (2) a move from credits to shares that generate carbon and biodiversity dividends as the main asset to be traded, (3) a primary market organized as a crowdfunding market, and (4) a largely public governance of the market.

Jurisdictional approaches differ from existing project-based approaches in that they operate at the scale of a jurisdiction (state, province, regions) through a formalized collaboration between governmental entities and actors of civil society and/or the private sector, based on practices and policies intended to apply to all affected stakeholders in the jurisdiction (von Essen and Lambin, 2021). In so doing, jurisdictional approaches acknowledge the government's critical role in monitoring, enforcing, and regulating land use. They are used in sustainable commodity production (aka eco-certification) and as part of the United Nations REDD+ scheme.

Jurisdictional approaches provide a number of advantages (von Essen and Lambin, 2021). First, their inclusive governance fosters greater buy-in and provides for a more holistic approach. Second, their larger scale and their alignment with the monitoring,

[4] https://www.theguardian.com/environment/2023/jan/18/revealed-forest-carbon-offsets-biggest-provider-worthless-verra-aoe

enforcement, and regulatory levels reduces selection issues and leakage, and improves baseline accuracy.[5] For these reasons, the additionality of jurisdictional-level projects is likely to be higher: all actors within the jurisdictions commit to the adoption of more sustainable resource use practices rather than just the actors who would have adopted such practices anyway. This also eliminates the risk of intra-jurisdiction leakage.

Our second building block concerns what is being traded. We propose that what is sold are not credits that recognize a flow benefit but instead shares in a nature-based provision project. In other words, buyers are investors. Their shares give them a right to carbon and biodiversity dividends. Shares in projects differ from credits in at least two important respects. First, credits are transactional – a company can buy a credit from a project one year and not the other. Instead, shares instill a longer-term perspective in investors who will be willing to encourage sustainable forest management even if this decreases the rate at which carbon and biodiversity benefits are generated. Shares increase the commitment to the sustainability of the project and minimize the risk of an exclusive focus on quick, short-term gains. The shareholder has incentives to preserve the value of the asset and thus, the permanence of the project. Second, unlike credits, dividends do not need to match the flow nature benefits of the project, year on year.[6] Very much like for corporations, flow benefits can be kept in the project as provisions for future unexpected shocks. If the accumulated nature benefits are at risk because of changes in climate or the biophysical environment, prudence requires that dividends are distributed parsimoniously. In addition, a prudent shareholder would set aside sufficient reserves to ensure the long-run protection of his assets.

Our third building block is the design of the primary market. The primary market refers to the market where shares in provision projects are first sold by jurisdictions. A challenge here is that projects – like the nature that underlines them – are highly multi-dimensional. The fact that what is traded is a share (i.e., a stock) rather than a credit (i.e., a flow) adds a time dimension to an already complex bundle of attributes. We propose to organize this primary market along the lines of equity crowdfunding marketplaces. Jurisdictions list large-scale projects, described qualitatively and using a number of pre-defined descriptors that capture the project's social, environmental and governance quality (see Appendix 2 for an illustrative list), with a requested minimum funding amount needed to carry them out. Investors decide how to allocate their funds across the listed projects. If a project attracts more funds than requested, the share price of this project increases until supply is equal to demand. If a project attracts less funds than requested, it is

[5] Note that not all nature-based initiatives proposed by jurisdictions have to cover the entire territory of these jurisdictions. There can be exceptions as, for example, in the case of the restoration of mangroves or peatlands which are very localized.

[6] Note that a current practice in the voluntary carbon market is to allow for a buffer whereby the number of credits issued is lower than the estimated carbon sequestration. This practice is similar to provisioning.

removed from the market, providing an opportunity for investors to reallocate their funds. The primary market clears when all remaining projects are funded.

