JPMorganChase | Carbon Direct

Optimizing for Biodiversity with Nature-Based Projects in the Voluntary Carbon Market

Principles for pursuing dual outcomes | October 2025

Contents

Acronyms and abbreviations

ACR: American Carbon Registry

AFOLU: agriculture, forestry, and other land use

ALM: agricultural land management

ARR: afforestation, reforestation and revegetation

CAR: Climate Action Reserve

CAR MFP: Climate Action Reserve's Mexico Forest Protocol

CAR SEP: Climate Action Reserve's Soil Enrichment Protocol

CCB: Climate, Community, and Biodiversity Standard

ERS: Ecosystem Restoration Standard

IAPB: International Advisory Panel on Biodiversity Credits

IFM: improved forest management

MMRV: measurement, monitoring, reporting and verification

NGO: non-governmental organization

REDD+: reducing emissions from deforestation and forest degradation in developing countries

VCM: voluntary carbon market

VCS: Verified Carbon Standard ("Verra")

Foreword

Buyer demand for voluntary carbon market (VCM) projects that incorporate nature-positive objectives is growing. As that trend continues, standards for projects that pursue outcomes for both carbon and nature are improving. This paper aims to further advance and support these developments using biodiversity as a measurement of nature-positive impact.[1,2]

Healthy ecosystems are vital for economic stability and growth. Natural capital—including soil, air, water, and living things—provides valuable goods and services for society and the economy. Overuse of these resources threatens businesses and communities by reducing the resources needed for physical and economic health.

The link between nature and climate is also gaining recognition. A changing climate is a major driver of change in nature, while continued loss of nature increases climate risks and contributes to a rise in greenhouse gas emissions.[3,4] Governments, non-governmental organizations (NGOs), companies, and others have called for integrated efforts to address climate and biodiversity loss, including scaling finance for both. In 2023, global climate finance reached US$1.9 trillion, while finance for nature was US$200 billion—both less than a third of the estimated amount needed to meet global climate and nature goals by 2030.[5,6]

Nature-based solutions, including reforestation and improved forest management, account for more than half of the available carbon credit supply in the VCM. By enhancing approaches to driving positive outcomes for both climate and nature, project developers may help increase the size and impact of investments already being made. Also, leveraging the established VCM can help scale nature finance more quickly while waiting for a separate market to develop.

A key challenge is effectively integrating dual nature-positive and carbon objectives. Methodologies to assess and verify nature-related

1 This paper uses the word "biodiversity," based on the definition of "biological diversity" from the Convention on Biological Diversity (CBD).

2 Convention of Biological Diversity. 2006. Convention on Biological Diversity, Article 2: Use of Terms. [accessed 2025 Sept 21]. https://www.cbd.int/idb/activities/difference-biodiversity-nature.pdf

3 Convention on Biological Diversity. 2024. Kunming-Montreal Global Biodiversity Framework. [accessed 2025 Aug 26]. https://www.cbd.int/gbf

4 United Nations Framework Convention on Climate Change. 2023. COP28 Joint Statement on Climate, Nature, and People. [accessed 2025 Aug 26]. https://www.cop28.com/en/joint-statement-on-climate-nature

5 Climate Policy Initiative. 2025. Global Landscape of Climate Finance 2025. [accessed 2025 Aug 26]. https://www.climatepolicyinitiative.org/publication/global-landscape-of-climate-finance-2025/

6 United Nations Environment Programme. 2023. State of Finance for Nature: The Big Nature Turnaround – Repurposing $7 trillion to combat nature loss. [accessed 2025 Aug 26]. https://www.unep.org/resources/state-finance-nature-2023

benefits are complex and may be less developed and measurable than those focused on carbon-related benefits. Balancing tradeoffs between these objectives can be difficult and public guidance is limited.

Building off of JPMorganChase's *Carbon Market Principles*,[7] JPMorganChase and Carbon Direct jointly drafted this paper to provide insights and an enhanced framework for market participants pursuing dual carbon and nature-positive outcomes via the VCM. In particular, the paper focuses on considerations for optimizing biodiversity as a key measure of nature-positive outcomes.

Through this effort, we hope to contribute to ongoing dialogue to advance the development of robust nature-based projects and the continued enhancement of the VCM and other mechanisms to scale financing for both climate and nature. We are grateful to Carbon Direct and the many experts who have contributed to this work—both in the writing of this paper and through years of learning and engagement.

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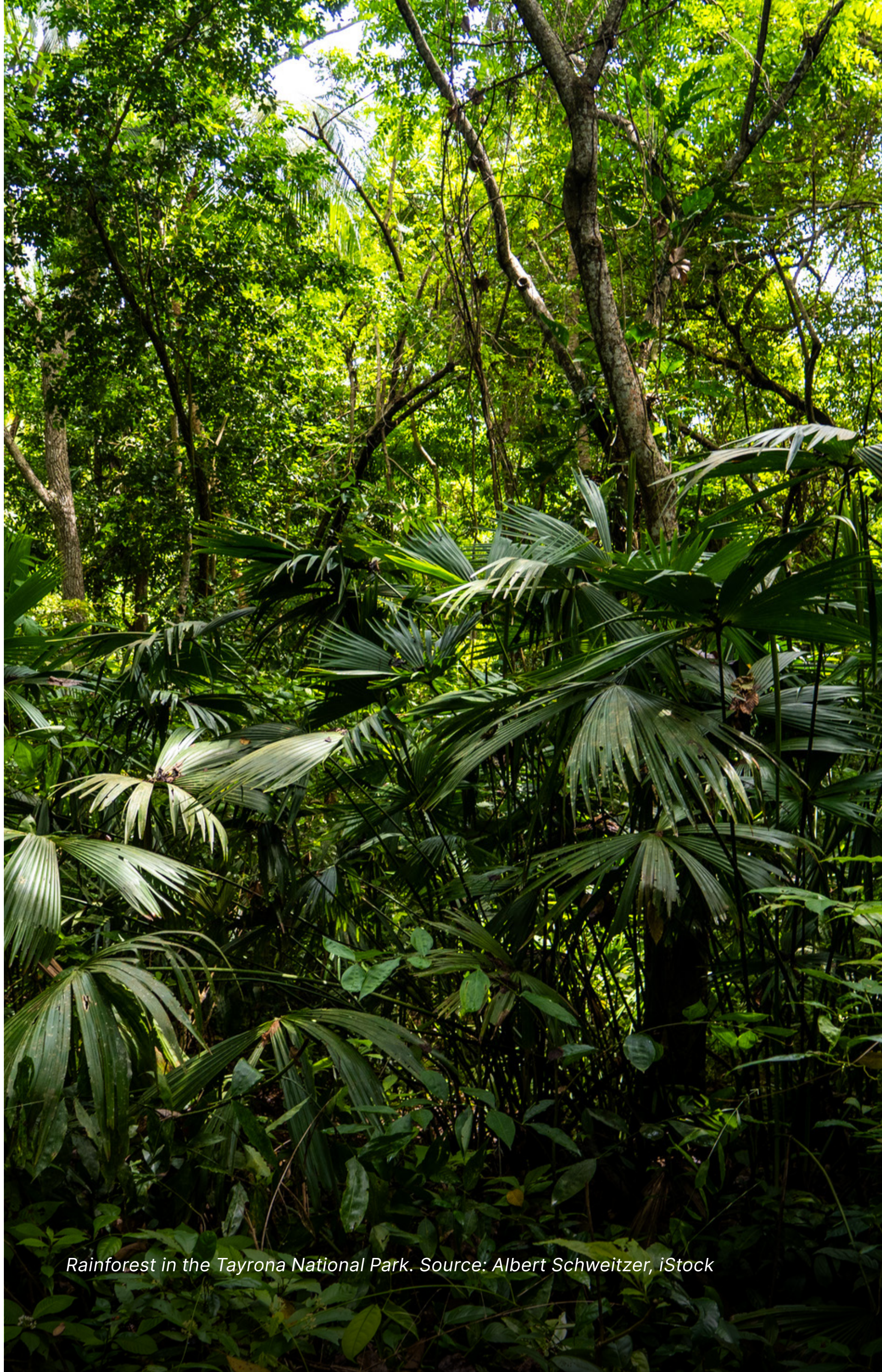
7 JPMorgan Chase & Co. 2023. Carbon Market Principles: Our approach to strengthening the voluntary carbon market to scale decarbonization solutions. [accessed 2025 Jan 16]. https://www.jpmorganchase.com/content/dam/jpmc/jpmorgan-chase-and-co/documents/carbon-market-principles.pdf


Rainforest in the Tayrona National Park. Source: Albert Schweitzer, iStock

Executive summary

Organizations are increasingly looking for opportunities to deploy finance toward projects in the voluntary carbon market (VCM) that meet dual carbon and **nature-positive** goals. This paper provides guidance for organizations pursuing such projects by outlining six principles for impactful nature-positive investment in the VCM.

Nature-positive goals are global, societal, and anchored in the mission and objectives of the Global Biodiversity Framework (GBF).[8] In this paper, we use **biodiversity** as a gauge for nature-positive impacts. We focus primarily on how high-quality biodiversity outcomes could be assessed in nature-based VCM projects. Our analysis draws insights from accepted, scientific best practices and a survey of relevant registered projects. We pay particular attention to forest-based carbon projects that can have elements of **ecological restoration**, such as projects centered around reforestation and improved forest management. While these examples guide much of our discussion, the outcomes and principles we outline in this paper may be broadly applicable to all nature-based project types.[9] However, the particulars of implementation, design, and monitoring will differ on a project-by-project basis. We do not analyze voluntary **biodiversity credits**, nor do we opine on the issuance of stacked carbon and biodiversity credits for a unique project.

Although the inextricable link between climate and nature is widely recognized in international discourse on climate, risk, and resilience, nature-positive markets are still relatively nascent. Through this paper and the introduction of these principles, our objective is to start a conversation that encourages a positive feedback loop for both nature and climate. We look forward to evolving and refining this work as science, policy, reporting frameworks, and markets advance.

Drawing on scientific best practices, industry standards, policy, and an analysis of 1,639 globally distributed nature-based projects with carbon removal elements, we present a decision-making framework for selecting rigorous projects that are

8 Finance for Biodiversity Foundation and United Nations Environment Programme. 2024. Finance for Nature Positive: Building a working model. Executive Summary. [accessed 2025 Jan 16]. https://www.unepfi.org/wordpress/wp-content/uploads/2024/09/Finance-for-Nature-Positive-Exec-Summary.pdf

9 For details on the limitations of this paper refer to **Appendix B**.

relevant to organizational priorities, setting reporting commitments, and evaluating claims. This framework centers around six principles for prioritizing high-integrity, quantifiable dual outcomes for biodiversity and carbon in VCM projects (**figure 1**).

Our survey of the VCM finds that, while some projects aim to show positive biodiversity outcomes, few are designed or incentivized to fully integrate both quantifiable biodiversity and carbon outcomes that can be reported against. While the VCM acknowledges environmental health and biodiversity as important co-benefits, biodiversity outcomes are not the traditional remit of the market; this is reflected in protocols and projects that are designed and structured to deliver quantifiable carbon outcomes, not biodiversity, even if a given project likely creates biodiversity benefits.

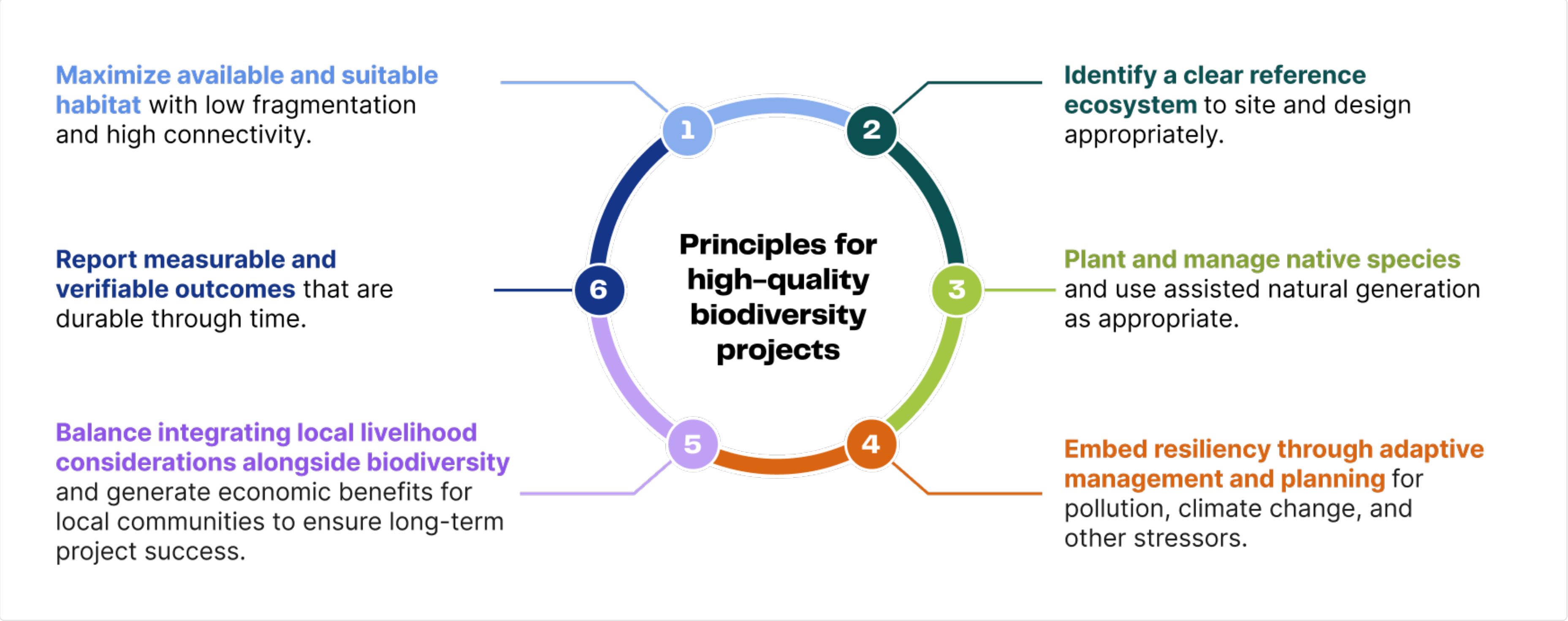


Figure 1. Six principles for prioritizing high-quality biodiversity projects in the VCM. Source: Carbon Direct.

By introducing the six principles above, we aim to provide a public resource for project developers seeking to embed dual outcomes in project design, and for buyers seeking to finance dual outcomes.

Buyers can catalyze market growth by supporting dual-outcome projects that are designed in accordance with these principles. Organizations can set priorities and policies that define net nature-positive investment, support project selection, and act as market signals for carbon market registry protocols and project developers.

Our analysis yields the following key takeaways for buyers wishing to support high-quality biodiversity outcomes in nature-based carbon projects in the VCM:

Center local context for global impact: Account for geographic and ecosystem specificities as biodiversity units are not fungible.

Ground outcome-based reporting in clearly defined objectives: Project measurement, monitoring, reporting, and verification (MMRV) should be science based and support biodiversity measures relevant to project objectives.

Accommodate an adaptive management mindset: Management approaches should allow for potential recalibration of success while maintaining initial project objectives and maintaining appropriate anti-greenwashing guardrails.

Take the long view: Timelines are not always aligned for optimizing carbon and biodiversity objectives. Reporting outcomes may need to be decoupled and reflect appropriate timelines.

Introduction

Natural capital is the value—both intrinsic and economic—of soil, water, air, and all living things. It underpins economies and societies by providing **ecosystem services** that regulate climate; provide food, quality water, and shelter; and that facilitate enjoyment, recreation, and cultural enrichment.[10] However, historic and contemporary human-mediated threats and unsustainable resource utilization degrade ecosystems and the services they provide. This degradation imposes significant costs to global economies and contributes to climate change.[11]

Nature-positive refers to the protection, restoration, and enhancement of natural capital, including **ecosystem functions**, species, and ecosystem services. Biodiversity, or the variation within and among living organisms, drives many nature-positive outcomes, including **resilience**. Most nature-positive targets focus on enhancing, conserving, or restoring biodiversity.[12] Therefore, we use biodiversity as a gauge for nature-positive impacts in this report.

