Business guidance *for deeper regeneration*

→ *Regenerative Agriculture Metrics: Biodiversity chapter*

World Business Council *for Sustainable Development*

op2b one planet business for biodiversity

Contents

Introduction

01.

01. Introduction

The imperative to transition to resilient and regenerative agricultural models

Amid the escalating climate crisis and compounding agricultural challenges, a shift in agricultural systems is becoming increasingly imperative. Farmers and agriculture value chain players are feeling the detrimental effects of these challenges while the economic system continues to rely on unsustainable practices. Regenerative agriculture emerges as a powerful counterpoint to business as usual – one that is adaptive, mitigative and resilient.

The opportunities from regenerative agriculture

Regenerative agriculture has gained momentum as a holistic solution to address climate challenges, reverse biodiversity loss and enhance soil health. Forward-thinking farmers have been pioneers in adopting regenerative practices on their lands. However, to scale up regenerative agriculture into a solution that drives significant environmental impact and helps society live within planetary boundaries, it is urgent to agree on how to measure and reward regenerative agriculture outcomes at farm, landscape and global scales. That is why we have developed the **climate and water** chapters so far. These will contribute to the final report and will include soil and socioeconomics to come.

The strong momentum to transition to resilient and regenerative agricultural models

The private sector is increasingly embracing regenerative agriculture for several reasons. First, the resilience of value chains depends on it. The agricultural industry is highly dependent on nature for ecosystem services, making it particularly vulnerable to climate change, biodiversity loss and water scarcity. Second, companies and financial institutions are shifting from voluntary to mandatory sustainability reporting and disclosure, which includes ambitious net-zero emissions and nature-positive strategies. Third, financial investments in regenerative agriculture are on the rise, supporting and de-risking the transition of farmers to these practices.[1] Furthermore, favorable policy environments in regions like North America and the European Union are creating incentives for the adoption of regenerative agriculture, encouraging businesses to champion this cause.

The One Planet Business for Biodiversity (OP2B) working definition of regenerative agriculture

Related to agroecological evidence and principles, regenerative agriculture is a holistic, outcome-based farming approach that generates agricultural products while measurably having net-positive impacts on soil health, biodiversity, climate, water resources and farming livelihoods at the farm and landscape levels. It aims to simultaneously promote above- and below-ground carbon sequestration, reduce greenhouse gas (GHG) emissions, protect and enhance biodiversity in and around farms, improve water retention in soil, reduce pesticide risk, improve nutrient-use efficiency and improve farming livelihoods.

Convergence on measurement: the imperative to scale up

To accelerate the transition to regenerative agriculture and agricultural models that operate within planetary boundaries, it is essential to converge on an integrated measurement architecture. Business must address and overcome the key challenges to alignment: fragmented and siloed data collection and reporting, a lack of alignment on definition and outcomes, a need to translate global frameworks into local action plans and a lack of inclusivity of farmers and Indigenous peoples and local communities (IPLCs) in the process.

As regenerative agriculture gains momentum, the need to establish an aligned and holistic method for measuring outcomes on climate, nature and equity grows. This will support greater transparency of claims made by businesses to counter greenwashing and unlock investments to finance the transition. The world is already starting to hold businesses accountable for the progress it is making. The demands for increased accountability and transparency will only continue to rise.

The World Business Council for Sustainable Development (WBCSD) has prioritized strengthening the climate-, nature- and equity-related **Corporate Performance and Accountability System** by launching the joint Regenerative Agriculture Metrics (RAM) working group with the One Planet Business for Biodiversity (OP2B) coalition.[1,2] This collaborative effort involves more than 52 members and 33 business-focused partners, engaging more than 1,100 businesses.

The working group's goal is to align farm-, landscape- and global-level metrics with corporate reporting. It aims to influence accounting, reporting and disclosure bodies to develop specific guidance for regenerative agriculture. Working group members and partners have initiated progress on this goal by aligning on metrics to measure climate-related outcomes in 2023, water- and biodiversity-related outcomes in early 2024 and outcomes related to soils and socioeconomics later in the year.

Fostering alignment beyond the private sector requires a collective effort. WBCSD is a partner of Regen10, a multi-stakeholder initiative that brings together representatives from across food systems – from farmers and landscape stewards to companies – to explore the potential of regenerative approaches. Regen10 is developing a farmer-centric outcome-based framework to complement existing approaches and frameworks for regenerative food systems.

The framework will support food system actors, including farmers and landscape stewards, through a holistic approach. It will incorporate socio-cultural, environmental and economic outcomes and outcome-based metrics into how they measure and track change in their farms and landscapes. Following an analysis of more than 150 existing frameworks, Regen10 published the Zero-Draft of the Outcomes Framework at the 28th United Nations Climate Change Conference (COP28).[4]

Regen10 is rigorously testing the Outcomes Framework with key stakeholder groups through extensive dialogues, consultations and on-the-ground trials throughout 2024. The final framework, when applied, will enable farmers and landscape stewards to collect primary data and evidence, receive rewards for positive outcomes and mobilize finance, thus accelerating a transition to deep regeneration. Through the Regenerative Agriculture Metrics working group and connecting with the Regen10 Outcomes Framework, WBCSD aims to identify and align on an integrated measurement architecture. This will connect global outcomes and metrics with those at the landscape and farm levels – the first step in creating an enabling environment for the transition.

Achieving an *outcome-based approach*

02.

02. Achieving an *outcome-based approach*

RAM working group members and partners support an outcome-based approach to regenerative agriculture that, at the broadest level, recognizes the need to incorporate and measure against environmental, social and economic categories. These three systems interlock to form a holistic outcome-based approach to regenerative agriculture that can bridge the gap between stakeholders and empower farmers by being cost-effective, context-specific, transparent and measurable.[5, 6]

Figure 1 outlines the concept we used to organize and understand how metrics contribute to achieving regenerative agriculture outcomes that more broadly connect to the respective environmental, social and economic categories.

Figure 2 outlines a working set of outcomes for regenerative agriculture that encompasses the economic and social aspects that are critical to the success of regenerative systems alongside environmental elements in line with the planetary boundaries associated with agriculture. While there is a general consensus on the environmental outcomes, this report focuses on biodiversity-related outcomes including: improved ecological integrity, increased cultivated biodiversity and reduced pesticide risk. We will refine the remaining set of outcomes as the work progresses in 2024.

It is essential for industry to align at a metric level to measure these outcomes to ensure a homogenous value chain approach to regenerative agriculture. Alignment on metrics will drive consistency and comparability and underpin the challenges related to financing the transition to regenerative agriculture.

Figure 1: Taxonomy for outcome-based regenerative agriculture and how it relates to the three categories for a holistic approach to regenerative agriculture

Source: Adapted from Soloviev, E. & HowGood, Inc. (2023) Framework.

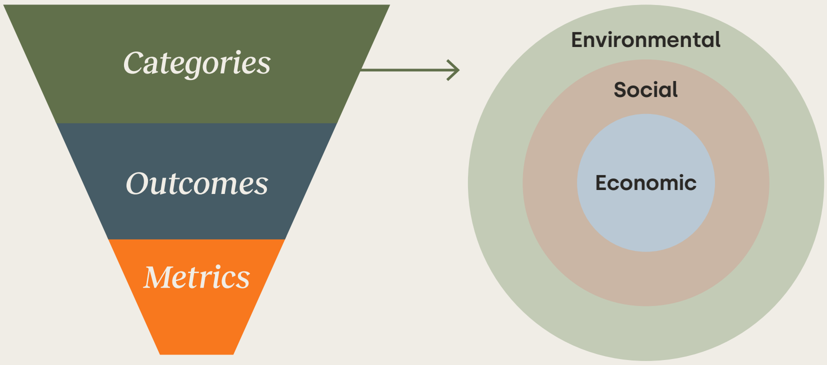
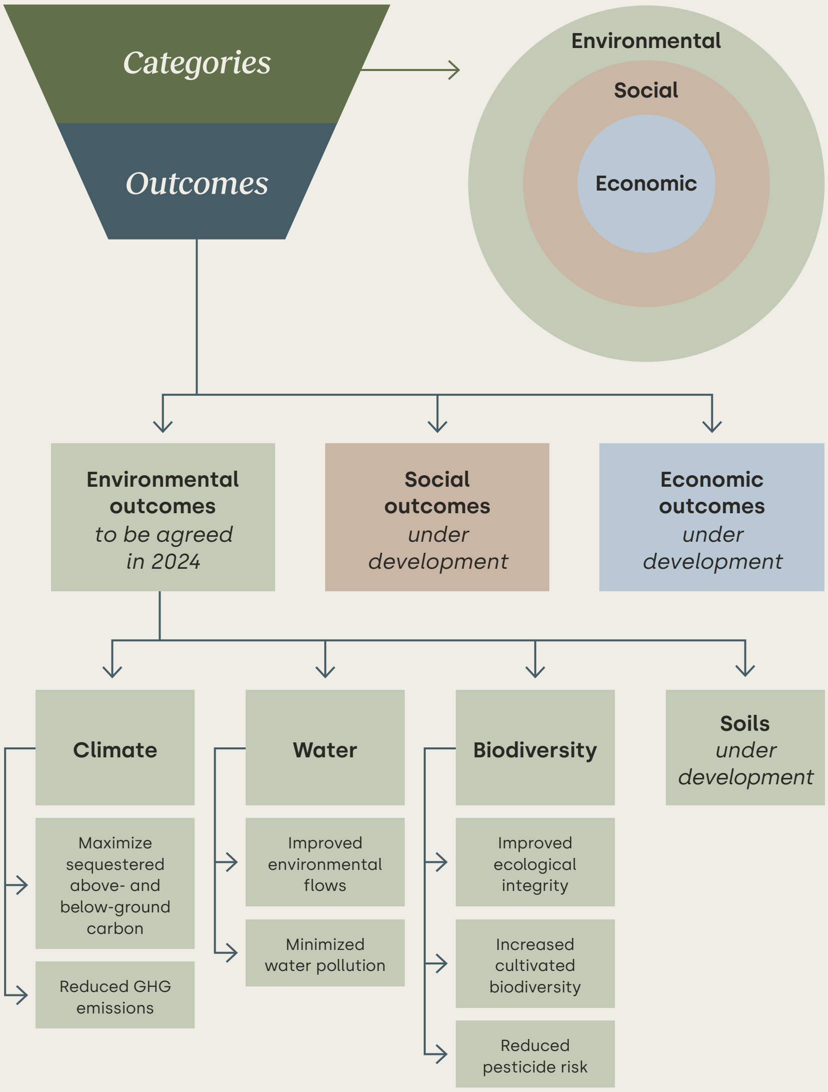


Figure 2: Working outcomes for regenerative agriculture at the corporate level showcasing agreed outcomes

Source: Includes figure adapted from Soloviev, E. & HowGood, Inc. (2023) Framework.



Measuring and reporting progress on regenerative agriculture at a company level

One of the major challenges for companies is to demonstrate their progress on regenerative agriculture credibly and transparently. To do so, companies typically measure progress either in terms of area transitioned to regenerative agriculture (such as 30% of the sourcing regions converted to regenerative agriculture by 2030) or in terms of the share of ingredients sourced from regenerative agriculture (for example, 30% of ingredients sourced through regenerative agriculture by 2030).

However, both approaches have challenges. On the one hand, measuring based on surfaces may cause a company to overlook a commodity with a significant impact that only occupies a small surface. On the other hand, when measuring based on ingredients, a company should define the correct unit (such as the number of ingredients, share of volume, share of value) and be sure to include ingredients with high impact but representing a small share.

Companies engaged with the Science Based Targets Network (SBTN) measure their impact by considering the quantity and origin of raw materials, the pressures on nature of each of these materials and the vulnerability of nature in the sourcing locations. These considerations require detailed information about the company's value chains and their nature-related materiality. However, in some cases involving a small number of key commodities with similar volumes and origins, companies may use measuring surfaces as a proxy to measure the impact.

It is critical to measure the outcomes of regenerative agriculture using a holistic approach that considers environmental, social and economic outcomes to ensure a complete picture of the impacts.

Nature & biodiversity *context*

03.

