Biodiversity Metrics, Accounting Systems & the Mitigation Hierarchy – Guidance for Uganda

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1. OVERVIEW

1.1 Purpose of this guidance document

This guidance note is aimed at Ugandan biodiversity experts, government departmental staff, project developers, academics, and non-governmental organizations. It outlines what biodiversity metrics are and how they are essential for application of the mitigation hierarchy, sets out a potential metric suite for use in Uganda, and proposes some key principles for developing an overall accounting system for use in application of mitigation policy. This document was co-developed with Ugandan biodiversity experts from the National Technical working Group of the COMBO+ Project.

1.2 What to find in this guidance note?

This document offers practical guidance to support the **development of defensible and pragmatic ecosystem condition metrics** for use in project development when applying the mitigation hierarchy to achieve No Net Loss/ Net Gain goals and when undertaking the necessary loss/gain calculations. The focus is principally on terrestrial biodiversity, and we use ecosystems as our unit of calculation. We also briefly discuss the use of species metrics but note that more detailed guidance is available elsewhere on species metrics. More general guidance on development of species and ecosystem metrics is also available here (COMBO+, 2024).

The guidance note first summarizes the purpose of metrics and why they're essential for application of the mitigation hierarchy and then outlines how metrics are used to calculate biodiversity losses and gains due to development projects and offsets. Next, a summary of ecosystem benchmarks and attributes developed by the Wildlife Conservation Society (WCS) and Uganda's National Technical Working Group is provided, followed by a proposed methodology for calculating overall losses and gains in ecosystems. Finally, recommendations are made for exchange rules and overall biodiversity accounting system in Uganda.

2. INTRODUCTION TO METRICS & BIODIVERSITY ACCOUNTING

2.1 What do we mean by 'metrics' and what is their purpose?

When it comes to developing and applying the mitigation hierarchy, the term metric (also often called a 'currency' or 'index' of biodiversity) is used as a unit to measure and quantify the state of and changes in the state of individual biodiversity components. Put simply, it is an approach we use to measure losses and gains in biodiversity due to development projects and their biodiversity offsets.

<u>Box 1 – What is the mitigation hierarchy?</u>

One of the major strategies by which countries and other jurisdictions attempt to balance development impacts with biodiversity conservation is a decision-making framework known as the mitigation hierarchy (BBOP, 2012; CSBI, 2015). This approach is designed to address negative impacts on biodiversity through first seeking to avoid impacts to the greatest extent possible, then minimising impacts and restoring biodiversity damaged by project activities, and finally - as a last resort - by offsetting any residual impacts. The overall aim of implementing these steps is to achieve No Net Loss or a Net Gain of biodiversity (BBOP, 2012; CSBI, 2015).

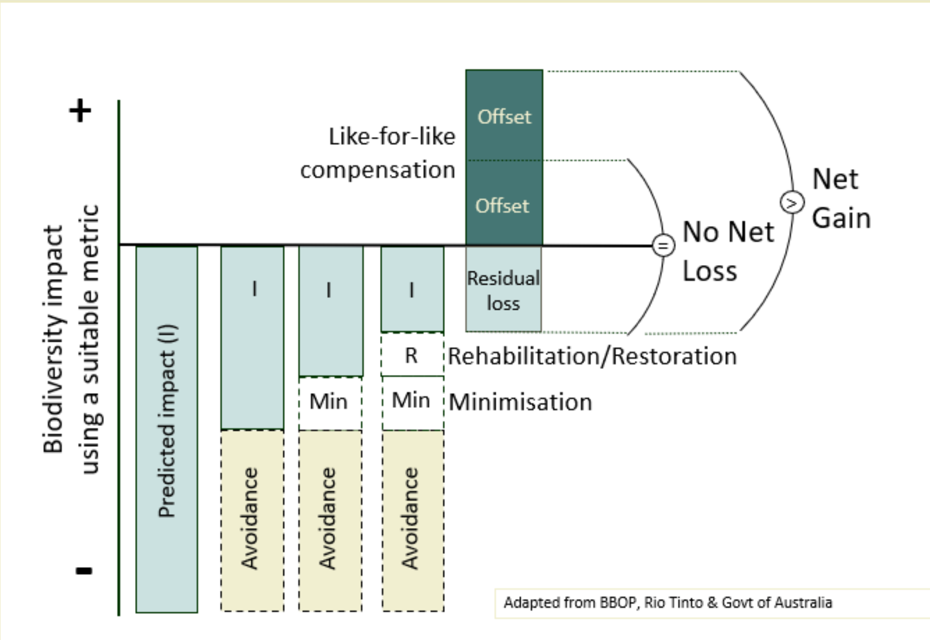

Figure 1. Suitable quantitative biodiversity metrics should be used for the different steps of the mitigation hierarchy (quantifying residual losses during avoidance, minimisation, restoration/ rehabilitation steps, and quantifying gains during offsets process).

This type of metric helps us measure baselines, the effectiveness of mitigation actions, and whether the desired results are being achieved (Marshall et al., 2020). It allows us to compare losses and gains quantitatively, and – ultimately - helps establish whether goals such as No Net Loss (NNL) or Net Gain (NG) can be or have been met (Cross-Sector Biodiversity Initiative (CSBI), 2015). While most papers on biodiversity metrics for the mitigation hierarchy focus on the last step of the mitigation hierarchy - offsetting residual impacts - metrics can also be used for prior steps in the mitigation hierarchy, i.e. impact avoidance, minimization, and restoration of damaged biodiversity.

Given the complexity of biodiversity, which comprises many different components and values, more than one metric is often needed to represent affected biodiversity components adequately (Mayfield et al., 2022). A single-metric approach is often not suitable. For example, a metric used to describe and quantify the condition (the relative intactness or degradation) of ecosystems found at a given site may not be able to represent the site's suitability for a species of interest if that species does not entirely rely on ecosystem intactness. However, this report focuses mainly on the development of ecosystem metrics for Uganda, because ecosystems can be mapped consistently across the entire country and are often used as the unit with which to quantify residual impacts and offset. Species metrics are discussed in general terms, with more detailed guidance available in COMBO+ (2024)s and Mayfield et al. (2022).

2.2 Why do we need biodiversity metrics?

To apply the mitigation hierarchy and achieve No Net Loss or Net Gain in biodiversity, a system for measuring the impacts of developments and offset actions on biodiversity is needed. But because biodiversity is almost infinitely variable – being the vast and complex array of all ecosystems, species, their genes, and their interactions – we are unable to measure everything. Metrics are tools that we use to simplify the complexity of biodiversity into something that is feasible for project developers and government to measure in the field, and track over time to monitor increases/decreases in biodiversity (Mayfield et al., 2022).

Biodiversity metrics are designed to be simple enough that they can be repeatedly and reliably measured whilst capturing enough detail to represent overall biodiversity condition. While all metrics must make some simplifications and assumptions, it is important that they are well-correlated to overall biodiversity condition to be of use.

In this document, we divide metrics into two broad categories: Ecosystem metrics & species metrics.

- Ecosystem metrics: Ecosystem metrics are used to measure the condition of particular ecosystem types (e.g. woodland, forest). The most widely used metric type used for ecosystems is 'Extent X Condition[1]', combining the physical area of the affected ecosystem with a measure of its condition.

[1] Extent X condition represents ecosystem extent multiplied by ecosystem condition

Ecosystem condition is determined by comparing a set of vegetation attributes at the affected site to the same attributes measured in a "benchmark" site (a good condition site used as a reference). The units for ecosystem metrics are normally assessed as *condition hectares*.

- Species metrics: Species metrics are used to measure the value of site for a particular species. This can be done by assessing a set of condition attributes that represent the suitability of habitat for a given species, or by measuring species abundance directly. The type of metric used depends on several factors, such as whether it is easily observed/counted, whether species abundance is correlated with habitat importance, and whether there are habitat attributes that are well correlated with site importance for species.

As mentioned above, the primary focus of this document is to outline why ecosystem metrics are essential for application of the mitigation hierarchy, and to set out a potential metric system for use in Uganda. However, **in addition to ecosystem metrics, we need to use species metrics for species considered to be of special conservation concern,** especially when they are not well represented by ecosystem metrics. Identification of such species and development of associated metrics should be clear priority for the future.

IMPORTANT

Any condition metric should be able to be expressed relative to the benchmark condition of the ecosystem or species habitat. Benchmarks are quantitative reference values, generally measured at sites that represent the undisturbed or best available condition of a particular ecosystem or species. Defining benchmark values is necessary in order to convert the absolute values measured in the field into relative scores on a scale ranging from low condition to high condition.

2.3 Metrics & Accounting Systems

For application of the mitigation hierarchy, metrics need to be integrated into an overall system which guides how development impacts are quantified, sets rules around what can be offset and what the loss/gain exchange can entail, and how to determine gains from an offset. Such systems, often referred to as accounting systems, generally take the form of government documents which outline how biodiversity metrics are to be applied, set the rules and requirements of offsets for different ecosystems/species exchange rules, and act as references against which developer's biodiversity management/offset plans are reviewed.

