European Commission

Measuring ecosystem condition- a primer for business

Align

Aligning accounting approaches for nature

Contributing authors: Jacob Bedford (UNEP-WCMC), Emma Calhoun (UNEP-WCMC), Sharon Brooks (UNEP-WCMC), Joël Houdet (The Biodiversity Footprint Company & Department of Business Management, University of Pretoria), Joshua Berger (CDC Biodiversité), Annelisa Grigg (GlobalBalance)

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Project consortium

The Align project - Aligning accounting approaches for nature - came into being with the objective to co-develop recommendations for a standard on corporate biodiversity measurements and valuation. Align is a three and a half-year project aiming at providing businesses and financial institutions with principles and criteria for biodiversity measurement and valuation. The Align project is funded by the European Commission. It is led by UNEP-WCMC, the Capitals Coalition, Arcadis, and ICF with the support of WCMC Europe.

EXECUTIVE SUMMARY

- **Ecosystem condition describes the overall quality of an ecosystem measured in terms of its biotic (living) and abiotic (physical rather than biological) characteristics.** It is an important concept for understanding the impacts and dependencies of business on nature.

- **Consideration of ecosystem condition is needed to meet the requirements of emerging disclosure frameworks and achieve the ambitious goals of the Kunming-Montreal Global Biodiversity Framework.** These frameworks and standards include the Corporate Sustainability Reporting Directive (CSRD), Taskforce on Nature-related Financial Disclosures (TNFD) and Global Reporting Initiative (GRI).

- **This primer aims to build on the Align project's 'Recommendations for a standard on corporate biodiversity measurement' to guide the measurement of ecosystem condition in different business contexts.**[1] The primer is designed to complement guidance developed by specific initiatives and standards, such as that produced by the TNFD.

KEY MESSAGES

- **Metrics of ecosystem condition reflect elements of ecosystem composition, structure and function.**

- **Measurement approaches for ecosystem condition vary in their underlying methods** and, in turn, in their appropriateness for different business contexts. For example, some approaches apply metrics of generic characteristics applicable across whole realms (i.e., terrestrial, freshwater and marine), whereas others apply tailored metrics of characteristics specific to individual ecosystem types or locations.

[1] UNEP-WCMC, Capitals Coalition, Arcadis, ICF, WCMC Europe (2022) Recommendations for a standard on corporate measurement and valuation, Aligning accounting approaches for nature. Available at: https://capitalscoalition.org/wp-content/uploads/2021/03/330300786-Align-Report_v4-301122.pdf

- **Increasing numbers of regional and global data layers are available to screen locations for potential risks and opportunities relating to ecosystem condition. Even so, there is still work to be done with increasing access to and coverage of these data**.

- **Condition-adjusted area (extent x condition) is a commonly applied unit** for expressing business impacts on ecosystems, but considering ecosystem condition and ecosystem extent separately is more comprehensive and meaningful for reporting against emerging disclosure frameworks.

- **How anthropogenic land uses such as cropland and pastureland are used to infer impacts on ecosystem condition is a key factor differentiating approaches and frameworks within the terrestrial realm**. Many anthropogenic land uses (e.g., urban areas) represent complete conversions of the original ecosystem type and thus result in a complete loss of condition. However, some land uses (such as agroforestry) can retain elements of the composition, structure, and function of the original ecosystem. Under these circumstances, they represent a partial loss of condition.

- **Measuring the state of ecosystems directly is the most robust way to record actual changes in ecosystem condition. The use of ecosystem specific metrics can make it possible to apply strict ecological equivalency, where losses in an ecosystem are only balanced by gains in the same ecosystem type**. However, it is still possible to estimate ecosystem condition using alternative methods when business applications only require an assessment of potential changes in ecosystem condition**.** When this is done, transparency on the approach used should be maintained. When ecological equivalency at the realm level is appropriate, realm-level metrics can be used.

- **New methods, data and thinking around ecosystem condition are rapidly developing** and the assessment of impacts and dependencies on ecosystem condition should be seen as an iterative process with flexibility to continually improve approaches over time.

1. INTRODUCTION

- **Comprehensively assessing the impacts and dependencies of businesses on biodiversity requires considering both ecosystems and species.**

- **Achieving healthy ecosystems is core to the global biodiversity policy agenda, with Goal A of the recently adopted Kunming-Montreal Global Biodiversity Framework (KM-GBF) explicitly referring to the integrity, connectivity, resilience, and area of ecosystems.** Broadly, ecosystem condition is defined as the overall quality of an ecosystem measured in terms of its abiotic and biotic characteristics[2]. Ecosystem integrity is a related concept and is further discussed in Box 1.

Box 1. What is the connection between 'ecosystem condition' and 'ecosystem integrity'?

- The condition of an ecosystem is determined by its characteristics. Characteristics of ecosystems describe elements of structure, composition, and function (section 2.1). Interpretation of measures of these characteristics, however, may vary based on management goals, e.g., biodiversity conservation versus maximizing provisioning of ecosystem services. The concept of 'integrity' helps interpret condition variables[3], where integrity is defined as the degree to which the composition, structure, and function of an ecosystem fall within their natural range of variation[4], and is often seen as the degree to which an ecosystem's key characteristics have been modified from a 'natural' state.

- Therefore, condition and integrity are often used interchangeably in differing initiatives to describe the 'quality' of ecosystems, with integrity being a useful way of framing the measurement of ecosystem condition. For example, Goal A of the KM-GBF includes that the '**integrity**, connectivity and resilience of all ecosystems are maintained, enhanced, or restored, substantially increasing the area of natural ecosystems by 2050'.

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[2] Czúcz, B., et al. (2019) Discussion paper 2.3: Proposed typology of condition variables for ecosystem accounting and criteria for selection of condition variables. Paper submitted to the SEEA EEA Technical Committee as input to the revision of the technical recommendations in support of the System on Environmental-Economic Accounting. Version of 18 October 2019. 27 pp. 3.