03. Nature & biodiversity context

3.1 The dependence of agricultural production on nature

According to the SBTN, nature refers to "all non-human living entities and their interaction with other living or non-living physical entities and processes," recognizing that "interactions bind humans to nature, and its subcomponents (e.g., species, soils, rivers, nutrients), to one another."[7] Nature has risen up the business agenda in recent years; there is no escaping rising nature-related risks – driving policymakers, regulators, investors, businesses, consumers and citizens to collectively call for rapid change. The 15th United Nations Conference of the Parties of the Convention on Biological Diversity (CBD COP15) culminated with the adoption of the Kunming-Montreal Global Biodiversity Framework (GBF) – setting a global ambition to halt and reverse nature loss by 2030, broadly understood as the "nature positive" pathway.[8] The goals and targets of the GBF align with the leading research on planetary boundaries[9] and the main drivers of nature loss: land-use change, climate change, natural resource use and exploitation, pollution and invasive species.[10]

The global agri-food system is crucial to feeding the world's growing population and supporting the livelihoods of some 2.5 billion people. This system relies on healthy ecosystems – freshwater supply and quality, land and soil quality, pollination, disease and pest control, climate regulation and other critical ecosystem services. Yet, in its current form, the system poses a significant threat to nature, representing the largest driver of deforestation, water use, biodiversity loss and soil degradation globally.[11] This unsustainable baseline also means great opportunity – for nature recovery, farmer livelihoods and business growth. Indeed, agriculture is both nature's biggest threat and humanity's best chance to halt and reverse nature loss.[12]

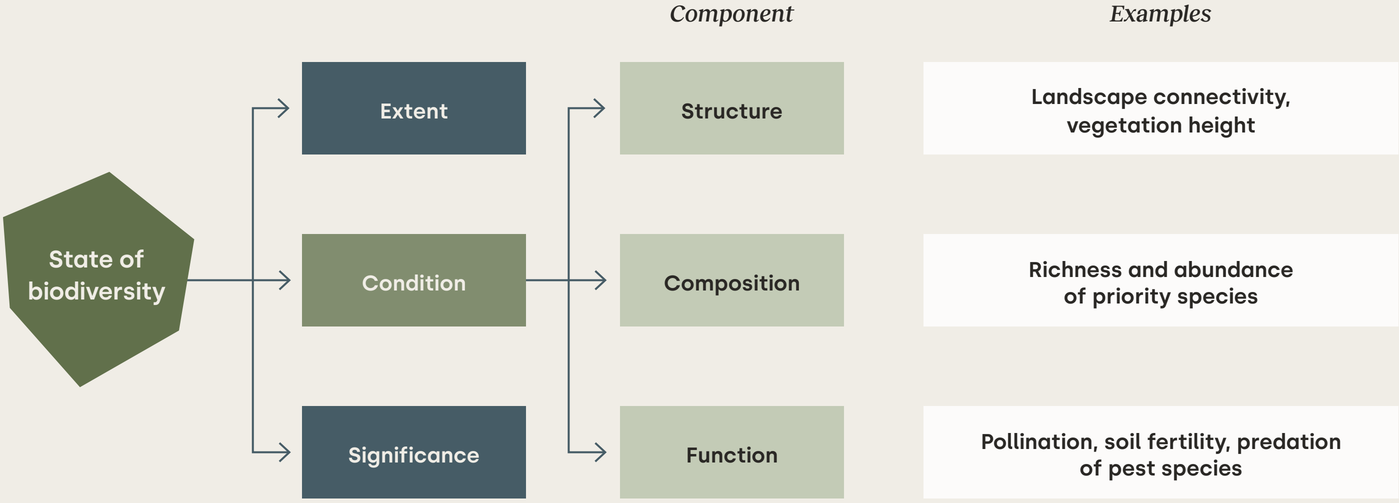
3.2 The impacts of agriculture on biodiversity

The Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) defines biodiversity as "the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part."[13] Agriculture depends on biodiversity and the ecosystem services it provides but is also the primary cause of global biodiversity loss. Agricultural production threatens 24,000 of the 28,000 (86%) species that are at risk of extinction.[14] At a global scale, experts consider agriculture a significant contributor to the potential transgression of four of the nine environmental planetary boundaries.[15]

Intensive agricultural production impacts biodiversity through a range of pressures, including land-use change and habitat fragmentation, pollution from pesticides and nutrient runoff, water abstraction, greenhouse gas emissions, as well as the loss of structural complexity in landscapes due to modern farming practices.[16] The conversion of natural habitats, driven largely by agricultural land expansion, is the major impact pathway threatening several populations of organisms (taxa).[17, 18] Agriculture is responsible for over 70% of freshwater withdrawal globally, leading to impacts on aquatic ecosystems. The system is a leading driver of pollution from excess nutrients and pesticides, which can have negative impacts on many species.[19] Finally, intensification of agricultural production has reduced habitat and structural diversity, producing more uniform landscapes.[20] This includes impacts on soil biodiversity, a key component of soil health to be covered in the soil chapter.

Some agricultural landscapes also have distinctive communities of species, particularly where there is a long history of low-intensity farmland management.[21] The biodiversity in natural and agricultural ecosystems provides important ecosystem services ranging from soil retention to crop pollination and natural pest control.[22] The loss of biodiversity at both landscape and farm scales therefore impacts the ability of ecosystems to provide the functions that enable resilient agricultural production – thus threatening the long-term sustainability of production systems.[23]

Figure 3: Ways to capture the state of biodiversity and the attendant conditions of structure, composition and function[30]



3.3 Biodiversity-related agricultural outcomes

In this document we focus on three key outcome areas related to biodiversity in the agricultural system and the ability of natural, semi-natural and agricultural ecosystems in the farmed landscape to provide important ecosystem functions.

Ecosystem integrity

Agricultural production impacts the extent and condition of natural and semi-natural habitats (NSH) within the farmed landscape. For example, studies have demonstrated that the creation of monoculture plantations, like rubber plantations, results in a decrease in species richness and modifications to the animal assemblage composition.[24] Yet, the availability of NSH is an important indicator of the ability of the agricultural landscape to provide important ecosystem services, including pollination, soil erosion control, nutrient cycling and pest control.[25]

Ecosystem measurement takes into account their extent and condition. There are various facets to an ecosystem's condition – composition, structure and function (see Figure 3).[26] Composition refers to the relative diversity and abundance of species present within habitats. For example, the abundance of some invertebrate groups can be important indicators of ecosystem service provision through pollination and natural pest control.[27] The responses of some taxonomic groups to agricultural pressures can be a signal of the wider condition of the ecosystem (such as water pollution indicator species).[28, 29]

Structure refers to the physical and chemical structure of the ecosystem, for example biomass or vegetation height. Lastly, function refers to ecological processes. For example, the connectiveness of NSH can influence their suitability for certain taxa and consequently their potential for ecosystem service provision.

Cultivated biodiversity

In agricultural systems, increasing the diversity of agricultural species can be important in supporting and restoring biodiversity and associated ecosystem functions.[31] The improved diversity of cultivated species within and between fields can be associated with higher levels of biodiversity, as demonstrated in agroforestry systems as well as farmland using crop rotations and cover crops.[32] Measuring the diversity of crop species is an important indicator for tracking outcomes of regenerative agricultural practice.

Pollution

Pollution also presents an important risk to biodiversity (as reflected by IPBES and the Earth Commission's planetary boundaries), including both nutrient runoff (covered in the **water chapter**) and pesticide risk (covered in this chapter). Pesticides may include insecticides, herbicides and fungicides. Agriculture uses a large variety of substances (both biological and chemical) in production. These vary in their effects on targets, environmental toxicity to humans and other species, persistence and potential for bioaccumulation. Different pesticides impact species groups in distinct ways which can be a substantial threat to some taxa. See examples in **Annex D**.

Environmental flows and water quality

Agriculture also has large impacts on water quantity and quality through the extraction of water (including surface and groundwater) and through runoff and pollution entering surrounding water bodies. These pressures can also impact biodiversity in aquatic ecosystems (as covered in the **water chapter**).

3.4 Potential benefits of regenerative agriculture for biodiversity

Regenerative practices offer the potential to reduce the negative biodiversity impacts associated with conventional agriculture and enhance biodiversity in agricultural landscapes. Regenerative agriculture encompasses various practices that can support biodiversity among other environmental and socioeconomic outcomes. By ensuring agricultural lands maintain biodiversity (both cultivated and natural), farmers can help create resilient agricultural systems that continue to receive the ecosystem services provided by different species and habitats.[33]

There is a growing evidence base for the beneficial impacts of regenerative agriculture practices on biodiversity. Note that the practices listed throughout this guidance are examples and not intended as prescriptive for all contexts or crops; our focus is on outcomes rather than practices. Some examples include:

- Crop diversity (including agroforestry, mixed cropping, crop rotation and cover crops) generally increases biodiversity and can have positive but variable effects on pest and disease control and crop production.[34]
- Reduced- or no-till systems can be positive for farmland biodiversity,[35] as can planting and maintaining buffer strips at the edge of fields.[36]
- Increasing complexity in agricultural landscapes (including remnant patches of natural habitats, increasing edges such as hedgerows and increasing the number of crops) has shown positive impacts on biodiversity, including important functional groups (pollinators, natural enemies).[37, 38]

Increases in biodiversity can lead to improvements in ecosystem functioning. Experts recommend a target of 20-25% of NSH per km^2 to ensure agricultural lands receive ecosystem functions (currently 18-33% of agricultural areas are below this level).[39] Regenerative agriculture typically aims to enhance and sustain soil fertility over time. While soil biodiversity is relatively poorly understood compared to above-ground biodiversity, biological indicators are an important component of soil health metrics. Regenerative agriculture can revive and sustain soil biodiversity, augment ecosystem services and foster carbon capture and storage.

Despite encouraging signs, it is important to note that the evidence for the benefits of regenerative agriculture on biodiversity and agricultural production is neither conclusive nor universal. The evidence for the biodiversity impacts of regenerative agriculture is limited to a few places and systems,[40] as well as potential decreases in crop yields from some practices, especially during the initial years of transition from conventional practices[41] (which should be understood within the current context of crop yield stagnation under conventional practices and accelerating climate-driven impacts). Further evidence is needed for the effects of regenerative practices on biodiversity, crop yields and climate resilience across diverse contexts.[42]

Studies that have tried to compile overall evidence across different types of outcomes show that outcomes beneficial to multiple services are possible from crop diversification in some contexts.[43]

The metrics and *how we designed them*

04.

04. The metrics and *how we designed them*

4.1 Our approach

Within the RAM working group, the biodiversity sub-group convened technical experts from 17 member and partner organizations over a five-month sprint. The objective of this sub-group was to identify metrics to support the biodiversity-related outcomes of regenerative agriculture (see **Figure 1**).

RAM working group participants have agreed on a set of principles to guide this work across the outcome areas (see **Annex D** for further principles and themes developed for this specific sub-group):

1. Ensure clarity of connection between metrics and ultimate outcomes, aligned with planetary boundaries.
2. Develop metrics that are clearly usable for companies and incorporate simple, scientific and robust agreed definitions.
3. Identify and build on synergies with the relevant existing efforts (frameworks, guidance, etc.) that measure and track metrics. This includes aligning methods and terminology with leading corporate sustainability and regenerative agriculture frameworks.
4. Ensure clarity on how data flows between farm, landscape and global corporate levels.
5. Consider and communicate the interconnectedness of sub-group metrics with other impact areas.
6. Focus on outcome-oriented core metrics, which intermediate (required for calculation) and additional (optional) metrics may accompany.
7. Alignment on metrics supports progress on understanding and scaling the success of regenerative agriculture and does not intend to be prescriptive or constrictive for companies.
8. Guidance should address key considerations and guardrails for implementation, including on land-use change differences across subsectors and value chains. (Note that while metrics for land-use change are beyond the scope of this effort, we consider no deforestation or ecosystem conversion as an important guardrail for regenerative agriculture. See **Annex D** for further details.)

4.2 Metrics to measure the biodiversity-related outcomes of regenerative agriculture

The working group has aligned on three measurable, evidence-based biodiversity-related outcomes for regenerative agriculture. These outcomes relate to the broad sustainability objectives of improving ecosystem functioning and the provision of on-farm ecosystem services as well as reducing pressures on nature from pollution. We recommend alignment on three core metrics to measure these outcomes, indicating improvement in ecosystem function and service provision within the agricultural landscape and reductions in key pressures on biodiversity (see Table 1).

Outcomes		*Core metrics*
Improved ecological integrity	→	Natural and semi-natural habitat (NSH) in agricultural land
Increased cultivated biodiversity	→	Crop diversity
Reduced pesticide risk	→	Environmental Impact Quotient (EIQ) field-use rating

We have classed metrics as either core or additional, with core as the default minimum set to apply in all cases when reporting at the corporate scale. We also include optional metrics that may more closely measure an improved state of nature related to these pressures. Companies should not use them instead of core metrics but rather to provide additional context where desired. Additional metrics may be more demanding to measure than core metrics but can provide valuable information in interpreting core metrics, demonstrating progress and informing adaptive management. Intermediate metrics are those required as inputs for the calculation of either core or additional metrics. It can be useful to disclose these alongside metrics to aid in contextualizing results.

Although covered in distinct chapters, it is important to view the outcomes and associated metrics holistically. For example, reduced pesticide risk is related to environmental outcomes for both soil and water (see **Annex A**), while we cover pollution from excess nutrients in the **RAM water chapter**. And all environmental outcomes can ultimately affect farmer livelihoods and health outcomes, which are covered in the chapter on socioeconomics.