Setting out a standardized metric methodology and accounting system ensures that suitable ecosystem and/or species metrics are used by all relevant project developers in the way set out in technical guidelines. This may include the use of metrics throughout the project phases, and for each step of the mitigation hierarchy, and not only for offsets. The use of the same metrics in all development projects helps national institutions monitor losses and gains of ecosystem and/or species of national concern (threatened, vulnerable, particularly significant etc.) due to project development. It can also support the process of determining project-level contributions to No Net Loss or Net Gain of biodiversity outcomes and national biodiversity targets.

Box 2: Measuring losses & gains in biodiversity.

Calculating losses and gains in biodiversity due to developments and offsets has four key components:

- **Exchange rules** that set out what biodiversity components are exchangeable, what net outcome is required, and where and what type of offsets are allowed
- **Metrics** in which to measure or estimate losses and gains
- **Ecological data** and understanding to enable estimates/projections of loss and gain at sites; and
- **Accounting systems** that bring all this information together and compare estimated losses and gains

There are a number of existing, national-level mitigation policies that are helpful references when thinking about metrics and accounting systems (zu Ermgassen et al., 2019). The UK government's statutory biodiversity metric is summarized in Panks et al. (2022), and the state of Victoria in Australia has guidance available in Parkes et al. (2003).

3. USING BIODIVERSITY METRICS: A HYPOTHETICAL EXAMPLE

Here, we outline a simplified example of how biodiversity metrics can be used to quantify residual development impacts on biodiversity after avoidance, minimization and restoration measures have been taken. Figure 2 outlines the major steps involved in performing a simple impact calculation, and brief descriptions are outlined in sections 3.1 - 3.4. A real-world example using Uganda specific-data is included in section 5. It is important to note that this simple example focuses on ecosystems alone, but most real-world situations would also include developing and applying metrics on species, ecosystem services or local communities.

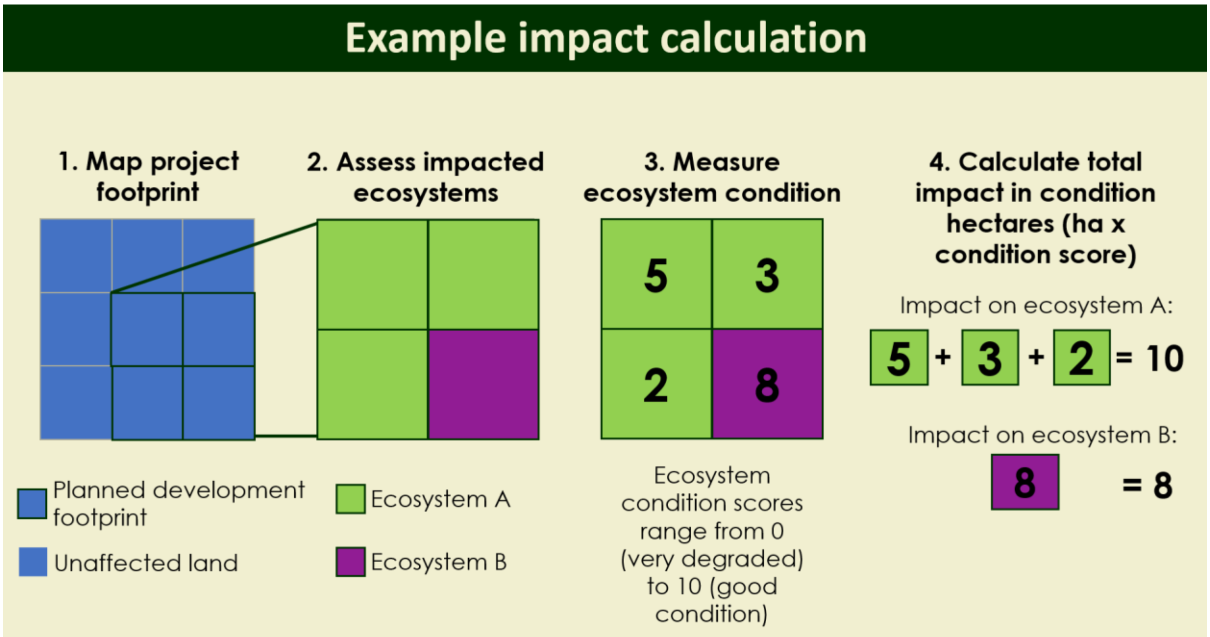

Figure 2. Hypothetical calculation of residual impacts from a development, using biodiversity metrics to quantify condition of impacted land and calculated overall impact on each ecosystem. Each square represents 1ha of land.

3.1 Map Project-related impacts ('footprint')

Once the project has carefully applied the first 3 steps in the mitigation hierarchy – Avoid, Minimise & Restore – then biodiversity metrics are used to quantify the remaining impacts, which are known as residual impacts. The first step in any calculation of development impacts is to generate a map of the area where residual project impacts will occur (Figure 2 – Step 1). This will be different for each project, but generally includes any area where land clearing or construction has/will occur, including any linear infrastructure like roads, pipelines etc. Because the impacts of habitat conversion are not restricted to the direct project footprint but also extend into adjacent areas through edge effects, increased human access etc., project impact calculations need to capture indirect and cumulative impacts as well. In this example, we have included a buffer that extends outwards from the edge of planned works but more sophisticated approaches to mapping the full suite of expected impacts adequately.

3.2 Assess Impacted Ecosystems

Once the project impact area is mapped, the next step is to determine the ecosystem types occurring there. This can generally be done by first using GIS to overlay the project 'footprint' with an official ecosystem map and then calculating the overall area of each ecosystem that will be impacted by the proposed development (Figure 2 – Step 2). It is then important to verify the type and area of each ecosystem expected to be impacted through field visits.

3.3 Assess Ecosystem Condition

Next, an assessment of the condition of each impacted ecosystem must be made using ecosystem metrics. Ecosystem condition is determined by comparing field-measured values of a set of vegetation attributes at the affected site to values obtained for the same attributes measured at "benchmark" sites (good condition sites used as a reference). Normally the benchmark values will be outlined in legislation or guidelines for the mitigation hierarchy, so project developers just need to assess ecosystem condition in the project area and then compare these values to the available reference values.

In practice, this means conducting a series of field surveys across all ecosystems within the project area, ensuring that a representative sample of each ecosystem is surveyed. This means that assessments should not look only at the good condition or bad condition parts of each ecosystem, but rather aim to conduct surveys across all condition levels. Once field surveys are complete, the data for each ecosystem patch are combined using approved equations (normally available in mitigation policy or guidelines) to generate an overall condition score (Figure 2 – Step 3).

3.4 Calculate Total Impact

Once the condition of each ecosystem patch has been assessed, the overall impact on each ecosystem can be calculated by multiplying the ecosystem condition score by affected ecosystem patch area, and then summing the results for each ecosystem (Figure 2 – Step 4). This gives us a single value for each ecosystem representing the overall impact that the development will have on that ecosystem. In Figure 2 each ecosystem patch is the same size for illustrative purposes, but in a real example each patch will have a different area. A more detailed example using data from Uganda is outlined in section 5.

4. DEVELOPING ECOSYSTEM METRICS FOR UGANDA

To promote robust development and application of mitigation policy, the COMBO+ project team at WCS in collaboration with national subject matter experts have developed biodiversity metrics and accounting systems for use in Uganda. The expert working group included;

- Taxonomists and ecologists from Makerere University (College of Natural Sciences, College of Agricultural and Environmental Sciences, the University Herbarium, National Biodiversity Databank (NBDB))
- NEMA-certified Environmental and Social Impact Assessment (ESIA) practitioners
- GIS and Remote Sensing team from NFA, National Environment Management Authority (NEMA), Uganda Wildlife Authority (UWA) and NBDB
- National and International researchers carrying out studies on metrics
- Potential metrics users from the private sector (oil and gas companies), Civil Society Organizations and government institutions
- Custodians/enforcers of the metrics - NEMA and UWA
- National and International staff of the Wildlife Conservation Society (WCS)

The expert working group's major tasks were to identify a suitable national ecosystem map to inform application of the mitigation hierarchy in Uganda, as well as develop a metric system that could be used to measure losses and gains in each ecosystem. The working group, led by WCS, conducted a rapid data review and a series of workshops between 2023 and 2024 to decide on the appropriate ecosystem map and metrics for use in Uganda, the results of which are summarised below.

Review of Uganda's ecosystem type maps

Four maps of current and historical ecosystem types were identified as potential maps for use. These included two maps with full national coverage: the Langdale-Brown map (Langdale-Brown et al, 1964) and the National Forestry Authority's (NFA) land cover/use maps developed every 5 years, a Murchison-Semuliki land use/cover map and a phytosociological map of Murchison Falls Protected Area. These maps were at varied scales and variation in the level of detail.