[3] Keith H, Czúcz B, Jackson B, Driver A, Nicholson E, Maes J (2020) A conceptual framework and practical structure for implementing ecosystem condition accounts. One Ecosystem, 5(2), 1-54-

[4] Carter, S.K., Fleishman, E., Leinwand, I.I., Flather, C.H., Carr, N.B., Fogarty, F.A., Leu, M., Noon, B.R., Wohlfeil, M.E. and Wood, D.J. (2019). Quantifying ecological integrity of terrestrial systems to inform management of multiple-use public lands in the United States. Environmental management, 64(1), 1–19

- **The concepts of 'ecosystem extent' and 'ecosystem condition' are emerging as key elements of measuring impacts and dependencies of business activities on nature within many key initiatives**:

  - These concepts are referred to in developing voluntary and mandatory reporting initiatives such as the TNFD framework version 1[5] and the Corporate Sustainability Reporting Directive's (CSRD) European Sustainability Reporting Standards E4 (ESRS-E4), as well as the Global Reporting Initiative's (GRI) exposure draft of the Biodiversity Topic Standard. This includes requirements for screening ecosystem condition at key locations, across both direct operations and value chains, as well as reporting measured impacts on ecosystem condition (Table 1).

  - Ecosystem extent and ecosystem condition underpin many natural capital accounting frameworks. These include the UN System of Environmental-Economic Accounting (SEEA) Ecosystem Accounting and British Standards Institute (BSI) standard on Natural Capital Accounting as well as approaches for corporate biodiversity accounting, for example the Biological Diversity Protocol[6].

Table 1. Requirements for screening and measuring ecosystem condition within example reporting and disclosure initiatives.

Example Initiative	Requirements for screening ecosystem condition at locations of operation	Requirements for measuring impacts on ecosystem condition
TNFD v1.0	Ecosystem integrity is a main criterion for identifying where an organization's operations interface with sensitive locations and whether those locations overlap with the organization's material nature-related dependencies, impacts, risks and opportunities. This forms part of TNFD's Locate-Evaluate-Assess-Prepare (LEAP) approach (an integrated assessment process for nature-related risk and opportunity management).[7]	Impacts on ecosystem condition and extent is included as a metric for internal assessments of impacts and dependencies within the LEAP approach. For disclosure, quantitative measurement of ecosystem condition (level of ecosystem condition by type of ecosystem and business activity) is a core disclosure metric under state of nature. The TNFD specifies that there are multiple options to measure ecosystem condition indicators.[8]
ESRS-E4 (draft)		Impact metrics are included that are related to biodiversity and ecosystems change.

[5] Specific guidance on ecosystem condition metrics applicable to the TNFD LEAP approach is provided by the TNFD as a supplement to the version 1 framework release.

[6] Biodiversity Disclosure Project (2018) Biological Diversity Protocol. Available at: https://nbbnbdp.org/bd-protocol/

[7] TNFD (2023) Guidance on the identification and assessment of nature-related issues: The LEAP approach. Available at: https://tnfd.global/tnfd-publications/

[8] TNFD (2023) Recommendations of the Taskforce on Nature-related Financial Disclosures. Available at: https://tnfd.global/tnfd-publications/

GRI 304-3 (exposure draft)	Organizations are required to disclose locations of operations or suppliers in areas of high biodiversity value (although ecosystem condition is not explicitly listed as an example criterion for defining high biodiversity value).	An organisation shall for each reported site disclose the condition of ecosystems that are or could be affected by its own operations and suppliers' activities (304-3-a-iii).

- **Tools, metrics, methodological frameworks, and data are emerging to help businesses understand the condition of ecosystems within their areas of operation and along their value chains**, to assess their impacts on them, and help them meet emerging voluntary and mandatory disclosure and accounting requirements. However, methodological differences exist in the underpinning approaches, which raises questions on how businesses should approach the measurement of ecosystem extent and condition within different decision-making contexts, from initial screening of risks to corporate biodiversity accounting.

- **This primer presents a typology of approaches for assessing ecosystem condition at a given location and discusses the concept of reference conditions, followed by an overview of ecosystem condition measurement within three core business contexts**:
  1. **Screening** ecosystem condition to prioritize locations and support risk and opportunity assessment. For example, to understand priority areas of impact across operations and value chains.
  2. **Measuring** changes in ecosystem condition to assess impacts.
  3. **Tracking** changes in ecosystem condition within corporate biodiversity accounting to assess performance.

2. APPROACHES FOR ASSESSING ECOSYSTEM CONDITION

2.1. ELEMENTS OF ECOSYSTEM CONDITION – COMPOSITION, STRUCTURE AND FUNCTION

- **Assessing ecosystem condition at a given location requires integrating measures of different relevant ecosystem characteristics through a range of indicators**[9]. Measuring ecosystem condition therefore entails identifying relevant characteristics, developing indicators and metrics for those characteristics, and combining them to assess overall condition (Table 2).

- **An optimal methodology for assessing the biotic elements of condition relates to characteristics across the three core dimensions of structure, composition and function**[5]. Together, these characteristics capture the overall integrity of the ecosystem, not just one dimension.

Table 2. Definitions of composition, structure and function indicators put forward by the Align recommendations to support measurement of ecosystem condition.

Composition	Indicators measure what species are present in the species assemblage as a whole and their relative abundances (rather than the number of individuals within a single species) within an ecosystem.
Structure	Indicators reflect aggregate biophysical properties of ecosystems, irrespective of specific species composition- such as vegetation heights or seabed habitat complexity. At a landscape scale, structure also includes levels of fragmentation and connectivity (i.e., how linked one patch of habitat is to another).
Function	Indicators measure a process that the ecosystem completes or reflects the ability to undertake these processes, e.g., net primary production, water filtration.