This design leverages the competition between jurisdictions to promote the additionality of the projects funded. It encourages them to adopt and describe credible measures to increase the attractivity of the project for investors, i.e. to avoid adverse social impacts, manage risks, prevent leakage, ensure permanence etc. The design also leverages the competition between investors and the price formation process to aggregate market preferences over project attributes. The primary market is complemented by a secondary market to ensure that investors who need to reallocate their funds can exit the market by reselling their shares.

Our final building block is market governance. Today, the voluntary carbon and biodiversity markets are largely privately governed: with some exceptions, standards are produced by private organizations; credit registries are maintained by private organizations; and marketplaces, when they exist, are run by private organizations. This contributes to their fragmentation and opaqueness and is part of the reason why transaction costs are so high. The inherently diverging interests of standard-setting organizations, certification bodies, and project developers undermine trust in the integrity of credits. We propose to replace this private market governance with a largely public and international market governance that set minimal eligibility criteria for projects, define monitoring, reporting, and verification (MRV) protocols, organize the primary market, maintain registries, and provide public guarantees for projects. This will address today's market fragmentation and reduce transaction costs as a result.

4.2. Details

Our proposal differs most sharply from existing approaches in the proposed asset design and market mechanism, and it is worth detailing what these entail and their implications.

Consider asset design. The move from credits to shares that produce dividends not only changes the time horizon of investors, it also changes the time and risk profile of the asset traded. In the existing credit-based market, project developers invest upfront but only recover their investment costs over time as the project produces credits. They entirely bear the risk that climatic or biophysical events destroy their forest or natural resource. Buyers of credits do not bear any of these risks. At most, they may bear some reputational risk if it is found that the credits they bought no longer represent climate or biodiversity benefits because a fire or another natural hazard destroyed the forest.

Our share-based asset design changes this time and risk profile. First, project developers – here jurisdictions – get the funding upfront at the end of the primary market. In other words, the timing of funding aligns with the timing of their main costs. Second, production risk – i.e. the risk that the climate and biodiversity benefits do not materialize as expected – is now borne entirely by investors. In principle, there is no reason to expect that investors are more or less risk averse than jurisdictions and so no reason to worry about this transfer of risk, except if project developers have an influence on the production of climate and biodiversity benefits. As described in Section 1.1, this is partially the case. If so, the share-based asset design introduces the risk that project developers do not take all necessary measures to deliver sustained carbon and biodiversity benefits (moral hazard).[7]

As time passes, the project produces climate and biodiversity benefits that eventually generate climate and biodiversity dividends. Given the non-permanence of nature-based benefits, prudence should apply when releasing these benefits in the form of dividends. Some of these benefits should be kept as provisions for future shocks and to ensure the long-run conservation of the project. The currency for these dividends are physical units (tCO2 and quality x ha or any other relevant metric to measure biodiversity benefit). They accrue to the shareholders, who can use them to claim climate and biodiversity contributions. We see little value in making these dividends transferable, the way carbon credits today are, and thus in organizing a market for those. The value of the investment in shares should be to receive these nature-based dividends, not to sell them.

