Metrics for Quantifying Biodiversity

How should biodiversity components be measured in the context of project development?

Impact Mitigation and Ecological Compensation
Thematic Group

Achieving the goal of the mitigation hierarchy—at least no net loss and preferably a net gain outcome for biodiversity affected by a project—requires an understanding of which and how much biodiversity is impacted by project development, both positively and negatively. This means that metrics describing different components of affected biodiversity (e.g. species, ecosystems, ecosystem services) are necessary. Biodiversity is inherently complex, so metrics of biodiversity are often very simplified. Metrics can sometimes act as proxies or "umbrellas" for other biodiversity components. Often, however, a suite of metrics representing a range of biodiversity components of particular importance (e.g. threatened species, different ecosystems) is required. The suite of metrics used needs to be fit for purpose, measurable at appropriate scales, and reflect valued biodiversity and/or ecosystem services. Such metrics provide the units, or currency, in which biodiversity losses and gains linked to a specific development project (and its mitigation measures) are measured. This measurement is done in an accounting framework, which helps estimate and compare the size of losses and gains.

To achieve at least no net loss (or a net gain) in the context of project development, any losses of biodiversity components must be balanced by gains of the same components ('like for like' or 'in-kind' exchanges). Both losses and expected or required gains need to be measured in the same way, using the same units of measurement, to ensure they are directly comparable. These measures are called 'metrics' or sometimes 'currencies'. However, biodiversity is complex, encompassing the composition, structure and function of entire ecosystems and the species that rely on them (see Brief 1 on *the Mitigation Hierarchy*). Given this complexity, metrics usually reflect simplified components of biodiversity. When implementing the mitigation hierarchy, loss-gain assessments for multiple distinct biodiversity components and ecosystem services (e.g. a threatened species, an ecosystem, particular use values) are usually needed, and so we need metrics that are suitable for measuring each component.

Metrics for ecosystems

When measuring losses and gains of a particular ecosystem or vegetation type (for example, littoral forest in south-eastern Madagascar), using the affected extent or area alone is inadequate. Understanding the condition (or quality) of the ecosystem is equally important. The loss of an area of high-condition, intact forest is of greater importance than the loss of the same area of highly degraded forest. Further, exchanging the loss of high-condition forest for a gain of poor-quality, degraded forest does not achieve 'ecological equivalence'.

Most metrics used for ecosystems or plant communities are composite metrics, based on measures of 'area x condition'. This type of metric represents the relevant area over which a particular ecosystem occurs at the project or the offset site, weighted by its condition. Such ecosystem-based metrics are used (within an accounting framework—see *Brief 9: Measuring Loss and Gain: Additionality*) to estimate the amount of 'quality hectares' affected by an action, or the change in 'quality hectares' attributable to an action.

In 'area x condition' metrics, the condition of a site is measured (or estimated) relative to a benchmark value. This benchmark value represents what the ecosystem is expected to look like in an undisturbed, or reference, state. The condition component of the metric normally comprises multiple attributes that appropriately describe the composition and structure of the ecosystem (e.g. the density of large old trees and the richness of native plant species). Guidance is available for selecting these attributes and developing benchmark values of each attribute for a particular ecosystem type (see Useful resources below).

Usually, the condition component of an 'area x condition' metric needs to be measured using appropriate methods on the ground for accuracy. In some situations, however, remotely sensed indices could be reasonable proxies for vegetation condition. Remotely sensed data are particularly useful in developing on-ground sampling designs, because a site often varies spatially in the condition of its vegetation. Adequate sampling of each broad condition state, combined with estimates of the extent of each vegetation type in that condition state, are both necessary for estimating the total quality hectares of affected ecosystem types at a site. This is a key starting point for estimating the change in quality hectares over time and/or due to an action (e.g. losses due to project development and gains due to conservation measures undertaken as part of a biodiversity offset).

Metrics for species

When applying the mitigation hierarchy, affected species should also receive individual consideration–especially those that are threatened, have a restricted distribution, or are otherwise regionally or locally important. This is because species may have particular requirements that are not well captured in ecosystem-based metrics. While 'area x condition' metrics for ecosystems can sometimes be useful proxies for species that inhabit them, many species are affected by factors other than ecosystem type or condition, such as hunting, predation, or disease.

For this reason, a combination of ecosystem-based 'condition x area' metrics alongside targeted, species-specific metrics, is often necessary when assessing losses and gains in the context of project development and associated mitigation measures, especially offsets.

Different types of metrics are suitable for different types of species, and detailed guidance is available to help identify which metric types work best in a given situation. The main categories of metrics for species are abundance-based metrics, and habitat-based metrics.

Abundance-based metrics

In many cases, such as for some plant species, direct measures or estimates of species population size at a site can be made using direct counts (like breeding pairs or individuals), or proxy counts like nests, burrows, or density of tracks. Such counts or estimations of the abundance of a species are often the best approach for species that are reliably present and readily detectable.

Habitat-based metrics

For species that are cryptic or whose presence at sites is temporally variable and unpredictable, the quality and amount of suitable habitat may be a more suitable proxy. This might mean developing a metric of habitat quality that includes attributes that only reflect the habitat features that are specifically relevant to that species. As such, a species-specific habitat metric might be quite different to a 'condition x area' metric used for an ecosystem. For example, a species-specific metric might include attributes that reflect particular limiting resources (e.g. trees with nesting hollows), or habitat patch size and connectivity in the landscape, for species sensitive to these measures. As is the case for ecosystem-based metrics, each attribute requires a benchmark value that represents the highest-quality habitat for the species in question. The resources below provide guidance on the development of metrics suitable for species.