[9] Keith H, Czúcz B, Jackson B, Driver A, Nicholson E, Maes J (2020) A conceptual framework and practical structure for implementing ecosystem condition accounts. One Ecosystem, 5(2), 1-54

2.2. SCALE OF MEASUREMENT

- **The ecosystem condition at a given location can be considered at different scales of specificity, i.e., "realms", "biomes" or "ecosystem types"**.
  - The IUCN Global Ecosystem Typology (GET), supported by national level classifications provides a useful hierarchy of scale for ecosystem condition measurement[10].
    1. At the largest scale, the condition at a given location can be measured using generic characteristics that are applicable at the level of the terrestrial, marine and freshwater "**realms**" of the biosphere.
    2. These realms, in turn, can be broken down into distinct "**biomes**" (Level 2 of the GET) e.g., tropical forests, marine shelves, grasslands etc.
    3. Then, based on similarities in functional characteristics and composition, these biomes can be broken down into more regionally specific ecosystem "functional groups" (Level 4 GET). For the terrestrial realm, these are aligned with the concept of 'ecoregions[11]'.
    4. At the finest scale, specific "**ecosystem types"** can be delineated (Level 5 and 6), often at the national level.
  - Tracking the condition of individual 'ecosystem types' allows understanding of changes in the diversity of ecosystems within an area, where each may host unique species groups or provide specific ecosystem functions and services locally.

2.3. TYPOLOGY OF APPROACHES

- **A typology of approaches to assess ecosystem condition is provided in Figure 1. There are two core points of difference that can be used to categorize approaches: the use of direct measurement and the scale of ecosystem specificity.**

  - **The condition of ecosystems can either be 1) directly measured, or 2) inferred through the levels of pressures present**.
    - Inferring condition through pressures can range from metrics that simply map the distribution of pressures, to metrics that apply models that translate these pressures into estimates of composition, structure, and function.
    - Many metrics and approaches can encompass elements of both state that has been inferred through pressures and state that has been directly measured.

[10] Keith, D. A., Ferrer-Paris, J. R., Nicholson, E., Bishop, M. J., Polidoro, B. A., Ramirez-Llodra, E., ... & Kingsford, R. T. (2022) A function-based typology for Earth's ecosystems. Nature, 610(7932), 513-518

[11] Dinerstein, Eric, et al.(2017) An ecoregion-based approach to protecting half the terrestrial realm. BioScience 67(6),534-545. Ecoregion descriptions can be explored at https://ecoregions.appspot.com/

- **Approaches also differ in whether they assess 1) the condition of specific biomes or ecosystem types** (such as types of wetlands, types of forests) using tailored metrics, or **2) ecosystem condition using generic characteristics applicable across whole realms while not necessarily considering the type of ecosystem**.

- **The degree to which an approach fits into these categories (Figure 1) can influence its accuracy, spatial precision, responsiveness to change and feasibility to apply at scale**. These method-related characteristics determine their suitability for being applied in different business contexts.

- **Specific guidance on ecosystem condition metrics applicable to the TNFD LEAP approach is provided by the TNFD as a supplement to the Version 1 framework release.**