Table 1: Recommended biodiversity metrics

Outcomes	Indicators	Core metrics	Additional Metrics	Type	Ecosystem condition components
Improved ecological integrity	**Natural/ restored habitat in agricultural landscapes**	**Natural/semi-natural habitat (NSH) in agricultural land** (% per km²)		State	Extent, structure & function
			Configuration of habitat: → *Connectance index* → *Proportion of NSH core area* → *Field border density*	State	Structure & function
	Presence/ abundance of priority species		*Farms in which priority species are stable or increasing in abundance (% of farms)*	State	Composition
Increased cultivated biodiversity	**Crop diversity**	**Crop diversity per km²** (modification of the Hill-Shannon Diversity Index) Intermediate metrics: → Crops grown → Spatial extent (ha) → Number of months grown	*Soil water holding capacity (%)* *([volume of water/total volume of saturated soil] x 100)*	State	Composition
Reduced pesticide risk	**Pesticide risk**	**Environmental Impact Quotient field-use rating** (EIQ score ecological component x application rate) Intermediate metrics: → Pesticides used & application rates (kg/ha) → Overall EIQ score		Pressure	

Core metrics: Recommended, aligned with disclosure requirements and key frameworks, together seek to represent the regenerative agriculture biodiversity outcomes (may require intermediate metrics to calculate)

Additional metrics: Companies can optionally report as standalone metrics to complement but not replace core metrics

Please see Annex D for full definitions.

State, pressure, response framework

This framework is commonly used to help define indicators and associated metrics to measure impacts on the environment, including biodiversity (see Figure 4):

- → State indicators track the condition of biodiversity itself
- → Pressure indicators track threats to biodiversity
- → Response indicators track actions to reduce these threats

For biodiversity, there are usually time lags in the cycle: pressures take some time to change after the initiation of responses and states take some time to change after reductions in pressure.

The metrics of state are often the most reliable. However, they can be difficult to collect or attribute to company action and may be slower to change than response or pressure indicators. Thus, we can also measure pressures that are influencing parameters or the responses that can reduce pressures or restore nature. Companies can use metrics of pressure where there is a strong evidence base for changes in pressures and the state of biodiversity. This working group focuses on state and pressure metrics, but response metrics can also be useful in demonstrating the actions taken and the outcomes delivered.

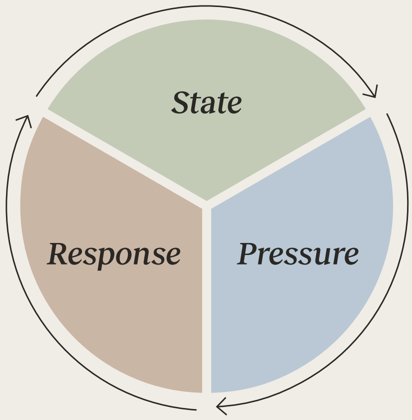
We have designed these metrics for use in tracking the performance and contribution of regenerative agriculture programs over time. This will help identify the contribution of regenerative agriculture to wider corporate nature goals. We include key guardrails (in **Annex D**) to help meet outcomes in a scientifically-rigorous manner and to minimize unintended trade-offs or perverse outcomes. Companies should measure the metrics against a historical baseline which they define – for example, previous year or the year that regenerative agriculture practices commenced. Nature-related target-setting methods (namely from the SBTN – Land targets[44]) can be instructive in this process (see **section 5.2** and **Annex E**).

State: Direct state of the environment in (i) the state of ecosystems (extent and condition), (ii) species (abundance and extinction risk) and (iii) ecosystem services (or the state of nature's contribution to people).

Pressure: Human activities that directly or indirectly change the state of the environment and ecosystem.

Response: Actions taken by companies or farmers to address pressures or to improve the state of nature on farmed land.

Figure 4: Examples of state, pressure, response framing for biodiversity-related metrics



Outcome: Improved ecological integrity

Indicator: Natural/semi-natural habitat in agricultural landscapes

Example metrics:

- NSH in agricultural land (% per km²)
- Land converted from natural or semi-natural habitat (ha)
- Percentage of riparian areas on farmed land with riparian buffer strips planted with native vegetation (%)

Outcome: Reduced pesticide risk

Indicator: Pesticide risk

Example metrics:

- Concentration of pesticides in receiving water bodies (mg/l)
- EIQ field use ratings for pesticides
- Percentage of farmed land using biological controls instead of pesticides (%)

4.3 Framework mapping and criteria assessment

To align the outcomes and potential metrics with existing corporate reporting requirements, we conducted:

- A review of biodiversity-related metrics included in relevant standards and frameworks;
- An assessment of the metrics against criteria to determine their scientific evidence base, ease of measurement, affordability, accessibility and applicability.

The framework mapping was a first step to check the initial list of metrics prioritized by the metrics sub-group against relevant frameworks for both regenerative agriculture and corporate sustainability and nature assessment, target-setting and disclosure. These include, for example:

- Sustainability frameworks: CDP, EU Corporate Sustainability Reporting Directive (CSRD), Global Reporting Initiative (GRI), SBTN – Land targets, Taskforce on Nature-related Financial Disclosures (TNFD) Food & Agriculture Sector Guidance, International Sustainability Standards Board (ISSB);
- Regenerative agriculture frameworks: Cool Farm Tool, Field to Market, OP2B, Regen10 outcomes framework v0, SAI Platform, Sustainable Markets Initiative, Textile Exchange.

This initial mapping highlighted points of agreement and divergence among the relevant frameworks, informing recommendations among potential metrics (tables 2 and 3 show results for the recommended core metrics, full mapping available in Annex B).

Table 2: Corporate sustainability framework mapping for recommended core metrics

Outcomes	Indicators	Metrics	Included in sustainability frameworks					
			SBTN Land	CDP Forests	TNFD	CSRD	GRI-304-Biodiversity & Agri Standards	ISSB (based on CDSB Biodiversity)
Increased cultivated biodiversity	Crop diversity	crop diversity per km²			Voluntary			
Improved ecological integrity	Natural/ restored habitat in agricultural landscapes	% NSH in agricultural land per km²	Needed		Needed	Intermediate	Intermediate	Voluntary
Reduced pesticide risk	Pesticide risk	Environmental Impact Quotient (EIQ)			Voluntary	Intermediate	Voluntary	Voluntary

Table 3: Regenerative agriculture framework mapping for recommended core metrics

Outcomes	Indicators	Metrics	Included in regenerative agriculture frameworks and tools						
			SMI	SAI Platform	Cool Farm Tool	Field to Market (Biod. & Land Use)	OP2B	Textile Exchange	Regen10
Increased cultivated biodiversity	Crop diversity	crop diversity per km²		Needed	Needed	Intermediate	Needed	Needed	Intermediate
Improved ecological integrity	Natural/ restored habitat in agricultural landscapes	% NSH in agricultural land per km²	Needed		Needed	Intermediate	Needed	Needed	Needed
Reduced pesticide risk	Pesticide risk	Environmental Impact Quotient (EIQ)				Needed	Needed	Needed	Needed

Needed metric for reporting — Intermediate metric that may needed to calculate end results — Voluntary metric, not required for reporting

We adapted metric design criteria for the context of regenerative agriculture from the TNFD's criteria for assessing state of nature metrics.[45] These criteria address key points related to scientific evidence base, scalability, attribution, practical applicability for companies and potential for misuse of metrics. (Table 4 shows results for the recommended core metrics, full mapping available in Annex C.)

Table 4: Criteria assessment results for recommended core metrics

Outcomes	Indicators	Metrics	Criteria								
			Relevance to objective	Evidence base	Scalability	Generality	Breadth	Potential for standardization	Potential for target-setting	Feasibility	Potential for gaming
Increased cultivated biodiversity	**Crop diversity**	**crop diversity per km²**	2	2	1	1	3	2	2	3	1
Improved ecological integrity	**Natural/ restored habitat in agricultural landscapes**	**% NSH in agricultural land per km²**	3	3	3	3	2	3	3	3	2
Reduced pesticide risk	**Pesticide risk**	**Environmental Impact Quotient (EIQ)**	2	2	2	2	1	3	1	2	1

- 0 — Does not meet the criterion
- 1 — Partially meets the criterion but has limited potential for improvement or some limited challenges/issues
- 2 — Partially meets the criterion and has substantial potential for future improvement or some considerable challenges/issues
- 3 — Fully meets the criterion

Opportunities for *metric implementation*

05.

05. Opportunities for *metric implementation*

5.1 Reporting on practices

Regenerative practices applied within fields, between fields and across wider landscapes can help deliver the ecosystem functions needed to support resilient agricultural production systems. If scaled, they could help to deliver many of the outcomes for biodiversity, water, soil and climate listed above.[46] Key practices can include:

- Increasing diversity of crop species
- Crop rotations
- Intercropping
- Introducing cover crops
- No-tillage or reduced-tillage agriculture
- Maintaining soil cover/reducing disturbance
- Conserving, restoring, creating and connecting areas of NSH
- Buffer and riparian strips of NSH
- Improving the efficiency of nutrient use and reducing associated runoff
- Reducing overapplication and environmental risk of pesticides, including through integrated pest management (IPM)[47]

According to context, these practices vary in how they can promote regenerative outcomes. Alongside outcome metrics, it can be useful for companies to report on practices to show how they are achieving the outcomes. This should include information about management measures and monitoring measures in place (such as % of farms with action plans for priority species or monitoring plans in place). This helps to inform adaptive management by indicating which practices are succeeding and where they may need to make changes. There may also be benefit to disclosing practices where farmer incentive schemes (meaning from downstream companies or banks) include practices as well as outcomes.

Case Study: UEBT

UEBT is a non-profit association working to regenerate nature and secure a better future for people through ethical sourcing of ingredients for the beauty, food, natural pharmaceuticals, flavors & fragrances, herbs and spices sectors, among others. Two landscape-level projects are highlighted here, aligning to the ACT-D framework to demonstrate the approach including the biodiversity-related metrics used:

	Vietnam – cassia	Madagascar – vanilla
Rationale	Local processing companies sought to identify cassia production models to address nature-related risks and promote restoration of agroforestry systems. UEBT, with the Vietnamese Research Center for Non-Timber Forest Products, proposed a project based on establishing and scaling-up pilot farms. The project includes four local processing companies with five pilots established and a total potential reach of more than 200 farmers.	Companies in the vanilla sector sought to test their sourcing areas against the UEBT regenerative approach. UEBT ran an assessment of regenerative parameters with the support of a local expert. The assessment was a small-scale pilot test with potential to scale-up to about 20 companies and more than 200 farmers.
Objectives	Maintain yields, improve farmer livelihoods, protect natural resources including soil and water, restore native biodiversity	
Assess: prioritization of risks & opportunities	→ Land conversion for farm expansion into natural areas, including protected forests → Monoculture and high-density farming is degrading soil, reducing genetic diversity and natural resilience → Pests are increasingly problematic; use of high-toxicity agrochemicals is contaminating soil and water → Changing climatic conditions – higher temperatures and longer dry seasons – may be affecting plant health	→ Vanilla plots often established on land converted with slash and burn practices → Incorrect farming practices (low-diversity monoculture system) causing biodiversity loss, soil degradation and erosion, diminished productivity and increased vulnerability to disease → Introduced and potentially invasive species commonly used as vanilla support trees
Commit: setting targets	Restore degraded agroforestry systems: 100% of farmed area to include natural and semi-natural habitat (NSH)	
Transform: specific actions	→ Select cassia variety adapted to local conditions, purchased from certified nurseries or self-produced from forest trees → Plant a maximum of 3300 cassia trees/ha to be thinned stating at year five → Interplant around 800 native plants/ha and/or in farm borders, minimum of four different species (5:1 ratio of cassia to other native species). → Manage weeds only in the young agroforestry system, clearing around 80cm diameter per tree. → Perform regular monitoring of the agroforestry system for early detection of possible pests/diseases.	Vanilla plots are turned into healthy agroforestry systems by: → establishing a high stratum of local trees in vanilla plots, → replacing introduced and potentially invasive species as vanilla support trees with native species, → keeping the ground covered with a live herbaceous cover and → incorporating live hedges in vanilla plots containing a diversity of native species. Surrounding ecosystems are maintained or restored by: → maintaining surrounding areas of natural forests, → restoring degraded forest plots with native species and → maintaining and restoring surrounding wetlands.
Disclose: indicators & metrics	→ NSH (total ha) → Number of native and beneficial species on-farm → Incidence of pests/diseases → Yield per hectare	→ NSH (total ha and %) → Number of native and beneficial species on-farm (per ha) → Number of invasive species identified on-farm → Number of cultivated species (per ha) → Number of local species cultivated (per ha)
Notes on monitoring	Initial monitoring is through field observations by UEBT and partners, who define guidance for farmers and companies to monitor thereafter. Google Earth is used to draft farm polygons and calculate total area of semi-natural habitat. In parallel UEBT will test in the cassia pilot remote sensing technology for tracking these metrics in order to improve time- and cost-efficiency of monitoring.	