From the meetings, it was agreed that 1) The Langdale-Brown habitat map, which includes ecosystem threat status, covers the whole country and has ecosystems representing ecosystem types of Uganda, should be used to inform development and application of mitigation policy in Uganda. To simplify use and understanding, the ecosystem names from the Langdale-Brown habitat map were shortened and refined to a simpler naming (Table 1).

It was also noted that;

1) Species composition and tree stature may differ within the same class for the different regions, especially the forest and woodland between the Albertine and the drier north and northeastern.
2) The NFA historical mapping (1990s) included codes to indicate biomass and soil moisture content. These could be used to infer on species composition differences

4.1 Developing ecosystem metrics

With an appropriate national-scale ecosystem map identified, the working group proceeded to compile a set of metrics for use in calculating losses and gains in each ecosystem. This required developing a series of attributes that reflect overall condition for each ecosystem, as well as identifying benchmarks for each – i.e., the maximum value for each attribute, based on measurements taken from a good condition patch of each ecosystem. To assess the condition of a particular area, attributes are measured in the field and compared to the corresponding benchmark value (representing a good condition ecosystem).

In the development of ecosystem metrics for Uganda, the working group decided to make use of existing benchmarks and attributes that were developed for the Murchison-Semliki landscape. These metrics were developed as part of the "vegetation mapping of Murchison conservation protected area" project commissioned by TotalEnergies, Uganda in 2015. The process involved developing maps of vegetation type, habitat quality and habitat condition, and involved substantial field-surveys to determine appropriate field attributes to represent habitat condition for different ecosystems (Nangendo et al., 2017). These existing metrics were aimed at assessing ecosystems of a specific locality, not a nationwide assessment, and using a less detailed map than the national-scale Langdale Brown map. As such, the working group first cross-walked the two maps by developing simplified ecosystem names from the Langdale-Brown map, to align well with the existing metrics developed for Murchison (Table 1). Figure 3a shows the detailed Langdale-Brown ecosystem maps, with Figure 3b showing the simplified classes that align with the ecosystem benchmarks. Table 1 provides some examples of this naming cross-walk for a selection of ecosystems, with full details provided in Appendix 1.

(a) (b)

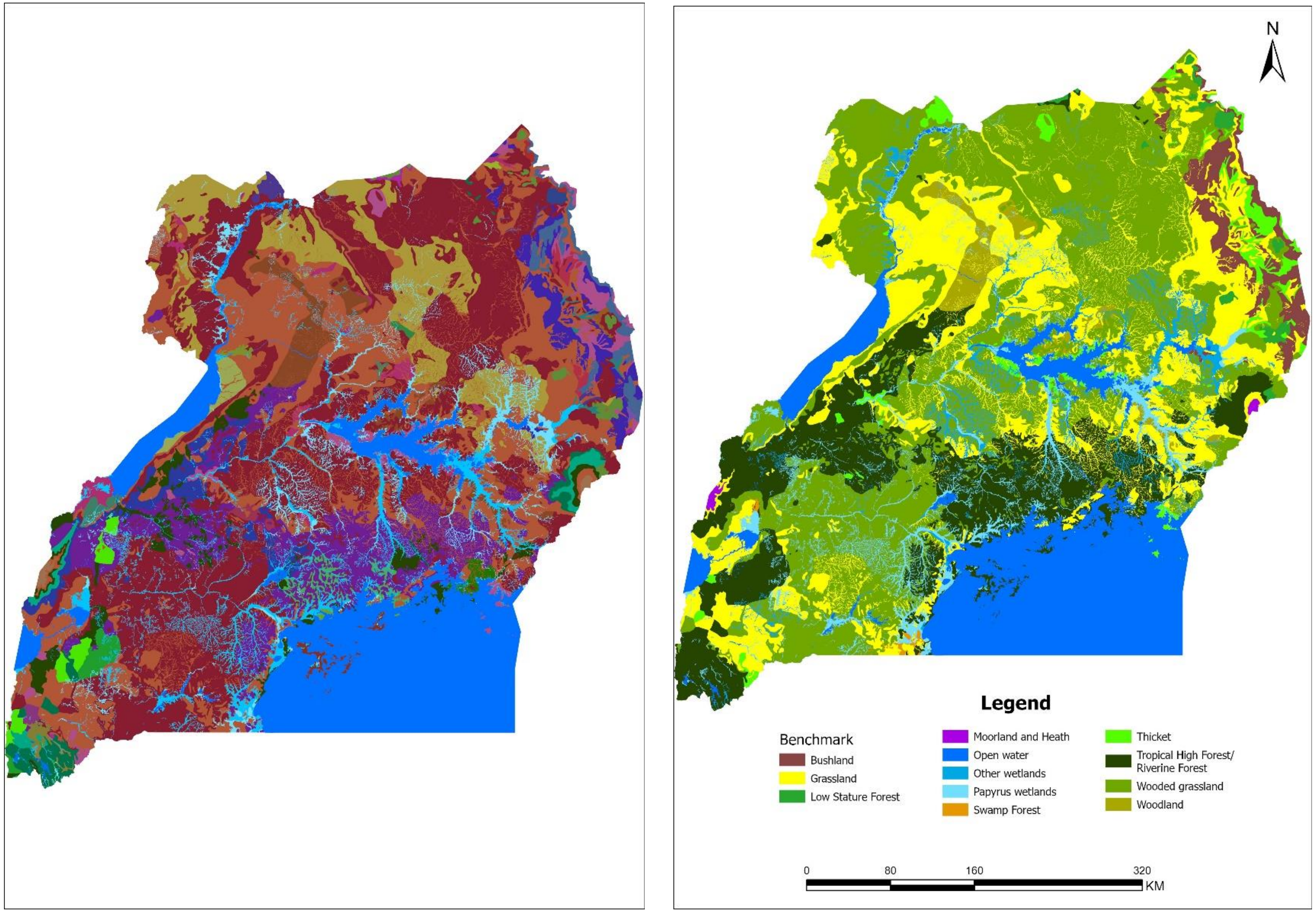

Figure 3: The Langdale-Brown habitat map (a), and the Langdale-Brown map classes aggregated into the 11 benchmark classes (b).

Table 1. Langdale-Brown habitat map attributes - hybrid class names

No.	Langdale-Brown Name	Shortened Name	Benchmark ecosystem class
1	Acaccia-Albizia-Dichrostachys Bushland+Acacia Mellifera Thicket	Bushland and thicket	Bushland
2	Acacia Tree and Shrub Steppe+Acacia Mellifera Thicket	Grassland and thicket	Grassland
3	Alchemilla-Helichrysum Moorland	Moorland	Moorland and heath
4	Acacia-Imperata Savanna Permanent Wetland	Wetland	Other wetlands (marshes and bogs)
5	Echinochloa Grassland+Cyperus Papyrus Swamp Seasonal Wetland	Wetland (Papyrus swamp)	Papyrus wetland
6	Riparian Thicket+Acacia-Setaria Savanna	Riparian thicket and wooded grassland	Thicket
7	Forest/Savanna Mosaic at High Altitudes+Forest/Savanna Mosaic at Medium Altitudes	Medium-high altitude forest	Low Stature Forest
8	Pygeum Moist Montane Forest	Prunus Moist Montane Forest	Tropical High Forest
9	Butyrospermum-Hyparrhenia Dissoluta+Combretum-Hyparrhenia	Vitellaria-Combretum wooded grassland	Wooded grassland
10	Vitex-Phyllanthus-Sapium-Terminalia Woodland+Terminalia Woodland	Woodland	Woodland

Overall, there were 11 broad ecosystem groups for which benchmarks and attributes were developed (Table 2, Figure 3b). For each broad ecosystem class, the attributes and benchmarks were reviewed for relevance and edited to ensure they provide a good assessment of overall ecosystem condition. Table 3 shows the attributes that were agreed upon.

Table 2: The benchmark ecosystem classes for which benchmarks were developed

No	Ecosystem Name	No. of attributes
1	Riverine Forest/Tropical High Forest	7
2	Low Stature Forest	8
3	Woodland (Closed or Open)	6
4	Wooded Grassland	7
5	Grassland	8
6	Bushland	
7	Thickets	5
8	Papyrus wetlands	3
9	Other wetlands (Marshes and bogs)	3
10	Swamp forest	3
11	Moorland	2

Table 3: Attributes selected for assessing the condition of ecosystems. All ecosystem classes, except the wetlands, used the same attributes but with different benchmark values for each attribute. The wetland condition will be assessed using 3 attributes.

Non-wetland classes	Papyrus Wetland
Number of large tree species in 20m radius (Tree richness)	Number of species in 5m radius (species richness)

Number of shrub species in 20m radius (shrub richness)	Percentage papyrus cover in 5m radius (Papyrus cover)
Number of herb species in 2m radius (herb richness)	Other species cover
Height of tree canopy in 20m radius	
Percentage tree canopy cover in 20m radius\\\\	**Other wetlands**
Percentage shrub cover in 20m radius	Percentage cover in 5m radius (cover of wetland species)
Number of large trees in 20m Radius	Percentage cover in 5m radius (cover of non-wetland species)
	Grass cover

To record field values and metric scores, benchmark tables\ were developed for each broad ecosystem class. Each benchmark table has a unique combination of attributes and field values that are used to score ecosystems from poor to good condition. Table 4 shows an example of a benchmark table for Tropical High Forest ecosystems, and all tables are available in appendix 2.