Civil and private organizations, as well as community members, have an opportunity to support multilateral nature-positive targets in concert with governments. To do this, tools and policies should be available to enable rigorous, relevant, and responsible engagement in voluntary contexts.

Enhancing nature-positive investment through the VCM

Emergent frameworks, advancements in global targets, and multilateral commitments related to biodiversity and restoration seek to mitigate and address risks to natural capital in organizations' operations and value chains. In several jurisdictions (including the European Union) institutions, investors, and companies are now required to disclose environmental impacts, such as land and water use and impacts to biodiversity, as part of mandatory corporate disclosures. The initial goal of these disclosures is to incentivize capital flow toward nature-positive investments.

> Biodiversity, or the variation within and among living organisms, drives many nature-positive outcomes.

10 Brondízio E, Settele J, Diaz S, Ngo HT, Experts G, Mohamed A. 2021. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. doi:10.5281/zenodo.3553579

11 Montanarella L, Scholes R, Brainich A. (eds.). 2018. The IPBES assessment report on land degradation and restoration. doi:10.5281/zenodo.3237392

12 Finance for Biodiversity Foundation and United Nations Environment Programme. 2024. Finance for Nature Positive: Building a working model. Executive Summary. [accessed 2025 Jan 16]. https://www.unepfi.org/wordpress/wp-content/uploads/2024/09/Finance-for-Nature-Positive-Exec-Summary.pdf

Over the past few years, private investment in ecosystem management and protection has grown, supporting climate action and the multiple benefits ecosystems provide. One avenue for investment is the VCM. Many organizations are already familiar with navigating the VCM and demanding quality in pursuit of meeting their carbon mitigation and climate targets. This includes JPMorganChase, which has published its *Carbon Market Principles*, outlining ways the firm supports a more effective carbon market and presenting a set of core principles it references when evaluating projects for its own portfolio.[13]

> Projects with quantifiable dual outcomes for carbon and biodiversity that buyers can report against are tractable market outcomes.

Organizations are increasingly looking for opportunities to deploy finance toward both carbon and nature-positive goals. Expanding the VCM to meet these dual goals could be a tractable near-term opportunity. Certain nature-based projects in the VCM may be positioned to provide measurable outcomes for both carbon and biodiversity because, broadly speaking, outcomes for carbon and nature are interlinked. These projects provide an opportunity for dual management and multiple outcomes for interested buyers. Because the VCM is more mature than emerging biodiversity credit marketplaces, such projects could enter the market more quickly than those focused solely on biodiversity.

These projects also have the potential for broader uptake by buyers that are already familiar with and active in the VCM. Further, best practices from the VCM can inform the development of a standalone biodiversity credit market. Conservation and restoration sciences, which predate carbon markets, provide important lessons on durability, economic development, and local engagement—factors that are necessary for improving long-term outcomes and supporting market development. Projects with quantifiable dual outcomes for carbon and biodiversity that buyers can report against are tractable market outcomes. However, pursuing quantifiable dual outcomes could increase cost and complexity, potentially resulting in multiple market mechanisms (e.g., separate assets, blended or stacked assets, etc.), due to multiple management objectives.

13 JPMorgan Chase & Co. 2023. Carbon Market Principles: Our approach to strengthening the voluntary carbon market to scale decarbonization solutions. [accessed 2025 Jan 16]. https://www.jpmorganchase.com/content/dam/jpmc/jpmorgan-chase-and-co/documents/carbon-market-principles.pdf

Current market observations

Ongoing market growth for both nature-based carbon credits and credits with co-benefits, including biodiversity, reflect a strong buyer preference for dual carbon and biodiversity outcomes. In a 2023 survey of carbon credit buyers, respondents indicated a willingness to pay more for carbon credits with co-benefits.[14] Survey respondents also indicated that environmental co-benefits, particularly biodiversity, were most valued—a finding consistent with observed price premiums for credits with co-benefit certifications.[15] In 2023, the share of VCM transactions from projects with co-benefit certifications grew to 28%, up from 22% in 2022, fetching an average price premium of 37%.[16] Nature-based carbon reduction and removal projects that have potential for environmental and biodiversity co-benefits display a similar market trend. This is particularly true for afforestation, reforestation and revegetation (ARR), and improved forest management (IFM) projects. Between 2022 and 2023, prices for ARR and IFM credits rose 31% and 11%, respectively.[17]

When pursuing dual goals with VCM purchases, organizations should seek high-quality projects that deliver credible, rigorous, and impactful outcomes for both biodiversity and carbon. How biodiversity is measured affects how decisions are made. Careful design of MMRV and metric selection is fundamental to project quality, ensures overall impact, and supports informed decision-making, risk management, and reporting. Currently, very few VCM projects are designed to accommodate both biodiversity and carbon metrics.

Further, the VCM is not currently structured to optimize for both carbon and biodiversity. Carbon projects are set up to sequester carbon and/or avoid or reduce emissions. A VCM project, by definition, is not *required* nor expected to enhance biodiversity; it simply should not cause environmental harm. While projects can, and often do, offer co-benefits such as biodiversity protection, pollution prevention, and job creation, co-benefits are not required and are rarely measured. Focusing solely on carbon can sometimes lead to *negative* outcomes for

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14 Ponce de León Baridó P, Nielsen J, Porsborg-Smith A, Pineda J, Owolabi B, Gordon M. 2023 Sep 12. In the Voluntary Carbon Market, Buyers Will Pay for Quality. BCG Global. [accessed 2024 Dec 5]. https://www.bcg.com/publications/2023/why-vcm-buyers-will-pay-for-quality

15 Ponce de León Baridó P et al., In the Voluntary Carbon Market, Buyers Will Pay for Quality.

16 Procton A. 2024. State of the Voluntary Carbon Market 2024: On the Path to Maturity. Ecosystem Marketplace: A Forest Trends Initiative. [accessed 2024 Dec 5]. https://3298623.fs1.hubspotusercontent-na1.net/hubfs/3298623/SOVCM%202024/State_of_the_Voluntary_Carbon_Markets_20240529%201.pdf

17 Procton A, State of the Voluntary Carbon Market 2024.

biodiversity.[18,19,20] For example, projects might seek to establish forests in ecosystems that were not historically forested (i.e., afforestation). When the ecosystem does not naturally support forest cover, like native grasslands, and when the starting area is not severely degraded, projects may result in beneficial carbon outcomes but are unlikely to benefit biodiversity, regardless of the species planted.[21,22,23,24,25,26] As a result, buyers seeking to meet both biodiversity and carbon goals through VCM purchases should be cognizant of the tradeoffs that exist in the current market. Buyers also need selection criteria that extend beyond current registry protocol requirements.

Guide to this paper

This report provides guidance for what high-quality biodiversity or nature-positive target setting, reporting, and procurement could look like in the VCM. Drawing on scientific best practices, industry standards, policy, and a review of 1,639 existing nature-based carbon projects, we present a decision-making framework for selecting projects with rigorous and measurable biodiversity targets. Topics not considered in this paper are further discussed in **Appendix B**.

This VCM-level framework focuses on projects that have elements of carbon removal, rather than on projects in the VCM more broadly. While our survey of the VCM includes REDD+ projects,[27] which can include elements of carbon removal, our

18 Bekessy SA, Wintle BA. 2008. Using Carbon Investment to Grow the Biodiversity Bank. Conservation Biology. 22(3):510–513. doi:10.1111/j.1523-1739.2008.00943.x

19 Tedersoo L, Sepping J, Morgunov AS, Kiik M, Esop K, Rosenvald R, Hardwick K, Breman E, Purdon R, Groom B, et al. 2024. Towards a co-crediting system for carbon and biodiversity. PLANTS, PEOPLE, PLANET. 6(1):18–28. doi:10.1002/ppp3.10405

20 Jindal R, Swallow B, Kerr J. 2008. Forestry-based carbon sequestration projects in Africa: Potential benefits and challenges. Natural Resources Forum. 32(2):116–130. doi:10.1111/j.1477-8947.2008.00176.x

21 Di Sacco A, Hardwick KA, Blakesley D, Brancalion PHS, Breman E, Cecilio Rebola L, Chomba S, Dixon K, Elliott S, Ruyonga G, et al. 2021. Ten golden rules for reforestation to optimize carbon sequestration, biodiversity recovery and livelihood benefits. Global Change Biology. 27(7):1328–1348. doi:10.1111/gcb.15498

22 Hua F, Bruijnzeel LA, Meli P, Martin PA, Zhang J, Nakagawa S, Miao X, Wang W, McEvoy C, Peña-Arancibia JL, et al. 2022. The biodiversity and ecosystem service contributions and trade-offs of forest restoration approaches. Science. 376(6595):839–844. doi:10.1126/science.abl4649

23 Hua F, Wang X, Zheng X, Fisher B, Wang L, Zhu J, Tang Y, Yu DW, Wilcove DS. 2016. Opportunities for biodiversity gains under the world's largest reforestation programme. Nat Commun. 7(1):12717. doi:10.1038/ncomms12717

24 Lewis SL, Wheeler CE, Mitchard ETA, Koch A. 2019. Restoring natural forests is the best way to remove atmospheric carbon. Nature. 568(7750):25–28. doi:10.1038/d41586-019-01026-8

25 Veldman JW, Overbeck GE, Negreiros D, Mahy G, Le Stradic S, Fernandes GW, Durigan G, Buisson E, Putz FE, Bond WJ. 2015. Where Tree Planting and Forest Expansion are Bad for Biodiversity and Ecosystem Services. BioScience. 65(10):1011–1018. doi:10.1093/biosci/biv118

26 Céspedes-Payret C, Piñeiro G, Gutiérrez O, Panario D. 2012. Land use change in a temperate grassland soil: Afforestation effects on chemical properties and their ecological and mineralogical implications. Science of The Total Environment. 438:549–557. doi:10.1016/j.scitotenv.2012.08.075

27 United Nations Framework Convention on Climate Change. n.d. What is REDD+? [accessed 2025 Aug 26]. https://unfccc.int/topics/land-use/workstreams/redd/what-is-redd

analyses and recommendations are dedicated to projects that are fundamentally centered on carbon removal rather than on avoidance or reduction. These project types include ARR, agricultural soils, IFM, mangroves, and more. We observe the clearest market signal from buyers who explicitly prioritize dual biodiversity and carbon outcomes in the context of ARR and IFM projects. Consequently, the majority of our analyses and examples focus on these project types. We emphasize that the principles outlined in this paper apply broadly across project types, though the particulars of implementation and design will differ.[28]

Fundamentally, designing for both biodiversity and carbon outcomes requires tradeoffs, as optimal outcomes for each on VCM timelines may not always be possible.[29] This paper assumes that stakeholders recognize these tradeoffs and choose to prioritize biodiversity. While important, we do not provide a detailed analysis related to the nuance of when and where a given carbon project type might be more appropriate in the context of biodiversity prioritization, deferring this discussion to future analyses (e.g., monoculture versus mixed species IFM in temperate versus tropical contexts). At the same time, current carbon market structures do not consistently or directly reward biodiversity, which constrains the extent to which prioritizing biodiversity can be realized in practice.

While this paper focuses on carbon removal project types that include ecological restoration, we emphasize that organizations should continue to prioritize the carbon mitigation hierarchy (i.e., avoid, reduce, replace, remove or compensate, in that order). When done well, protection and conservation initiatives have strong carbon, biodiversity, and community outcomes and can protect against land conversion. Multiples studies show that for projects to have strong durability, local engagement and buy-in is key to ensuring long-term stewardship of the land. Determining how conservation and protection can be advanced in the context of voluntary markets (e.g., REDD+) remains an important goal. It can and should include clear stakeholder mapping with local engagement, support, consultation, and participation to facilitate opportunities and maximize equitable and durable outcomes.[30,31]

28 Carboncredits.com. 2024 May 23. Google, Meta, Microsoft, and Salesforce Launch "Symbiosis", Pledging for 20M Tons of Nature-Based CDR Credits. [accessed 2025 Aug 26]. https://carboncredits.com/google-meta-microsoft-and-salesforce-launch-symbiosis-pledging-for-20m-tons-of-nature-based-carbon-removal-credits/

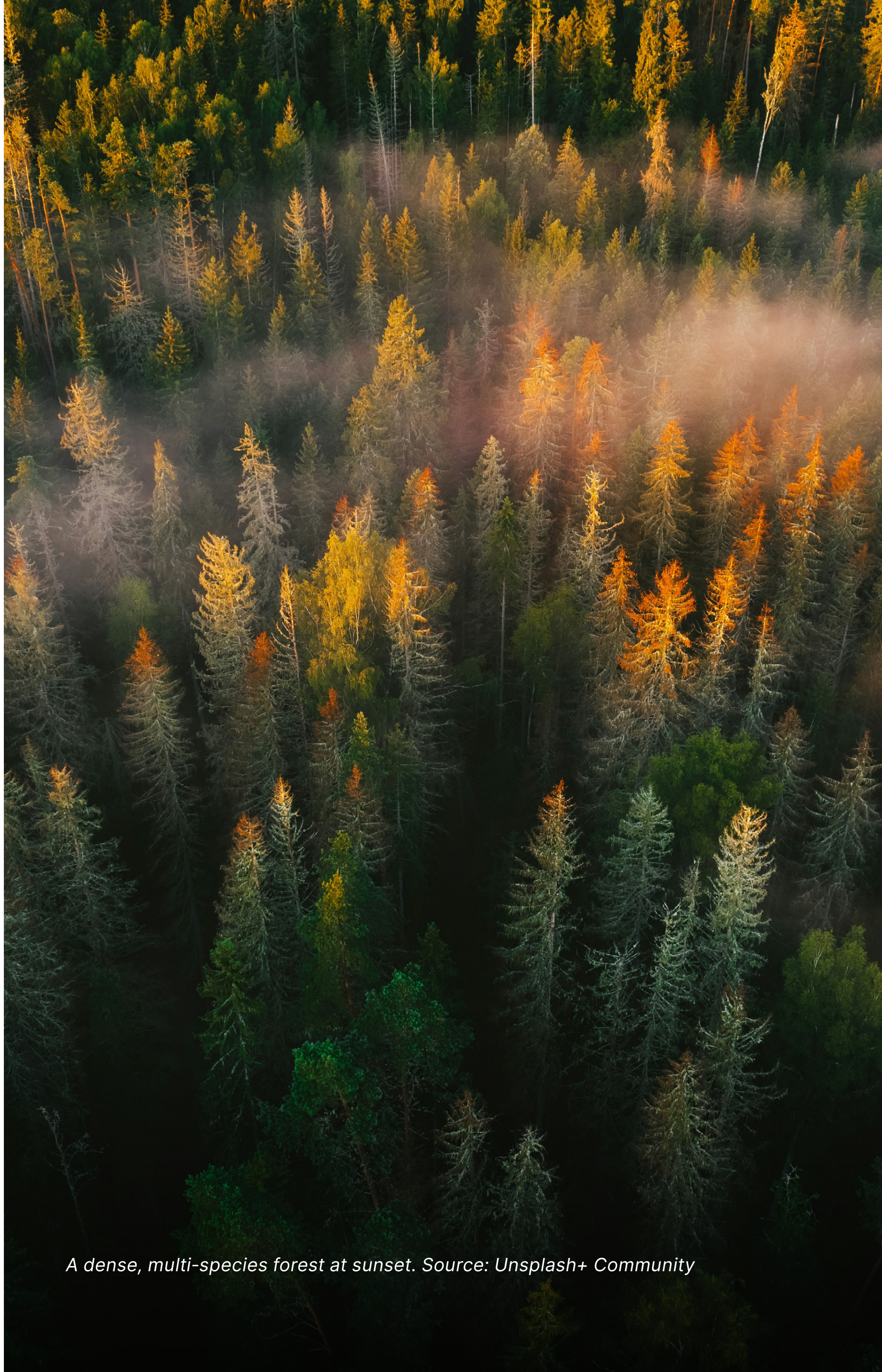
29 Strassburg BBN, Iribarrem A, Beyer HL, Cordeiro CL, Crouzeilles R, Jakovac CC, Braga Junqueira A, Lacerda E, Latawiec AE, Balmford A, et al. 2020. Global priority areas for ecosystem restoration. Nature. 586(7831):724–729. doi:10.1038/s41586-020-2784-9

30 Dawson NM et al. 2021. The role of Indigenous peoples and local communities in effective and equitable conservation. Ecology and Society 26(3): 19. https://doi.org/10.5751/ES-12625-260319

31 Erbaugh JT, Pradhan N, Adams J, Oldekop JA, Agrawal A, Brockington D, Pritchard R, and Chhatre A. 2020. Global forest restoration and the importance of prioritizing local communities. Nature Ecology and Evolution. https://doi.org/10.1038/s41559-020-01282-2.