Source: UEBT

5.2 Target-setting

These indicators and associated metrics can provide a basis for corporate target-setting on regenerative agriculture outcomes. Defining targets or thresholds is not in the scope of this effort but there are numerous resources to help companies define appropriate targets, monitor and disclose progress.

Companies along the full agri-food value chain are likely to be developing targets and strategies to address impacts on nature and contribute to global goals for nature recovery (such as through alignment with the nature-positive concept).[48] Both regulatory and voluntary corporate sustainability frameworks require (or strongly recommend) that companies set targets related to dependencies, impacts and risks, disclose them and report on progress (such as the EU CSRD, TNFD, CDP, GRI, ISSB).[49] SBTN has developed methods to set corporate science-based targets for impacts on nature that align with global goals of nature recovery and consider local context.[50] These are useful resources for target-setting regardless of whether a company is aiming for official verification or not.

Resources for nature-related target development and tracking include:

→ **SBTN Land Guidance** – for companies setting science-based targets for land in direct operations and upstream activities.

→ **SBTN Water Guidance** – for companies setting science-based targets for water stewardship.

Regenerative agriculture can play an important role as part of these strategies, helping to reduce risks and minimize the impact of production systems on nature. We recommend the outcomes and metrics presented here for use as part of wider strategies for tracking farm- and landscape-level outcomes from regenerative practices and reporting progress at the corporate scale.

However, regenerative agriculture is only part of the strategy required for most organizations. They need to implement further actions to avoid, minimize, restore and compensate for impacts. Strategies should consider impacts throughout value chains and at the landscape scale. Generally, it is important to consider trade-offs when developing targets to avoid achieving one objective at the cost of another or, where unavoidable, to be able to make an informed and transparent decision.

Demand for regenerative agriculture is growing and transforming entire supply chains: this shift by major food and beverage companies creates a demand signal to traders, producers and cooperatives along the value chain.

Premiums for regenerative agriculture are developing: offtakers are showing increased willingness to pay premiums to producers as this helps in securing “sustainable” sourcing in the face of increased competition among buyers and enabling suppliers to comply with more demanding regulation (e.g., EU Deforestation Regulation, Brazil Forest Code, etc.). For examples, see **OP2B case studies** and **WBCSD Nature Positive Roadmap** and landscape **deep dives**.

5.3 Remaining gaps and challenges

Data for measuring biodiversity-related outcomes

A range of resources and datasets is available to help measure the outcomes of regenerative agricultural practices (see **Annex E**). However, there are also significant challenges in generating appropriate, high-quality data relevant to biodiversity outcomes across different farming contexts. Measuring the integrity and extent of NSH within farmed landscapes requires up-to-date, high-resolution data on vegetation and habitat types within farms, which organizations will likely improve in the near future with enhancements in satellite imagery. Similarly, pesticide risk currently relies on toxicity indicators where there are often gaps or limitations in the underlying evidence base. Improvements in models for measuring pesticide risks (such as through updates to EIQ or incorporating more aspects of toxicity into USETox – see **Annex D**) will likely improve the accuracy of metrics.

Limited evidence base for some practices

There is often a good evidence base for the outcomes of many regenerative practices to improve biodiversity-related outcomes at a field or farm level. For example, the Conservation Evidence project has many examples of agri-environment practices that can lead to improvements in biodiversity in the farmed landscape.[51] However, the evidence base is sometimes mixed or limited. The research and agri-business communities need to do further work to build the evidence base for regenerative practices in different contexts. A solid evidence base for the effectiveness of specific practices is essential when deciding to measure responses instead of pressure or state indicators, which can be more costly and time consuming to assess.

Understanding trade-offs between yield and environmental gains

As highlighted as a key guardrail for the use of these metrics (**Annex D**), yield and production statistics are important to consider when transitioning to regenerative practices. In some cases, regenerative agriculture may lead to yield increases[52] (possibly more often in the long term than in the short term). However, this is difficult to test given inconsistencies thus far in defining regenerative agriculture. Given documented crop yield stagnation under conventional practices and accelerating climate-driven impacts, an understanding of the potential impacts of regenerative agriculture practices on yield is an important research area,[53] including the need for more field references in different contexts. The RAM working group seeks to align on a holistic set of metrics across the environment, social and economic categories. The socioeconomic chapter will provide recommendations and guidance on metrics related to farmer livelihoods.

Interoperability of standards and frameworks

There is a clear need for a high degree of interoperability and connectivity with existing frameworks and platforms, including standards, reporting and disclosure. This work seeks to align and drive the incorporation of regenerative agriculture into these systems to strengthen corporate performance accountability systems for carbon, nature and equity.

Case study: Bayer Crop Science

Regenerative agriculture is Bayer's vision for the future of farming. Bayer believes that regenerative outcomes can reshape global agriculture for the better as we face the challenges of climate change and food security. Bayer is bringing theory into practice through a network of farms committed to regenerative agriculture known as the Bayer ForwardFarming network.

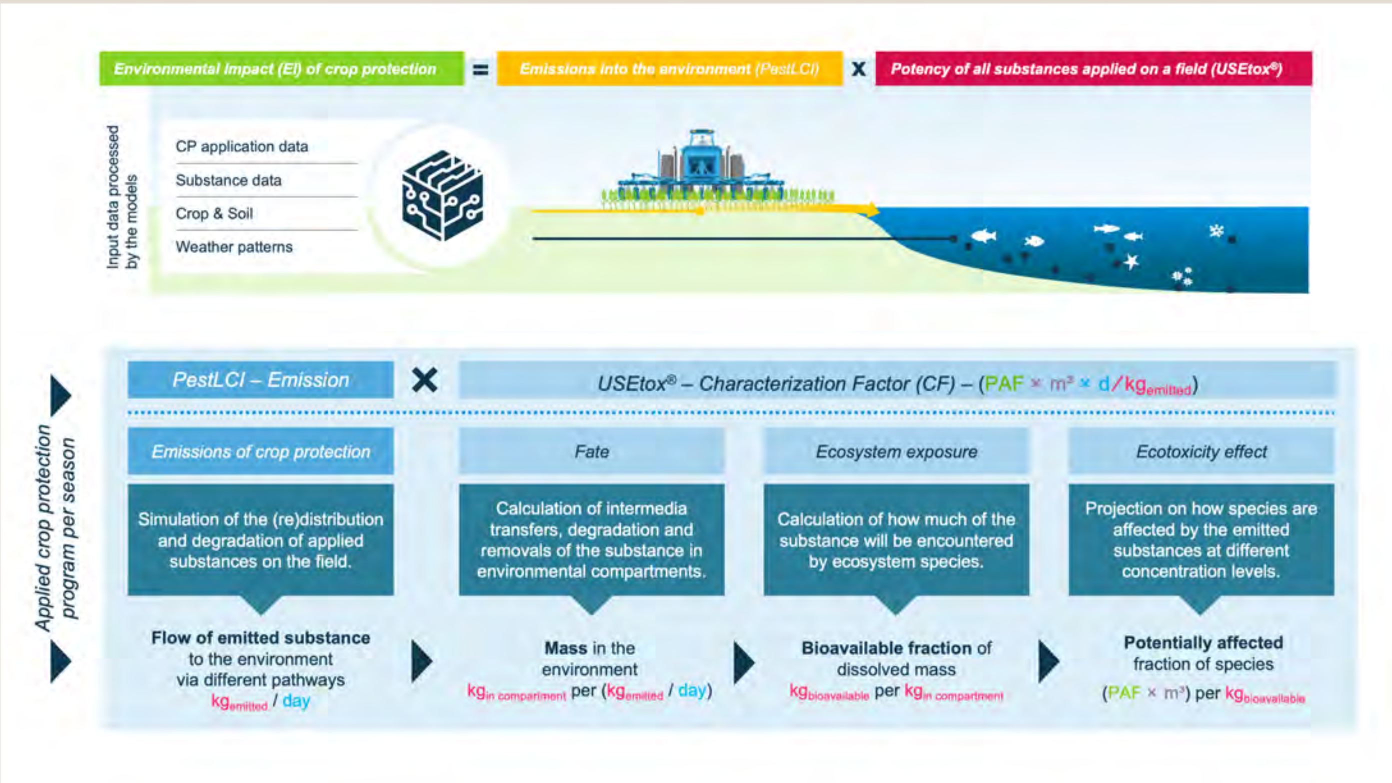
Across the ForwardFarming network, Bayer partners with independent farmers to show how tailored solutions, modern tools and practices, proactive stewardship measures and partnerships are enabling farmers to run successful businesses, while providing enough food for a growing world and in a way that preserves the environment.

In Latin America, Bayer is supporting farmers with tailored crop rotations for the region and recommendations for seeds, crop protection (CP) and agronomic practices such as cover crops. This system is compared with the average farm management practices of the corresponding region. On the ForwardFarm in Argentina, Bayer has implemented this program over the course of eight years, collecting data on both economic and environmental parameters.

Among other outcomes, Bayer assessed the environmental impact of the crop protection spray programs using externally-developed consensus models (PestLCI and USEtox®), which require information about the active ingredients applied and application methods. This approach allows for capturing improvements in the environmental impact of crop protection based on changes in applied products, their volume and the application method. The graphic below outlines how the two models work together to produce the final relative value.

The program has demonstrated a 13% increase in crop productivity and a 22% increase in gross margin/ha for the farmer, while at the same time improving the carbon footprint (CO_2 eq kg/ha) by 65%, sequestering 1.428 kg CO_2/ha, increasing biomass by 40% and reducing the environmental impact of CP by about 30%. The main drivers for the latter were a change in CP products mainly due to different weed and pest pressure in the improved system. This also required slightly less CP volume compared to the baseline system. Learn more at: [Agrícola Testa | Bayer Global].

The approach of using consensus models is part of the evolution in metrics for capturing pesticide impacts, from pure input-based approaches (ie, volume), to hazard-based approaches (ie, EIQ), to risk-based approaches which can capture innovations such as improvements in CP product environmental profile and application methods. Expanding the scope of PestLCI and USEtox® to capture broader impacts (beyond aquatic systems) and continued field-testing will help inform the path ahead for Bayer and other stakeholders.



Source: Bayer Crop Science

Next steps to *accelerate the transition to regenerative agriculture*

06.

06. Next steps to accelerate *the transition to regenerative agriculture*

The ultimate objective this work is to enable companies to measure and report on the main outcomes of regenerative agriculture. The concept of nature – as the enabler of life on Earth and all social and economic systems – underpins our holistic approach to measuring regenerative agriculture. To date, this working group has published recommended metrics for outcomes on climate, water and biodiversity.

Our work with OP2B on regenerative agriculture metrics aims to address common pain points in the system relating to "measure and manage performance". Aligning on a common set of indicators to measure the outcomes of regenerative agriculture will lead to outcomes that align, incentivize and accelerate progress on nature targets (as well as net-zero emissions and equity-related targets) and secure the necessary financing to propel the transition by cultivating transparency.

In 2024, WBCSD and OP2B will continue to facilitate the system-wide transition to regenerative agriculture as part of the broader drive for corporate performance and accountability on climate, nature and equity, as well as action at landscape level and enabling environment. This includes:

Accountability

- → Framing regenerative agriculture outcomes and metrics within the broader context of sustainable land use, as outlined in the *Roadmap to Nature Positive* for the agri-food system;[54]
- → Engaging with the relevant reporting frameworks and standard-setting bodies (including the Task Force on Climate-related Financial Disclosures (TCFD), TNFD, SBTN, GHG Protocol, CSRD, Science Based Targets initiative Forests, Land and Agriculture (SBTi FLAG) Guidance, CDP and others) to support 1) alignment on metrics that are scientifically robust and practical for corporate use and 2) guidance for implementation (on materiality, value chains, data challenges and more).

Landscape action

- → Clarifying the financing needs and opportunities to de-risk farmers' transition to regenerative in distinct farm archetypes. In Europe, this includes identifying opportunities for co-investment, building on the existing business case.[55] In addition, the work includes understanding costs of the transition and demonstrating the business case in a smallholder farm archetype.
- → Catalyzing public-private investment opportunities by convening roundtables to bring to light public/private investment opportunities for a large-scale landscape project feasibility study.
- → Supporting comprehensive farmer financing mechanisms by developing a guide on investment options to de-risk farmer transitions to regenerative agriculture.
- → Supporting the COP28 Action Agenda on Regenerative Landscapes, which aims to aggregate, accelerate and amplify existing efforts and new commitments to transition large agricultural landscapes to regenerative landscapes. In 2024, the Action Agenda aims to advance the mapping of existing and planned regenerative landscape efforts. It will do this by brokering partnerships across the food and agriculture value chain, with financiers and the public sector, and communicate efforts and results to amplify the landscape approach and mobilize additional action.

Enabling

- → Driving awareness of the regenerative agriculture business case in policy by improving its positioning in global fora (CBD COP16, New York Climate Week, the European Union, etc.).
- → Financing regenerative landscape projects by developing clear policy asks on blended funding for regenerative landscapes, laying the groundwork for a public-private partnership in Europe.
- → Aligning a strong position for regenerative agriculture in upcoming EU policy.