Table 4: Example benchmark table for Tropical High Forest ecosystems, showing attributes used and the scores assigned to the habitat condition. Metric Score ranges from 1 (poor condition) to 5 (good condition), with all attributes being equally weighted.

			Score				
Attribute	Measured Attribute		1	2	3	4	5
Tree Richness	# of large tree species in 20m radius	Field Value	<3	3-4	5-7	8-10	>10
Shrub Richness	# of shrub species in 20m radius	Field Value	<3	3	4	5	>5
Herb Richness	# of herb species in 2m radius	Field Value	<3	3	4	5-6	>6
Tree canopy height	Height of tree canopy in 20m radius	Field Value	<15m	15-19m	20-24m	25-29m	>29
Tree Canopy cover	% cover in 20m radius	Field Value	<15%	15-29%	30-44%	45-59%	>59
Shrub cover	% cover in 20m radius	Field Value	<5%	5-9%	10-19%	20-29%	>29%
Large trees	# in 20m Radius	Field Value	<3	3-4	5-7	8-10	>10

4.2 Developing field measurement guidelines

To ensure a standardized, repeatable method for measuring each attribute, a field survey methodology was developed based on Nangendo et al., (2017). The field survey methods have been developed to guide the implementation of the national biodiversity and social offset guidelines.

At each point of data collection, GPS coordinates should be taken and recorded. This should be done at the centre of the plot. Voucher specimens should be collected and pressed for confirmation of identification at the Herbarium. Preliminary identification may be carried out in the field.

Data should be collected, at each sampling site, on all parameters identified for each ecosystem. Appropriate internationally agreed procedures that make use of fixed area plots (i.e. circular, rectangular or square) should be used. Proportionate sampling should be carried out to represent all affected habitats. The sampling intensity of the area of influence should be at least 10%.

Note: The benchmarks provided here are based on a specific plot size. The plot sizes use for all non-wetland ecosystems are 12.5m² for herbs, and 1,256.6m² for all trees greater than 10 cm DBH. Should the expert choose to use a different plot size that significantly differ from these, they will need to revisit the benchmark values too. For the papyrus and other wetlands, a different area was used (78.5m²).

The application of the field sampling guidelines summarized here is demonstrated in a case study in section 5. Here below we outline what the plot layout would be like if the sampling was carried out using circular or square plot.

At each site, sampling is carried out within each ecosystem assessment unit. Standard nested plots that are most suitable for the ecosystem under consideration, are set up. The habitat plant forms to be assessed in each subplot are as follows:

a) Circular Plots:

1) Subplot 1 (radius = 2m or area of $12.5m^2$): record all herbs.
2) Subplot 2 (radius = 20m or area of $1{,}256.6m^2$: record all trees greater than 10 cm DBH.
3) Papyrus and other wetlands (radius = 5m or area of 78.5 m^2): record all plant species, separating papyrus from others.

b) Square Plots:

1. Subplot 1 (width/length = 3.5m or area of $12.25m^2$): record all herbs
2. Subplot 2 (width/length = 35.5m or area of 1260.25 m^2) record all trees greater than 10 cm DBH
3. Papyrus and other wetlands (width/length = 8.86 or area of 78.5 m^2): record all plant species, separating papyrus from others.

5. APPLYING ECOSYSTEM METRICS IN UGANDA

Because there is currently no common, widely accepted metric to quantify biodiversity losses and gains from development in Uganda, the process is conducted differently for each development. This makes it extremely difficult for developers, who want guidance on how they should measure biodiversity, and for regulators/assessors, who must review a new methodology with each development. By creating a transparent, common metric that is used for all developments, it becomes simpler and easier to understand the losses of biodiversity caused by developments, to calculate corresponding offset requirements, and to determine when offset sites have achieved the required gains in biodiversity.

Measuring losses and gains in biodiversity from a development requires repeated measurements to be taken at both the project site and the offset sites, before and after development or offset activities take place. Here, we present a step-by-step process for assessing the losses in biodiversity caused by a planned development, and for calculating gains in biodiversity due to offsets. To ensure this example is practical and realistic, we use an example case study from a powerline development in Gangu Central Forest Reserve (CFR). While an offset has already been applied for this development, we here simply use it as an example, and do not offer commentary on the selection process or adequacy of the existing offset.

Gangu CFR is approximately 1054 ha and it is located in Butambala and Mpigi districts of Central Uganda. The CFR covers 11 km2 on the western shores of Lake Victoria, easily accessible along the Kampala-Masaka highway, between Latitude 0o0 and 0o3N and between Longitude 21o45 and 32o30E. The CFR is dominated by tropical high forests classified as Piptadeniastrum-Albizia-Celtis forest. Approximately 27.12 ha of Gangu CFR was cleared during the construction of the Kawanda-Masaka 220/132/33kV high voltage electricity transmission line by Uganda Electricity Transmission Company Limited, and we here use this project's area of impact as an example to demonstrate hypothetical use of ecosystem metrics.

5.1 Measuring impacts of a development

The following steps demonstrate how to use the metrics to calculate residual impacts caused by a development project. The same approach can also be used to measure gains in biodiversity due to an offset. To demonstrate the use of a standardized ecosystem metric, we consider a portion of the 137-kilometer-long double circuit transmission line that was recently constructed between Kawanda and Masaka West substations. For high voltage powerlines, effort is often made to avoid major settlements and towns to ensure human safety, instead potentially impacting natural habitats like wetlands and forests. The Kawanda - Masaka transmission line crosses Gangu Ccentral Fforest Reserve, which is classified as a Strict Nature Reserve (SNR) (MWLE, 2002). Here, we consider just the section of powerline that crosses the Gangu CFR as an example development, although in a real scenario the impacts of a development would be calculated for the entire project.

Step 1: Map project's area of impact

The first step in measuring the residual impacts of a development is to generate an accurate map of the area of impacts. This should include not only the location of any final infrastructure (e.g. roads, mines, powerlines), but also the location of any other areas where construction or other activities will impact biodiversity and will not be restored through earlier stages of the mitigation hierarchy (e.g. road buffer zones, clearing for machinery storage).

For many developments, including the powerline development in Gangu CFR, the impacts of the project extend beyond the immediate location of the powerline, as vegetation is cleared along a wide strip on either side of the powerlines. Here, we have used a 1-kilometre buffer broadly to represent the project's impacts associated with forest clearing and we have ignored other direct, indirect and cumulative impacts (Figure 4).

Case study – Map project footprint

Example of mapping project impacts associated with forest clearing and degradation for the Gangu CFR powerline development. The powerline location is shown as a dotted line, but the overall impact area is taken as a 1km buffer either side of the powerline.

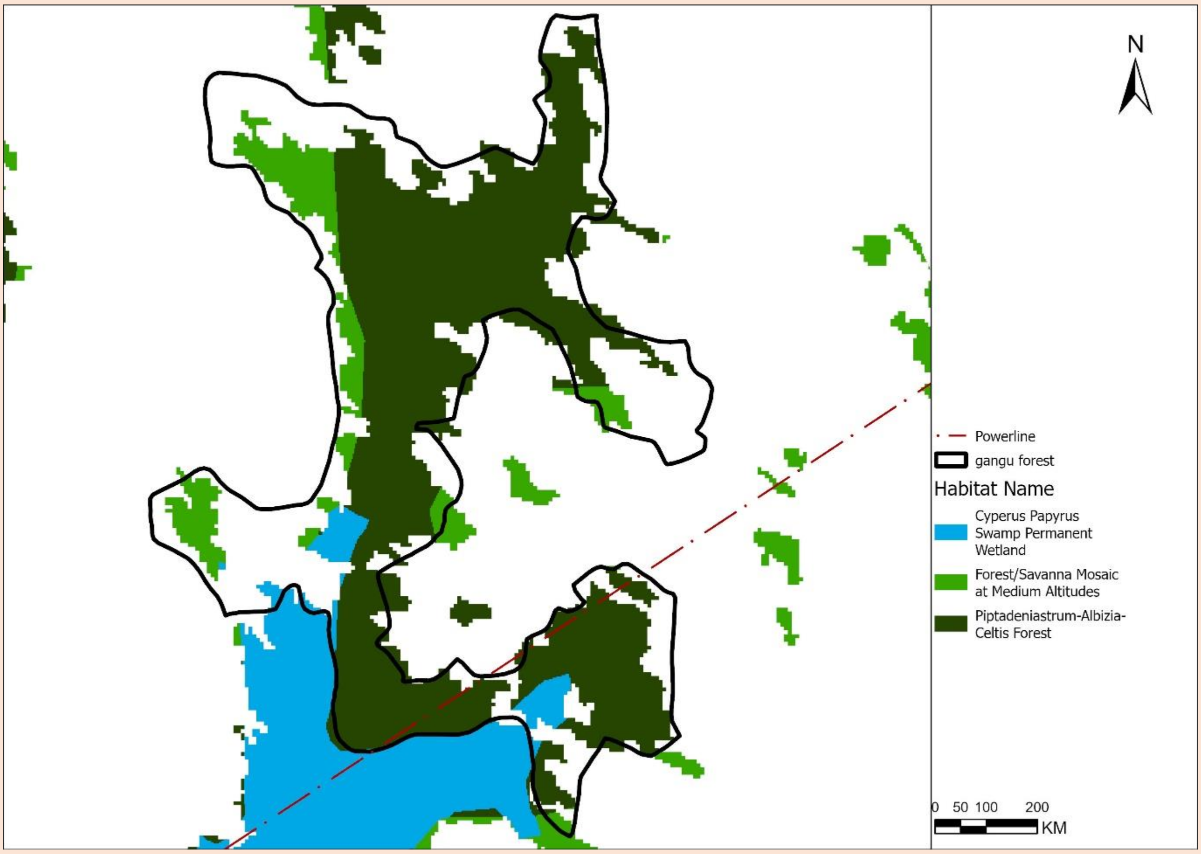

Figure 4. Gangu CFR with the location of the electricity power line development (dotted line).