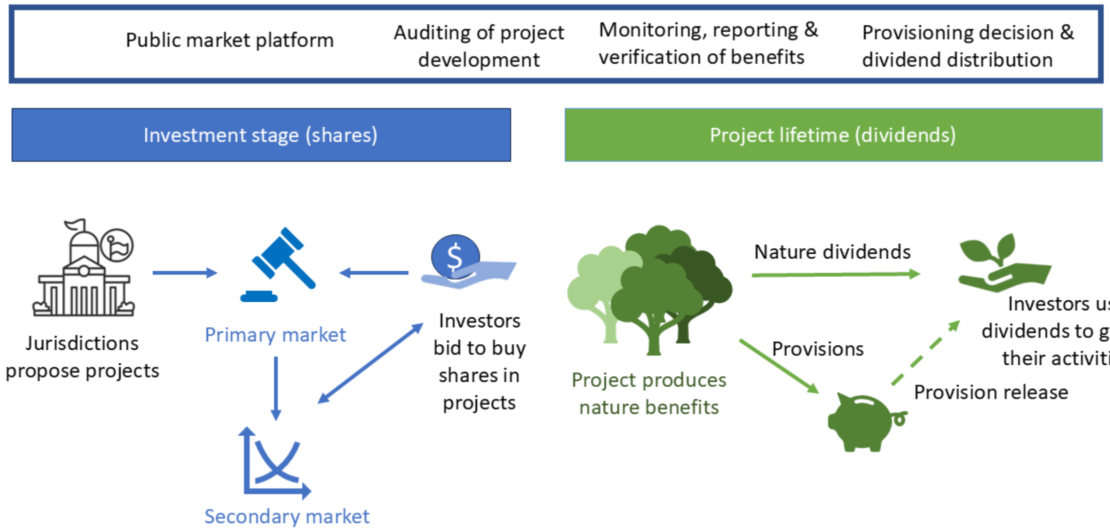
Consider next the market design. A particularly tricky part here is the muti-attribute character of the projects whose shares are offered. There is no such thing as an apple and an apple. Each project is unique in its combination of attributes. This is why we propose that jurisdictions describe their projects both qualitatively and using several pre-defined indicators that capture the social, environmental, and governance quality of the project. In that way, specific projects can appeal to investors with specific interests in an ecosystem (e.g. tropical forests, mangroves, mountains, ...), an environmental issue (e.g. conservation of birds, seashores, soils, ...), a geographic area (e.g. the Amazon basin, the Himalayas, the African savannas, ...), and/or a category of actors (e.g. indigenous groups, smallholder farmers, livestock herders, ...).

Despite this diversity, there is a role for a market or, more precisely, for competition between jurisdictions offering projects to be funded and investors bidding on projects. In our proposed design, jurisdictions post a minimum funding cost for their projects, below which the project cannot take place. These are non-negotiable. Jurisdictions cannot reduce their minimum ask price if demand for their project is insufficient. On the other hand, if demand exceeds the number of shares available at that ask price, the price is adjusted upward until demand equals supply. These features together are useful for two reasons. First, because prices can go above the minimum ask price, jurisdictions have no incentive to inflate their minimum funding costs. An ask price above what is

[7] Another potential source of moral hazard is that the project developer takes the money and does not develop the project at all. The fact that jurisdictions are the project developers or at least project sponsors, reduces this risk.

needed for the project can only result in the project not being funded, even if there would be sufficient demand for the project at its actual cost. This encourages additionality. Second, when demand exceeds the funding needs, the equilibrium price reveals information about how investors value the bundle of attributes that the project offers.

Figure 4: The ecosystem of nature-based equity market



Ensuring a liquid secondary market is important given that the asset is a share and not a credit (flow benefit). Without one, investors would be stuck with their investment and unable to exit if their circumstances change. This would reduce the attractiveness of the primary market. There are lessons to be learned from both the failure to establish a liquidity market for carbon credits and the design of secondary markets for treasury bills. The voluntary carbon market is illiquid because buyers care about the quality of the credits they buy. Attempts by exchanges to standardize and bundle credits that meet specific requirements have met resistance from market participants eager to avoid adverse selection: paying the price of a peach but instead getting a lemon (World Bank, 2023). Treasury markets face a similar problem: treasury bills come with different remaining maturities. Organizing one market (and thus one price) for each remaining maturity would result in low liquidity. But they have overcome this problem. Treasuries of different maturities are sold in a single market, and a pre-agreed conversion factor is applied to the price whenever the delivered treasury bill departs from the benchmark one. We propose to do something similar, by leveraging the information generated in the primary market about investors' preferences. Specifically, for those projects that sell at a higher price than the minimum ask price, the primary market generates prices for each bundle of attributes.[8] We can use this information to generate conversion rates between projects within project categories, and organize a market for each project category. By

[8] Technically speaking, this is done using a hedonic regression of equilibrium prices on project attributes.

construction, investors should be (nearly) indifferent about receiving any of these shares once the conversion rate is applied.