It is important to note that the leading nature-related and regenerative agriculture corporate frameworks – and the scientific methodologies and data that underpin them – continue to evolve and improve. Users should see this work as a starting point to help align industry with the regenerative agriculture outcomes and metrics that organizations are likely to develop and improve in the future. We will revisit our recommendations periodically to keep up with the latest developments.

Annex A:
Glossary

Taxonomy

Impacts

Ultimate state of nature effects sought.

Indicators

Values or characteristics that provide insight into a particular phenomenon or situation.

Metrics

System or unit of measurements.

Outcomes

Quantitative or qualitative parameters that measure achievement or reflect changes over time; may be short or long term.

Nature-related

State of nature

Refers to measures of the direct state of the environment in three categories: the state of ecosystems (extent and condition), species (abundance and extinction risk) and ecosystem services (or the state of nature's contribution to people).[56]

Pressure

Human activities that directly or indirectly change the state of the environment and ecosystem. Following the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES),[57] five key pressures contribute most to the loss of nature globally: land- and sea-use change, direct exploitation of organisms, climate change, pollution and invasion of alien species.[58]

Response

Actions taken by companies or farmers to address pressures or to improve the state of nature on farmed land.

Biodiversity-related

Biodiversity

According to IPBES, "The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. This includes variation in genetic, phenotypic, phylogenetic, and functional attributes, as well as changes in abundance and distribution over time and space within and among species, biological communities and ecosystems." [59]

Ecosystem services

According to IPBES, "A service that is provided by an ecosystem as an intrinsic property of its functionality (e.g. pollination, nutrient cycling, nitrogen fixation, fruit and seed dispersal). The benefits (and occasionally disbenefits) that people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; and cultural services such as recreation and sense of place. In the original definition of the Millennium Ecosystem Assessment the concept of ecosystem goods and services is synonymous with ecosystem services."[60]

Natural habitat

According to IPBES, "Areas composed of viable assemblages of plant and/or animal species of largely native origin and/or where human activity had not essentially modified an area's primary ecological functions and species composition."[61]

Natural or semi-natural habitat (NSH)

A habitat within or outside a crop made up of a community of primarily native, non-crop plant species, which human activity may modify but is able to contribute to enhanced ecosystem services.

Priority species (in the context of these metrics)

Those considered indicators of healthy agro-ecological systems that can help to maintain the functioning of key ecosystem services. This can include taxa of importance for ecosystem services provision, functionally important groups or indicator species of ecosystem integrity.

Annex B:
Alignment of biodiversity metrics with key frameworks

Table 5: Alignment of biodiversity metrics considered with key regenerative agriculture frameworks

Outcomes	Indicators	Metrics	Included in regenerative agriculture frameworks and tools						
			SMI	SAI Platform (0)	Cool Farm Tool (1)	Field to Market (Biod. & Land Use) (2)	OP2B (3)	Textile Exchange (4)	Regen10 (5)
Increased cultivated biodiversity	**Crop diversity**	**# crops per km²**		Needed	Needed	Intermediate	Needed	Needed	Intermediate
	Connection of habitats	Various metrics of connectivity		Needed				Intermediate	Needed
	Crop rotation	# crops in the rotation (annual crops)			Needed	Needed	Intermediate		
	Intercropping	% of intercropping (# ha with intercropping/ total farm ha) (perennial crops)			Needed		Needed	Needed	
Improved ecological integrity	Connection to off-farm habitats	Various metrics of connectivity							Needed
	Natural/ restored habitat in agricultural landscapes	**% NSH in agricultural land per km²**	Needed			Intermediate	Needed	Needed	Needed
	Land-use efficiency	Land-use efficiency/ ha per unit of production				Needed		Intermediate	Needed
	On-farm trees	Such as number of on-farm trees		Intermediate	Needed	Needed		Needed	
	Agricultural Biodiversity Indicator (FAO TAPE)								
	Tree sapling regeneration	Tree sapling regeneration rate						Needed	
Reduce pesticide risk	**Pesticide risk**	**Environmental Impact Quotient (EIQ)**				Needed	Needed	Needed	Needed

- Intermediate metric that may needed to calculate end results
- Voluntary metric, not required for reporting
- Needed metric for reporting

Table 6: Alignment of biodiversity metrics considered with key sustainability frameworks

Outcomes	Indicators	Metrics	Included in sustainability frameworks					
			SBTN Land (6)	CDP Forests	TNFD	CSRD (7)	GRI-304-Biodiversity & Agri Standards (8)	ISSB (based on CDSB Biodiversity) (9)
Increased cultivated biodiversity	**Crop diversity**	**# crops per km^2**			Voluntary			
	Connection of habitats	Various metrics of connectivity						
	Crop rotation	# crops in the rotation (annual crops)						
	Intercropping	% of intercropping (# ha with intercropping/ total farm ha) (perennial crops)						
Improved ecological integrity	Connection to off-farm habitats	Various metrics of connectivity				Intermediate		Voluntary
	Natural/ restored habitat in agricultural landscapes	**% NSH in agricultural land per km^2**	Needed		Needed	Intermediate	Intermediate	Voluntary
	Land-use efficiency	Land-use efficiency/ha per unit of production	Needed			Intermediate		
	On-farm trees	Such as number of on-farm trees			Intermediate	Intermediate	Intermediate	
	Agricultural Biodiversity Indicator (FAO TAPE)							
	Tree sapling regeneration	Tree sapling regeneration rate			Intermediate	Intermediate		Intermediate
Reduce pesticide risk	**Pesticide risk**	**Environmental Impact Quotient (EIQ)**			Voluntary	Intermediate	Voluntary	Voluntary

Intermediate metric that may needed to calculate end results

Voluntary metric, not required for reporting

Needed metric for reporting

Notes to tables 5 and 6:

→ This is the initial mapping exercise; metrics have evolved over the course of the work
→ We have included those **bolded**, or a form of them, in the recommended core metrics

0 – SAI Platform requires to enhance the number of species, further guidance forthcoming on inclusion of agricultural crops.

1 – Information on crop diversity, crop rotation and intercropping are used in the calculation of the Cool Farm Tool biodiversity score.

2 – Edges (i.e., connection of habitats), crop rotation and intercropping are used as weighting factors in calculation of biodiversity scores. Pesticide management and tree planting could potentially be included as estimates of management.

3 – Crop rotation, intercropping and crop diversity included as practices that link to the metrics.

4 – Some components of the FAO TAPE indicator are listed in the soil metrics for Textile Exchange.

5 – On farm trees could be included under preservation of landscape features.

6 – Tree sapling regeneration and connection to habitats could potentially be included as estimates of function.

7 – Connection of habitats, on farm trees and regeneration could potentially be included as estimates of function. EIQ could be included as an impact on water quality.

8 – Tree planting could be included if presence of threatened trees. A measure of pesticide risk, although not EIQ, is required by the agri-specific standards.

9 – Sapling regeneration and connectivity could be included as an estimation of function. Amount of fertilizer and pesticides used listed as a possible metric for pollution risks.

Annex C:
Metrics criteria assessment

WBCSD's technical partners first developed a set of criteria against which to evaluate each potential metric. We then scored each potential metric based on how well they met these criteria, as follows in Table 7.

Metric criteria	Explanation
1 Relevance to objective	Is the metric likely to drive effective change in the right direction?
2 Evidence base	Is the evidence base linking metric to objective adequately robust?
3 Scalability	Can the metric be aggregated across farm, landscape, corporate scales?
4 Generality	Can the metric be applied meaningfully in all geographic and agricultural contexts (either in a single version or in biome/subsector variants)?
5 Breadth	How fully does the metric cover the relevant sub-objective/indicator – would it need supplementing with other metrics in order to fill gaps?
6 Potential for standardization	Can the metric methodology be clearly defined and standardized for consistent application [also relates to verification]?
7 Potential for target-setting	Is the metric amenable to defining baselines and targets?
8 Feasibility	Are effort/cost/capacity requirements compatible with widespread implementation?
9 Potential for gaming or creating perverse outcomes	Are there significant risks that the metric could be misleading or misapplied, resulting in undesired outcomes, absence? This includes if the metric is likely to be attributable or responsive to farm-level changes.
10 Alignment	How well aligned is the metric with existing reporting frameworks?

Table 7: Scoring of potential metrics based on how well they meet the criteria

Outcomes	Indicators	Metrics	Criteria								
			Relevance to objective	Evidence base	Scalability	Generality	Breadth	Potential for standardization	Potential for target-setting	Feasibility	Potential for gaming
Increased cultivated biodiversity	**Crop diversity**	**# crops per km²**	2	2	1	1	3	2	2	3	1
	Crop rotation	# crops in the rotation (annual crops)	2	2	1	0	2	2	1	3	2
	Intercropping	% of intercropping (# ha with intercropping/total farm ha) (perennial crops)	2	2	2	1	2	1	2	3	2
Improved ecological integrity	Connection of habitats	Various metrics available	2	1	2	2	1	2	1	1	2
	Natural/ restored habitat in agricultural landscapes	**% NSH in agricultural land per km²**	3	3	3	3	2	3	3	3	2
	Land-use efficiency	Land-use efficiency/ ha per unit of production	1	2	2	1	2	2	1	2	1
	On-farm trees	Such as number of on-farm trees	1	1	1	0	3	1	1	2	0
	Tree sapling regeneration	Tree sapling regenerationrate	0	0	0	0	3	1	2	1	1
Reduce pesticide risk	**Pesticide risk**	**Environmental Impact Quotient (EIQ)**	2	2	2	2	1	3	1	2	1

0 Does not meet the criterion

1 Partially meets the criterion but has limited potential for improvement and some limited challenges/issues

2 Partially meets the criterion and has substantial potential for future improvement and some considerable challenges/issues

3 Fully meets the criterion

Notes to table 7:

→ This is the initial mapping exercise; metrics have evolved over the course of the work
→ We have included those **bolded**, or a form of them, in the recommended core metrics

Annex D:
Technical discussion of recommended metrics

Principles

Note that the nature-related sub-groups (on water, biodiversity and soils) have aligned on further points to support the general principles outlined including:

- Importance of local context;
- Spatial scope is farm boundary, unless otherwise noted;
- Metrics referring to nature-related pressures provided there is a clear evidence base linking to improved state of nature;
- Considering sub-sector differences (e.g., row crops vs grazing);
- Building in flexibility to adapt recommendations as frameworks and science continue to evolve.

The biodiversity metrics sub-group further identified key themes of relevance to complement the principles common across the broader exercise, including:

- Landscape-scale and land-use change considerations
- Production effects and risk of leakage
- Key practices (response metrics) as "guardrails" for appropriate use of pressure and state metrics
- Note ongoing/future developments in metrics and modeling (e.g., regarding ecosystem integrity, pesticide risk and other key areas).

Outcome: Improved ecological integrity

Percentage of natural and semi-natural habitat (NSH) in agricultural land (core metric)

- Type of metric: state
- Ecosystem condition components: composition, structure and function
- Spatial scope: km^2 including on-farm and up to 1 km^2 beyond farm boundary
- Temporal scope: annual or more frequent

The recommended core disclosure is to report the percentage of NSH in agricultural land, assessed per square kilometer. A developing evidence base is highlighting the importance of these habitats and their associated biodiversity in maintaining ecosystem services within the agricultural landscape, such as pollination, natural pest control, local climate regulation and the prevention of nutrient loss and soil erosion.[62] The metric is feasible to measure, scalable, amenable to target-setting and strongly aligned with other initiatives.

Assessment of this metric takes place at the km^2 level because it is important that NSH be present across the whole agricultural landscape (see also Configuration below). When a company establishes a target threshold, for example 20% of land area, it should apply this for each km^2 grid, not only as an average at the overall landscape level. The company should report the metric as a mean value across km^2 grid cells, along with standard deviation to indicate variance across cells.

For the purposes of this metric, we do not distinguish between NSH in the agricultural landscape for measurement – defining both as: A habitat within or outside a crop made up of a community of primarily native, non-crop plant species, which human activity may modify but is able to contribute to enhanced ecosystem services.

Further, we propose the following definition of "primarily native:" A majority of abundance and richness of the community is composed of native species and it retains functional characteristics of communities comprised entirely of native species.