Step 2: Identify the impacted ecosystems within project site

The next step when using metrics to calculate project impacts is to identify the different types of ecosystems in the project impact area. Developers should use the official ecosystem map described above to identify the different ecosystems that are impacted by a project (Figure 5). This must be confirmed with field visits to ensure that all ecosystems in the project area are captured accurately. The result should be a list of all affected ecosystems present in the project area.

Case study – Identify the ecosystems affected by the project

Example of mapping impacted ecosystems for the Gangu CFR powerline development. All ecosystems covered by the development (black line) must be assessed and have metric values calculated.

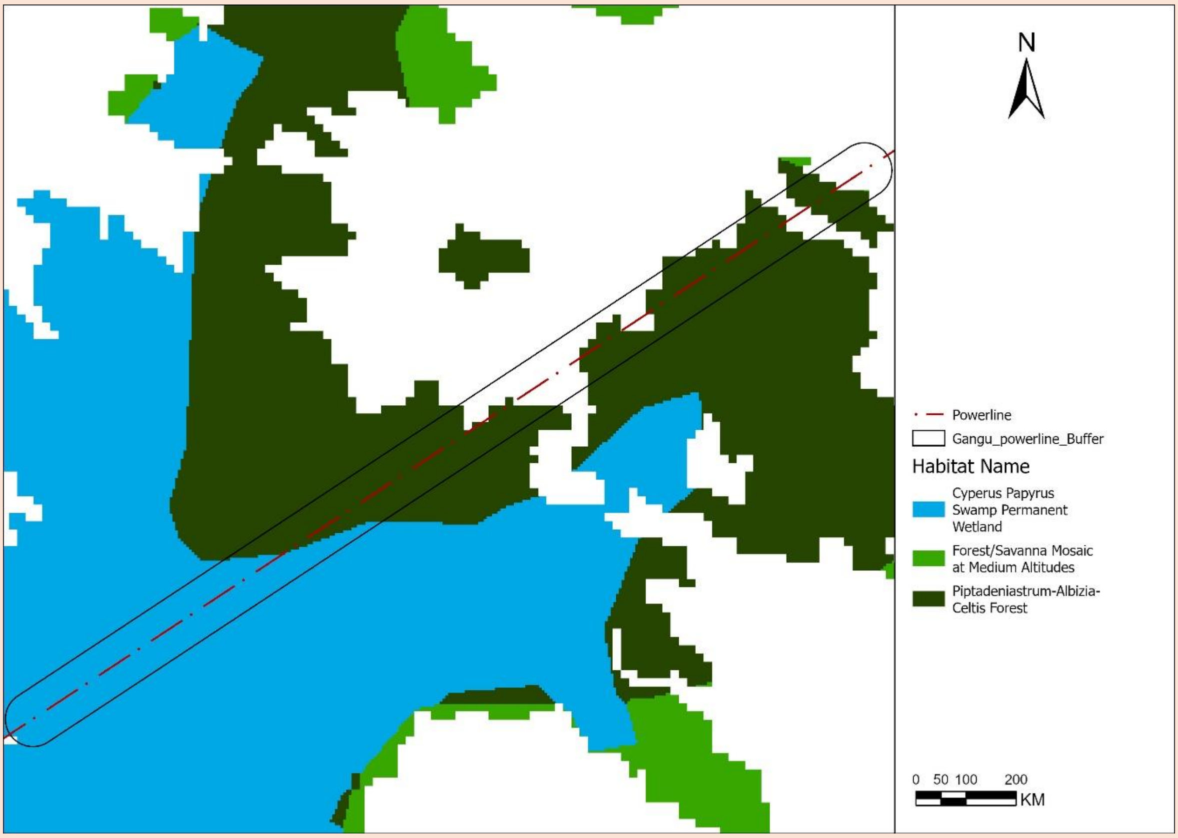

Figure 5. Mapping impacted ecosystems. For the Gangu CFR case study, we shall consider a 1km buffer from the electricity power line to identify the impacted area as shown in the map above

Step 3: Identify assessment units to stratify sampling

Once a list of ecosystems is developed for the project site, the next step is to design a field sampling strategy to plan field data collection of condition attribute measurements. Sampling must be conducted at multiple locations within each ecosystem type that is affected by the project.

Because there may be variation in the condition of areas within each ecosystem type, the first step is to identify a number of assessment units, with each assessment unit being a defined area that is broadly homogeneous in both ecosystem type and condition (Figure 6A). These assessment units must be mapped and are best delineated through a GIS analysis complemented with a field visit.

Case study - Identify assessment units to stratify sampling

Example of identifying assessment units for the Gangu CFR powerline development. Figure A shows delineation of assessment units, which represent areas of similar condition within each ecosystem (there is one unit - A1 - identified for ecosystem A, and two units – B1 and B2 - for ecosystem B). Figure B shows the distribution of sampling sites within each assessment unit, which are where field values will be sampled to calculate ecosystem condition. The number of sampling sites per unit is related mainly to the size of the unit, but in general 3 to 10 sampling sites are required for each assessment unit, depending on their size and configuration.

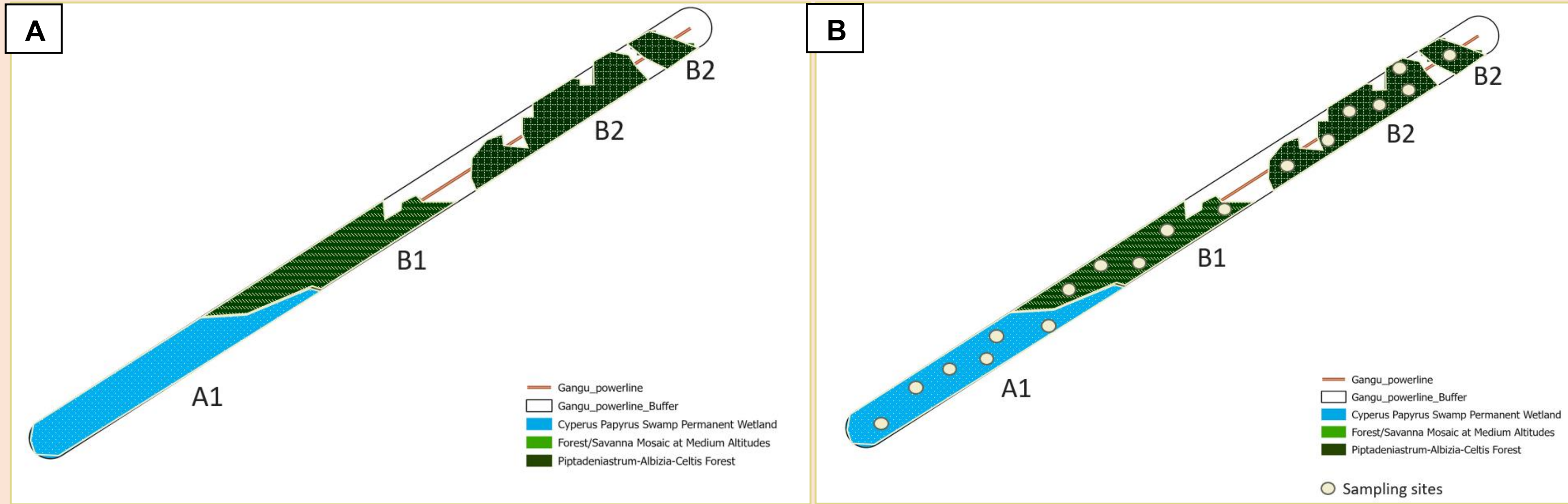

Figure 6 - A) Stratifying the Gangu CFR project area into assessment units, B) mapping sampling sites within each assessment unit.