Figure 4 illustrates our proposed new market design. Because the asset traded is a share, and not a credit, we need to distinguish the investment stage, from what happens during the lifetime of the project. At the investment stage, investors can buy shares in the primary market where jurisdictions offer their projects for funding. In parallel, a secondary market for shares is organized to allow investors to sell their shares or buy from other investors. The outcome of the primary market is used to generate conversion rates between shares in different projects and therefore ensure sufficient liquidity in the secondary market. During its lifetime, the project produces carbon and biodiversity benefits, some of which are distributed as nature dividends, others are kept with the project as provisions against future shocks and to pay for protection. Some of these provisions may be distributed later, others may be withheld to pay for conservation of the asset. Investors may use the nature dividends they receive to offset the nature impact of their activities.

4.3. Advantages of the new design relative to existing credit-based approaches

We now argue that our proposed design addresses many of the issues existing credit-based approaches face. We have already argued that competition between jurisdictions in the primary market encourages them to quote a minimum ask price that corresponds to their costs of carrying out the project. If a project is not additional, i.e., if it would take place even in the absence of external funding, then a jurisdiction should in theory quote a zero price for that project. Note that it does not mean that all projects will be funded at the least cost since the price is allowed to increase in case of excess demand. That's the sacrifice we must pay to ensure that the market performs two roles: fostering additionality and aggregating preferences over project attributes.[9]

The close alignment between the project and administrative boundaries of jurisdictions reduces leakage relative to credits based on smaller projects. Likewise, we can also expect the large project size to reduce the costs linked to certification and the monitoring-reporting-verification cycle since most of these costs are fixed.

Our design offers a chance to aggregate investors' preferences over project attributes and therefore generate a price for each attribute. Not only does it facilitate the development of a liquid secondary market, but it also avoids the current situation where the currency for credits is a ton of CO2, but they sell at different prices based on a subjective evaluation of the reputational risk associated with different sources of credits. In the new design proposed here, shares in projects will sell at different prices the same

[9] In fact, one may argue that the prospect of getting more than what was asked can create a virtuous circle where jurisdictions have an incentive to propose projects with a bundle of attributes that are attractive to investors.

way different stocks sell at different prices, based on objective attributes that are made explicit. The implicit price for the carbon and biodiversity benefits they generate will be the same. Last but not least, our design instills a long-term perspective what is largely today a transactional market.

Table 2: Comparison between existing credit-based approaches and our new market design

	Existing credit-based approaches	Proposed market design
Additionality	Certifier establishes additionality but is subject to conflict of interest	Competition induces jurisdictions to ask for the minimum needed to support the project, encouraging additionality
Leakage	Rampant given the small size of projects	Large scale of jurisdiction reduces leakage
Transaction costs	Very high (certification, MRV)	Lower transaction costs thanks to larger size and reduced market fragmentation
Valuation of non-carbon benefits	Implicit, through the co-existence of several prices (per ton of CO2) for different types of credits	Explicit, through the generation of a conversion rate for project attributes
Buyer / investor interest in the long-term permanence of nature benefits	Minimal, given the transactional nature of credits	Value of the asset depends on provisioning for future shocks and paying for protection

4.4. Remaining open design and governance issues

This chapter has so far laid out the contours of our proposed market design, but its implementation depends on several fine-tuning decisions that require a sound understanding of projects' specificities and their market and institutional context. We highlight a few here for illustration.

One question that arises is to what extent we should place strict conditions for project eligibility rather than let the market sort out projects according to their quality. Current attempts at fixing the voluntary carbon markets have taken the route of raising standards for eligibility. This increases the quality of the project pool but also reduces its size. In principle, our proposed market design allows for many project attributes and could accommodate a larger pool of projects. This is an advantage as long as the list of project indicators can clearly distinguish between "low quality" and "high quality" projects. Too many indicators may generate obfuscation, rather than information.