Our paper does not consider the quality of the individual projects from a carbon perspective, nor does it provide recommendations on use cases for biodiversity project investment or guidance on deploying claims. Organizations like the International Advisory Panel on Biodiversity Credits (IAPB) have recently published guidance on these topics.[32] Importantly, this paper is focused on defining principles for buyers and developers to tactically prioritize project quality to support biodiversity claims. These principles are presented in the *Optimizing for both biodiversity and carbon in the VCM* section of this paper. This paper also does not address the validity of biodiversity credits as fungible units for nature-positive claims or mitigation. Ultimately, our objective with this paper and these principles is to start a conversation that encourages a positive feedback loop for both nature and climate.

32 International Advisory Panel on Biodiversity Credits. 2024. Framework for high integrity biodiversity credit markets. [accessed 2024 Dec 1]. https://www.iapbiocredits.org/framework



A dense, multi-species forest at sunset. Source: Unsplash+ Community

Fundamentals of biodiversity for nature-positive projects

SECTION OVERVIEW

- → Biodiversity has many dimensions. Understanding their interplay is necessary for effective management and monitoring.
- → Four key dimensions of biodiversity—taxonomic, phylogenetic, functional, and genetic—have important variations in their characteristics and temporal and spatial scales.
- → The dimension or dimensions that are most relevant to a given project will determine which measurement tools are best suited to monitor project outcomes.
- → Given the dynamic nature of biodiversity, it is important that outcomes are measured across geographic and temporal scales to ensure their durability.

Biodiversity is inherently complex and dynamic, which makes MMRV for biodiversity-oriented projects challenging. To overcome this, stakeholders should clearly understand project context and objectives and how they relate to key measurable dimensions of biodiversity.

Biodiversity is generally thought about in terms of four major dimensions: (1) taxonomic, (2) phylogenetic, (3) functional, and (4) genetic (**figure 2, Appendix C**).[33] Depending on the systems in question, the geography and scale of the project, and its desired outcomes, one or more of those dimensions might be most appropriate to focus on. That focus will determine which measurement tools are best suited to monitor project outcomes.

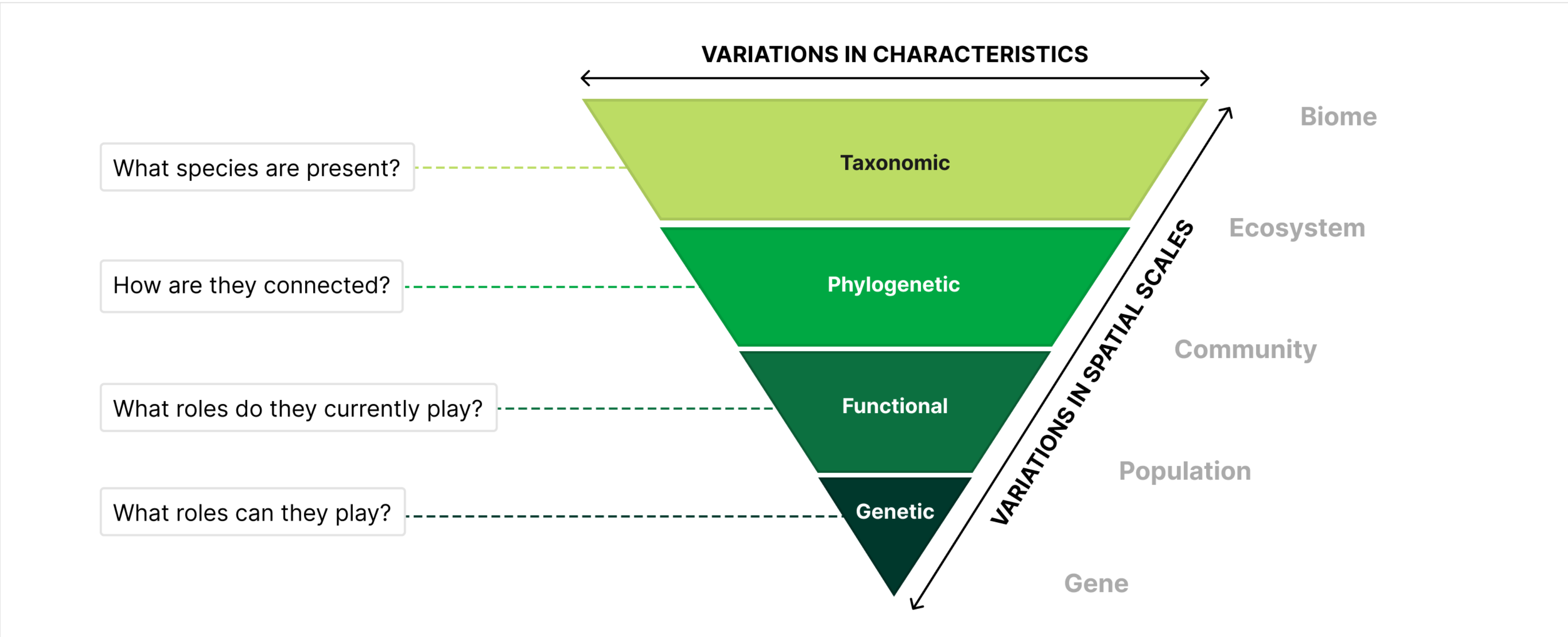


Figure 2. Dimensions of biodiversity. Source: Carbon Direct.

33 Sigwart, JD et al. 2018. Measuring Biodiversity and Extinction—Present and Past. Integrative and Comparative Biology, Volume 58, Issue 6. https://doi.org/10.1093/icb/icy113

More broadly, contextualizing measurement across spatial scales enables monitoring and assessment of whether the project is supporting outcomes that are meaningful through time.

Taxonomic diversity

Taxonomic diversity describes the number and relative abundance of species present within a given geography and is the most commonly used heuristic method for assessing biodiversity. Global species diversity is incredibly vast, making a complete assessment of any given site unrealistic. Generally, taxonomic surveys are performed for a specific set of organisms grouped by interest, such as birds or plants, or known "indicator organisms," which might act as proxies for overall ecosystem health.

> Biodiversity is not static. As such, it should be measured and monitored across geographic and temporal scales to ensure durable outcomes.

Phylogenetic diversity

Phylogenetic diversity is the measure of how evolutionarily connected or distinct taxa are from one another. Evolutionary relatedness can sometimes be predictive of how organisms function, an understanding of which can enable more targeted and predictive evaluations of diversity compared to taxonomic surveys.

Functional diversity

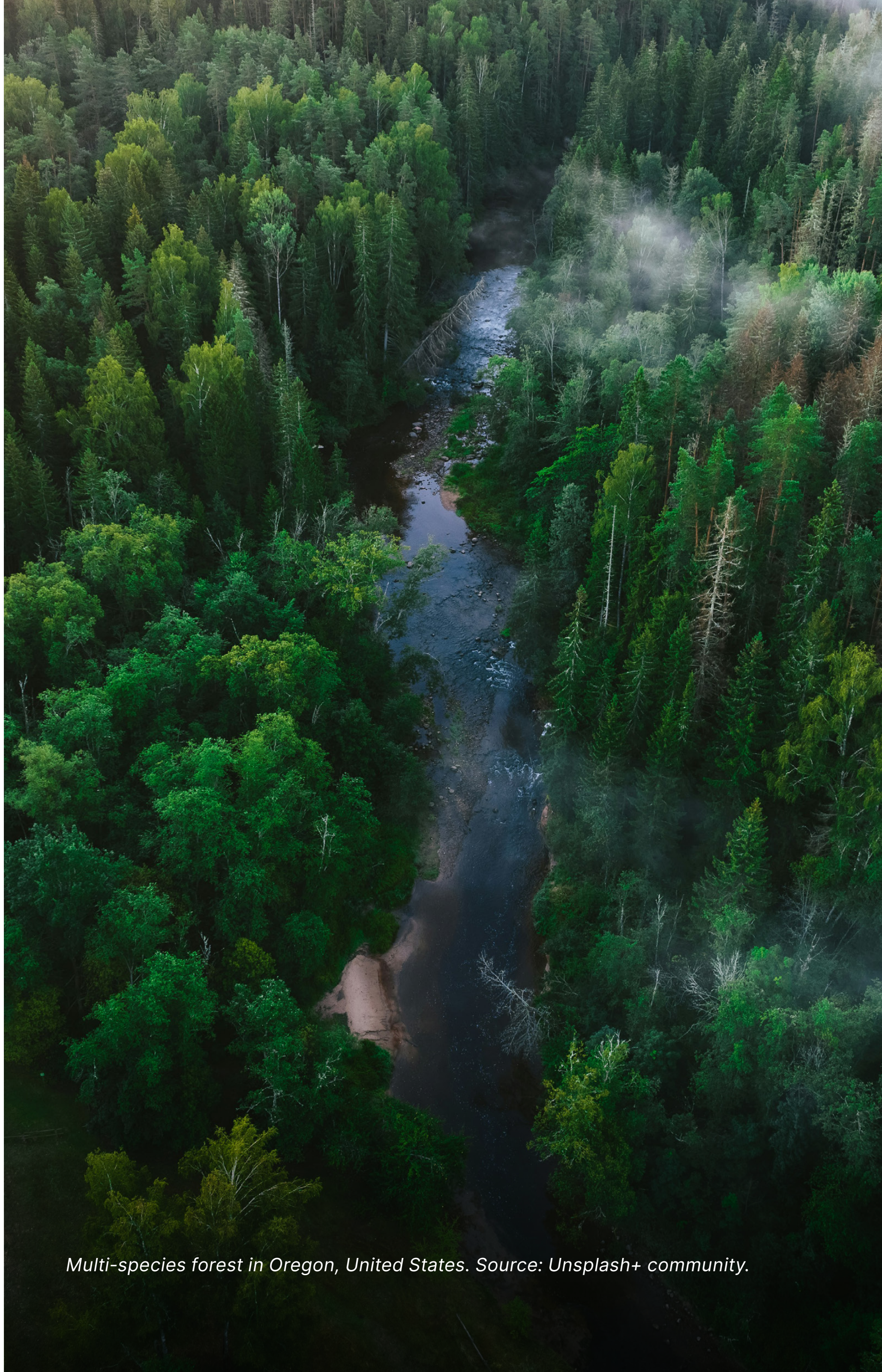
Functional diversity generally describes the range of roles that organisms play in ecosystems and communities. It also refers to the range of biological traits (e.g., morphological, physiological, behavioral) exhibited by organisms within an ecosystem. These traits influence how species interact with their environment and with each other, ultimately shaping ecosystem processes and services. Understanding the breadth and depth of functional diversity can tell us a great deal about ecosystem health.

Genetic diversity

Molecular or genetic diversity can be a helpful proxy for estimating resilience, or the ability of species and populations to persist through time, which is key to biodiversity protection. Robust conservation, management, and restoration plans require understanding what species are or could be present in a given region and how resilient those species are to perturbation. To assess resilience, scientists use proxies such as population size or abundance, habitat suitability, and molecular diversity. These proxies are discussed further in the next section. Populations that lack genetic diversity are generally less resilient to perturbations like pests, disease, environmental changes, and habitat disturbance.

The big picture

Evaluating biodiversity along any of these dimensions, together or alone, does not provide meaningful indicators unless the larger context is also considered. Biodiversity is not static. As such, it should be measured and monitored across geographic and temporal scales to ensure durable outcomes. This includes monitoring the scale, suitability, and structure of available habitat to support species and populations through time. This is especially important in a changing climate where ecosystems may be stressed or shift geographically. Academic and private-market actors are actively developing innovations that leverage artificial intelligence, modeling, and remote sensing. These advancements could also benefit or enhance MMRV throughout a project's lifespan.



Multi-species forest in Oregon, United States. Source: Unsplash+ community.

Opportunities for and barriers to driving biodiversity impact in carbon projects

SECTION OVERVIEW

- → To enable successful outcomes, stakeholders should acknowledge and reconcile key differences in the characteristics of carbon and biodiversity value propositions.
- → In certain types of nature-based projects, the timeframes to realize carbon and biodiversity outcomes may be misaligned.
- → Differences in how carbon and biodiversity outcomes are measured may present challenges in effectively integrating dual objectives in project design.

Considerations for prioritizing dual outcomes

Importantly, projects that prioritize both carbon and biodiversity may not optimize outcomes for each within project timelines or investment profiles. Even if outcomes are broadly aligned, the precedented incentive structure to optimize carbon in the VCM may lead developers to prioritize certain carbon-oriented design considerations at the expense of those related to biodiversity.

Plant species differ in the rates at which they sequester carbon. For example, a carbon-forward project might prioritize those species that sequester carbon rapidly, predictably, and within the project crediting period. By contrast, projects that incorporate a diversity of native species will, in many circumstances, have enhanced biodiversity outcomes and may eventually accumulate more carbon, but this accumulation will likely occur over a longer timespan than is relevant to most nature-based crediting periods. Similarly, projects that use a mosaic approach with diverse stands and ecological corridors alongside commercial plantations, depending on their design and overall objectives, can provide a range of benefits including connectivity, increased resilience, and enhanced carbon storage over time. Because native-species and mosaic approaches often have less predictable carbon curves and may generate fewer credits within project crediting periods, they can be less attractive to carbon-focused investors and developers compared to plantations with commercial species.

In addition, projects that mimic natural succession—with fast-growing species dominating the early years of the project and a more diverse selection of slower-growing species planted underneath—have the potential to provide rapid carbon accumulation initially while facilitating the transition to a more biodiverse state as the project matures. Some ARR and uneven-aged-stand IFM projects already have a precedent of mimicking natural succession and integrating Indigenous knowledge to support local communities while promoting biodiversity. Over time, species-rich forests and ecosystems generally store more carbon than less diverse environments due to more efficient and complementary use of resources. Ultimately, the appropriate intervention will depend on the geographic context and project priorities, but being aware of potential tradeoffs between carbon and biodiversity can facilitate informed decision making for market stakeholders.

Figure 3 illustrates carbon accumulation rates for three common tree genera used in carbon projects in the neotropics, overlaid on typical IFM and ARR carbon crediting periods (i.e., timeframes within which a project generates credits) and durability terms (i.e., the full length of the project, or the duration of stored carbon). Carbon accumulation rates and crediting periods are largely optimally aligned. Below the graph, we show ranges gathered from the literature for biodiversity outcomes during recovery of a mixed-species neotropical secondary forest to an old-growth forest state. The key takeaway is that successful carbon and biodiversity outcomes often have different time horizons. These timelines do not always align with VCM project crediting periods. This means that while a project might meet both carbon and nature-positive commitments, reporting against those outcomes may be decoupled.