Next, multiple sampling sites, at which site-based attribute data are collected, are then established within each assessment unit (Figure 6B). The number of sampling locations or plots needed per assessment unit needs to be sufficient to give good precision and confidence that sampled sites represent the unit. As a rule of thumb, a small and very homogenous assessment unit of a few hectares might require only 3 sampling sites, while a 100-ha assessment unit will require up to 10 sampling sites. The sampling sites should be randomly located within the assessment unit but the scheme can be adapted considering fieldwork constraints.

Step 4: Collecting field data at sampling sites

Once assessment units and sampling sites are identified, field sampling must be conducted at each sampling site. The specific attributes to be measured will depend on the ecosystem type in question (refer to appendix 1 for attributes associated with each ecosystem group). Finally, once the collected data are recorded, checked and stored, they will be used to derive the overall condition score for each assessment unit, which can then be used to calculate the final metric value (Table 5).

Case study – collect field data at sampling sites

Example of completed survey table for assessment unit B1 in the Gangu CFR. Attributes are measured at each sampling site, following field data collection protocol. The values for each sampling site are then used to calculate condition scores for each assessment unit. This table must be completed separately for each assessment unit.

Table 5. Field-sampled vegetation attributes for sampling sites in assessment unit B1.

Sampling sites in AU1	Tree Richness	Shrub Richness	Herb Richness	Tree Canopy Height (m)	Tree Canopy Cover (%)	Shrub Cover	Large Trees
Sampling site 1	7	4	4	26	43	25	7
Sampling site 2	5	3	3	24	40	25	6
Sampling site 3	6	4	5	25	32	17	5
Sampling site 4	7	5	5	24	38	19	6
Sampling site 5	8	3	4	27	40	23	6

Step 5: Calculating the final metric value for each ecosystem

Once field values for each assessment unit have been measured, final metric values can be calculated.

i. **Convert attribute values to scores using the relevant benchmark tables.**

First, the field measured value for each attribute can be converted to condition scores using the relevant benchmark table (see Table 6 for an example). These tables give scores ranging from 1 (poor condition) to 5 (good condition). The score for each attribute in each sampling site should be recorded in a table.

Table 6. Scoring table used to translate field measurements of condition attributes into scores ranging from 1 (poor condition) to 5 (good condition). This table is for Tropical High Forest, but tables for all ecosystems are available in appendix 1.

			Metric Score				
Attribute	***Measured Value***		***1***	***2***	***3***	***4***	***5***
Tree Richness	# of large tree species in 20m radius	Field Value (#)	<3	3-4	5-7	8-10	>10
Shrub Richness	# of shrub species in 20m radius	Field Value (#)	<3	3	4	5	>5
Herb Richness	# of herb species in 2m radius	Field Value (#)	<3	3	4	5-6	>6
Tree canopy height	Height of tree canopy in 20m radius (m)	Field Value (m)	<15	15-19	20-24	25-29	>29
Tree Canopy cover	% cover in 20m radius	Field Value (%)	<15	15-29	30-44	45-59	>59
Shrub cover	% cover in 20m radius	Field Value (%)	<5	5-9	10-19	20-29	>29
Large trees	# in 20m Radius	Field Value (#)	<3	3-4	5-7	8-10	>10

ii. **Calculate the condition score (C) for each sampling site**

Next, an overall condition score (C) combining the different attributes can be calculated for each sampling site (i.e. sampling sites 1-5 in Assessment unit A1). This is done by summing the scores for each attribute, and then dividing by the maximum possible score to give an overall C value. For the example above, there are 7 attributes with a maximum score of 5 each, so the overall score would be divided by 35. This results in a final condition score (C) that is always between 0-1, even if ecosystem metrics have differing numbers of attributes that are measured in the field.

iii. **Calculate the mean condition score (C) for each assessment unit**

Once we have calculated the condition score (C) for each sampling site within an assessment unit, we need to calculate the mean condition score (C) for the assessment unit. This is done by adding the condition scored for each sampling site and dividing by the total number of sampling sites to give an average C value for the entire assessment unit between 0-1.

iv. Calculate the final metric value

The final metric value for each assessment unit is calculated by multiplying the mean condition score (C) by the area of the assessment unit. This generates a composite unit (area x condition) that can be called a Quality.hectare, which represents both the condition and the size of each assessment unit. If there are multiple assessment units for the same ecosystem, the Quality.hectare values for each assessment unit must be summed to give an overall Quality.hectare score for each ecosystem.

Case study – Calculate the final metric

Calculating a final metric value for assessment unit B1. First, C scores for each sampling site are calculated by using the relevant scoring table to convert field-measured attributes into scores (see table 6). Next, the average condition score is calculated within each assessment unit, by taking the mean of condition scores from all sampling sites within that assessment unit. Finally, the mean condition score C is multiplied by the assessment unit area to calculate the overall **Quality.hectares** value.

For assessment unit B1, the metric can be calculated as follows :

Step 1 – convert field values to metric scores for each sampling site. This is done using a scoring table which is provided for each broad ecosystem type (see appendix 1). Field-measured attribute values for each sampling site are used to generate scores between 1-5 for each attribute (Table 7).

Table 7. Field-sampled vegetation attributes for sampling sites in assessment units B1.

	Tree Richness	Shrub Richness	Herb Richness	Tree Canopy Height (m)	Tree Canopy Cover (%)	Shrub Cover	Large Trees
Sampling site 1 - attribute value	7	4	4	26	43	25	7
Metric Score (from scoring table – see Table 6)	**3**	**3**	**3**	**4**	**3**	**4**	**3**
Maximum possible score	**5**	**5**	**5**	**5**	**5**	**5**	**5**

Step 2 – sum attribute scores and divide by the maximum possible score to generate an overall condition score C for each sampling site. The scores for each attribute are summed, and then divided by the maximum possible score to give an overall condition score for the sampling site that is always between 0-1.

$$Condition\ score\ (C) = \frac{3+3+3+4+3+4+3}{35} = 0.66$$

Step 3 – generate condition scores for all sampling sites and calculate the mean condition score for the assessment unit. Steps 1-2 are repeated for each sampling site within the assessment unit, to generate a condition score (C) for each sampling site. The mean value of C scores is used to generate an overall C score for the assessment unit.

Assessment unit B1	Condition Score
Sampling site 1	0.66
Sampling site 2	0.73
Sampling site 3	0.8
Sampling site 4	0.55
Sampling site 5	0.67
Mean Condition Score	**0.68**

Step 4 – multiply the mean condition score C by the assessment unit area. The final Quality.hectares score is calculated by multiplying the mean condition score by the area of the assessment unit.

Overall Metric Value (Assessment unit B1) = *Condition score (C) X B1 Area*

Overall Metric Value (Assessment unit B1) = *0.68 X 5.2ha = 3.54* ***Quality.hectares***

If there are multiple assessment units within the same ecosystem, then the Quality.hectare scores for each should be summed to give an overall score for the ecosystem.

Step 6: Calculating the overall residual biodiversity impact for a project

To calculate the overall impact on biodiversity from a development project, the above steps are applied for each ecosystem that occurs within the project area.

i. **For projects causing total ecosystem loss:** If the project will lead to total loss of impacted ecosystems, then the overall impact is simply the total Quality.hectare score for each ecosystem, as a reduction to zero for each ecosystem is assumed.

ii. **For projects causing reductions in ecosystem condition:** If a project will not lead to total ecosystem loss but will cause a reduction in ecosystem condition, then for each ecosystem the Quality.hectare scores will need to be generated both before and after the project activities occur. Then, the overall impact of the project is the difference in Quality.hectare scores for each ecosystem between the before and after project calculations.

5.2 Measuring impacts of an offset activity

To ensure that gains in biodiversity from offset activities are equivalent to losses in biodiversity caused by a development, it is essential that the same methodology is used to quantify both losses and gains. As such, the methodology above is used to measure biodiversity gains as well as losses.

To measure gains in ecosystem condition due to offset activities, the same broad steps outlined above are followed. First, the ecosystems within each offset area are identified and delineated into assessment units.

Next, field sampling is conducted at sampling sites, condition scores (**C**) is calculated for each sampling unit, and then the mean of these scores is calculated for each assessment unit. The mean C score is then multiplied by the area of the assessment unit to generate overall **Quality.hectare** scores for each ecosystem.

These measurements must be taken before any offset activities occur, and then repeated over time as offset actions like habitat restoration lead to improvements in biodiversity. By repeatedly measuring the offset sites using this consistent methodology, biodiversity gains can be quantified over time. The exact amount of gain required for an offset to be sufficient depends on both the amount of biodiversity loss caused by the development, and on any rules and regulations placed on offset requirements by the mitigation policy (e.g. stipulating the frame of reference for No Net Loss outcomes).

5.3 Key assumptions

It is impossible to measure every potential facet of biodiversity, so metrics, in this case for ecosystem condition, are an attempt to quantify losses and gains in biodiversity in a defensible but pragmatic way. To develop metrics that are feasible for project developers and government to use, a number of assumptions must be made. Here we outline some key assumptions and considerations that apply to biodiversity metrics in general, exemplifying them using the case study outlined above.