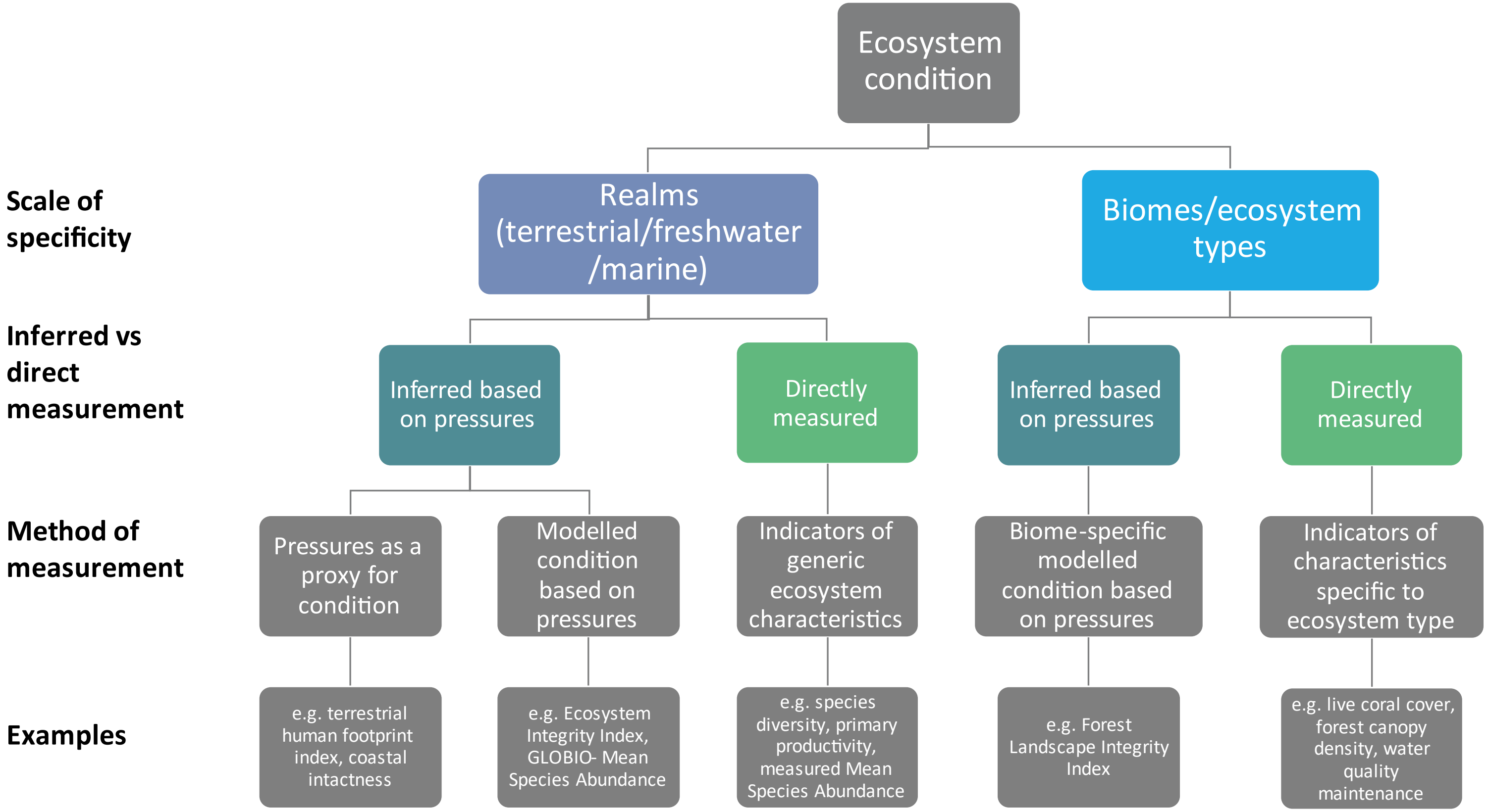

Figure 1. Typology of approaches for measuring the ecosystem condition within an area, with a non-exhaustive list of example metrics within each category[12]. This is separate from composite metrics such as condition-adjusted area, or time-integrated approaches, which are discussed further below. Importantly, many metrics and approaches may encompass elements of different method categories, and the same metric may develop over time, e.g., incorporating more ecosystem specific information in the future.

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[12] Venter, Oscar, et al. (2016) Sixteen years of change in the global terrestrial human footprint and implications for biodiversity conservation. Nature communications, 7(1),12558

Williams, Brooke A., et al. (2022) Global rarity of intact coastal regions. Conservation Biology 36(4), e13874.

Hill, Samantha LL, et al. (2022) The Ecosystem Integrity Index: a novel measure of terrestrial ecosystem integrity with global coverage. https://doi.org/10.1101/2022.08.21.504707 (pre-print publication).

Schipper, Aafke M., et al. (2020) Projecting terrestrial biodiversity intactness with GLOBIO 4. Global Change Biology 26(2), 760-771

Grantham, H. S., et al. (2020) Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity. Nature communications 11(1), 5978

2.4. REFERENCE CONDITIONS

- **To measure the condition of ecosystems, and set baselines, indicators are assessed compared to a reference condition to assess the degree of modification** (see Box 2 for an explanation of the difference between reference conditions and baselines).
  - Some examples of potential reference conditions that different approaches may apply include[13]:
    - "Undisturbed or minimally disturbed condition of an intact ecosystem: The condition of an ecosystem with maximum ecosystem integrity with no or minimal disturbance".
    - "Historical condition: The condition of an ecosystem at some point or period in its history that is considered to represent a stable natural state (e.g., pre-industrial or pre-intensive agriculture)".
    - "Least-disturbed condition: The currently best available condition of an ecosystem".
    - "Contemporary condition: The condition of an ecosystem at a certain point or period in its recent history for which comparable data are available".

- **While baselines to understand impacts from interventions are likely to be derived from snapshots of the current condition of an ecosystem, the undisturbed or minimally disturbed condition of an intact ecosystem is likely to be the optimal method for setting a reference in terms of ecological validity.**
  - This may be a historical condition or drawing from a current example of that ecosystem deemed to be undisturbed. However, definitions based upon minimal disturbance still leave room for interpretation. For example, what threshold is set for 'minimal' and how 'natural range' takes account of cycles in ecosystems (e.g., fire regimes).

- **Methodologies should always make clear which approach for setting reference conditions has been applied. Users should make sure that this information is understood before interpreting results**.
  - Different tools, approaches and frameworks can apply different ways of setting reference conditions, including whether reference conditions considered specific ecosystem types or were set at the realm level. For example, where the types of ecosystem have changed over time, comparing to a 'best potential state' of the current ecosystem type versus comparing to a historical ecosystem type would yield different results and interpretations of the current condition.

[13] Maes, J. (2022) SEEA EA Ecosystem condition accounts [Webinar]. Joint Research Centre. Webinar slides viewable at https://seea.un.org/sites/seea.un.org/files/Trainings/SEEA_EA_2022/seea_ea_ecosystem_condition_accounts_training_28_april_2022.pdf

Box 2. What is the difference between 'reference conditions' and a 'baseline'?

- The concept of reference condition/state to assess ecosystem condition is different from the concept of a baseline to measure impacts of a business or track performance.
- Reference conditions are used to calibrate individual measures of ecosystem condition over time.
- The baseline is chosen by a business and is used at the start of when business performance is tracked. For example, a business might inherit an area of ecosystem with low integrity compared to a reference state. It would not be directly responsible for that initial lower integrity compared to the reference state. It may however further decrease the integrity, or alternatively work to increase integrity over time[14]. Measures of condition would then be used to track this change relative to the reference condition.
- Examples of how a selection of measurement approaches consider baseline and reference conditions are provided in Aligning Biodiversity Measures for Business (2019)[15].