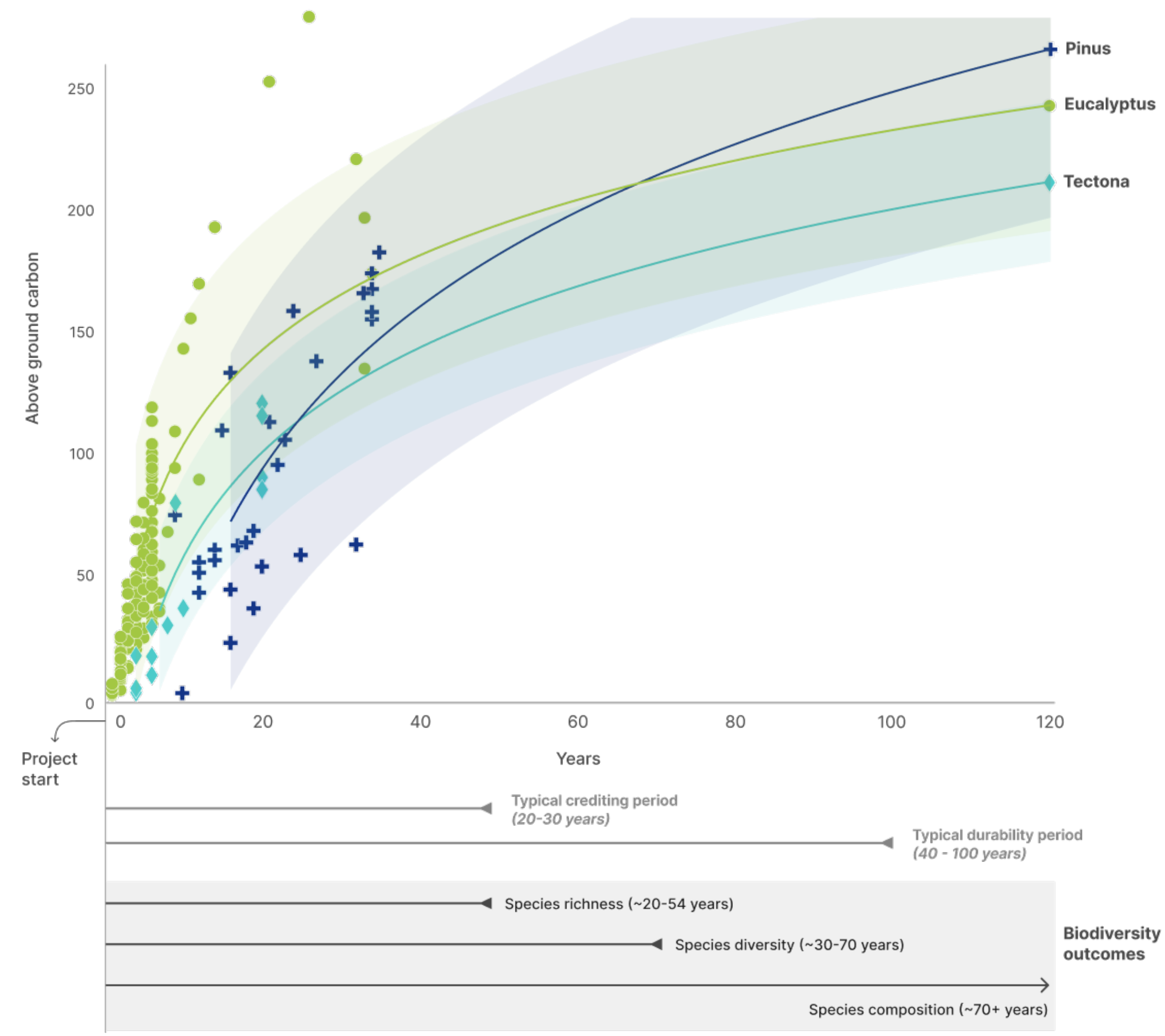


Figure 3. Comparison of timelines for forest carbon projects and biodiversity outcomes. Source: Carbon Direct.

Key differences in quantifying biodiversity and carbon

Ecosystems are dynamic. When measuring and monitoring biodiversity outcomes of recovery, the metrics of success will vary depending on the successional stage of the ecosystem and the state of recovery. Ecological successional dynamics reflect how ecosystems change over time (e.g., from degraded secondary forest to old-growth forest). In restoration, success metrics shift with stages—initially **species richness**, then diversity and ultimately stable, functional community composition. In the VCM, the crediting period and biodiversity outcomes that indicate success are not optimally aligned (**table 1**), which could lead developers to focus on single species or low-diversity, non-native plantings to optimize for carbon.

Table 1. Key characteristics of nature-based projects prioritizing carbon versus biodiversity

	Carbon	Biodiversity
Goal	Carbon sequestration and emissions reduction/avoidance	Biodiversity enhancement, conservation, restoration and uplift to support nature-positive outcomes
Unit(s) of measure	Single unit of measure: metric tonnes of carbon dioxide equivalent avoided, reduced, or removed (mtCO_2e)	Multiple units of measure, including abundance and richness of species, habitat extent and condition, and ecosystem integrity[34]
Unit(s) of exchange	Generally treated as semi-fungible	Outcomes are local and site specific; not considered fungible
Scale	Often cost effective and successful at scale	Highly site specific, can be expensive, and often most effective at small scales
Measurement, monitoring, reporting, verification (MMRV)	Various protocols and accounting methods exist, but there is broad convergence around monitoring requirements and methods	Established methods for monitoring and measuring biodiversity outcomes, with variations by location, project, and desired outcomes
Certification and verification	Myriad protocols and accounting methods for certifying and verifying carbon projects	Limited frameworks for certifying and verifying biodiversity as co-benefits; may be in the form of add-on certifications in existing carbon programs or jurisdiction and species-specific habitat banking

34 International Advisory Panel on Biodiversity Credits. 2024. Framework for high integrity biodiversity credit markets. [accessed 2024 Dec 1]. https://www.iapbiocredits.org/framework

Optimizing for both biodiversity and carbon in the VCM

SECTION OVERVIEW

- Although quality considerations for biodiversity projects and carbon projects are broadly aligned, effective integration involves carefully balancing aspects unique to each objective.
- We identify key challenges and opportunities for integration and offer practical guidance for balancing related considerations.
- In particular, we highlight six principles for pursuing high-quality biodiversity outcomes as part of carbon projects.

At a high level, quality considerations for biodiversity projects and carbon projects are similar. JPMorganChase and Carbon Direct have each published principles and criteria specifically for carbon, many of which also apply to biodiversity.[35,36] In summary, high-quality projects should:

- Be additional against a rigorous baseline;
- Avoid, minimize, and transparently account for both market and activity-shifting leakage;
- Employ robust and conservative MMRV;
- Engage with and account for local community priorities and Indigenous peoples following best practices;
- Ensure durable outcomes through time; and
- At a minimum, not cause harm to environments and ecosystems, and ideally result in uplift.

However, as highlighted in the previous section, optimizing for dual outcomes involves several unique considerations (**table 1, figure 3**). In this section, we further explore challenges and offer practical guidance for effective integration of biodiversity aims in carbon projects.

Considerations for biodiversity and carbon in project design

While climate, biodiversity, and nature are inextricably linked, carbon storage and sequestration are ecosystem services distinct from biodiversity uplift and protection. A standard nature-based project in the VCM that prioritizes carbon will not automatically prioritize biodiversity without additional safeguards and design considerations. Here we explore key differences in priorities and opportunities for reconciling project design and MMRV to meet both carbon and biodiversity objectives.

When prioritized together, outcomes for both carbon and biodiversity cannot always be maximized, and misaligned priorities for project design and implementation may exacerbate these differential outcomes.[37] Misaligned priorities generally arise from five key structural issues or challenges (**table 2**). Overcoming these requires clear articulation of project goals and value propositions from market actors including buyers, project developers, and registries. Opportunities for overcoming these structural challenges are linked to the principles for high-quality biodiversity projects outlined in **table 3**.

35 JPMorgan Chase & Co. 2023. Carbon Market Principles: Our approach to strengthening the voluntary carbon market to scale decarbonization solutions. [accessed 2025 Jan 16]. https://www.jpmorganchase.com/content/dam/jpmc/jpmorgan-chase-and-co/documents/carbon-market-principles.pdf

36 Carbon Direct and Microsoft. 2025. 2025 Criteria for High-Quality Carbon Dioxide Removal | Carbon Direct. [accessed 2025 Mar 3].https://www.carbon-direct.com/criteria/2025-edition

37 Strassburg BBN, Iribarrem A, Beyer HL, Cordeiro CL, Crouzeilles R, Jakovac CC, Braga Junqueira A, Lacerda E, Latawiec AE, Balmford A, et al. 2020. Global priority areas for ecosystem restoration. Nature. 586(7831):724–729. doi:10.1038/s41586-020-2784-9

Table 2. Challenges and opportunities for maximizing carbon and biodiversity in the VCM

Challenge	Description	Opportunity/ Solution
Inconsistency in terms and definitions, which means that developers have little direction in what to prioritize and buyers cannot consistently evaluate biodiversity outcomes.	Across standards, "biodiversity" is often inconsistently defined and used. In an assessment of nine commonly used nature-based carbon protocols, Carbon Direct finds that biodiversity is either not defined, or that protocols use different terms as proxies (e.g., ecosystem restoration, improvement of ecological conditions, etc.).[38] Moreover, most standards do not explicitly distinguish between the four major dimensions of biodiversity (taxonomic, phylogenetic, functional, and genetic).	Developers and buyers should prioritize projects that report measurable and verifiable outcomes that are durable through time (**Principle 6**). For this, projects should: (1) identify which dimension of biodiversity aligns with the project goals and context, (2) choose an appropriate monitoring metric, and (3) develop a repeatable sampling method to collect the required data for the metric through time. For example, an afforestation, reforestation or revegetation (ARR) project taking place in an area of conservation priority for birds may choose to focus on avian taxonomic diversity and could use Shannon's diversity index.[39]
Inconsistency in acceptable levels of impact, which means that developers may have unclear guidance on acceptable project outcomes.	Standards tend to have inconsistent definitions of acceptable levels of impact, ranging from "do no significant harm," all the way to "maximize recovery," often without clear definitions for either. For example, the program-wide requirements in the Verified Carbon Standard refer to no negative impacts on biodiversity and ecosystems,[40] whereas program-wide requirements in the Ecosystem Restoration Standard refer to ecosystem restoration and reference systems[41] without defining these terms.	At a minimum, recognizing that every action has a potential impact to the environment, it is important to ensure that projects should result in no net harm. However, projects aiming to deliver biodiversity uplift should strive to restore ecosystems relative to a reference ecosystem (**Principle 2**) and with appropriate metrics. For example, projects could strive to demonstrate a statistically significant increase in the appropriate biodiversity metric (e.g., Shannon's diversity index for taxonomic diversity) over time for species that are ecologically appropriate to the target reference ecosystem.

38 The nine protocols assessed include the American Carbon Registry (ACR)'s Improved Forest Management (IFM) on Non-Federal U.S. Forestlands, Climate Action Reserve (CAR)'s Mexico Forest Protocol (MFP), CAR's Soil Enrichment Protocol (SEP), Verra's Climate, Community, and Biodiversity (CCB) Standard, Ecosystem Restoration Standard's (ERS) Methodology for Terrestrial Forest Restoration (M001), Plan Vivo's Carbon Standard (PV Climate), and the Verified Carbon Standard (VCS) VM0042, VM0045, and VM0047 methodologies.

39 Shannon's diversity index (H') is calculated as $H' = -\Sigma (p_i * \ln(p_i))$ where p_i = proportion of individuals in species i and ln = natural logarithm. The index measures diversity of species in a location by accounting for number and proportion of species.

40 Verra. 2024. VCS Standard. [accessed 2025 Jan 13]. https://verra.org/wp-content/uploads/2024/04/VCS-Standard-v4.7-FINAL-4.15.24.pdf

41 Ecosystem Restoration Standard. 2024. Programme. [accessed 2025 Jan 13]. https://docs.ers.org/programme-v1.1.pdf

Challenge	Description	Opportunity/ Solution
Monitoring biodiversity outcomes is not a standard VCM requirement, which means that buyers cannot reliably track and report on outcomes.	Existing carbon protocols are not currently set up to rigorously monitor biodiversity and restoration outcomes, either because guidance on how to implement monitoring is limited, or because most protocols do not require the use of appropriate reference ecosystems against which to monitor outcomes.[42] Currently, only one protocol, the Ecosystem Restoration Standard, requires a reference ecosystem to track and monitor ecosystem outcomes associated with ARR activities (**table 4**). In general, biodiversity certifications such as the Climate, Community, and Biodiversity (CCB) Standard only require that projects demonstrate that net impacts on biodiversity are positive as compared to the biodiversity conditions *under a use scenario without the project*.	Developers should monitor biodiversity outcomes against a reference ecosystem following established best practices for defining a reference (**Principle 2**). Alternatively, buyers could pay a premium or pay directly for biodiversity monitoring. This should be selected based on similar matching criteria used to match control plots to project plots for dynamic carbon accumulation baselines. For example, an ideal biodiversity reference area should be in the same ecoregion and jurisdiction and under the same land use (at project initiation). The reference ecosystem should also inform the specific metrics monitored.
Most carbon standards do not consider resilience and adaptive capacity, which means that developers have little incentive or guidance to ensure that biodiversity uplift interventions are durable to projected future climate and disturbance regimes.	Only one protocol, the Ecosystem Restoration Standard's M001, explicitly requires projects to take an adaptive management approach (e.g., updating the project's ecological recovery objectives and interventions every four years based on an updated assessment of the project). Similarly, the Ecosystem Restoration Standard is the only protocol that directly encourages projects to account for climate change and its future effects with respect to species selection,[43] while other protocols mention resilience in the context of potential project activities (e.g., supporting climate adaptation).	Developers should update and adapt biodiversity uplift approaches at regular intervals (e.g., every 5–10 years) based on ongoing monitoring and assessment of ecosystem indicators/metrics (**Principle 4**). Buyers can encourage or support projects that are well positioned to have durable biodiversity impacts by supporting projects that have done species-specific analyses of future changes in habitat suitability, consider topographic climate refugia, and have built adaptive management and flexibility into their project approach, while recognizing or acknowledging that this activity is non-trivial.

42 Aide TM. 2024. The Biodiversity Credit Market needs rigorous baseline, monitoring, and validation practices. npj Biodiversity. 3(1):1–4. doi:10.1038/s44185-024-00062-6

43 The Climate Action Reserve Mexico Forest Protocol does allow for the use of native species "outside of their historic range [...] if the use is intended as an adaptation strategy against climate change," but does not directly require or encourage projects to select species based on projected future climate and disturbance regimes.

Challenge	Description	Opportunity/ Solution
Crediting timelines are misaligned with biodiversity and ecological recovery timelines in ARR and IFM projects, which means that developers are incentivized to prioritize carbon and disincentivized to prioritize longer-term biodiversity recovery.	Biodiversity and forest recovery tends to occur over longer timescales and at slower rates than carbon accumulation rates. Depending on the metric, biodiversity and forest recovery tends to occur over decades and, in some cases, centuries, far exceeding the average crediting timespan of a carbon project.[44,45] Most nature-based projects on the voluntary carbon market as of 2025 have a crediting period of less than or up to 40 years.[46] In some instances, this may create an incentive to prioritize species or planting approaches that accumulate carbon faster within this predefined time frame or, conversely, disincentivize prioritizing biodiversity outcomes that occur over longer time scales.	Buyers should support projects with clear plans for long-term durability and where the initial planting design supports a successional trajectory that maximizes long-term biodiversity outcomes (**Principle 6**). For example, an ARR project that includes a mix of early and late successional species will be on a successional trajectory with more durable biodiversity uplift than a project that only plants early successional trees without plans to help transition the forest to an older growth composition.