A second question concerns the amount of provisioning. Depending on the project, the risk of impermanence may be so high that only limited carbon and biodiversity dividends can be distributed, reducing the project's investment value.[10] One alternative might be insurance. Several companies today offer carbon credits insurance to project developers. These insurance policies mainly cover the financial loss to project developers, however, and do not always include provisions to address the release of carbon due to the destruction of the forest or land. When they do, they provide funds for reforestation or purchase of carbon credits from other projects. One additional challenge in our context is that biodiversity is particularly place-specific and, therefore, even harder to compensate in case of a loss. As a result, insurance is only a partial substitute for provisioning in our context, and we only see a limited role for it.

A third question concerns the governance of funded projects. Shares in projects do not change the ownership of the land but because shareholders bear the climate and biodiversity benefits risk, they should be able to influence or at least constraint the broad land management decisions. An appropriate governance needs to be put in place to respect land sovereignty and local environmental knowledge, which is highly place-specific and requires detailed expertise. One possibility is an oversight by some international independent agency, which could check the implementation of the projects according to plans and, possibly, withhold some of the funds until full implementation. This approach would address investors' concerns about moral hazard, without changing ownership or land management rights by simply ensuring that jurisdictions indeed have the incentive to deliver according to their promises.

A final consideration is the treatment of carbon dividends in the context of the Paris Agreement. Currently, some REDD+ credits are used by countries for their nationally determined contributions (NDC) under Article 6.2. of the Paris Agreement: the climate benefit is transferred from the selling country to the buying country. This logic would apply here too: when project investors are countries, the benefit can be claimed for their NDC. When the investor is a private entity, the host country can keep the climate benefit.

4.5. Ensuring demand

One aspect we have not discussed so far is the demand side. Today, the bulk of demand in the carbon and biodiversity markets stems from voluntary corporate action. This demand is bound to decrease as compliance markets expand.

Integration with compliance markets is not a desirable route. Even though some carbon credits are currently eligible for compliance and there are voices calling for further integration, Paris-aligned greenhouse gas emissions trajectories require both nature-based carbon sinks *and* anthropogenic emissions reduction. Counting nature-based carbon removals towards anthropogenic emissions reduction, as implied by market

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[10] Note however that the large scale of our projects compared to most projects in the existing credit-based market already provides some risk diversification, reducing this risk.

integration, would amount to double-counting (Cantillon and Slechten, 2024b). We need to reduce emissions *and* increase nature-based carbon removals. Integration is even more problematic in the case of biodiversity because biodiversity is highly place-specific.

This leaves regulation to ensure demand. One possible route is to mandate funds marketed in the EU to offer Paris and Montreal-aligned portfolios. This goes beyond the Paris-alignment approach described in Bolton et al. (2022) in which decarbonization is achieved through the choice of stocks in firms that are reducing their carbon emissions in line with the net zero transition pathways. Our scheme opens an additional possibility for decarbonizing financial portfolios: shares in nature projects would be another class of (carbon-negative) assets that portfolio managers could use, in addition to equity reshuffling, to reduce the carbon footprint of their portfolios. Pension funds, whose size can represent several times the national GDP in countries with deferred benefits systems, are another route. Given their long-time horizon perspective, some of these pension funds are already leaders in sustainable investment but more could be done to nudge the vast amount of money these funds control. France, for example, has introduced an obligation for companies to offer so-called 90-10 savings funds to their employees, under which between 5 and 10% of the collected funds are invested in social enterprises and microfinance. The system is so popular that the ceiling has been raised to 15% in 2025.[11] It could provide a template for boosting demand for project shares.

5. The challenge of nature conservation

There is no doubt that nature conservation should be a priority. The damages from deforestation today are considerably larger than the climate and biodiversity gains from reforestation, afforestation and nature restoration. Conserving existing forests is also in many cases cheaper than reforesting.

The challenge is the economics of conservation. Conservation avoids damages but generates lower flow benefits beyond those captured by local communities. Moreover, it is subject to recurring opportunity and maintenance costs.