The definition is thus inclusive of most definitions of natural habitat, including the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES).[63] To be inclusive of semi-natural habitat, the definition builds upon the definitions of IPBES[64] and the European Investment Bank, recognizing the importance of these modified habitats for the provision of some ecosystem services in the agricultural landscape. It also broadens the scope to include in-crop habitats and created habitats that can contribute to enhanced ecosystem services.[65, 67] We deemed this appropriate given the focus of regenerative agriculture on maintaining the ecosystem functioning in the agricultural landscape. However, the definition used also explicitly excludes predominately crop-based habitats or those involving mainly non-native species. In this definition, non-native species may be present but should be a relatively small proportion of the species, abundance and biomass of the assemblage. Evidence suggests that including mainly native plants in created habitats will support more biodiversity and better ecosystem service provision than planting exotic species,[68, 69, 70] although including certain exotic plant species may be useful in some circumstances, such as extending the season of food availability for pollinators in flower strips.[71] Examples of applicable habitats will vary by context but could include:

i. Patches of natural habitats (e.g., forest/woodland patches/wetland) within the farmed landscape, including set-aside areas of high conservation value;

ii. Riparian corridors planted, or left to regenerate, with native vegetation;

iii. Hedgerows, wildflower and buffer strips with native plant species used or left to regenerate;

iv. Shade grown systems where crops grow underneath a canopy of native plant species;

v. Agroforestry systems where crop plants or trees grow alongside native tree or shrub species;

vi. Field bird islands.

When interpreting the metric, it is important to recognize that different types of habitat will likely provide different levels of ecosystem function and associated ecosystem services. Intact natural habitats are likely to provide a more complete set of services than degraded ones, some semi-natural habitats will provide many of the same services as natural ones, especially when their structure is similar, but at lower levels, whereas other types of semi-natural habitat (e.g., wildflower strips) may only provide a limited number and level of ecosystem services. It is also important to use this metric alongside production statistics to guard against possible displacement impacts (see **Annex E**). Satellite imagery can be a key aid in helping assess the extent of natural habitats. Depending on their physical structure, identifying and measuring the extent of semi-natural habitats from imagery may be more challenging. Companies may require farm-level verification to ensure they capture regenerative practices in assessments of semi-natural habitat coverage.

Configuration of NSH (additional metrics)

- → Type of metric: state
- → Ecosystem condition components: structure and function
- → Spatial scope: km^2, including on-farm and up to 1 km^2 beyond farm boundary
- → Temporal scope: annual or more frequent

The core metric captures the composition of habitats in the landscape. Ensuring that enough area of NSH is present within agricultural areas is the key consideration but how the company configures those habitats (the location, size and connectivity of different areas of habitat) is also important to ensure that ecosystem functions are resilient and the company provides ecosystem services effectively across the agricultural landscape.[72] An additional set of disclosure metrics thus relates to the configuration of NSH on-farm.

There are multiple aspects of habitat configuration and multiple potential ways to measure these. Based on ecological theory, three aspects are likely to be particularly important in supporting ecosystem function and service provision within an agricultural landscape:

> Our objective is not to establish thresholds for metrics reporting or target-setting. However, it is useful to highlight the latest science and field experience. In 2023 the **Earth Commission** estimated that between 20-25% of NSH is optimal to maintain ecosystem function within the agricultural landscape (and could thus be considered as a generalized target). The same research points to 10% NSH as a minimum threshold below which several critical ecosystem services are lost altogether. We acknowledge that regional differences will affect implementation practicalities for this range of NSH percentages, i.e., between landscapes with large expanses of uninterrupted farmland (such as in the US Midwest or Brazilian Cerrado) and contexts with smaller or more fragmented farms (such as in much of continental Europe and the UK).

1. Connectivity of NSH – Connection between habitat patches (including with habitat off-farm) supports species movement and dispersal, sustaining greater species diversity and improving population persistence.
2. Presence of larger NSH patches – The presence of some relatively large habitat patches is important for maintaining source populations of species (that are able to disperse to other patches to support an overall meta-population), as well as for supporting larger or more area-demanding species such as birds of prey.
3. Proximity of NSH to production areas – Long distances between habitat and production areas of agricultural land may constrain the delivery of some ecosystem services, particularly those provided by mobile fauna, such as pest regulation and pollination.[73]

Note that these considerations have particular relevance for field-based crop or livestock systems. In other production systems, such as shade crops intermixed with NSH or extensive grazing on semi-natural pastures, different configuration aspects may be important.

Within the target proportion of land area with NSH, these three aspects of configuration will often involve trade-offs in field-based systems. The systems require a balance between larger patches and a network of habitat strips (such as hedgerows or riparian buffers) that can act both as connected dispersal corridors and to bring ecosystem services close to production areas.

A variety of configuration metrics are also available, focused on different aspects and requiring varying levels of effort to measure and assess.[74] No single metric can straightforwardly capture the three aspects of patch size, connectivity and proximity outlined above. Companies can thus best measure landscape connectivity by triangulating between the three complementary metrics. The evidence base to support detailed optimization of habitat configuration for ecosystem service provision in agricultural landscapes is also limited.

With these considerations in mind, we propose three simple additional metrics for configuration of NSH, with provisional thresholds and targets for balancing trade-offs:

- Connectance index – Relating to aspect (1), an index measuring how connected different patches of NSH are in the landscape. The metric is equal to 0 when no patches are joined and 100 when all patches are joined. We define "joined" as the habitat edges being within a defined distance of each other: we propose a threshold of 5 meters provisionally. A metric of connectivity should integrate beyond the farm boundary to ensure connection of habitats on farm with those in the wider landscape. The proposed spatial scope here is 200 meters beyond the farm boundary. (Methodology available on Fragstats.[75])
- Percentage of NSH defined as core area – Relating to aspect (2), an index measuring the area of core habitat (beyond a defined distance from the edge of a patch) compared to the overall area of NSH. Larger and more compactly configured patches will have a higher percentage of core area. In natural habitat, ecological edge effects may be apparent at long distances from the edge (100 meters or more), although this varies by ecosystem and by effect. In a regenerative agriculture context, with a focus on ecosystem services, a substantially smaller depth-of-edge threshold is more likely to be appropriate. The proposed distance-from-edge threshold here is 15 meters. (Methodology available on FRAGSTATS.[76])
- Field border density – Relating to aspect (3), the length of all borders of agricultural fields composed of NSH, per total crop area (units: m ha-1). This includes, for example, hedgerows, buffer strips and flower strips that meet the definition of NSH. Provisionally, we propose a minimum width of 2 meters for conserving borders as NSH.[77] For a defined minimum proximity to crops (i.e., the distance from field border to field center) there will be a defined minimum field border density. (Methodology outlined in Hass et al. 2018.[78])

It is best to measure landscape connectivity by triangulating between the three complementary metrics. If a user were to pick only one or two, they would need to be aware of the limitations and need to report consistently. The optimal configuration for NSH – and the balance between the three aspects measured by these configuration metrics – will vary by context. Unfortunately, evidence to support configuration design remains limited, as understanding what will work best in a particular landscape and agricultural context requires detailed information on the flow of local ecosystem services and the connectivity required for their continued functioning.[79]

Based on the example below, we suggest placeholder minimum targets for these metrics below. Companies may adapt these for particular agro-ecological contexts where relevant additional evidence is available.

- Connectance index: value of at least 80
- Field border density: at least 100 m/ha
- Percentage of NSH that is core area: at least 30%

An important consideration when contemplating configuration is the imperative to conserve existing areas of natural habitat on-farm, especially larger patches and areas identified as being of high conservation value. Established natural habitat will often have high biodiversity value that is challenging and slow (or impossible) to restore or create elsewhere and conversion of natural habitat does not align with regenerative agriculture outcomes nor with global goals for nature. Appropriate management interventions are to protect such threatened to degraded areas, allowing natural recovery, and to improve their connection to other natural habitat areas by creating or restoring habitat corridors.

Assessing and balancing configuration metrics: a simple worked example

Companies should apply the three configuration metrics for NSH as a set, with an appropriate balance struck between field border density (relating to proximity to production area) and core area (relating size and shape of larger patches) in particular.

Connectance: Connectance (relating to simple connectivity between patches) should be as close to 100 as possible, meaning all patches are physically connected (within the threshold distance to be considered "joined"). However, companies can achieve an index of 100, in theory, with two connected patches, which is clearly not an optimal configuration – hence they must also consider field border density and core area.

Field border density: Use a target for proximity to calculate a minimum threshold for field border density, i.e., the threshold distance for the border from the center of the field. An appropriate target proximity will depend on the agro-ecological context and the ecosystem services prioritized. The evidence for this is limited and context-specific (e.g. examples for pollination[80]) - we suggest a default target of 50 meters.

For a simple rectangular field layout in a 1 km^2 (100 ha) square grid, the minimal configuration needed to meet this proximity target (with full connectance) would be for NSH field borders around the edges of the 1 km^2 grid and across the grid at 100 meter intervals. (Note that this is a minimal configuration for this target – additional north-south field borders to improve connectivity and proximity would likely improve ecosystem functioning and services.)

In this example, field border length = 13,000 meters (thirteen strips of 1 km length each) and field border density = 130 m/ha.

Core area: Taking a target of at least 20% NSH per 1 km^2, the minimum natural habitat area target for this grid is 20 ha.

With minimum field border width of 2 meters and field border length of 13,000 meters, field borders should make up at minimum 26,000 m2 or 2.6 ha.

This leaves a maximum of 17.4 ha (17,400 m2) for other NSH. If this area was one circular patch (the most efficient shape for core area), it would have a radius of c. 235 meters and a core area radius of (74-15) = 220 meters. This equates to a total core area of c. 15.2 ha or 76% of the total area of NSH.

For this scenario, the configuration metrics thus should have a minimum value of 130 meters/ha for field border density and a maximum value of 55% for NSH that is core area. Expectations are for the optimal – and practical – configuration to sit between these limits.

Abundance of priority species (additional metric)

- Type of metric: state
- Ecosystem condition components: composition
- Spatial scope: on-farm and up to 500 meters beyond farm boundary
- Temporal scope: annually for multiple years, preferably >=5 years

The composition of ecosystems is another important component of ecosystem integrity. Many species and species groups are vitally important for the provision of ecosystem services within agricultural systems and agricultural activity can negatively impact them. For example, pollinator-dependent crops make up 35% of global crop production, yet wild pollinators have declined substantially at local and regional scales.[81] Some insect and vertebrate taxa are also important in helping to control pests.[82] Other species are considered characteristic of healthy agro-ecological systems, such as a suite of farmland bird species in the UK.[83] As an additional metric, we recommend the identification of priority species on farms and the measuring of their relative abundance over multiple years to assess trends. At the farm level, the proposed metrics to report are:

- The number and proportion of priority species with stable or increasing populations.
- An aggregated population trend indicator showing average change in species abundance, compared to a baseline measure, over time. The calculation is the geometric mean of percentage change over time in individual species populations, a simple version of the Living Planet Index method.[84]

At the corporate scale, companies would report the number and proportion of farms where all (or a threshold proportion) of priority species are stable or increasing and a mean and standard deviation for the aggregated population trend index.

Because biodiversity and the services that species support are so location-specific, it is not feasible to define a universally applicable metric focused on a pre-defined set of taxa. Selection of priority species also needs to take into account the feasibility of monitoring change in abundance over time, as for some species and situations this can be technically demanding and costly.

For the purposes of this metric, we define priority species as: *those considered indicators of healthy agro-ecological systems that can help to maintain the functioning of key ecosystem services. This can include taxa of importance for ecosystem service provision, functionally important groups or indicator species of ecosystem integrity.*

Examples may include pollinator species, species of importance for pest control or freshwater invertebrate groups used as an indicator of freshwater ecosystem condition. By defining priority species in this general way, companies operating in very different contexts can apply the metric. It is also compatible with other abundance-based metrics for key taxa such as the EU-NRL Grassland Butterfly Index[85] and the UK Farmland Bird Index.[86]

The metric will usually require the collection of farm-level data on species presence and abundance. The proposed default spatial scope is farm boundary plus 500 meters but companies may adjust this (with clear rationale) based on local context.

When designing data collection and undertaking and reporting analysis, it is important to consider several points:

- Species abundance can fluctuate substantially within and between years for a variety of reasons and changes in abundance may not always be attributable to the actions of a specific farm – particularly for highly mobile species.
- Companies should therefore carry out monitoring over multiple years and ideally at least once a year, within the same season (preferably on approximately the same dates) for particular species.
- Companies can survey different target species/groups at different times of the year if ecologically appropriate.
- Sampling should cover the appropriate natural, semi-natural or modified habitats across farm in an unbiased way (e.g., through a systematically allocated set of sample points in flower strips).
- Survey efforts should consider the statistical power needed to detect actual changes (see below).
- Companies can calculate changes in population from two time points in theory but this is likely to be unreliable. Preferably, they should plot trend line slopes to multi-year data (ideally five years or greater) to assess overall change over time. They should ensure that positive change is statistically detectable (i.e., the probability that trend line slope does not differ from zero is <0.05) before reporting it.
- In reporting the metrics, companies should explain which taxa they've included in the calculation, why they were selected and the timeframe and methods of surveys.