44 Poorter L, Craven D, Jakovac CC, van der Sande MT, Amissah L, Bongers F, Chazdon RL, Farrior CE, Kambach S, Meave JA, et al. 2021. Multidimensional tropical forest recovery. Science. 374(6573):1370–1376. doi:10.1126/science.abh3629

45 Rozendaal DMA, Bongers F, Aide TM, Alvarez-Dávila E, Ascarrunz N, Balvanera P, Becknell JM, Bentos TV, Brancalion PHS, Cabral GAL, et al. 2019. Biodiversity recovery of Neotropical secondary forests. Sci Adv. 5(3):eaau3114. doi:10.1126/sciadv.aau3114

46 Carbon credit issuances (and therefore carbon revenues and project incentives) only occur during the project crediting period. While some programs require monitoring for reversals for up to 100 years after the first credit issuance, the crediting period is a better proxy for project durability.

Principles for prioritizing biodiversity in the VCM

Organizations seeking to optimize for biodiversity outcomes in carbon projects should consider the following principles and their tradeoffs related to project design and implementation (**table 3**). These principles and their tradeoffs are based on well-established best practices from the literature, recommendations from conservation and restoration practitioners,[47] and from expert knowledge of the evolution of the VCM. Existing VCM projects that we reviewed do not meet all six of the principles listed below—not for lack of ambition or care, but due to the current alignment of the VCM toward carbon-centered outcomes. Projects taking a dual outcome approach may be more challenging to implement and finance but are likely to also result in positive carbon outcomes, whereas those with a carbon-first approach may not result in optimal biodiversity outcomes.[48]

> To concurrently prioritize carbon and biodiversity, projects should take similar design and MMRV approaches to existing carbon standards while also incorporating the biodiversity guidelines above. More generally, projects should consider optimizing for biodiversity outcomes first.

47 Di Sacco A, Hardwick KA, Blakesley D, Brancalion PHS, Breman E, Cecilio Rebola L, Chomba S, Dixon K, Elliott S, Ruyonga G, et al. 2021. Ten golden rules for reforestation to optimize carbon sequestration, biodiversity recovery and livelihood benefits. Global Change Biology. 27(7):1328–1348. doi:10.1111/gcb.15498

48 Lewis SL, Wheeler CE, Mitchard ETA, Koch A. 2019. Restoring natural forests is the best way to remove atmospheric carbon. Nature. 568(7750):25–28. doi:10.1038/d41586-019-01026-8

Table 3. Principles for prioritizing high-quality biodiversity projects in the VCM

Principle	Implementation	Limitations and considerations
1 **Maximize available and suitable habitat** with low fragmentation and high connectivity.	Buyers could prioritize projects that actively seek to create biological corridors that connect habitat patches.	Less fragmented projects are more vulnerable to landscape-scale disturbances such as pathogens and fires than projects with many geographically dispersed parcels.
2 **Identify a clear reference ecosystem** to site and design appropriately.	For example, a tropical forest may have low densities of tree species but high diversities in a given area, while the opposite may be true of a temperate forest. Project design should understand this ecological context by incorporating a reference ecosystem into project design.	For example, due to climate change, pollution and human influence on nature, reference ecosystems should be carefully selected.
3 **Plant and manage native species** and use assisted natural generation as appropriate.	Buyers could prioritize projects where developers consult restoration ecologists and clearly document native species selection in the context of project type, location, and expected future climate and disturbance regimes. Assisted natural regeneration is not always appropriate for a project area but should be incorporated when possible.	Non-commercial native species, especially their growth rates, are not as well characterized as commercial alternatives. Native species growth rates and carbon accumulation rates may be slower and less predictable, making outcomes more difficult to predict and measure, and requiring shifts in management activities and flexible definitions of success.
4 **Embed resiliency through adaptive management and planning** for pollution, climate change, and other stressors.	Buyers could support projects that have explicit plans to use species that are resilient to climate change and future disturbance regimes and to use climate resilience strategies, such as assisted migration, wherein genetic resources (seed, seedlings, etc.) are moved from one bioclimatic zone to another in anticipation of projected climate conditions. Buyers could also support projects with explicit plans to develop nurseries and/or expand native seed supply in the project region.	Infrastructure and supply chain robustness present a systemic risk to broadscale project development and success. It is important to actively support the development of sustainable, equitable infrastructure underpinning these projects, such as seed supply chains, nursery operations, and the propagation protocols required to meet the growing demand for these resources.

Principle	Implementation	Limitations and considerations
5 **Balance integrating local livelihood considerations alongside biodiversity** and generate economic benefits for local communities to ensure long-term project success.	Buyers could prioritize projects that incorporate the project's longer-term economic sustainability and benefits for local communities beyond the sale of carbon credits and/or after the life of the carbon project (e.g., forest products, income from watershed or cultural services, ecotourism, etc.).	Farmers/landowners may prefer to plant (non-native) species that deliver higher economic value or more useful products but that do not promote biodiversity as well as some native species.
6 **Report measurable and verifiable outcomes** that are durable through time.	Buyers could prioritize projects that explicitly define target project outcomes and a clear monitoring and reporting framework, this should include acknowledgement of and accounting for potential perturbations with clear mitigation plans.	Projects with high restoration, recovery, or biodiversity potential or that are sited in high-priority areas (e.g., highly degraded areas) may be located in areas with a higher reversal risk and be unable to avoid the risk of natural disturbance through site selection. They may also be more expensive to develop. Dimensions of equity and resource imbalance in design could be components of this tradeoff as well.

Readiness of the VCM to support biodiversity commitments

SECTION OVERVIEW

→ Exploring the current state of integration of biodiversity considerations in the context of the VCM offers insights into how dual-objective projects may be better enabled in the future.

→ We evaluate alignment of existing registry protocols for nature-based carbon projects with the principles outlined in this paper, highlighting the opportunity for them to provide structural guidance to market participants interested in both biodiversity and carbon outcomes.

→ We summarize findings of a survey of 1,639 nature-based carbon removal projects currently registered in the VCM, exploring how key principles for prioritizing biodiversity are represented in existing projects.

Nature-based carbon projects in the VCM are first and foremost designed to promote carbon reduction or removal. A defining high-quality criterion for a carbon project is that it should, at a minimum, prevent net harms to ecosystems and biodiversity. However, current criteria do not *require* projects to enhance or uplift biodiversity. When implemented with biodiversity in mind, carbon projects can enhance ecosystem services as well as their underlying ecological and environmental processes and functions, including flood and erosion control, maintenance of genetic and functional diversity, water filtration, and soil health.

We believe there is significant potential to leverage the VCM to scale investment in and support biodiversity as well as carbon. In this section, we undertake a detailed exploration of the current state and opportunities for integration of biodiversity and carbon objectives in the VCM.

Biodiversity-related principles in existing protocols for natural climate solutions

Existing registry protocols are designed to optimize for carbon, not biodiversity. However, some protocols for nature-based carbon projects do include relevant criteria. To explore the potential for further integration of biodiversity and carbon outcomes in the VCM, it is therefore useful to understand how well such protocols currently align with the principles outlined in this paper (**table 3**).

Table 4 provides a non-exhaustive summary of criteria for biodiversity represented in the following existing protocols for nature-based carbon projects:

- American Carbon Registry's (ACR) Improved Forest Management (IFM) on Non-Federal U.S. Forestlands
- Climate Action Reserve's (CAR) Mexico Forest Protocol (MFP)
- CAR's Soil Enrichment Protocol (SEP)
- Verra's Climate, Community, and Biodiversity (CCB) Standard[49]
- Ecosystem Restoration Standard's (ERS) Methodology for Terrestrial Forest Restoration (M001)
- Plan Vivo's Carbon Standard (PV Climate)
- Verified Carbon Standard's (VCS) VM0042, VM0045 and VM0047 methodologies

49 The CCB Standard can be used in conjunction with any agriculture, forestry, and land-use (AFOLU) projects under the VCS.

Table 4. Comparison of biodiversity-related criteria in existing carbon protocols[50] for natural climate solutions

	1. Encourages or requires projects to maximize available and suitable habitat with low fragmentation and high connectivity	2. Mentions reference ecosystems (e.g., as part of site selection or for monitoring)	3. Requires or encourages planting or managing for native species or the use of assisted natural regeneration	4. Encourages resiliency and/or adaptive management	5. Encourages projects to maximize local livelihoods and generate economic benefits for local communities	6. Requires projects to report on measurable and verifiable biodiversity outcomes
ACR IFM	No	No	Yes	No	Indirectly[51]	No[52]
CAR MFP	No	No	Yes	Indirectly[53]	Yes	Yes[54]
CAR SEP	No[55]	No	No	Indirectly[56]	Yes	Indirectly[57]
Verra CCB[58]	Indirectly[59]	No	Yes	Indirectly[60]	Yes	Yes
ERS M001	Yes	Yes	Yes	Yes	Yes	Yes

Criteria mentioned and defined — Criteria mentioned but not defined (or indirectly mentioned in another context) — Criteria not mentioned

50 Carbon Direct assessed the most up-to-date version of each protocol (as of publish date of this paper).

51 ACR requires that grievance redress mechanisms are in place, that affected communities will share in the project benefits, and that projects mitigate and monitor potential *negative* social impacts.

52 ACR projects must report on *negative* environmental impacts only.

53 Resiliency and adaptive management is mentioned in the context of species selection (e.g., the use of native species outside of their historic range is permitted if the use is intended as an adaptation strategy against climate change).

54 CAR MFP projects must monitor compliance with environmental safeguards more broadly, and monitor progress toward the protocol's native species requirement, the compositional diversity of native species in the activity area and maintenance of natural land cover.

55 CAR SEP does not allow for clearing/conversion of native ecosystems.

56 CAR SEP discusses continuous and adaptive practice change as part of farming approaches that intend to restore soil health over time.

57 CAR SEP encourages projects to report on environmental co-benefits more broadly.

58 The CCB Standard can be used in conjunction with any agriculture, forestry and land-use (AFOLU) projects under the VCS.

59 CCB includes this as an example of optional criteria for implementing strategies to help communities and biodiversity adapt to climate change. It is also included as a potential variable that can be monitored as part of a biodiversity impact monitoring plan.

60 Resiliency and adaptive management is mentioned in the context of strategies to support climate adaptation of local communities.

	1. Encourages or requires projects to maximize available and suitable habitat with low fragmentation and high connectivity	2. Mentions reference ecosystems (e.g., as part of site selection or for monitoring)	3. Requires or encourages planting or managing for native species or the use of assisted natural regeneration	4. Encourages resiliency and/ or adaptive management	5. Encourages projects to maximize local livelihoods and generate economic benefits for local communities	6. Requires projects to report on measurable and verifiable biodiversity outcomes
PV Climate	Indirectly[61]	No	Yes	Yes[62]	Yes	Yes
VCS VM0042	No[63]	No	No	Yes[64]	Indirectly[65]	No
VCS VM0045	Indirectly[66]	No	Indirectly[67]	Yes[68]	Indirectly[69]	No[70]
VCS VM0047	Indirectly[71]	No	No[72]	Yes[73]	Indirectly[74]	No[75]

Criteria mentioned and defined | Criteria mentioned but not defined (or indirectly mentioned in another context) | Criteria not mentioned

61 Fragmentation is included as a potential negative impact that must be assessed, mitigated, and monitored. Increasing connectivity is included as a potential project benefit.

62 Plan Vivo requires projects to update its ecosystem baseline every 10 years. Environmental and social risk mitigation measures should also follow an adaptive approach "that is responsive to changing conditions illustrated by monitoring results."

63 VM0042 does not allow for clearing/conversion of native ecosystems. VCS projects must demonstrate that they will not negatively impact areas needed for habitat connectivity (VCS program requirements for all project types.

64 Required under the AFOLU Non-Permanence Risk Tool.

65 Net-positive social impacts are required through CCB certification. The VCS AFOLU Non-Permanence Risk Tool requires any AFOLU project to assess its net impact on the social and economic well-being of the communities that derive livelihoods from the project area, if baseline activities were subsistence driven.

66 VCS projects must demonstrate that they will not *negatively* impact areas needed for habitat connectivity (VCS program requirements for all project types).

67 Natural regeneration is included as a potential project activity, and the use of native species is required for projects that seek CCB certification.

68 Required under the AFOLU Non-Permanence Risk Tool.

69 Net-positive social impacts are required through CCB certification. The VCS AFOLU Non-Permanence Risk Tool requires any AFOLU project to assess its net impact on the social and economic well-being of the communities that derive livelihoods from the project area if baseline activities were subsistence driven.

70 VCS projects must report on *negative* environmental impacts only.

71 VCS projects must demonstrate that they will not *negatively* impact areas needed for habitat connectivity (VCS program requirements for all project types).

72 VCS does not fully exclude or prohibit the use of non-native/exotic species, but the use of native species is required for projects that seek CCB certification.

73 Required under the AFOLU Non-Permanence Risk Tool.

74 Net-positive social impacts are required through CCB certification. The VCS AFOLU Non-Permanence Risk Tool requires any AFOLU project to assess its net impact on the social and economic well-being of the communities that derive livelihoods from the project area if baseline activities were subsistence driven.

75 VCS projects must report on *negative* environmental impacts only.

Moving forward, registry protocols could provide structural guidance on how to ensure that the six principles outlined in this paper are represented in the design of projects seeking to prioritize both carbon and biodiversity outcomes.

Readiness of current projects to support biodiversity commitments and targets

To explore how the six principles in **table 3** show up in carbon projects today, understanding that biodiversity is not a core target for many existing projects, Carbon Direct evaluated landscape-scale metrics that are predictive of biodiversity outcomes for 1,639 nature-based carbon removal projects across the four major registries—ACR, CAR, Gold Standard, and VCS. We collected geographic data for all 1,639 projects, 951 of which contained project boundary data.[76] All 951 of these projects came from the ACR, CAR, and VCS registries—none were available from Gold Standard. Screening of these projects showed 807 (84.9%) had valid data suitable for further analysis, while the other 144 (15.1%) had unresolvable issues and were not included. Unresolvable issues included the lack of a coordinate reference system (6 projects), absence of polygons in the file (114 projects), no valid data source (1 project) and other issues (23 projects).

Figure 4 summarizes attributes of the 1,639 projects reviewed, which spanned six continents and 74 countries. Projects are unevenly distributed across the globe, and project density does not necessarily correspond to the location of biodiversity hotspots, which are sometimes used as proxies for prioritizing interventions (a). There are: 15 biomes with the top 10 listed below (d), and a variety of project types (b) with the largest proportion of projects categorized as IFM (814 projects, 48%), agricultural land management (ALM) (434 projects, 26%), and ARR (304 projects, 18%). Manual validation of 43 ARR projects revealed that monocultures made up 24% of ARR projects, while projects vary in both number of species planted and proportion of native and non-native plantings (c).[77]

76 We collected centroid data for all 1,639 projects and boundary data for 951 (58%).

77 Spatial analysis of projects' centroids found that 65% (n=1097) occur in priority areas for conservation, defined by biodiversity "hotspots" (i.e., areas with high species richness).