Firstly, metrics should use attributes that are related to overall ecosystem condition, and their selection should be based on research and/or expert knowledge. For each ecosystem, metrics shoud aim to include the most relevant information on key characteristics that are descriptive of that ecosystem, and are also sensitive to changes in ecosystem condition. However, ongoing testing and improvement of metrics will be important to ensure their appropriateness.

Next, because metrics assess ecosystem condition through measurement of a range of field attributes, there is an implicit tradeability among attributes. This means that individual ecosystem patches may receive similar metric scores but have different characteristics – e.g. one patch scoring high for tree canopy height, and one scoring high for shrub cover. This is why selecting appropriate attributes is important, as is insight into the results of calculations.

In a similar way, ecosystem condition and area can also be traded against each other, because the final **Quality.hectares** score is a product of ecosystem condition and area. This means that a 1-hectare area with a condition score of 1 will have the same **Quality.hectares** score as a 2-hectare area with a condition score of 0.5, or a 5-hectare area with a condition score of 0.2. Because of this, mitigation policies need to define exchange rules, such as placing minimum quality thresholds on potential offset areas, to avoid situations where loss of good condition ecosystem patches is traded for offsets in very large patches of degraded ecosystems. Such thresholds should be strongly considered for Uganda.

6. A GENERAL BIODIVERSITY ACCOUNTING SYSTEM FOR UGANDA

This document has so far summarised how ecosystem metrics have been developed for Uganda and how they can be utilised to track losses and gains in biodiversity. These metrics must be applied as part of a broader accounting system which set outs the rules and requirements for how impacts on biodiversity are managed, measured and compensated for. Accounting systems generally take the form of government documents/guidelines which set out a mandatory approach that must be followed by developers. As such, this document does not attempt to outline a full accounting system for Uganda, but instead presents some key considerations that should guide development of such a system.

6.1 Setting offset requirements

One of the major considerations for a biodiversity accounting system is to determine the amount of biodiversity gain required to compensate for a given loss of biodiversity caused by a development. The minimum standard is generally that offsets deliver at least No Net Loss of biodiversity compared to the pre-project (including its offset) situation. This means that a developer must deliver at least as much unit of gain of Quality.hectares for each ecosystem type as was lost due to the development activities. By using the standardised metric methodology outlines in this document, it becomes relatively simple for assessors to determine if biodiversity losses and gains have been measured adequately and NNL achieved.

In many jurisdictions, mitigation policies require going being No Net Loss to achieve a Net Gain of biodiversity. Net Gain is when the increases in biodiversity due to an offset actually exceed the amount of biodiversity loss caused by a development. For example, in Mozambique any development in threatened ecosystems must achieve a 15% Net Gain of biodiversity compared to the pre-project situation (i.e. 15% more gain than is required to achieve a No Net Loss outcome). In other countries, offset requirements are scaled according to outcomes-based targets set for the state of affected ecosystem types (Simmonds et al., 2019). Regardless of the method used to determine No Net Loss or Net Gain requirements, it is crucial for mitigation policies to set out limits to what can be offset, to ensure that developers screen for high biodiversity priority areas (e.g. threatened ecosystems) at the project planning stage, and design development plans to avoid impacting these areas before work commences (Cross-Sector Biodiversity Initiative (CSBI), 2015).

6.2 Placing limits on what can be offset

A critical role of mitigation policy and biodiversity accounting systems is to place limits on what can be offset. In other words, this means to identify ecosystems, species, or geographical areas that are of such unique importance that a development should not be permitted or should be strongly discouraged from occurring in that location. In many jurisdictions, protected areas and other conservation zones are deemed to be generally off-limits to development, except in cases where there are factors of overriding public concern that present exceptional circumstances. Other policies place strong limits on development within threatened ecosystem types, vegetation communities, or species ranges. In Uganda, Red List of Ecosystems results are already available, presenting an opportunity to design similar regulations, for example restricting development in threatened ecosystems as much as possible.

6.3 Ensuring like-for-like offsets

In general, a cornerstone of robust mitigation policies is a requirement that offsets are "like-for-like", i.e. that offsets generate gains the same element of biodiversity (e.g. species, ecosystem) that was impacted by a development. By using a standardised metric to calculate offset requirements, and ensuring offsets occur in the same ecosystem as was impacted, mitigation policies can be most confident that gains in biodiversity are truly equivalent. If offsets are allowed to occur in different ecosystems to those which were impacted by a development, it becomes difficult to determine a suitable offset amount, and to determine when sufficient biodiversity gains have been delivered.

Some mitigation policies do allow impacts in less threatened ecosystems to be offset by gains in highly threatened ecosystems – known as "trading up". While this can be a useful tool to generate gains in highly threatened ecosystems, it comes with a number of challenges. Because the success of ecological restoration is uncertain, trading up implies that guaranteed losses in one ecosystem are traded for potential gains in another ecosystem. Trading up also comes with the risk of rapidly depleting less threatened ecosystems quite quickly, unless data on the extent of ecosystems is kept rigorously up to date, or thresholds/limits of change are applied. Because of these risks, it is recommended that trading up not be applied for Uganda.

6.4 Ensuring offset additionality

Additionality is another crucial principle in biodiversity offsets, ensuring that conservation outcomes are genuinely new and would not have occurred without the offset intervention. In the case of Uganda, it is critical that biodiversity offsets deliver an overall net positive impact, rather than simply maintaining or displacing existing conservation efforts that would have otherwise been undertaken by government, civil society etc. Without efforts to ensure additionality, an offset project might claim credit for biodiversity improvements that would have happened anyway, leading to a false sense of ecological progress. These challenges are particularly acute in mitigation policies that permit averted loss offsetting, where offsets conserve areas that would otherwise face degradation or destruction. These rely on uncertain calculations of hypothetical future scenarios for calculation of offset requirements, and there can be many challenges with demonstrating that offset areas were genuinely at risk of future loss/degradation. While challenges still remain, mitigation systems that use a comparison between pre- and post-project biodiversity condition can face less problems with additionality, and are recommended for use in Uganda.

6.5 Suggested exchange rules for Uganda

Here we provide a summary of exchange rules agreed upon by the experts;

The exchange rules outlined here are interdependent and thus shall not be used in isolation as none is more important than the other. When planning a development project developers or project proponents should recognize that –

i. Developments should not negatively affect critically endangered or endangered ecosystems
ii. Offset requirements should be weighted by ecosystem threat status and therefore the offset requirements are higher for more threatened ecosystems, as this would ensure that biodiversity targets can be met
iii. A fixed baseline is used to assess gains. This means that biodiversity gain is determined as the difference between the pre-project / pre-offset state of biodiversity (initial site condition score) and realistically expected biodiversity condition (projected or achieved condition score after offset implementation). Counterfactuals should not be used.

As a rule of thumb, the like-for-like-or-better principle shall be strictly adhered to by ensuring that:

1. Offsets are implemented in the same ecosystem type as the one impacted by the project
2. Critical micro-habitats, critical ecological linkages as well as obligate species within the larger landscape or area of impact are conserved
3. The expected outcomes is for offset sites to hold similar or better values and benefits in comparison to the site(s) impacted by the development. This can include restoration of degraded areas over time, but offsets are only complete once No Net Loss of biodiversity has been achieved.
4. Developments are not undertaken in isolated habitats where critically endangered or endangered species occur
5. When ecological restoration is undertaken, offset site(s) shall not displace other natural ecosystems.

7. CONCLUSION

To apply the mitigation hierarchy and achieve No Net Loss or Net Gains in biodiversity, a system for measuring the impacts of developments and offset actions on biodiversity is needed. But because biodiversity is almost infinitely variable – being the vast and complex array of all ecosystems, species, their genes, and their interactions – it is impossible to measure all elements of nature. This document offers practical guidance to support the development of defensible and pragmatic ecosystem condition metrics for use in project development when applying the mitigation hierarchy to achieve No Net Loss/ Net Gain goals, and when undertaking the necessary loss/gain calculations. While species metrics are not the focus of this report, it is important that species are also considered in application of mitigation hierarchy, and detailed guidance is available from the COMBO project. Moving forward, this information can be used by Ugandan biodiversity experts and government staff to adapt and complement the existing regulations and guidelines on the mitigation hierarchy further aligning thiswith international best practices.

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9. APPENDIX

Appendix 1: Benchmark tables developed

In this Appendix, we provide all the benchmarks that were developed for assessing habitats in Uganda. A score of 1 represents a habitat of the lowest quality and a score of 5 represents the best quality habitat.