Aligned with Taskforce on Nature-related Financial Disclosures (TNFD) guidance, we note that realm-scale metrics such as mean species abundance (MSA) and ecosystem integrity index (EII) can help estimate the state of biodiversity by extrapolating data on pressures and general responses of biodiversity to pressures. These kinds of metrics are suitable for footprinting assessments and for identifying where to focus more detailed data collection and interventions across a wide range of sites. However, such global layers are unlikely to be responsive to changes in local biodiversity (relevant to the MSA and one of the three components of the EII – composition), so may need reassessment at a local scale for use as farm-level metrics.[87]

Example for annual reporting at farm scale (means ± standard deviation)

- Core: NSH in the farmed landscape
  - Mean 17 ± 4% coverage of NSH per km^2
- Additional: Configuration of habitats
  - Field border density = mean 220 ± 45 m/ha per km^2
  - Connectivity index = 65 ± 40 per km^2
  - Percentage of NSH in core area = 40 ± 18 % per km^2
- Additional: Abundance of priority species
  - Out of 10 priority species monitored over at least 3 years, 9 (90%) are stable or increasing in abundance and 1 (10%) shows decreases
  - Abundance trend index for priority species: +4% per year

Outcome: Improved crop diversity

Crop diversity index (core metric)

- Type of metric: state
- Ecosystem condition components: composition
- Spatial scope: farm boundary
- Temporal scope: over a defined time period (three years recommended)

There is a growing evidence base that increasing the diversity of crop species, inclusive of key regenerative practices such as intercropping, cover crops and crop rotation, can improve ecosystem service provision in the agricultural landscape.[88] Effects vary according to specific contexts and there is a limited evidence base for the positive impacts of some practices but, in general, crop diversification practices can lead to enhanced crop production, biodiversity and associated ecosystem services.[89, 90] This in turn can help improve resilience to biotic, abiotic and economic risks at the farm and landscape levels.[91] For example, organizations are increasingly promoting using N-fixing crops in crop systems or as cover crops as a form of diversification.[92]

A challenge in designing a single metric for crop diversity is that there are many different approaches to increase crop diversity, the appropriate one varying with context. Crop rotation, intercropping and cover crops could be relevant in different circumstances and diversity is representable in both space (e.g., intercropping) and time (crop rotation). The balance between different crops is also important – just considering the total number of crop species (as in some other frameworks) is potentially misleading. For instance, if one crop dominates production with very small areas given over to others.

Similar issues arise when measuring species diversity. Companies can assess crop diversity in a single metric using an adapted species diversity index. Such an index can incorporate both the number of crop species/varieties and their spatial and temporal evenness.

The "Hill series" mathematically generalizes species diversity indices, with different exponents related to different index properties, in particular how indices weight the number and evenness of species. For crop diversity, the metric proposed is a modification of the Hill-Shannon Index for calculating species diversity, which is a balanced and widely applied diversity metric.[93]

The crop diversity index accounts for both the number of crop species planted and their evenness over space and time and is inclusive of different practices to increase crop diversity. Companies calculate the measure over a defined time period (proposed as 3 years) and at the km^2 level. Note that the km^2 scale is the denominator for reporting, as farms differ in size. Inputs required are: number of crop species, area planted per km^2 and number of months the crops are present. We provide details on the methodology for this metric below.

For crop-based systems, companies can readily apply the metric across farms and aggregate it at a corporate level. There are, however, challenges with defining appropriate baselines and targets across different agricultural settings. This will require further research. For example, the metric may be less well suited to solely perennial crop systems (although companies would include these crops in the calculations).

It is also of limited applicability for some livestock systems, although potentially relevant for grazing systems. Companies could use the metric to look at the diversity of grasslands/swards in some settings where improved grassland diversity can lead to increased ecosystem function. If used in this way, the company should report the metric separately from the crop diversity metric and not combine it into an aggregated score that covers both crops and grasslands.

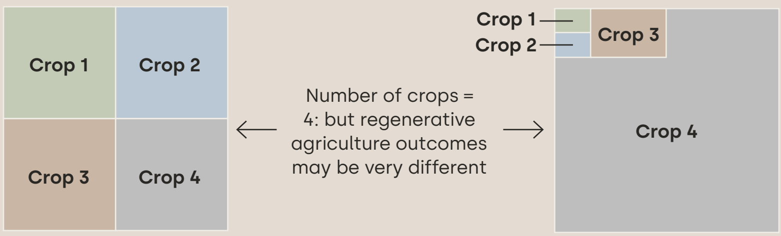
There is only a limited evidence base for animal diversity itself as a contributor to regenerative agriculture outcomes.

Disclosure examples for annual reporting at farm level:

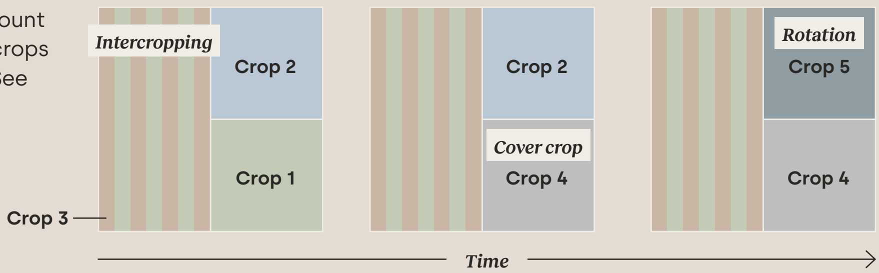
→ Core: Crop Diversity Score for preceding three years
  - Mean Crop Diversity Score 6.2 ± 1.8 (standard deviation) per km^2
  - Achieved through implementation of cover crops on 50% of land, crop rotation on 100% of farmland and intercropping on 5% of land.

Deeper dive: calculating crop diversity

A simple "richness"-based metric for crop diversity (i.e., number of crops grown) has the potential for misapplication as companies could achieve increases in the metric in different layouts and timeframes of crop production, which are likely to have differing benefits in terms of ecosystem functioning. See an extreme example in the image to the right.



A diversity metric therefore needs to account for differences in the extent of different crops and how those crops change over time. See some examples to the right.



Companies can address both these issues using an adapted species diversity metric that incorporates both the number of crop species/varieties and their spatial and temporal evenness. A range of species diversity metrics are available that account for the number of species and their evenness in a sample (e.g., Simpson's Diversity Index, Shannon Diversity Index). Different species diversity metrics balance number and evenness differently.[95]

The "Hill series" mathematically generalizes diversity metrics, with different exponents related to different metric properties. We recommend using the Hill-Shannon metric. This is a version of the classic Shannon diversity metric, defined as the Hill number when the exponent tends to zero.[96] We have chosen this as it is a balanced metric that does not favor either "rare" or "common" crops in the calculation.

To calculate the metric, companies should follow these steps:

1. Over a defined timespan assess for each crop species/variety per km^2:
   - The area cultivated (ha)
   - The number of months the crop was present (mo)
   - For each crop i, then calculate the:
2. Number of ha-months (ha-mo) crop cultivated
   - Proportion of the total ha-mo represented by this crop, Pi
   - (Total hectare-months per km2 over three years = 36 x 100 = 3600 ha-mo)
3. Calculate the Hill-Shannon crop diversity across all crops, per km^2

$$e^{-\sum_{i=1}^{S} p_i \, ln(p_i)}$$

Companies can interpret the calculated diversity as an effective number of crop species or varieties, i.e., equivalent to the number of crop types grown in a perfectly even system. The table below representing a range of different cropping systems provides examples to aid with calculation:

Crop	Traditional monocropping		Intercropping –small areas for non-main crop		Crops in rotation (each year)		Intercropping, rotation or crops per cycle	
	Ha-mo	P_i	Ha-mo	P_i	Ha-mo	P_i	Ha-mo	P_i
A	*3600*	*1*	*3475*	*0.97*	*1200*	*0.33*	*600*	*0.17*
B			*25*	*0.01*	*1200*	*0.33*	*600*	*0.17*
C			*25*	*0.01*	*1200*	*0.33*	*600*	*0.17*
D			*25*	*0.01*			*600*	*0.17*
E			*25*	*0.01*			*600*	*0.17*
F			*25*	*0.01*			*600*	*0.17*
Total	**3600**		**3600**		**3600**		**3600**	
Number of crops (S)		**1**		**6**		**3**		**6**
Hill-Shannon diversity		**1**		**1.23**		**3**		**6**

Outcome: Reduced pesticide risk

EIQ field-use ratings (core metric)

- → Type of metric: pressure
- → Ecosystem condition components: n/a
- → Spatial scope: farm boundary
- → Temporal scope: annual or more frequent

Pesticides can pose a key risk to farmland biodiversity and some can accumulate in receiving water bodies, persist in the soil or bio-accumulate in food chains, potentially leading to detrimental impacts on human health, livestock and the wider environment.[97] Impacts of pesticides depend on type and exposure but can affect a wide range of taxa directly and indirectly, including aquatic biodiversity,[98] soil fauna,[99] pollinators[100] and potentially birds.[101] Reduction of pesticide risk is key to maintaining ecosystem services on-farm and reducing broader environmental impacts, aligning with the Global Biodiversity Framework's Target 7.[102]

The Environmental Impact Quotient (EIQ) is a widely used measure to assess the hazards posed by different pesticides.[103] The approach uses published literature to score the toxicity of pesticides to different components of biodiversity, as well as to health of farmers and the general human population. It then combines the different toxicity scores into an aggregate toxicity score for the product. The approach is considered straightforward and scores are accessible via a public database, although there is significant farm-level data needed including dosage, product formulation and frequency of application.[104]

To indicate biodiversity-related regenerative agriculture outcomes, it is appropriate to use the ecological component of the score, which considers hazards to both terrestrial and aquatic fauna, including key groups important for ecosystem service provision (e.g., pollinators). From this, the company calculates a field-use rating, combining this ecological toxicity score (a measure of overall ecological hazard) with the application rate of active ingredient per hectare. As intermediary metrics, disaggregated reporting of EIQ and pesticide application rates shows if farms are moving towards using less-risky pesticides and also reducing application rates for those pesticides. Considering aggregated EIQ field-use ratings alone can mask a lower-rate use of more risky pesticides.

Although EIQ is widely used, as a hazard-based metric, it does not provide a measure of *overall pesticide risk*.[105] This includes how different toxicity components are weighted in its calculation and unsuitability of its scoring system for assessing severely high-risk pesticides. It also does not take into account how companies may mitigate risks through, for example, different application techniques and technologies. Organizations are likely to further develop the approach, with ongoing field trials by Regen10 and research (ongoing at Cornell University) looking to publish a new version in the coming years.

An alternative approach to assess pesticide risk is USETox, which would be combined with PestLCI, a modular model for estimation of pesticide emissions from field application to the different environmental compartments (see case study above on Bayer Crop Science approach).[106] This provides a risk-based score based on the amount of pesticide used combined with an estimate of their ecotoxicity, exposure risks and fate. This approach is more sophisticated but also technically more demanding to apply than EIQ. It currently only measures specific aspects of ecotoxicity (i.e., aquatic ecotoxicity) but its further development is likely to include more components (i.e., effect on pollinators, soil and air pollution, farm workers and end-consumers). A public-facing calculator under development will help increase understanding and field-testing of this metric as a complement to or potential improvement on EIQ. Pesticide risk assessment is an evolving technical field and we plan to revisit the recommended metrics for this outcome in the future.

Disclosure examples for annual reporting at farm level:

- → Core: EIQ ecological component field use rating
- → Intermediate metrics: Overall EIQ scores. Application rate.
  - – e.g., EIQ (10.2), % active ingredient (15%), x application rate (4 kg per acre)
  - – EIQ field-use rating = 6.1
  - – EIQ ecological component field-use rating = 7.2

Additional technical notes

Links to other metrics and environmental outcomes

These indicators and metrics aim to capture the major impact pathways through which agricultural activities influence ecological integrity, cultivated biodiversity and pesticide risks. Other RAM chapters capture additional pathways that can also impact biodiversity and biodiversity-related environmental outcomes:

- Excess use of nutrient fertilizers can be highly damaging to some biodiversity components in the agricultural landscape, leading in particular to eutrophication of receiving and downstream water bodies. **The water-related metrics** capture the pressures caused by nitrogen (N) and phosphorous (P) application and runoff.
- Soil biodiversity is an important aspect of biodiversity in the farmed landscape. The water- and soil-related metrics include those related to soil health.

For the pressure metrics included here (e.g., pesticide risk), there is a clear link between changes in those pressures and expected changes in biodiversity. Directly assessing state measures (e.g., for water and soil quality that capture pesticide levels) can be challenging and resource intensive. It may also be difficult to attribute findings to actions at individual farms, as in many cases upstream inputs in the wider hydro-basin will influence both baseline levels and trends over time.

Aggregating metrics

Companies can aggregate metrics measured at the farm level straightforwardly to other scales, such as for all operations within a defined landscape or region; all operations producing a particular commodity; or to the corporate level. Companies should weight farm-level measures by farm area (or the area over which they've made measurements) when averaging, to ensure an appropriate proportional contribution to the aggregate value from different-sized farms. They should also contextualize aggregate values expressed as ratios or percentages by providing total quantities (e.g., total area, total application of pesticides, etc.). Reporting the variation in means (as standard deviations or the maximum and minimum values) is good practice that helps interpretation.