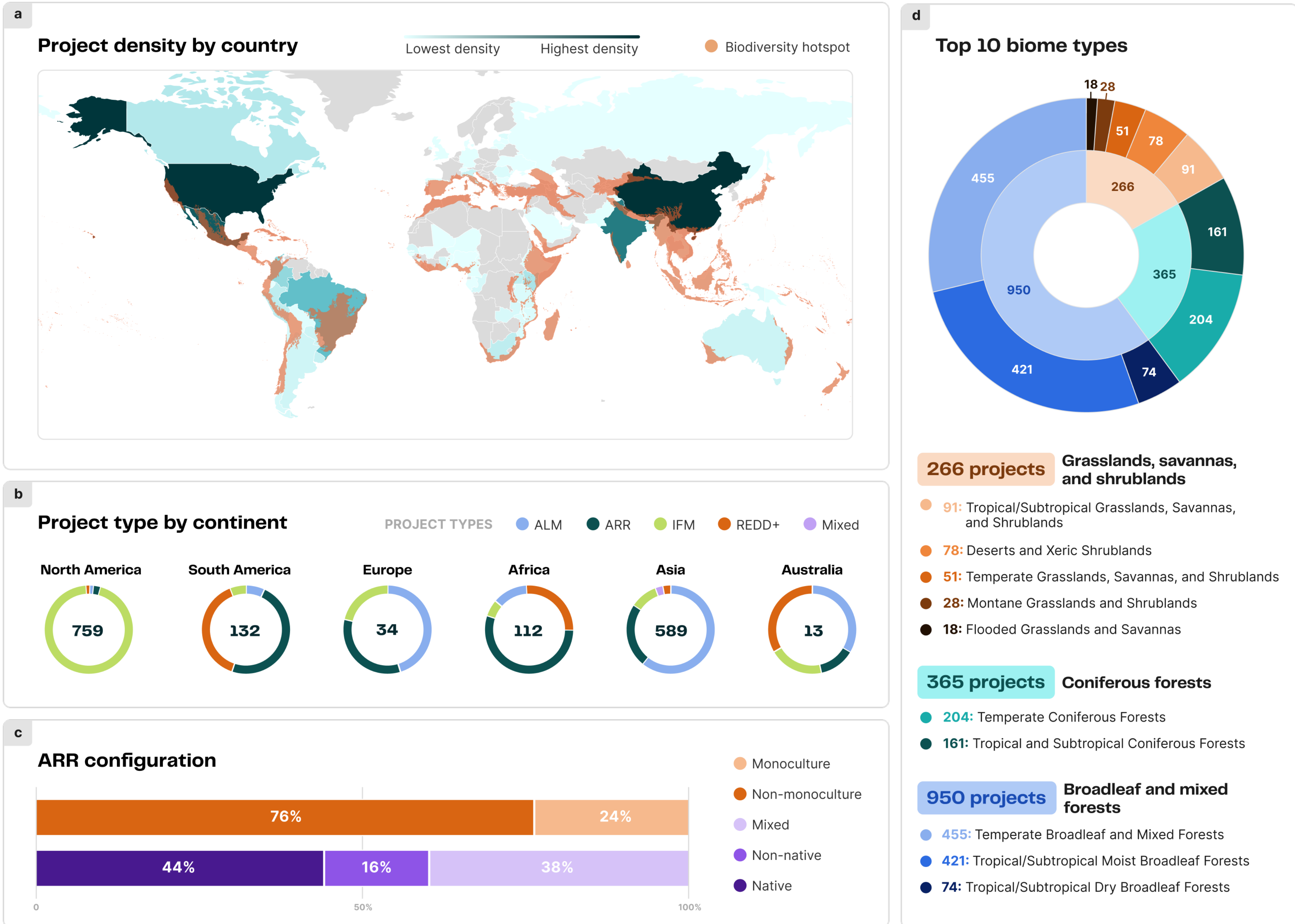


Figure 4. Summary of attributes for 1,639 nature-based carbon projects reviewed. Source: Carbon Direct.

Carbon Direct assessed the readiness of projects to support biodiversity from a habitat availability and suitability perspective, defined by whether the projects are supporting native species, preventing levels of fragmentation, and encouraging spatial connectivity. Our analysis focused on ARR and IFM, excluding agricultural land management and avoided deforestation projects. Using a large language model, we extracted species names and classified them into mixed versus monoculture and native versus non-native groups based on project location.[78] This analysis covered 313 ARR and 997 IFM projects. Manual validation from 83 projects revealed that the average number of native and non-native species planted or managed was eight (SD=19) and two (SD=8), respectively.[79]

While it is encouraging to see native species management across the VCM, the diversity of plantings is not necessarily representative of a target reference ecosystem in areas with high species richness but may be appropriate for temperate managed forests such as those found in North America (**Principles 2 and 3, table 3**). The appropriateness and diversity of species plantings should be evaluated in the context of a project area. Similarly, monocultures, which are not representative of natural ecosystems, made up 24% of manually validated projects, with eucalypt (*Eucalyptus* spp.), pine (*Pinus* spp.) and acacia (*Acacia* spp.) genera being dominant (**Principles 2 and 3, table 3**). While metrics of levels of fragmentation vary, our analysis of over 1,600 carbon projects in the VCM indicates that projects are, by-in-large, highly fragmented and present few opportunities to connect to intact habitat or protected areas (**figure 5**, and contrary to **Principle 1, table 3**).

These findings suggest that ARR and IFM nature-based carbon projects in the VCM were likely not designed with the dual objectives of carbon and biodiversity in mind. Therefore, these projects are currently not well aligned with the majority of the principles for high-quality biodiversity projects (**table 3**). Highly fragmented projects that do little to enhance landscape-level connectivity are unlikely to support durable biodiversity outcomes. Nature-based projects are in a unique position to increase landscape-level connectivity and reduce extinction risk, both of which are expected to compound as species ranges shift with climate change.[80]

78 *The gemini-1.5-flash* large language model was used to extract species names from project documentation. Documents including project descriptions, verification reports, and validation reports were web-scraped. Text from documents were extracted using LangChain's PyPDFLoader and concatenated by project. The large language model prompt used was "extract the names of plant species planted or managed." Manual validation of 83 projects revealed an overall species extraction accuracy of 76%. Classification of species into native versus non-native categories was applied to projects at a national-level.

79 SD = standard deviation.

80 Newmark WD, Jenkins CN, Pimm SL, McNeally PB, Halley JM. 2017. Targeted habitat restoration can reduce extinction rates in fragmented forests. Proceedings of the National Academy of Sciences. 114(36):9635–9640. doi:10.1073/pnas.1705834114

Highly fragmented landscapes—and projects sited within them—are strong indicators of poor biodiversity outcomes through time. Land use change due to human activities drives accelerating levels of habitat fragmentation resulting in population decreases and species losses. There is strong evidence to support that sufficiently large, well-placed, and well-managed protected areas can provide *spatial* connectivity (i.e., the physical structure of a landscape and how it facilitates or hinders movement) among habitat patches. However, functional connectivity (i.e., the actual movement of organisms and flow of ecological processes) among protected areas is key for effective conservation and management of biodiversity.[81,82] We note that while connectivity is key to project design, this alone is not a sufficient measurement of project success or guarantee of outcomes due to a risk of "empty habitat" outcomes where structural or process-based improvements occur without corresponding biodiversity gains.

Figure 5 illustrates that landscape configuration determines biodiversity intervention success through time. The probability of biodiversity persistence is directly related to the size and connectivity of habitat patches in a given landscape (a). Snapshots of three illustrative projects are highlighted as examples of the spectrum of fragmentation that can exist on the landscape in the context of the VCM, with low fragmentation indicating more support for biodiversity outcomes (b).

Future opportunities exist to plan and manage nature-based carbon projects that directly benefit and support landscape-level biodiversity. In particular, our analysis highlights the importance of incorporating ecosystem function as well as land tenure and ownership into landscape-level approaches to carbon project implementation. Moving forward, a holistic understanding of the greatest threats to connectivity will be critical for effective project design and planning to achieve biodiversity goals.

81 Hilty J et al. 2020. Guidelines for conserving connectivity through ecological networks and corridors. IUCN. [accessed 2024 Dec 5]. https://portals.iucn.org/library/node/49061. https://doi.org/10.2305/IUCN.CH.2020.PAG.30.en

82 Hilty J, Keeley A, Lidicker Jr. WZ, Merenlender AM. 2018. Corridor Ecology, Second Edition. Island Press. [accessed 2024 Dec 5]. https://islandpress.org/books/corridor-ecology-second-edition

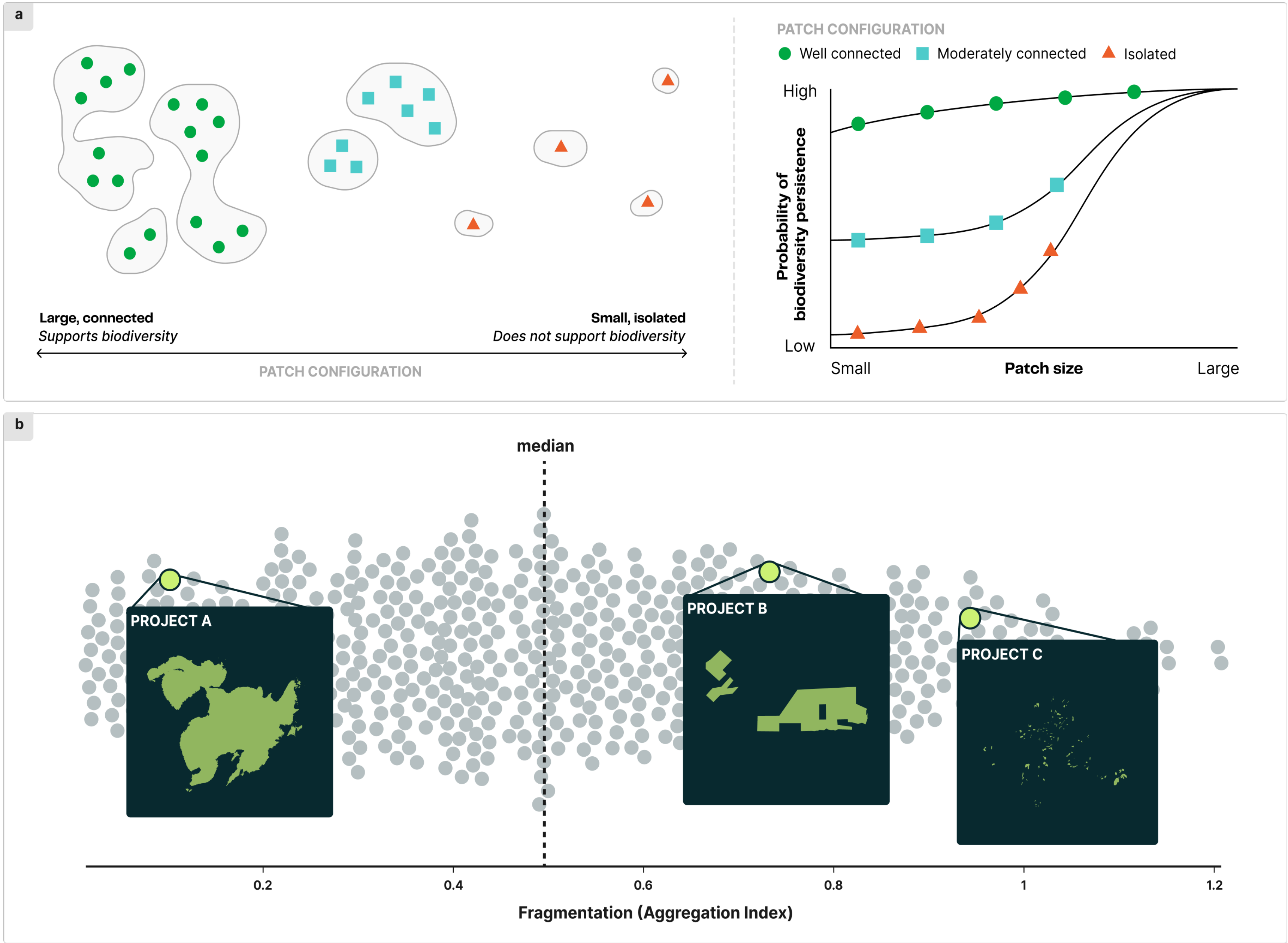


Figure 5. Importance of landscape configuration in success of biodiversity interventions through time. Source: Carbon Direct.

MMRV considerations for biodiversity

SECTION OVERVIEW

- → Transparent and rigorous MMRV is critical to understanding dual carbon and biodiversity outcomes, and for enabling reporting. Organizations cannot report against what is not measured.
- → We discuss how appropriate metric selection and MMRV design can enable scaled reporting across project portfolios, followed by key considerations for effective MMRV design at the individual project level.
- → In addition, we offer guidance for metric selection and MMRV design with a view to balancing ecosystem complexity and feasibility.

Careful MMRV design and metric selection is key to informed decision-making, risk management, and reporting. Because biodiversity is multifaceted, MMRV design remains an ongoing challenge where transparency is key. Projects should clearly identify those aspects of biodiversity that support nature-positive commitments and that are reported as project outcomes.

Reporting outcomes across portfolios

Disclosure, whether voluntary or driven by emerging regulations in some jurisdictions, may enable more informed decision-making on biodiversity-related risks and opportunities. However, reporting across multiple projects can be complicated, as biodiversity-oriented projects are rooted in local and regional contexts, leading to specific and diverse target outcomes that are not fungible across ecoregions and cultural contexts. This makes metric selection and careful MMRV design at both the project and portfolio level paramount.[83,84]

Buyers seeking to aggregate outcomes at the portfolio level should consider strategies for reporting across diverse projects, such as total numbers of hectares restored or protected. They should be aware that biodiversity gains are not interchangeable (i.e., fungible) when selecting priority geographies and ecosystems for investment. In this context, more focus on specific project outcomes and rigorous intervention-level MMRV should occur within the portfolio at the project level.

Project-level MMRV design

How biodiversity is measured shapes decision-making and reporting. MMRV design is determined by specific project aspects and ideally follows a three-step process that includes: (1) defining project boundaries, (2) defining the scale of diversity, and (3) defining the monitoring tools that will deliver project outcomes against steps 1 and 2 (**figure 6**).

> How biodiversity is measured shapes decision-making and reporting.

83 Existing bodies like the IAPB provide guidance on how organizations should approach claiming project outcomes that are intended for use as biodiversity credits. We support IAPB's guidance and do not seek to retread these recommendations. Rather, we discuss here how appropriate metric selection and MMRV design can enable scaled reporting across portfolios. There are many emergent frameworks and regulatory requirements. We do not include an exhaustive list here.

84 International Advisory Panel on Biodiversity Credits. 2024. Framework for high integrity biodiversity credit markets. [accessed 2024 Dec 1]. https://www.iapbiocredits.org/framework

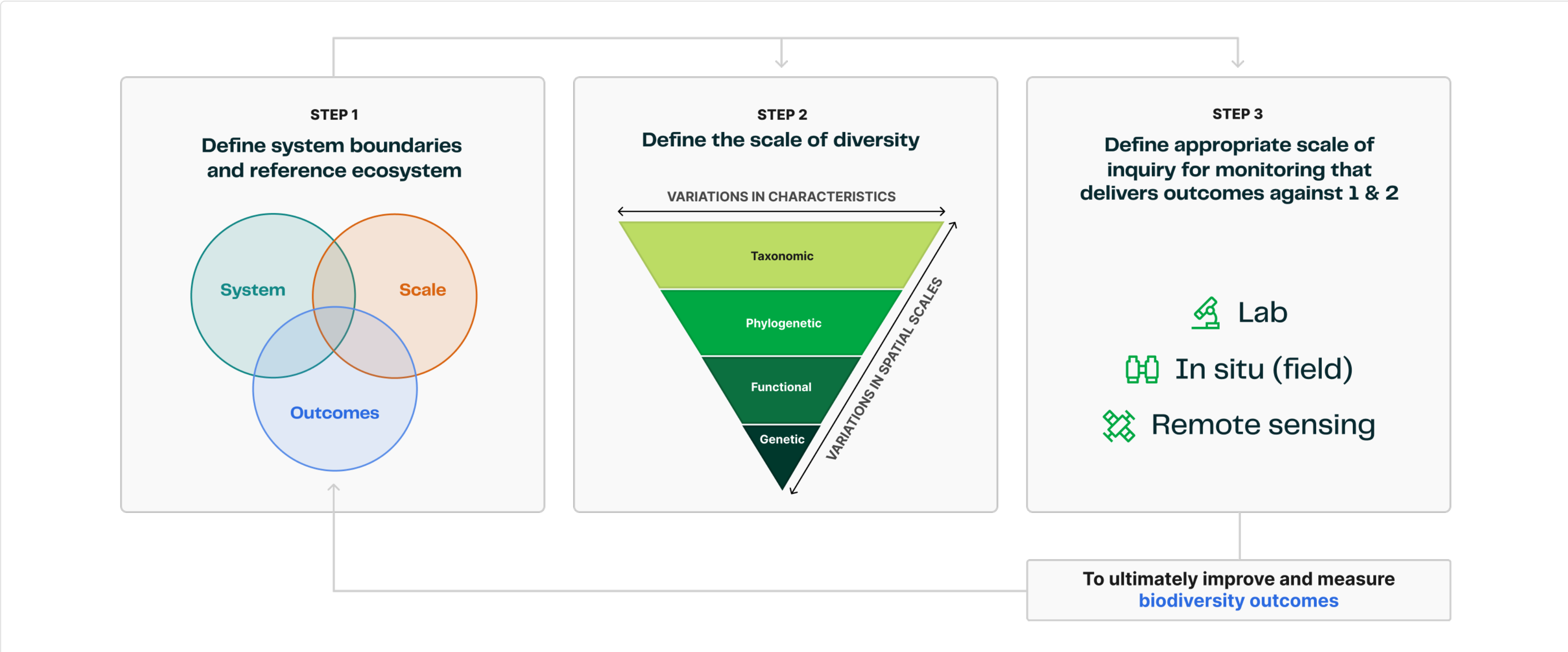


Figure 6. Project aspects determining biodiversity-oriented MMRV design. Source: Carbon Direct.