Woodland types

Woodland						
Tree Richness	Score	1	2	3	4	5
Number of tree species in 20m radius	Field Value (#)	1	2	3	4	5+
Shrub Richness	Score	1	2	3	4	5
Number of shrub species in 20m radius	Field Value (#)	1	2	3	4	5
Herb Richness	Score	1	2	3	4	5
Number of herb species in 2m radius	Field Value (#)	≤2	2-3	4-5	6-7	>7
Tree ht	Score	1	2	3	4	5
Height of tree canopy in 20m radius	Field Value (m)	<3m	3-6m	6-9m	9-12m	>12m
Tree Canopy cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	<50	50-54	55-65	66-70	>70%
Trees	Score	1	2	3	4	5
Number of trees in 20m radius	Field Value (#)	≤3	4-7	8-11	12-15	>15

Wooded Grassland						
Tree Richness	Score	1	2	3	4	5
Number of tree species in 20m radius	Field Value (#)	<2	2	3	4	5+
Shrub Richness	Score	1	2	3	4	5
Number of shrub species in 20m radius	Field Value (#)	<2	2	3	4	5+
Grass Richness	Score	1	2	3	4	5
Number of grass species in 2m radius	Field Value (#)	<3	3	4	5	6+
Other herbs richness	Score	1	2	3	4	5
Number of herb species in 2m radius	Field Value (#)	<3	3	4-5	6 to 7	7+
Tree canopy ht	Score	1	2	3	4	5
Height of tree canopy in 20m radius	Field Value (m)	<2	2m	3m	4m	≥5m
Tree Canopy cover	Score	1	2	3	4	5

Percentage cover in 20m radius	Field Value (%)	5 to 10	10 to 15	15 to 30	30 to 35	35 to 40
Shrub Canopy cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	Greater than 50	50 to 35	35 to 15	15 to 5	<5
Grass cover	Score	1	2	3	4	5
Percentage cover in 2m radius	Field Value (%)	<25%	26-35	36-45	46-60	>60%
Large trees	Score	1	2	3	4	5
Number of trees taller than 2m in 20m radius	Field Value (#)	2	3-4	5-6	7-8	Greater than 8

Forest Ecosystems

Low Stature Forest						
Tree Richness	Score	1	2	3	4	5
Number of large tree species in 20m radius	Field Value (#)	<3	4	5	6	>6
Shrub Richness	Score	1	2	3	4	5
Number of shrub species in 20m radius	Field Value (#)	<3	3	4	5	>6
Herb Richness	Score	1	2	3	4	5
Number of herb species in 2m radius	Field Value (#)	<3	3-4	5-6	7-9	>10
Tree canopy ht	Score	1	2	3	4	5
Height of tree canopy in 20m radius	Field Value (m)	<5m	5-7m	8-11m	12-14m	>15m
Tree Canopy cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	<15%	15-25%	26-39%	40-49%	>50
Shrub cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	<15%	15-25%	26-39%	40-49%	>50%
Herb cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	<15%	15-25%	26-39%	40-49%	>50%
Large trees	Score	1	2	3	4	5
Number in 20m radius	Field Value (#)	<3	4	5	6	>6

Riverine Forest/Tropical High Forest						
Tree Richness	Score	1	2	3	4	5
Number of large tree species in 20m radius	Field Value (#)	<3	3-4	5-7	8-10	>10
Shrub Richness	Score	1	2	3	4	5
Number of shrub species in 20m radius	Field Value (#)	<3	3	4	5	>5
Herb Richness	Score	1	2	3	4	5
Number of herb species in 2m radius	Field Value (#)	<3	3	4	5-6	>6
Tree canopy ht	Score	1	2	3	4	5
Height of tree canopy in 20m radius	Field Value (m)	<15m	15-18m	19-22m	23-25m	>25
Tree Canopy cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	<15%	15-29%	30-44%	45-59%	>59
Shrub cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	<5%	5-9%	10-19%	20-29%	>29%
Large trees	Score	1	2	3	4	5
Number in 20m Radius	Field Value (#)	<3	3-4	5-7	8-10	>10

Wetlands

Papyrus wetland						
Species Richness	Score	1	2	3	4	5
Number of species in 5m radius	Field Value (#)	>40	31-40	21-30	11-20	<10
Papyrus cover	Score	1	2	3	4	5
Percentage cover in 5m radius	Field Value (%)	<10%	11-39%	40-59%	60-79%	≥80%
Other species cover	Score	1	2	3	4	5
Percentage cover in 5m radius	Field Value (%)	>80%	50-79	30-49%	11-29%	≤10%

Swamp forests						
Trees: number of individuals above 3m ht	Score	1	2	3	4	5

Number of trees in 20m radius	Field Value (#)	<3	3-5	6-9	10-19	>20
Trees cover	Score	1	2	3	4	5
Percentage cover in 20 m radius	Field Value (%)	<20%	20-29	30-39	40-59	>60%
Shrub cover	Score	1	2	3	4	5
Percentage cover in 20 m radius	Field Value (%)	>50%	41-49%	36-40%	31-35	≤30%

Other wetlands (marshes & bogs)						
Cover of Wetland Species	Score	1	2	3	4	5
Percentage cover in 5m radius	Field Value (%)	<10%	11-39%	40-59%	60-79%	>80%
Cover of non-wetland Species	Score	1	2	3	4	5
Percentage cover in 5m radius	Field Value (%)	>35%	25-35	16-24	6-15%	<5%

Grass and Bushlands

Grassland						
Tree Richness	Score	1	2	3	4	5
Number of large tree species in 20m radius	Field Value (#)	>3	3	2	1	0
Shrub Richness	Score	1	2	3	4	5
Number of shrub species in 20m radius	Field Value (#)	>4	4	3	2	<2
Grass Richness	Score	1	2	3	4	5
Number of grass species in 2m radius	Field Value (#)	<2	2	3	4	>5
Other herb Richness	Score	1	2	3	4	5
Number of herb species in 2m radius	Field Value (#)	<2	2	3	4	>5
Tree Canopy cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	≥5	4	3	2	<2
Shrub cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	≥15%	10%-14%	6%-9%	3%-5%	<3%

Grass cover	Score	1	2	3	4	5
Percentage cover in 2m radius	Field Value (%)	<15%	15%-29%	30%-59%	60%-79%	>80%
Large trees	Score	1	2	3	4	5
Number in 20m radius	Field Value (#)	>3	3	2	1	0

Thicket						
Tree Richness	Score	1	2	3	4	5
Number of tree species in 20m radius	Field Value (#)	0	1	2	3	>3
Shrub Richness	Score	1	2	3	4	5
Number of shrub species in 20m radius	Field Value (#)	1	2-4	5-7	8-10	>10
Herb Richness	Score	1	2	3	4	5
Number of herb species in 2m radius	Field Value (#)	0	1-2	3-4	5	>5
Shrub cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	40-50%	51-65%	66-80%	81-90%	>90
Herb cover	Score	1	2	3	4	5
Percentage cover in 2m radius	Field Value (%)	>40	39-30%	29-20%	19-10%	<10

Bushland						
Vegetation Height	Score	1	2	3	4	5
Height of shrubs and small trees	Field Value (m)	0	0.5	0.5-1.5	1.5-2.5	2.5-3
Tree Richness	Score	1	2	3	4	5
Number of tree species in 20m radius	Field Value (#)	more or equal to 5	4	3	2	1
Shrub species Richness	Score	1	2	3	4	5
Number of shrub species in 20m radius	Field Value (#)	1	2	3	4	>5
Shrub and small tree cover	Score	1	2	3	4	5
Percentage cover in 20m radius	Field Value (%)	40-50%	51-65%	66-80%	81-90%	>90
Herb cover	Score	1	2	3	4	5

Percentage cover in 2m radius	Field Value (%)	>50	40-50%	20-40%	10-20%	<10

Moorland and heath						
Shrub Richness	Score	1	2	3	4	5
Number of shrub species in 20m radius	Field Value (#)	1	2	3	4	≥5
Herb Richness	Score	1	2	3	4	5
Number of herb species in 2m radius	Field Value (#)	≤2	3-4	5-6	7-8	>8

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ABOUT COMBO+

This report was produced under the COMBO+ (Conservation, Mitigation and Biodiversity Offsets) Programme, an initiative that supports reconciling economic development and conservation objectives in six countries in Africa and Asia: Guinea, Uganda, Mozambique, Madagascar, Lao PDR and Myanmar.

The COMBO+ partners are working with governments, industry, financial institutions and civil society to define and implement policies aimed at achieving no net loss, and preferably a net gain, of biodiversity while contributing to meeting national biodiversity targets aligned with the Kunming-Montreal Global Biodiversity Framework (GBF). Key areas of COMBO+'s programme of work are to assist host governments with policy development and the necessary governance systems that can support robust application of the mitigation hierarchy (policy and practice), preparing and collating key biodiversity data and guidance, building the capacity of government officials, private sector actors and civil society, including the exchange of experiences, and investigating and testing implementation mechanisms for successful mitigation measures, including biodiversity offsets.

The four-year COMBO+ Programme (2021 – 2025) builds on a successful first phase of work, completed in 2020. COMBO+ is implemented by the Wildlife Conservation Society (WCS) in partnership with Biotope France, Biotope Madagasikara, BIOFUND, Guinée Ecologie, the Myanmar Biodiversity Fund and the University of Queensland. The Programme is currently funded by the Agence Française de Developpement (AFD) and the Fonds Français pour l'Environnement Mondial (FFEM), with co-financing from other donors