Temporal considerations

Companies should measure the metrics against a historical baseline that they define – for example, previous year or year the regenerative agriculture project commenced. For some metrics (e.g., pesticide risks), temporal variation in measurements is expected based on seasonal changes, crop production cycles and varying weather conditions. Companies should collect metrics over timeframes appropriate to incorporate such variations and allow meaningful comparisons and assessment of trends. It is also important to be aware of these influences, to help interpret short-term changes in metrics, and assess long-term trends that may be more responsive to regenerative practices on-farm. Many of the metrics are amenable to reporting annually in line with corporate sustainability reporting cycles but companies could report them over longer or shorter timeframes, i.e., to reflect seasonal or short-term changes in outcomes.

Thresholds for metrics

The purpose of this guidance is not to define thresholds for target-setting related to the respective metrics and indicators. However, defining such thresholds will be useful as companies push to develop targets for regenerative agriculture and broader nature strategies that align with global sustainability targets. Leading organizations are developing resources to help define appropriate thresholds and set compatible targets. Namely, the Science Based Targets Network (SBTN) provides guidance on setting science-based land and freshwater targets for nature. As an example, the Earth Commission has recently estimated that maintaining effective ecosystem services in agricultural landscapes requires 20-25% of the human modified landscape to be set aside as NSH.[107] This guidance outlines provisional minimum targets for landscape configuration elements but they require field testing.

Guardrails for appropriate use of metrics

Viewing the metrics and outcomes from regenerative agriculture as a whole

As highlighted above, it is important to view regenerative outcomes, indicators and metrics holistically. Metrics that are not heading in the desired direction are a prompt for further investigation, followed by adaptive management to change practices if required. It may be that actions are not having the desired consequences, that the practice or the indicator is not appropriate for the specific agricultural context or that practices have positive effects for some outcomes but negative ones for others.

Yield and economic returns are vital contextualizing metrics

For many regenerative practices, there is a good evidence base showing benefits to biodiversity at a field or farm level.[108] Practices may also lead to improvements in the long-term yield of agricultural production. However, in other cases yields could decrease, particularly in the initial years of transition. When considering outcomes at the corporate scale it is important to view yield measures alongside environmental metrics to highlight potential socioeconomic benefits or displacement effects. Note the chapter on livelihoods includes metrics and guidance supporting the socioeconomic outcomes of regenerative agriculture.

No deforestation and no conversion of natural ecosystems

An important guardrail on the use of these metrics is that there should be no deforestation or conversion of natural ecosystems to clear land for farming activities, in accordance with so-called mitigation hierarchy principles.[109] This is essential for alignment with leading land-use frameworks and requirements (namely, target-setting guidance from the Science-Based Targets Network and Science-Based Targets initiative, the EU Deforestation Regulation, OP2B and others). We note that OP2B strongly supports zero deforestation and zero land conversion as an overarching imperative and considers ecosystem protection to go hand-in-hand with these principles.[110] It is considered good practice to maintain or restore existing areas of natural and semi-natural habitat or any areas of high value for biodiversity rather than to convert or degrade habitat areas and attempt to restore later. Context-specific guidelines and regulations for deforestation- and conversion-free agri-production may differ across landscapes and jurisdictions.[111]

Recognizing limitations in indicators and metrics

This guidance outlines a set of indicators and associated metrics that companies can apply generally across many agricultural contexts to show progress on desired regenerative outcomes. A standardized set of metrics facilitates consistent measurement, comparisons and aggregation. However, the great diversity of potential contexts, in relation to a location's ecology, climate, geology, history, target products, management and landscape setting, mean that a one-size-fits-all approach inevitably has limitations. Many other indicators and metrics are potentially relevant or might be more practical or robust in specific contexts.

Individual metrics may not reflect all facets of the indicators and outcomes they link to and it is important to consider this when interpreting results. For example, information on priority species abundance will only include a sub-set of monitored species deemed important for agro-ecosystem service provision and will not reflect trends in all species within the agricultural landscape. Similarly, a crop diversity metric may not capture some ecosystem benefits of specific types of agriculture, e.g., planting perennial vs annual crops.

Some metrics may have limited applicability in some agricultural contexts. For example, crop diversity may not be well-suited for intensive livestock systems. When metrics are not relevant for a particular context, the company should provide a clear rationale to explain why it has not reported them.

Landscape and supply-chain considerations

The recommended spatial scope for measuring and reporting nature-related metrics is the farm boundary, unless otherwise noted. But it is also essential to interpret some metrics in light of the wider landscape context, for example the overall presence and connectivity of NSH in the landscape.

The metrics outlined here focus on the farm-level and do not generally consider the embodied impacts of farm inputs upstream in the supply chain. This is not likely to be a major consideration for biodiversity-related metrics but if companies make changes in the source or type of inputs used, e.g., for pesticides, any large changes in the impacts of the production process (e.g., environmental toxicity upstream) they may also consider them as context for interpreting metrics on-farm.

It is also important to consider how outcomes of actions on farms may vary depending on wider landscape trends. For example, changes in pesticide or fertilizer use or the extent and configuration of the placement of NSH in the surrounding landscape may affect population trends of priority species on-farm.

Annex E: *Key resources*

Regenerative agriculture frameworks	
Biodiversity Monitor for the Dairy Farming Sector	A joint initiative of FrieslandCampina, Rabobank and the Dutch chapter of the World Wide Fund for Nature (WWF Netherlands) which aims to quantify biodiversity results to reward dairy farmers through supply chain partners and other stakeholders.
Cool Farm Tool	The Cool Farm Tool is a farm management software that allows a farmer to calculate their greenhouse gas (GHG) emissions based on simple data entry on their farm. There is also a tool to calculate water use and impacts, as well as for biodiversity. The water module, requires inputs on farm characteristics, soil type, crop grown and water sources and irrigation used. It then computes water use statistics for the user.
Field to Market Sustainability Metrics Overview Documentation	This initiative aims to help farms assess their sustainability performance using a series of indicators across various environmental themes. Field to Market has metrics for biodiversity, land use, soil conservation, water irrigation use, water quality and carbon emissions.
OP2B Framework for Regenerative Agriculture	OP2B is an international, cross-sector and action-oriented business coalition on biodiversity with a specific focus on regenerative agriculture. In 2021, OP2B, its members and partners proposed an initial set of four key principles and eight indicators for measuring progress on regenerative agriculture.
Regen10 Zero Draft Outcomes-Based Framework	Regen10 is a global endeavor committed to achieving regenerative outcomes for people, nature and climate. When complete, the framework will provide a holistic set of outcomes, indicators and metrics to understand and measure change that happens over time on farms and across landscapes.
Sustainable Agriculture Initiative (SAI) Framework for Regenerative Agriculture	This initiative aims to drive alignment on the use and measurement of regenerative agriculture practices. It defines 4 impact areas: soil health, water, biodiversity and climate. A given farm/organization then uses these criteria to identify the most "material" risks. It identifies 10 outcome metrics to measure progress against the 4 impact areas. It then provides a list of practices for use to help deliver against these impact areas, which require monitoring to assess progress.
Sustainable Markets Initiative	A taskforce assigned to help scale regenerative farming. It has identified four levers to create change: A) funding, re-risking and new sourcing models, B) priority common metrics for environmental outcomes, C) government policy requirements to reward farmers for transition and D) ways to make environmental outcomes pay. Priority metrics include: greenhouse gas (GHG) emissions factors, soil organic carbon, natural and restored habitat in agricultural land, blue water withdrawal and nitrogen-use efficiency.
Textile Exchange Regenerative Agriculture Outcome Framework	This framework helps the fashion, textile and apparel industry align on outcomes for regenerative agriculture by providing a range of farm and corporate level metrics. The framework splits the farm-level outcomes into those related to social and economic equity (e.g., human rights, sharing costs and risks, rights of indigenous community), animal welfare (e.g., good health and welfare) and ecological health.
UEBT Regenerative Programme	Framework used to engage companies that wish to promote regenerative practices and contribute to the UEBT vision of a world in which all people and biodiversity thrive

Corporate sustainability frameworks	
CDP - Forests	A corporate disclosure program focused on risks posed to forest ecosystems.
Corporate Sustainability Reporting Directive (CSRD)	This EU initiative on corporate sustainability reporting requires all large companies and listed companies to disclose risks and opportunities from social and environmental issues, as well as their impacts.
Global Reporting Initiative (GRI)	This commonly used reporting framework provides disclosure requirements for various environmental and social topics, including water and biodiversity-specific frameworks. It also includes a specific standard for agriculture, aquaculture and livestock.
International Sustainability Standards Board (ISSB)	The framework under development is for sustainability-related risks and opportunity disclosures. It has issued the International Financial Reporting Standards (IFRS) 1 and 2 on general requirements and climate related disclosures in 2023. It is in the process of developing standards for other sustainability topics. It recommends using the Climate Disclosure Standards Board's (CDSB) guidance for water, which remains useful until the ISSB issues guidance on the topic.
Science Based Targets Network (SBTN)	Provides guidance on setting targets for nature. It splits the process into five steps: 1) assess organizational impacts, 2) interpret and prioritize results, 3) measure, set and disclose targets, 4) act to deliver the targets and 5) track progress. Guidance is available for the first three stages at present. There is also specific guidance for setting SBTs for freshwater.
Task Force on Climate-related Financial Disclosures (TCFD)	This is a market-led initiative launched by the Financial Stability Board (FSB) in 2017. It aims to support stakeholders in assessing risks related to climate change by promoting disclosure of climate impacts and risks.
Taskforce on Nature-related Financial Disclosures (TNFD)	This is a market-led initiative launched in 2021. The initiative builds upon the related TCFD, aiming to give the same focus for nature and biodiversity. The TNFD Framework ultimately aims to support a shift in global financial flows away from nature-negative outcomes and toward nature-positive outcomes. The TNFD recommends metrics for core disclosures as well as metrics and guidance specific to different sectors and biomes and other related guidance.
Taskforce on Nature-related Financial Disclosures (TNFD) Tools Catalogue	The TNFD tools catalogue contains useful resources on biodiversity and other nature-related topics.
Taskforce on Nature-related Financial Disclosures (TNFD) Food & Agriculture Guidance	This draft provides the sector-specific core and additional disclosure requirements and guidance for the TNFD, specific to the food and agriculture sector. TNFD will finalize this guidance in 2024.

Biodiversity-related resources	
Environmental Impact Quotient (EIQ) Calculator and Pesticide Values	A resource to help explain EIQ methods, an online calculator and access to the underlying EIQ toxicity scores over 500 pesticides.
Conservation Evidence	A resource highlighting the available evidence for the effects of different conservation actions on biodiversity. This includes many actions relevant to regenerative agriculture
FRAGSTAT	A useful resource for accessing information on connectivity metrics between patches of habitat.
HESTIA	Data on the environmental impacts of different production practices across the value chain.
New Zealand Sustainability Board Biodiversity Assessment Tool Prototype	This tool makes it easy to assess and report on how biodiversity-friendly farm management actions are.
Our World in Data	A useful resource for providing information on biodiversity impacts.
USETox	A scientific consensus model for characterizing human and ecotoxicological impacts of chemicals – as a complement or potential risk-based metric alternative to EIQ in the future

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About Regen10

Regen10 is a global endeavor committed to achieving regenerative outcomes for people, nature and climate. Originally funded by IKEA Foundation and The Rockefeller Foundation, Regen10 has recently secured further funding from the McKnight Foundation to support its work. In addition to WBCSD, partners include 1000 Landscapes for 1 Billion People, The Food and Land Use Coalition, Global Alliance for the Future of Food, IUCN, Leaders' Quest, Meridian Institute, Sustainable Food Trust, Systemiq, and World Farmers' Organisation.

www.regen10.org

About One Planet Business for Biodiversity (OP2B)

One Planet Business for Biodiversity (OP2B) is an international, cross-sectoral and action-oriented business coalition on biodiversity with a specific focus on regenerative agriculture. We are determined to drive transformational system change and catalyze action to protect and restore cultivated and natural biodiversity within agricultural value chains. The coalition focuses on scaling up regenerative agriculture; developing transparent outcome-based reporting for regenerative agriculture; advocating for positive policy for de-risking the transition for farmers; and promoting crop and food ingredient diversification.

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About WBCSD

The World Business Council for Sustainable Development (WBCSD) is a global community of over 220 of the world's leading businesses, representing a combined revenue of more than USD $8.5 trillion and 19 million employees. Together, we transform the systems we work in to limit the impact of the climate crisis, restore nature and tackle inequality.

We accelerate value chain transformation across key sectors and reshape the financial system to reward sustainable leadership and action through a lower cost of capital. Through the exchange of best practices, improving performance, accessing education, forming partnerships and shaping the policy agenda, we drive progress in businesses and sharpen the accountability of their performance.

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