For instance, an agroecology project designed to support pollinator activity by reducing agrochemical applications (**figure 6, step 1**) will likely focus more on functional diversity than a project that plans to restore spotted owl populations (**figure 6, step 2**). Restoring specific populations relies on available and suitable habitat but also requires monitoring of individual species and populations. In contrast, monitoring pollinator outcomes should be targeted at understanding pollinator *health* and *persistence* across the project area and through time as a more holistic functional unit, which will require a combination of monitoring scales (**figure 6, step 2**).

Mitigations for fragmentation include creating animal pathways (i.e., dispersal corridors) between project areas that allow plants and animals to disperse or move between habitat fragments. Similarly, projects can be sited in locations that are adjacent to protected areas. However, these interventions should be complemented with rigorous population monitoring. Otherwise, while a given species may be present, it will not be possible to determine if it is persisting in a healthy and sustainable manner.

MMRV design should also consider how interventions perform over space and time. When thinking about project performance in a spatial context, we focus on how the project protects or promotes suitable habitat and connectivity to support populations through time (**Principles 1 and 6, table 3**). Without careful design, project areas can become isolated islands of suitable habitat in fragmented landscapes that are not sufficient to support populations of plants and animals through time.[85]

When thinking about the temporal aspects of project performance, we focus on how the intervention outcomes will persist through time. For example, a simple tally of species present in a project area is insufficient to characterize whether or not they will persist through time. Persistence is contingent on a combination of: (1) **resistance**, (2) resilience,[86] (3) community structure (e.g., how different species are interacting with each other and whether the functional diversity required for a species to reliably disperse its seeds is present), and (4) the spatial structure and availability of suitable habitat. Effective monitoring of persistence and the ability to make claims or report against outcomes requires a temporal baseline and clear counterfactual (i.e., a hypothesis, ideally one grounded in control plots and a dynamic proxy, of what would have happened in the absence of the project).

Importantly, projects focused on conserving, enhancing or restoring biodiversity will likely require adaptive management. This may require adaptive MMRV plans so that measurements remain aligned with updated priorities and indicators of success. De-risking for a biodiversity project should focus on embedding flexible performance indices and milestones to accommodate the shifting nature of biodiversity protection, and to provide a more nuanced view of project progress to buyers. As such, investors should be willing to accommodate shifting management approaches to achieve desired outcomes and

85 In North America, there are tracts of protected lands covering hundreds of miles in the form of national parks. However, many species of mammals are disappearing from national parks because the parks are too small to support them, meaning that there is insufficient suitable habitat. Parks as large as Yosemite (3,027.7 km^2) and Mount Rainier (956.5 km^2) have lost more than 25% of the species originally found there, and smaller parks have lost as much as 35–40%. Some of these local extinctions (extirpations), such as the grizzly bear from Yosemite, occurred prior to each park's establishment, and some afterward. These species losses are due to the fact that national parks are essentially islands of habitat existing in a fragmented landscape. Because of their isolation, these parks can only support so many species, and many parks are too small to retain intact mammalian fauna.

86 In the context of carbon projects, resistance can describe the ability of individual trees to persist in the face of some stress (like a drought), whereas resilience refers to the broader ability of the population to return to a similar state after a disturbance (like resprouting after catastrophic fire). Resilience is more relevant to biodiversity outcomes and resistance is more relevant to carbon reversal.

potentially recalibrate what success means. However, recalibration should have defined guardrails to mitigate greenwashing risks and avoid moving the goalpost forward, which may dilute the ambition of the initial objective.

As illustrated in **figure 7**, the methods used for quantifying project outcomes depend on the type of baseline they are measured against. Dynamic baselines compare project plots against similar control plots and are measured over time. Measurement against dynamic baselines may provide a more accurate quantification of biodiversity outcomes than measurement against static baselines, which are based on business-as-usual scenarios and operate out of assumptions rather than direct measurement.

> The key to a successful monitoring plan is choosing a model that can be feasibly and consistently implemented through time and by a variety of practitioners with diverse levels of expertise.

Metric selection for MMRV, similar to appropriate monitoring tool selection, depends on project context and objectives. Therefore, we do not include a prescribed metric or method in this paper. Understanding the range of options and their potential applications and limitations is required for credibly characterizing and reporting against outcomes. Broadly, project measurements—which define what metrics can ultimately be reported—can be collected at four scales: (1) in-situ (field) observations, (2) laboratory analysis, (3) remotely sensed observations, and (4) socio-economic data. The appropriate balance of these four scales of inquiry will depend on the project and goals in question but will likely include a combination of each (**Appendix D**).[87] Once collected, measurements can be used as metrics, which are generally broken into two classes: aggregated metrics (a single value that describes complex environmental elements) and disaggregated monitoring data (a series of simple metrics). Each type of metric has merits and drawbacks. The aggregated metric is simple, easy to communicate and potentially more tractable for comparing outcomes across scales and geographies. Disaggregated data on the other hand enable greater visibility and are more flexible to specific project instances, potentially providing more nuanced and holistic perspectives on project outcomes.

87 Cavender-Bares J, Schneider FD, Santos MJ, Armstrong A, Carnaval A, Dahlin KM, Fatoyinbo L, Hurtt GC, Schimel D, Townsend PA, et al. 2022. Integrating remote sensing with ecology and evolution to advance biodiversity conservation. Nat Ecol Evol. 6(5):506–519. doi:10.1038/s41559-022-01702-5

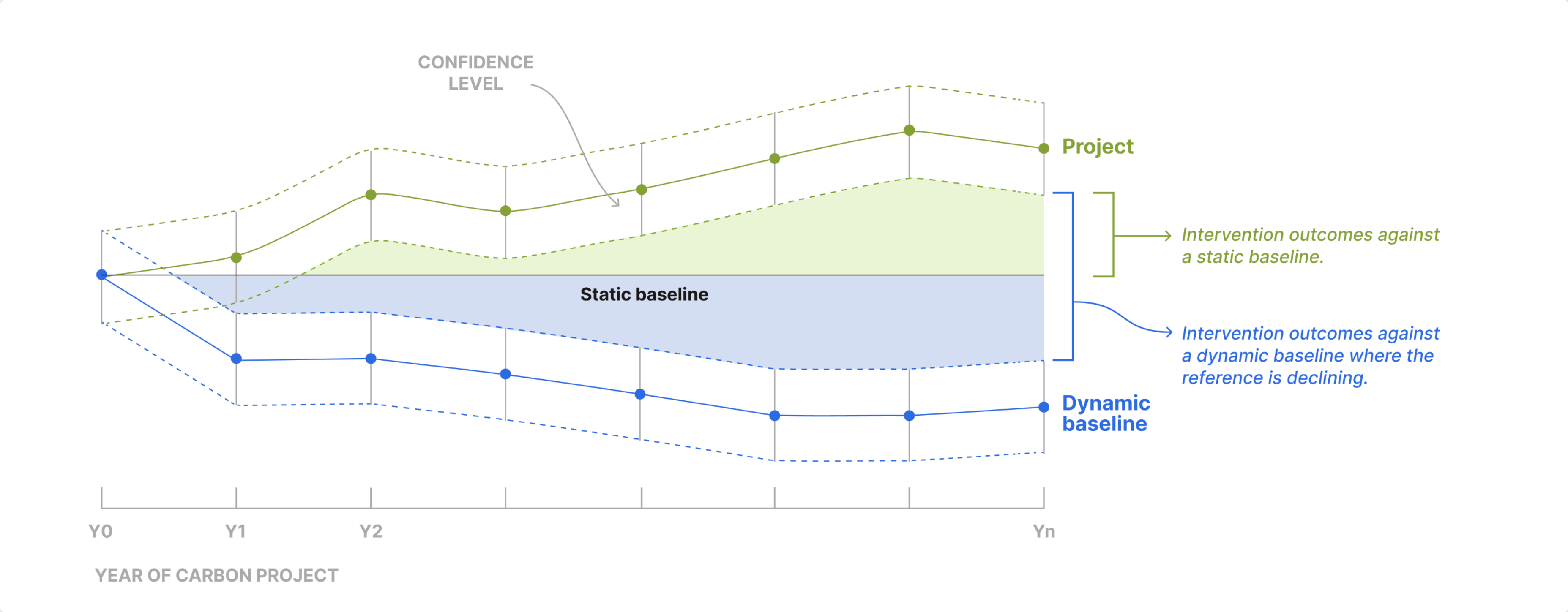


Figure 7. Static versus dynamic baselines. Source: Carbon Direct, based on a figure by Indigo Ag.

The key to a successful monitoring plan is choosing a model that can be feasibly and consistently implemented through time and that can be robustly implemented by a variety of practitioners with diverse levels of expertise. Where possible, relying on data factors that can be collected autonomously by equipment and with remote sensing can reduce costs, increase credibility, and enhance usability.

In summary, project developers and buyers could keep the following points in mind when considering aspects of MMRV design for nature-based projects with biodiversity goals:

- **Species diversity is incredibly vast. Projects should be explicit about what outcomes they are prioritizing and how their monitoring plan will enable measurement of progress against those targets (Principles 3 and 6).**

Rather than attempting a complete survey of any given site, projects should focus on targeting specific taxonomic groups (e.g., the number of bird or moth species), ecosystem functions (e.g., seed dispersers), or conservation priorities (e.g., endangered species). Projects should prioritize native species and leverage assisted natural regeneration as appropriate.

- **Biodiversity assessments are necessarily spatially explicit. Project developers should contextualize projects and outcomes within the broader landscape and community and socio-economic context (Principles 1, 2 and 5).** Species are not evenly distributed across space, making both site- and landscape-scale assessments important for ensuring that a project is structured and sited appropriately. Individual species have specific habitat and environmental requirements. Projects impact human communities and should be developed through community engagement and with social benefits in mind. Predicting the outcomes of interventions, from the individual species level to overall ecosystem health, is possible only with a clear understanding of the extent of available habitat and how a given species functions within it.
- **Capacity for adaptation is key to success. Project developers should plan for and understand the adaptive capacity of the project area and habitat, and buyers should be prepared for shifting performance indicators (Principle 4).** Ecosystems are dynamic and species have environmental and physical tolerances. Assessment behind shifting performance indicators should be transparent at the project's commencement and have guardrails.
- **Species interactions affect outcomes. Project developers should account for multi-species outcomes in monitoring plans and buyers should be aware of the possibility of these outcomes (Principle 3).** This is true in both managed and natural ecosystems. For example, in the United States, pollinator species diversity can increase almond productivity, while high densities of honeybees can result in decreased almond productivity due to competition.[88]
- **Time matters. Project developers should be explicit about measuring progress over time against a counterfactual baseline to ensure that outcomes are durable and meaningful (Principle 6).** Quantifying biodiversity against a rigorous counterfactual baseline and across temporal scales is essential to understanding the impact of an intervention and the drivers of biodiversity changes.

88 Alomar D, González-Estévez MA, Traveset A, Lázaro A. 2018. The intertwined effects of natural vegetation, local flower community, and pollinator diversity on the production of almond trees. Agriculture, Ecosystems & Environment. 264:34–43. doi:10.1016/j.agee.2018.05.004

Conclusion

Organizations may be able to leverage nature-based projects in the VCM to meet both carbon and biodiversity goals. Ideally, buyers should be able to report against individual project outcomes to support nature-positive goals that ladder up to global societal targets such as those articulated by the Global Biodiversity Framework. However, most projects in the VCM today were not designed nor set up to support these goals as historical demand signals are, understandably, carbon-focused. Overall, the market lacks a clear signal from buyers that quantifiable and meaningful biodiversity outcomes are a priority on par with carbon. This is compounded by a lack of clarity on what constitutes a high-quality project in terms of both biodiversity and carbon.

Buyers in the VCM have an opportunity to catalyze structural changes to protocol design by signaling clear demand for projects that rigorously account for biodiversity outcomes while maintaining high-quality carbon project standards.

To guide project selection for buyers and clearly articulate design considerations for developers and registry protocols, we present six principles for incorporating high-quality biodiversity outcomes in VCM projects (**table 3**).

The six principles for incorporating high-quality biodiversity outcomes in VCM projects prioritize projects that:

1. **Maximize available and suitable habitat** with low fragmentation and high connectivity;
2. **Identify a clear reference ecosystem** to site and design appropriately;
3. **Plant and manage native species** and use assisted natural generation as appropriate;
4. **Embed resiliency through adaptive management** and planning for pollution, climate change, and other stressors;
5. **Balance integrating local livelihood considerations alongside biodiversity** and generate economic benefits for local communities to ensure long-term project success; and
6. **Report measurable and verifiable outcomes** that are durable through time.

The principles above could enable buyers to better assess projects that target dual biodiversity and carbon outcomes and enable project developers to embed biodiversity outcomes into project design where appropriate. To do so, buyers wishing to support high-quality biodiversity outcomes in nature-based carbon projects in the VCM could consider the following:

Center local context for global impact: Unlike carbon, where a metric tonne of carbon dioxide is universally measurable across geographies, biodiversity benefits are often local and difficult to compare across landscapes. Buyers should consider strategies that account for this nuance and be aware that units of biodiversity measurement may not be interchangeable (i.e., fungible) when selecting priority geographies and ecosystems for investment.

Ground outcome-based reporting in clearly defined objectives: Biodiversity is multifaceted. Projects should clearly identify the aspects of biodiversity that support nature-positive objectives and that are reported in project outcomes, such as habitat conserved, created, restored, or enhanced. Project MMRV should be grounded in scientific best practices and designed to support project objectives.

Accommodate an adaptive management mindset: Projects focused on conserving, enhancing, or restoring biodiversity will likely require adaptive management. Investors should be willing to accommodate shifting management approaches to achieve desired outcomes and potentially recalibrate what success means. However, recalibration should have defined guardrails to mitigate greenwashing risks and avoid diluting the ambition of the initial objective.

Take the long view: Successful carbon and biodiversity outcomes often have different time horizons. These timelines do not always align with VCM project crediting periods. This means that while a project might meet both carbon and nature-positive objectives, reporting against those outcomes may be decoupled. Credible MMRV should reflect outcome-appropriate timelines.

Appendix A: Glossary

Biodiversity (biological diversity): The variation within and among living organisms.[89]

Biodiversity credits: Generally transacted in voluntary markets (as opposed to offsets, which are transacted in regulatory markets), these are broadly quantifiable units representing a conservation and/or enhancement claim using a scientific methodology. This is a flexible mechanism that does not place a price on nature itself, but on the labor and technology costs to facilitate conservation or uplift. These credits most often require measurement and reporting on biodiversity outcomes following a practice change. In principle, these deliver equitable, nature-positive outcomes aligned with climate goals, and are led by governments, businesses, non-state actors, multi-stakeholder processes, Indigenous Peoples, and local communities.