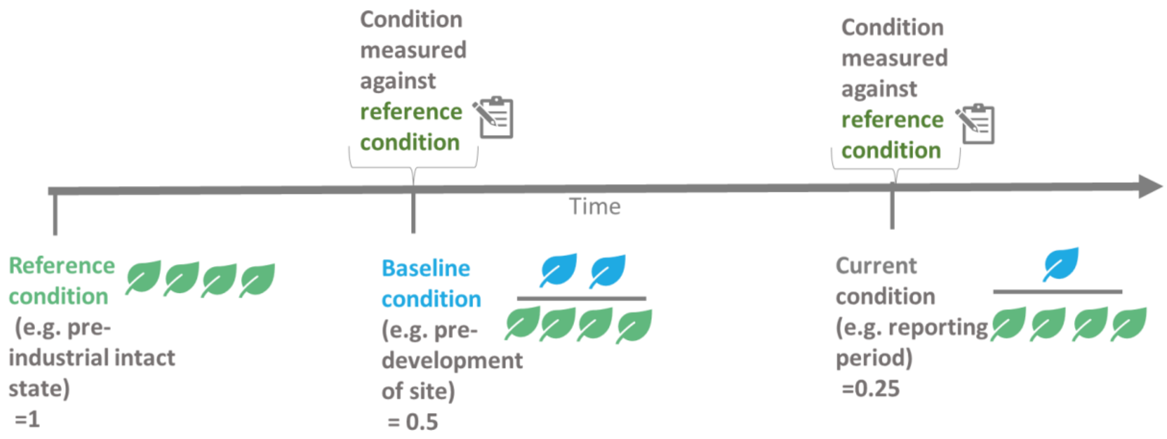

Figure 2. Difference between reference condition and a baseline within ecosystem condition measurement.

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[14] Simmonds, J.S et al. (2020) Moving from biodiversity offsets to a target-based approach for ecological compensation. Conservation Letters, 13(2), 1-11

[15] Aligning Biodiversity Measures for Business (2019) Technical Workshop on Aligning Biodiversity Measurement Approaches for Business - Discussion Paper 1: Identifying Common Ground between Corporate Biodiversity Measurement Approaches. Available at: https://www.unep-wcmc.org/system/comfy/cms/files/files/000/001/608/original/1_Aligning_Biodiversity_Measures_for_Business_Brazil_Workshop_DiscussionPa....pdf

3. BUSINESS CONTEXTS FOR ECOSYSTEM CONDITION MEASUREMENT

3.1. SCREENING THE ECOSYSTEM CONDITION OF LOCATIONS TO SUPPORT PRIORITISATION AND RISK AND OPPORTUNITY ASSESSMENT

- **A key element of screening processes is characterizing the ecosystem condition of the locations directly operated in or along the value chain.**
  - This screening is a requirement within many emerging disclosure initiatives. For example, areas of high integrity may be identified as high priority for avoidance or mitigation measures, while areas of low or declining integrity may have lower capacity for providing ecosystem services and present dependency-based risks and may be targets for restoration efforts.

- **These screening processes can apply 'static' metrics that provide a snapshot of condition compared to a reference state**, i.e., they do not need to reflect change in condition from a baseline in response to company actions or determine causality.

- **For rapid, comparable, high-level screening across multiple locations, approaches that have high feasibility to be applied at scale are most appropriate.**
  - Currently, these are often data layers that are at the realm level, rather than specific ecosystem types. To achieve large spatial coverage of estimated condition, these data layers may assess condition at locations using methods that infer state using pressure data.
  - Available ecosystem condition data layers tend to primarily focus on the terrestrial realm. Although data layers revealing distribution of pressures exist for freshwater, coastal and marine realms, there is currently a key data gap for data layers that reflect the condition of marine ecosystems.

- **More in-depth screening approaches may focus on characterizing the types of ecosystems at a given location through global or national level ecosystem maps, their extent (area coverage) and their condition using ecosystem-specific data layers.** For example, identifying priority locations within forest landscapes may require spatially explicit, biome specific metrics.

- **A multi-scale approach (screening ecosystem condition at multiple scales) maximizes the information gained through screening metrics (Table 3).**
  - Screening locations beyond site or supplier boundaries is important to put the ecosystem condition that falls within the company's responsibility into a wider context. This is because many ecosystem service flows may occur over these wider 'landscape scales' and may be affected by multiple stakeholders. Therefore, screening at these scales is needed to capture the capacity of ecosystems to provide services or the potential for impacting ecosystem service flows.

- **While there is no standard definition of the phrase 'landscape scale', a relevant spatial unit can be identified depending on the local context and stakeholders**.
  - Jurisdictional boundaries or other socially defined areas, areas with similar natural features, or areas with distinct economic processes (e.g., commodity production[16]) can be used to support the delineation of landscapes.
  - Ecosystem service flows can also define the landscape scale. For example, water catchments or basins can be useful for capturing ecosystem conditions that influence water provision regulating services[17].

- **The most useful information is gained when considering condition/integrity alongside multiple dimensions of the 'significance' of the ecosystems for biodiversity**, including species listed as Threatened on the IUCN Red List of Threatened Species and any area-based designations, e.g., protected areas or Key Biodiversity Areas at the location.

- I**dentifying the national or global threat status of the ecosystem type operated in can also provide useful context for screening processes.**
  - Once fully developed (several assessments have already been completed), the IUCN Red List of Ecosystems will be a useful resource[18]**.** For example, the location may represent a locally high-condition patch of an ecosystem type that is globally threatened or on the brink of collapse. Even moderate or low condition occurrences of a highly threatened ecosystem may have high conservation value. This can be particularly true if these low condition locations are all that remains and therefore in need of priority restoration activities.

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[16] Denier, L., Scherr, S., Shames, S., Chatterton, P., Hovani, L., Stam, N. (2015) The Little Sustainable Landscapes Book: Achieving sustainable development through integrated landscape management. Oxford, UK: Global Canopy Programme.

[17] Tallis, Heather, et al. (2015) Mitigation for one & all: An integrated framework for mitigation of development impacts on biodiversity and ecosystem services. Environmental Impact Assessment Review, 55, 21-34.