The voluntary carbon market has somehow circumvented the problem by talking about emissions avoidance and creating credits based on what would have happened without funding. This trick has led to concerns about additionality and overcrediting, which no improvement in technology or governance can fix because conservation is intrinsically different from provision. Moreover, counterfactual scenarios based on projections of likely future land-use changes absent a nature conservation project will always remain

[11] See https://www.finance-fair.org/fr/actualites/epargne-salariale-vers-encore-plus-de-solidarite-grace-un-nouveau-decret (accessed March 2, 2025)

highly uncertain given the challenge in predicting how increasingly unstable climate, and geopolitical conditions will affect a specific place and ecosystem

We formulate two desiderata for funding allocation mechanisms for nature conservation. The first desideratum is to guarantee additionality. Large areas of forests are currently not under threat and their conservation does not need to be financed. Additionality is important considering the funding gap for biodiversity. While COP16 signatories committed to mobilizing $200 billion annually for conservation by 2030, including $20 billion in international contributions by 2025, current funding is much more limited. Existing mechanisms, such as the Global Biodiversity Framework Fund, have so far raised only $383 million, highlighting the need for a more robust financial architecture.[12] The second desideratum is to encourage solutions that structurally reduce the threat to forests and other natural resources, thereby reducing the opportunity cost of conservation.

One option is to bundle conservation with provision and integrate both in the mechanism we have described in Section 4. This would have two advantages. First, by further expanding the geographical scope of projects offered for funding, it would not only further decrease leakage risk but also encourage reallocation of land where needed, contributing to the second desideratum. But it would reduce the climate and biodiversity returns of these projects, decreasing their attractiveness to investors and requiring public or philanthropic funding to close the gap.

A second option is to develop a separate funding mechanism for conservation. The advantage is that this mechanism could be tailored in its governance to the specificities of conservation and, for example, prioritize areas for conservation depending on their natural value. This would contribute to meeting the first desideratum. The disadvantage of this option is the flip side of the advantages of the first option: it would generate no benefit in terms of leakage or efficient reallocation of land. We are agnostic as to the most appropriate option.

6. Concluding comments

Nature provides immensurable services to our societies but it is in danger. External funding is needed, especially in the Global South, to support the provision and conservation of natural ecosystems. Markets can play a role to match projects and

[12] To address this challenge, COP16 established a roadmap for biodiversity finance beyond 2030 and launched a high-level dialogue between environment and finance ministers to accelerate resource mobilization. Although the agreement did not provide specific details on these mechanisms, it acknowledged the UN Biodiversity Finance Initiative (BIOFIN) catalogue, which outlines various financial solutions such as biodiversity offsetting and carbon credits (Carbon Pulse, 2025).

stakeholders interested in contributing, but the current market governance is plagued by poor incentives and low trust.

We have proposed a new market mechanism to channel funds to nature provision projects. The main innovation of our proposal is the move from the transactional credit-based approach of today to an approach where the main asset to be traded is a share in a project. We have argued that our approach would address many of the concerns about the existing market and, importantly, instill the needed long-term perspective in market participants. We propose that this new market design be coupled with a mandate or an incentive for funds (pension funds or any other market funds) to include shares in nature provision projects. This would ensure that there is sufficient demand for these shares. Moreover, leveraging financial funds, rather than companies, offers the additional advantage that the carbon and biodiversity benefits generated are not used to offset emissions or biodiversity damages by those that cause them directly. In our proposal, companies are still responsible for their emissions and biodiversity impacts.

In the text, we have focused on carbon and biodiversity dividends from forests for simplicity. However, nothing in the proposal limits the design's applicability to forests, or to these nature benefits. One could apply the same type of approach to peatland restoration, mangroves, etc., as well as other ecosystem services such as water purification, pollination or nutrient cycling. The main constraint is practical: can we measure these benefits?