Ecological restoration: The process of assisting the recovery of a degraded, damaged, or destroyed ecosystem to reflect values regarded as inherent in the ecosystem and to provide goods and services that people value.[90]

Ecosystem functions: The diverse array of natural processes and interactions that sustain ecosystems, encompassing the flow of energy (e.g., conversion of sunlight into chemical energy via photosynthesis), water fluxes (e.g., evapotranspiration), cycling of nutrients (e.g., the weathering of rocks to form soil), and the dynamics of organic matter (e.g., decomposition).

Ecosystem services: The benefits people obtain from ecosystems.[91] These benefits have been grouped into provisioning (e.g., food, timber, medicine), regulating (e.g., climate regulation), cultural (e.g., recreation, spiritual, and religious value), and supporting (e.g., soil formation, pollination) services.[92]

Functional traits: Characteristics that mediate an organism's response to the environment and/or their effects on ecosystem properties or functions. These characteristics can be morphological (e.g., deep roots), physiological (e.g., photosynthetic rate), biochemical (e.g., leaf nitrogen content), or phenological (e.g., timing of flowering).

Nature-positive: The protection, restoration, and enhancement of the species, ecosystem functions, and ecosystem services that underpin our natural world and global economies. As biodiversity drives many nature-positive outcomes, this paper uses biodiversity as a proxy for nature-positive impacts.

Resilience: The ability to return to a pre-disturbance state (e.g., a fire kills all mature trees, but seedlings grow back from a fire-resistant seed bank).[93]

Resistance: The ability to withstand change without loss in the face of disturbance or variation (e.g., thick bark conferring resistance to fire).[94]

Species richness: A count of the number of species in an area.[95,96]

89 Secretariat of the Convention on Biological Diversity. 1992. Convention on Biological Diversity. Text and Annexes. [accessed 2024 Dec 6]. https://www.cbd.int/doc/legal/cbd-en.pdf.
90 Martin DM. 2017. Ecological restoration should be redefined for the twenty-first century. Restoration Ecology. 25(5):668–673. doi:10.1111/rec.12554.
91 Danley B, Widmark C. 2016. Evaluating conceptual definitions of ecosystem services and their implications. Ecological Economics. 126:132–138. doi:10.1016/j.ecolecon.2016.04.003.
92 Reid WV, Mooney HA, Cropper A, Capistrano D, Carpenter SR, Chopra K, Dasgupta P, Dietz T, Duraiappah AK, Hassan R, et al. 2005. Ecosystems and human well-being - Synthesis: A Report of the Millennium Ecosystem Assessment. Island Press. https://www.millenniumassessment.org/documents/document.356.aspx.pdf
93 Standish RJ, Hobbs RJ, Mayfield MM, Bestelmeyer BT, Suding KN, Battaglia LL, Eviner V, Hawkes CV, Temperton VM, Cramer VA, et al. 2014. Resilience in ecology: Abstraction, distraction, or where the action is? Biological Conservation. 177:43–51. doi:10.1016/j.biocon.2014.06.008.
94 Lake PS. 2013. Resistance, resilience and restoration. Ecological Management and Restoration. 14(1):20–24. doi:10.1111/emr.12016.
95 Moore JC. 2013. Diversity, Taxonomic versus Functional. In: Levin SA, editor. Encyclopedia of Biodiversity (Second Edition). Waltham: Academic Press. p. 648–656. doi:10.1016/B978-0-12-384719-5.00036-8.
96 See the **Fundamentals of biodiversity in nature-positive projects** section of this report for an in-depth description of how this differs from the many dimensions of biodiversity.

Appendix B: Limitations of this paper

This paper establishes six guiding principles for prioritizing dual biodiversity and carbon outcomes in nature-based projects in the VCM. In this context, nature-based projects represent deliberate human actions to steward and manage ecosystems in the service of climate change mitigation. We refer to nature-based projects synonymously with agriculture, forestry, and other land use (AFOLU) mitigation measures as defined by the International Panel on Climate Change.[97] We recognize the broad scope covered in this paper. While we have attempted to detail the constraints that guided the development of our principles, there may be related topics of interest that have not been addressed in this document. The following identifies some topics may be considered for future exploration.

While the principles defined in this paper apply to AFOLU mitigations broadly, to date we have observed the highest demand for dual carbon and biodiversity outcomes in the market centered in forest-based projects—specifically native-species reforestation (e.g., Symbiosis Coalition).[98] As such, the majority of the case studies and examples tendered in this paper refer to reforestation, in contrast to IFM and afforestation.

AFOLU covers many interventions, landscapes, geographies, and management goals; therefore, the principles we present are also necessarily broad so that they can be applied across many contexts. Importantly, AFOLU projects often involve actively managing landscapes for multiple uses. As with all ecosystem management activities, this requires working closely with stakeholders to develop shared goals, accepting the possibility of tradeoffs between goods and services, and developing ongoing active management plans that may optimize different uses and interventions across landscapes. However, the specific goals and tradeoffs are context- and location-specific; as such, in this paper we do not discuss the nuances of specific management practices and their tradeoffs with regard to dual outcomes.

For example, plantations and forests managed for wood products—while primarily focused on fiber production sometimes associated with biodiversity constraints—vary widely in design and management; certain models may be more or less compatible with biodiversity objectives. At a minimum, though, AFOLU activities should be climate additive, recognize the impact of humans on landscapes, have no net-negative impact on food and fiber supply, and generate no net harm to biodiversity, while ensuring actions are implemented sustainably and in equitable, socially responsible, and culturally responsible ways.

97 Intergovernmental Panel on Climate Change (IPCC). 2023. Agriculture, Forestry and Other Land Uses (AFOLU). In: Climate Change 2022 - Mitigation of Climate Change: Working Group III Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press; p 747–860 [accessed 2025 Sept 21]. https://doi.org/10.1017/9781009157926.009

98 Carboncredits.com. 2024 May 23. Google, Meta, Microsoft, and Salesforce Launch "Symbiosis", Pledging for 20M Tons of Nature-Based CDR Credits. [accessed 2025 Aug 26]. https://carboncredits.com/google-meta-microsoft-and-salesforce-launch-symbiosis-pledging-for-20m-tons-of-nature-based-carbon-removal-credits/

Similarly, biodiversity is vast, multifaceted, and underpinned by a deep body of research. As such, we do not address nuances of navigating tradeoffs or the longstanding discourses surrounding biodiversity conservation and uplift prioritization, such as whether biodiversity hotspots are a viable means of setting global goals for prioritizing where interventions are sited or where buyers' portfolios should be centered.[99,100]

Appendix C: Dimensions of biodiversity

Taxonomic diversity

Taxonomic diversity describes the number and relative abundance of species present within a given geography and is the most commonly used heuristic for biodiversity. Global species diversity is incredibly vast, making a complete assessment of any given site unrealistic. Generally, taxonomic surveys are performed for a specific set of organisms grouped by interest, such as birds or plants, or known "indicator organisms," which might act as proxies for overall ecosystem health. Taxonomic diversity profiles can answer questions such as: How many species occur here and nowhere else?

When designed to incorporate species abundance (i.e., the total number of species in a given area), repeated taxonomic surveys can be informative tools for understanding how a given site is, or is not, supporting diverse assemblages of species through time. This information can also be used for building responsive conservation and management strategies (e.g., whether the species surveyed are persisting in healthy populations or are in decline).

Finally, surveys of taxonomic diversity are also employed as powerful tools of discovery. For example, scientists estimate that there may be as many as 400,000 species of flowering plants. This number is uncertain because many species remain to be discovered, and many newly discovered species occur in some of our most threat-ened ecosystems—making their discovery and protection a priority. Conservation management and planning efforts often aggregate species richness for specific groups of organisms in combination with population-level metrics to identify "hot spots"[101] of biodiversity and priority areas for protection.

99 Marchese C. 2015. Biodiversity hotspots: A shortcut for a more complicated concept. Global Ecology and Conservation. 3:297–309. https://doi.org/10.1016/j.gecco.2014.12.008
100 Mayers N, et al. 2015. Biodiversity hotspots for conservation priorities | Nature. [accessed 2025 Sept 21]. https://www.nature.com/articles/35002501
101 Global Forest Watch. 2024. Biodiversity hotspots. [accessed 2024 Dec 5]. https://data.globalforestwatch.org/documents/4f661b45cc8249afa2d25ed624bc74f2/about

Phylogenetic diversity

Phylogenetic diversity, or the measure of how evolutionarily connected or distinct taxa are from one another, provides a framework for more targeted and predictive evaluations of diversity compared to taxonomic surveys. For example, while an important long-term goal for pharmaceutical discovery, a complete survey of all species of all flowering plants followed by screening for potential pharmacological benefits is intractable over a short time period. Rather than take a shotgun approach to evaluation, scientists can use their understanding of evolution to ask questions about the predictability of certain traits of interest and use those analyses to direct discovery or seek to potentially maximize diversity across traits. A study employing a phylogenetic discovery approach evaluated 939 naturally derived and clinically approved pharmaceuticals and found that 80% of them were clustered within 17 plant families. In contrast, the study also screened 19,721 bioactive natural products and showed a scattered distribution across groups of related species.[102] These data suggest that evolutionary relatedness can be predictive of pharmaceutical discovery, while a purely exploratory approach leveraging taxonomic diversity may not be as productive for this purpose.

Functional diversity

Functional diversity generally describes the range of roles that organisms play in ecosystems and communities. It also refers to the range of biological traits (e.g., morphological, physiological, behavioral) exhibited by organisms within an ecosystem. These traits influence how species interact with their environment and with each other, ultimately shaping ecosystem processes and services. For example, ecosystems and biomes are generally characterized by their vegetation. Flowering plants that reproduce sexually must ensure that their progeny can establish at some optimal distance from their parent in order to have the best chance of survival. This is achieved through a process called seed dispersal. Many plants rely on animals to disperse their seeds, and these animals can be grouped into the functional class of “dispersers.” For example, in Madagascar, roughly 17 species of lemur have gone extinct in the past 2,000 years (a timeline that aligns with one wave of human arrival on the island). All of these species were larger-bodied than the extant (i.e., living) species today. Scientists can infer, using various methods, that many of them ate fruit and dispersed seeds. The extinction of these large-bodied dispersers has cascading consequences for the structure of forest ecosystems in Madagascar more broadly. There are tree species that no longer have a reliable means of dispersal, these species have seeds that are too large for currently extant lemur species to swallow and later disperse.[103] Those species

102 Zhu F, et al. 2011. Clustered patterns of species origins of nature-derived drugs and clues for future bioprospecting. Proc Natl Acad Sci USA. 108(31):12943–12948. doi:10.1073/pnas.1107336108

103 Federman S, Dornburg A, Daly DC, Downie A, Perry GH, Yoder AD, Sargis EJ, Richard AF, Donoghue MJ, Baden AL. 2016. Implications of lemuriform extinctions for the Malagasy flora. Proceedings of the National Academy of Sciences. 113(18):5041–5046. doi:10.1073/pnas.1523825113

are now at a dispersal disadvantage, as they are unable to reliably set their progeny up for success through animal dispersal. Over time, we might expect these large-fruited species to become less abundant in Madagascar's forests and potentially go extinct. Understanding functional diversity can provide invaluable insight into conservation and management strategies. For example, the largest remaining fruit-eating lemur species is also critically endangered.[104] Prioritizing its protection would have a broadly positive impact on forest protection and health given its key ecosystem function as a disperser. Understanding the breadth and depth of functional diversity can tell us a great deal about ecosystem health.

Genetic diversity

Molecular or genetic diversity can be a helpful proxy for estimating resilience, or the ability of species and populations to persist through time, which is key to biodiversity protection. While understanding what species are present in a given region is essential to developing conservation and management plans, so too is understanding how robust those species are to perturbation. To assess resilience, scientists use proxies such as population size or abundance, habitat suitability and molecular diversity. If a population lacks genetic diversity, this is an indicator that it will not be able to withstand challenges, such as pests, disease, environmental changes and habitat disturbance. Bananas are a classic example. Bananas are grown as clones, which means that plantations are largely genetically uniform, leaving them incredibly vulnerable. In fact, what was once the most commonly grown banana varietal, the Gros Michel, was almost entirely wiped out in the 1950s by a fungal pathogen commonly known as the Panama disease and is only memorialized today through artificial banana flavorings. Today, Cavendish bananas are the most common varieties sold on global markets. These varieties are also produced clonally and face similar risks as the Gros Michel.[105] Although molecular or genetic diversity is an important part of resilience, there are many additional factors that can result in resilience, such as post-disturbance establishment strategies like resprouting, the robustness of seed banks, other life history strategies and **functional traits**.

104 Federman et al., Implications of lemuriform extinctions.

105 de Figueiredo Silva F, Kaplan S, Tobar FAM, Potts MD, Martinez RLE, Zilberman D. 2023. Estimating worldwide benefits from improved bananas resistant to Fusarium Wilt Tropical race 4. Journal of the Agricultural and Applied Economics Association. 2(1):20–34. doi:10.1002/jaa2.41

Appendix D: Commonly used aggregated metrics for biodiversity outcomes

Metric	Approach and outcomes	Weaknesses and limitations
Species threat abatement and restoration (STAR). This metric uses data from the International Union for Conservation of Nature Redlist to estimate how actions in a given area can reduce species extinction rates.	STAR is an area-based metric that can be used to identify risks and opportunities, set science-based targets and compare the effectiveness of conservation efforts. STAR uses global data to calculate scores for any site, region, or country.	STAR considers only threatened species and assumes threats are constant across all species. It is developed based on bird, amphibian and mammal surveys, which limits its effectiveness for broader inferences. STAR does not incorporate new or worsening conditions. STAR does not consider genetic diversity. STAR does not account for spatial variation, which limits it from accounting for how species population and densities may vary across space and time.
Mean species abundance (MSA). MSA is a measure of population intactness of a given area compared to a definition of intactness without human intervention.	MSA is commonly proposed as a measure of biodiversity for financial institutions and corporations.	MSA is not always an acceptable indicator of other priority metrics such as species richness or extinction risk. MSA does not scale linearly. Maximizing MSA in a series of project areas is not the same as maximizing MSA over a larger area. For example, two portfolios could have different footprints not because their impact on biodiversity differs but because the scale at which MSA is measured differs.

Metric	Approach and outcomes	Weaknesses and limitations
Species richness. Species richness is a widely available metric that describes the total number of species, for specific groups of organisms, in a given area.	Species richness does not account for species population sizes or distributions. Species richness is a widely used metric for comparing biodiversity between areas and for monitoring changes to community assemblages over time.	Species richness is limited in its ability to capture the dynamic nature of biodiversity in changing environments. It does not distinguish between native and non-native or invasive species. It also does not provide important information on characteristics such as function, density, or demography. Species richness similarly does not account for genetic diversity and therefore adaptability. Species richness is sensitive to sampling effort and therefore prone to bias by relative abundance. It is also influenced by the rarest species present in the sampling area. Because species richness captures the net difference between colonization and extinction, it does not capture compositional turnover in a given area.
Potentially disappeared fraction (PDF). The PDF metric is commonly used in life cycle assessments to indicate the potential loss of species richness due to a pressure, such as land occupation, eutrophication, climate change, or other drivers.	The PDF does not measure final extinction, as the changes in a footprint are generally small compared to globally occurring extinction drivers.	The PDF metric can be overly simplistic. It often relies on average extinction rates from local studies, which may not accurately reflect dynamics of biodiversity loss across geographic scales. It additionally assumes that disappearances are temporary and that recovery is possible if pressures are mitigated. Thus, it can underestimate effects on biodiversity.

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Carbon Direct

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