[18] IUCN (2020) IUCN Red List of Ecosystems Database. Available at: https://assessments.iucnrle.org/

Table 3. Example information gained though screening ecosystem condition at different spatial scales.

Spatial scale of screening	Description	Information gained
National/global condition of ecosystem type	Established national or global level assessments of ecosystem condition are used to screen the ecosystems operated in	- The national/global significance of the ecosystem, which can provide context to the significance of potential impacts - Informs on potential contributions to global biodiversity goals on integrity
Landscape	The overall condition of the wider landscape operated in is assessed	- Screens condition at the scale of ecosystem service provisioning - Screens potential contribution to landscape level trends - Screens competing trends/pressures that may undermine mitigation actions
Location of operations	The boundaries of a specific operation's Area of Influence are identified and the condition within boundaries is assessed	- Provides a summary of the current condition at the location, and a high level estimate of the potential impact at the location

3.2. MEASURING CHANGES IN ECOSYSTEM CONDITION TO ASSESS IMPACTS

3.2.1 IMPACTS ON ECOSYSTEM CONDITION

- **Ecosystem condition measurement can be used to estimate negative impacts by measuring the change in ecosystem condition that results from business activities.**

- **There are two main ways a business may negatively impact ecosystem condition within an area (Figure 3):**
  1. They can degrade the condition of an ecosystem type
     - For example, disturbances such as noise and pollutants, partial vegetation clearance/selective harvesting and changes in micro-climate and water stress may all alter the structure, composition and/or function characteristics of ecosystems from their reference state.
  2. They can transform the ecosystem type
     - Business activities may also reduce the condition to such a degree that they completely transform the ecosystem type (Box 3). Within national ecosystem accounting, or in the compilation of national level indicators for ecosystem targets, these complete and persistent transformations would be logged as ecosystem 'conversions'. Guidance on how these transformations are defined and detected is provided in the UN SEEA EA[19] .
     - Only by knowing and measuring the reference ecosystem types at a location can change in ecosystem condition through conversions be fully understood. For example, establishing a forest on native grassland may be a complete conversion of the grassland ecosystem. Measures of condition at the realm level will not account for changes in the type of ecosystem.

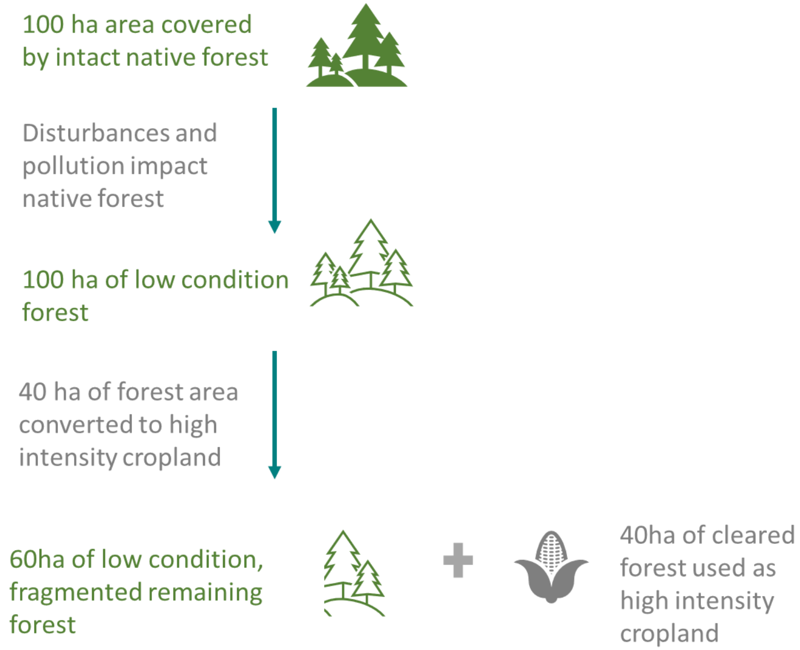


Figure 3. Examples of impacts on the condition of an intact ecosystem.

[19] United Nations et al. (2021) System of Environmental-Economic Accounting — Ecosystem Accounting (SEEA EA). White cover publication, pre-edited text subject to official editing. Available at: https://seea.un.org/ecosystem-accounting

- **Business can also have positive impacts on ecosystem condition by reducing pressures on ecosystems, engaging in conservation efforts, or actively restoring them.**

Box 3. How should anthropogenic land use be captured in ecosystem condition measurement?

- Many of the most intensive land use systems, such as intensive cropland, are likely to not resemble the composition, structure and function of the reference ecosystem type, and therefore reflect a complete ecosystem conversion. Lower intensity anthropogenic land use systems such as agroforestry may more closely resemble 'natural' systems than high intensity farming systems, with evidence that a degree of integrity of the reference ecosystem type is retained.

- Approaches and frameworks may differ in their handling of anthropogenic land use systems. Many approaches at the terrestrial realm level seek to generalize the impacts of different land uses on ecosystem condition as a method of estimating condition within an area. Some approaches and frameworks may also include land use systems such as cropland and pastureland within ecosystem typologies. However, an understanding of the historic or potentially recoverable 'natural ecosystem' type within the area would be required to 1) most accurately measure the degree to which these land uses modify natural ecosystems or represent complete conversions; 2) understand the full amount of past losses in extent and condition within the area; and 3) capture the opportunity cost for restoration.

3.2.2. CONSOLIDATING IMPACTS ON ECOSYSTEM CONDITION INTO A COMMON UNIT: ‘CONDITION-ADJUSTED AREA’

- **When assessing business impacts in an area, it is important to first assess the extent of ecosystems potentially impacted. This is the total area coverage of the different ecosystems within the area of operation**.
  - This is a fixed area over which the **condition** of the different ecosystem types (or realms) is measured and changes over time are recorded.
  - Complete conversions of ecosystems are recorded as a complete reduction in condition.