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Appendix 1: Nature and biodiversity measurement

In carbon markets, the universally accepted unit of account is a ton of CO_2 equivalent. In biodiversity and nature markets, no such standard exists. More than 600 different measures have been used, each capturing distinct aspects of habitat condition, species populations, and ecosystem health, as shown in an exhaustive review of metrics complied by the Nature Positive Initiative in 2025.

Effective biodiversity metrics must balance ecological detail with practicality. They should be transparent, straightforward to compute, and adaptable for organizations with varying capacities. Strong metrics incorporate biological diversity, habitat conditions, taxonomic-specific factors, and species of concern, drawing on local knowledge where relevant.

The challenge is not a lack of biodiversity metrics but their sheer variety and the absence of consensus on which to use. This inconsistency hinders the scaling of biodiversity markets. Table 3 provides an overview of key metrics currently in use.

Table 3: Overview of the most commonly used metrics to measure nature and biodiversity

Metric	Definition	Reference
Biodiversity Habitat Index	Level of species diversity expected to be retained within any given spatial reporting unit as a function of the area, integrity and connectivity of natural ecosystems across that region	Harwood et al., 2022
Biodiversity Intactness Index	Model-based indicator of terrestrial biodiversity which averages the abundance of a large and diverse set of organisms in a given geographical area, relative to their reference populations	Scholes and Biggs, 2005
IUCN Red List Index	Average of a score in {0, 0.2, ..., 1} that corresponds to an extinction stage of major species groups over time	Rowland et al., 2020
Living Planet Index (LPI)	Geometric mean of the global abundances of all species in a defined taxonomic group, normalized to the baseline year (1970). Highlights average rates of change in a large number of populations of terrestrial, freshwater and marine vertebrate species	Loh et al., 2005
Mean Species Abundance (MSA)	Average abundance of individual species under influence of a given pressure, compared to their abundance in an undisturbed situation	Schipper et al., 2020
Potentially disappeared fraction (PDF)	Probability that a species, randomly chosen amongst all species present at a spot, will get extirpated	De Schryver et al., 2010
Shannon Index	Diversity index that quantifies species richness, with higher values indicating greater diversity	Keylock, 2005
UK BNG: Biodiversity Unit	Standardized measure that calculates a habitat's ecological value by factoring in its size, condition, significance, type, difficulty of creation or enhancement, and the time required for restoration	DEFRA, 2023

Appendix 2: Illustrative list of project descriptors

We propose that project descriptions cover at least the following aspects:

Relevance and impact: How will a significant reduction in GHG emissions and/or in the degradation of ecosystems/biodiversity be achieved directly from the project activities?

Monitoring, reporting and verification (MRV): Based on which indicators will the reductions be verifiable and measurable in the short, medium and long term?

Additionality: Will the project have an additional impact compared to the "business-as-usual" scenario and beyond any reduction already required under prior commitments of the country and/or affecting the place of the project, or by legal and judicial decisions in the country of the project?

Permanence: Will the project have a permanent effect? What measures will be adopted to ensure permanence?

Do no harm: What measures will be adopted to ensure that the project causes no significant negative impact on local communities and on other ecosystem services?

Co-benefits: Does the project generate environmental and/or social co-benefits? Which ones?

Benefit sharing: Will the local communities managing the ecosystems of the place of the project receive a fair share of financial resources?

Risk management: Which strategies are adopted to mitigate the risk of project failure and to compensate any actor that would be harmed by the project activities following unforeseen impacts?

Leakage: What measures will be adopted to ensure that the project will not cause a leakage/displacement of emissions or of activities associated with ecosystem/biodiversity degradation to another sector or another location?

Systemic approach: In what way does the project adopt a systemic approach to solutions and impacts?

Financial feasibility: Does the project have a high potential to be financially viable in the long term, intrinsically or through additional funding from public or private sources?

Transparency: What measures will be adopted to ensure that all relevant information on the project design, management and impacts will be disclosed in a transparent manner?