The Grey Crowned Crane represents a species suited for habitat-based metrics, while the African masked weaver is a species best monitored using abundance-based metrics. African savanna serves as an example of an ecosystem where broader, ecosystem-based metrics are critical for assessing overall health and sustainability.

Metrics for ecosystem services

Measuring losses and gains of ecosystem services requires measures related not only to ecosystems directly, but also that capture the benefits people receive from those ecosystems. They can include diverse social, cultural, and economic benefits.

Ecosystem services metrics are thus complex and context specific, depending to a large degree on the values and preferences of particular beneficiaries. Both qualitative (e.g. change in recreation experience) and quantitative (e.g. change in fish catch) measures can be appropriate to link ecosystem characteristics and social aspects. Gains in ecosystem service provision may be able to be achieved through actions such as restoration or improved management of habitat for species that provide the services—for example, improving fish nursery habitat to compensate for lost fish catch due to disturbance in a marine area. To account adequately for residual impacts on these services at the development site, or from offset or compensation activities, these gains must benefit—and satisfy the needs of—the people who are affected (see *Brief 7: Considering People as well as Biodiversity*).

Trading up

Demonstrating no net loss of biodiversity outcomes generally relies on like-for-like exchanges, where losses and gains are considered ecologically equivalent. In exceptional circumstances, such as where impacted biodiversity is of relatively low concern, a mitigation or offset policy may allow for 'trading up' (out-of-kind exchanges). This means that, where offsets are required, the offset may target biodiversity components that are of higher conservation concern than those negatively impacted. It is important to recognise that this means that the type of biodiversity that is impacted will suffer a residual net loss if this approach is used. It is, therefore, not appropriate to apply trading up when losses involve biodiversity of conservation concern, such as threatened species or ecosystems.

Trading up presents an additional complexity in the use of metrics, because even if the gain is not of the same type as the loss, it must be at least the same amount. However, if the loss and gain are of different biodiversity components, they might be measured in different ways. If both components are measured using a condition x area metric, then the comparison can be simplified—quality hectares for quality hectares. However, if they are not measured using this metric, an 'exchange rate' may be required, in order to provide assurance that out-of-kind gains really are at least as valuable as the loss for which they are compensating.

Accounting systems

Once appropriate metrics are available to enable the quantification of affected biodiversity, these metrics can be used within an accounting framework to estimate the losses and the gains for each of the relevant biodiversity values. Metrics themselves don't tell us what an adequate loss-gain exchange would be in a given situation—they just establish the units, or currency, that will be used in the relevant calculations. *Brief 9* describes how to estimate losses and gains within an accounting system, using appropriate metrics.

About COMBO+ and IMEC

From 2016 – 2025 AFD and FFEM financed the **Conservation, Mitigation and Biodiversity Offsets Programme (COMBO+)**, as part of which technical briefs 1 -10 were drafted, in collaboration with the IUCN Thematic Group Impact Mitigation and Ecological Compensation. COMBO has been implemented across six countries in Africa and Asia, together with government, private sector and civil society, to help reconcile economic development and biodiversity conservation through application of the mitigation hierarchy in policy and practice to achieve no net loss or net gain of biodiversity and contribute to national biodiversity targets aligned with the Kunming-Montreal Global Biodiversity Framework. The initiative was led by the Wildlife Conservation Society in partnership with Biotope, BIOFUND, Guinée Ecologie, Myanmar Biodiversity Fund and the University of Queensland.

The **Impact Mitigation and Ecological Compensation (IMEC)** Thematic Group of the IUCN's Commission on Ecosystem Management (CEM) serves as an international community of practice, guiding best practice application of the mitigation hierarchy and improving alignment of impact mitigation and ecological compensation with biodiversity targets.

Useful resources

- Business and Biodiversity Offset Programme (BBOP). (2012). *Resource Paper: No net loss and net gain calculations in biodiversity offsets. trends.org/publications/resource-paper-no-net-loss-and-loss-gain-calculations-in-biodiversity-offsets/*
- Business and Biodiversity Offset Programme (BBOP). (2012). *Biodiversity Offset Cost-benefit Handbook. https://www.forest-trends.org/publications/biodiversity-offset-cost-benefit-handbook/*
- Business and Biodiversity Offset Programme (BBOP). (2012). *Resource Paper Limits to what can be offset. https://www.forest-trends.org/publications/resource-paper-limits-to-what-can-be-offset/*
- Deffner, A., Thouzeau, A., Cotillon. S. (2024). *COMBO+ Programme Guidance Note Developing suitable metrics for use in loss and gain calculations of ecosystems and/or species*.
- Gibbons, P,. Evans, MC., Maron, M et al. (2016). A Loss-Gain Calculator for Biodiversity Offsets and the Circumstances in Which No Net Loss Is Feasible. *Conservation Letters*. *https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/conl.12206*
- Mayfield, HJ., Bird, J., Cox, M et al. (2022). Guidelines for selecting an appropriate currency in biodiversity offset transactions. *Journal of Environmental Management. https://www.sciencedirect.com/science/article/pii/S0301479722016334*
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