- **The condition of an ecosystem and the extent can be combined to make one unit: ‘condition-adjusted area’**.
  - This is the extent of the ecosystem adjusted for its condition, so the unit (equivalent ha or equivalent km) represents the residual condition (or ‘accumulated positive impact’ within that area).
  - Numerically, as an equivalent area metric, 100ha of 50% condition is equal to 50ha at 100% condition. In this case, the accumulated positive and negative impacts are both equal to 50 ha eq. Although equivalent area metrics are useful as a proxy for summarizing information, they do not imply changes are equivalent on an ecological level. For example, a smaller area of high condition ecosystem may have higher conservation value than a larger area of low condition ecosystem.

- **Over the fixed spatial extent, reductions in condition change the total condition-adjusted area of the ecosystem**.
  - The negative impacts of a business over the period assessed can then be expressed as the equivalent area reduced to zero condition during that period. For example, a loss of 50% condition over 100ha is numerically equivalent to a complete loss of 50ha to zero condition during the period assessed.
  - The ‘conversion’ of an ecosystem would translate into a reduction of its ecosystem condition down to 0 over its extent.
  - Based on the hypothetical example in Figure 3, the extent being measured is a 100ha area covered by intact native forest (e.g., European beech forest). The resulting state after business activities are conducted includes 60ha of low condition forest and 40ha of cleared forest area used as intensive cropland. Assuming the intensive cropland has been assessed to represent a complete conversion (i.e., a complete loss of integrity with a condition score of 0), and the remaining forested area has been assessed as having a condition score of 0.5 (maximum = 1) then the resulting condition (accumulated positive impact) over the 100ha is 30ha equivalent of the original intact native forest, or an accumulated negative impact of 70ha equivalent.

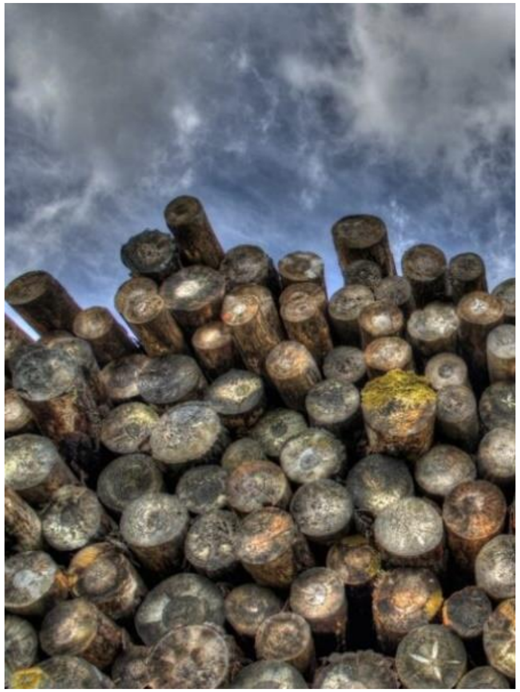
3.2.3. UNDERLYING METHODOLOGIES FOR MEASURING IMPACTS ON ECOSYSTEM CONDITION

- **There are two core methods for assessing impacts of a business on ecosystem condition (impact expressed in condition-adjusted area)[20] (Table 4).**
  - One method involves using model-based approaches to infer changes in condition resulting from either specific company pressures or generic sector pressures. These typically work with land use type (land cover and land use intensity) and other pressures (such as fragmentation or terrestrial acidification) as a ‘package’ of pressures to estimate impacts on ecosystem condition generically at the realm level, using realm-level metrics (Section 3.2). Life Cycle Analysis that includes an ecosystem quality endpoint metric uses this approach (Box 4).
  - The other method involves directly measuring change in the condition of ecosystems on the ground via field surveys or using remote sensing, with an appropriate condition rating system (Table 4). For many biomes or specific ecosystem types, there may be established, commonly applied methodologies for assessing their condition, based on tailored indicators. Engaging with local researchers to design rating systems for ecosystem types where these are not developed can aid in filling method gaps. These methods focus on spatially-specific impacts like land use change, rather than assessing impacts on non-spatial company pressures such as carbon emissions.

[20] UNEP-WCMC (on behalf of the Aligning Biodiversity Measures for Business initiative) (2019) Discussion Paper 1 for the Technical Workshop on Aligning Biodiversity Measures for Business: Identifying common ground between corporate biodiversity measurement approaches. Available at: https://www2.unep-wcmc.org//system/comfy/cms/files/files/000/001/608/original/1_Aligning_Biodiversity_Measures_for_Business_Brazil_Workshop_DiscussionPa....pdf

Table 4. Comparison of core approaches to measuring impacts on ecosystem condition, including method of determining causality.

Approach	Specificity of measurement	Coverage of biotic condition indicators	Method of determining causality	Primary strengths	Examples
Inferred condition based on pressures.	Often realm level (so not producing a metric for a specific ecosystem type).	Can cover aspects of composition, structure, and function, but available methodologies predominantly cover composition only (e.g., as measured by Mean Species Abundance or Potentially Disappeared Fraction).	'Translates' company pressures into an estimated footprint on ecosystem condition, so inherently models causality. Not based on measuring a realized condition change on the ground.	Feasibility to apply at scale means they are most applicable for estimating potential impacts as part of risk screening. They also allow for assessing non-spatial impacts across value chains (e.g., impacts from carbon emissions).	- Global Biodiversity Score (GBS) - Biodiversity Footprint for Financial Institutions (BFFI) - CDC Biodiversité (2021) Global Biodiversity Score-2021 Update
Direct measurement of condition.	Often tailored to ecosystem type/biome (for example coverage of specific type of vegetation, measuring specific ecosystem functions, etc.).	Can cover aspects of composition/structure and function.	Condition measured first before causality determined. Contextual information may be required to determine if changes within areas of business operation are caused by external factors.	Accuracy and spatial specificity means that direct measurement is best practice for measuring realized site-based impacts. Different data collection methods (e.g., field survey and remote sensing) will vary in their accuracy, spatial precision, and interpretation.	- WET-health - Forest Integrity Assessment (FIA) tool - Bioidentification of Ponds and Pond Ecosystems - (BECOME) Index



Box 4. How is ecosystem condition covered in Life Cycle Analysis?

- Life Cycle Analysis (LCA) approaches increasingly cover ecosystem quality within their endpoint indicators[21]. These translate pressures into an estimated potential impact on ecosystem condition, focusing mainly on changes in species richness at the realm level.

- LCA approaches often integrate a temporal dimension to this measurement to express impact in species loss over space and time, and to reflect the ongoing/persistent impacts that some pressures can have on biodiversity over time. They seek to answer the question: "What impacts on the state of biodiversity will the pressures applied during the assessment period cause over their 'lifetime?".

- Unlike other methods, a 'snapshot' of condition is not taken for a specific time point, and the method does not report changes in ecosystem condition. For example, an impact expressed in Potentially Disappeared Fraction (PDF per square meter per year, or PDF.m^2.yr) does not provide an absolute change in ecosystem condition in PDF. They do *not* answer the question: "What is the current state of remaining biodiversity and how much damage is being caused during the period assessed?".

- Whether a metric of ecosystem condition has a time dimension is important for interpreting results of analysis. It answers a different question and can lead to different footprinting results. Therefore, whether time-integration factors are included in methodologies should be understood when comparing results from different models and methods[22].

[21] Winter, Lisa, et al. (2017) Including biodiversity in life cycle assessment–State of the art, gaps and research needs. Environmental Impact Assessment Review, 67, 88-100

[22] CDC Biodiversité (2020) 'GBS Review: Core Concepts'. Final version. https://www.cdc-biodiversite.fr/wp-content/uploads/2023/01/20200518_GBS-review_Core-concepts_final-version_no-track-changes.pdf. Table 3: Comparison of dynamic/static vs time integration in the context of biodiversity footprint

3.3. TRACKING CHANGES IN ECOSYSTEM CONDITION WITHIN CORPORATE BIODIVERSITY ACCOUNTING

- **Corporate biodiversity accounting is the systematic process of identifying, measuring, recording, summarizing and reporting the biophysical state of ecosystem and material species assets, as well as the periodic and accumulated changes to those assets**[23].
  - Guidance on developing corporate biodiversity accounts is provided in the Align Recommendations. More specific requirements for measuring ecosystem condition are associated with compiling corporate biodiversity accounts to ensure robustness and consistency.

- **A core component of corporate biodiversity accounting is the compilation of an asset inventory**. This involves compiling a list of the ecosystem types present at location of operations and recording the extent and condition of these ecosystem types.

- **Individual accounts are then developed for each ecosystem type**.
  - This means that equivalency is maintained, so that gains in one ecosystem type do not compensate for losses in another. Maintaining an asset inventory of individual ecosystem types, rather than broader biomes or realms can ensure stricter ecological equivalency.

- **To ensure consistency between accounts globally, the condition of ecosystems in the asset inventory can be compared to the ecosystem type that would occur in the area if allowed to recover**.
  - This may require different historical timescales for each ecosystem type in the asset inventory.
  - For anthropogenic land uses, such as cropland or monoculture plantations, the ecosystem type that would occur if the area was allowed to recover should be identified. These anthropogenic land uses likely reflect a complete transformation of the original ecosystem type. However, where there is evidence that a given land use sufficiently retains elements of the composition, structure and function of the original ecosystem type, a higher condition score may be applied. Agroforestry systems compared to native forest ecosystems are an example of situation where a higher score might be appropriate.
  - The asset inventory reflects the standing stock of condition and what has been lost. The baseline set by the business can then be used to account for periodic changes in this stock compared to the baseline, including being able to account for improvements in condition.

- **Approaches that use direct measurement of condition characteristics should be used to assess condition at the ecosystem type level (Table 4).**

[23] Endangered Wildlife Trust (2020). The Biological Diversity Protocol (BD Protocol) (2020). National Biodiversity and Business Network - South Africa, 123p. Available at: https://407264.p3cdn1.secureserver.net/wp-content/uploads/2022/05/bdp_final_080321.pdf

- Direct measurements assess realized impacts (while pressure-based measurements assess potential impacts). This includes commonly accepted methods for that ecosystem type where they are available (Box 5[24]). Where model-based or more inferred methods are used to fill information gaps, this should be made transparent.

Box 5. How can different condition rating methods for different ecosystems be made comparable?

- The unit 'condition-adjusted area' can be calculated using different condition rating methods, for example different methods for different ecosystem types, and still be comparable. For any given condition score, this is divided by the maximum potential condition score within that given rating method. This rescaling means that condition is always a proportion of a maximum potential condition.

- Different condition rating systems can also be placed on a simplified scale (for example a condition scale of 1 to 5), for simple application and interpretation. Grouping continuous condition scores (e.g., percentage condition rating) into simple categories can also help avoid issues of false precision and accuracy. For example, 0-20% condition scores, could be grouped as 'very low condition' or given a score of 1 out of a possible 5.

- Simple categories can also aid in communicating state for management decision making. For example, 'very high' condition areas may be viewed as priorities for avoidance of impacts.

[24] Houdet, J & Teren, G. (2022) Quality Biodiversity Footprint Assessments in Practice: Why Organisational Biodiversity Accounting Matters. A Position Paper of the Biodiversity Disclosure Project (BDP). National Biodiversity and Business Network, Endangered Wildlife Trust, South Africa.