Threatened Species Recovery Hub

National **Environmental Science** Programme

# Currencies for use in offset loss-gain calculations

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# Contents

# Executive summary

Approximately two thousand species and ecological communities are listed as threatened in Australia. Significant adverse impacts on these can trigger the requirement to offset those impacts. Best practice offsetting requires that both the losses and the expected gains for those biodiversity features must be measured, to ensure that impacts are fully counterbalanced. The units, or currency, in which they are measured must therefore be direct measures, or effective proxies, for the biodiversity features in question.

Different currencies are suitable for use in calculations of impacts and benefits (losses and gains) for different species – for some, area x habitat condition indices are suitable proxies for benefit to a species; for others, population size or density may be a more appropriate and direct way to measure losses and gains. Here, we develop a framework for determining which types of currencies are most appropriate for measuring losses and gains in an offsets context.

The criteria for an effective and appropriate currency used to measure losses and gains include that it should be closely correlated with the viability of the particular biodiversity feature in question, and able to be accurately measured with a reasonable survey effort. When the biodiversity feature is a terrestrial ecological community, defined primarily based on vegetation, existing benchmark approaches such as Queensland government BioCondition (Eyre et al., 2015) or New South Wales Government Biodiversity Assessment Method (State of NSW and DPIE, 2020) are practical, well-established and effective methods. When the biodiversity feature is a species, however, the available currencies are less developed and guidance on which to use has not reached a consensus.

Here, we provide decision trees for selecting a currency for fauna and flora species that take into account a species' detectability, population fluctuations, and the availability of proxies of abundance. Where a species' population at a site can be directly (or indirectly) and reliably measured, we suggest that such measures are an appropriate currency for measuring (or estimating) losses and gains at sites. Where the decision tree suggests a habitat-quality score is a more suitably proxy, but no approach yet exists, we make recommendations for an approach to develop a habitat-quality score on a species-specific basis. In particular, we recommend that a species-specific habitat-quality score should include between three and five key habitat components. We suggest that some required components should be hurdles to a site being considered potential habitat for a species. If one or more components one of a habitat score is a limiting resource, the value of that component should set a cap on site quality. We also recommend to allow for variable weightings for each components according to species-specific criteria, keeping in mind that for some species, separate scoring approaches may be required for sites that meet different ecological functions, such as breeding and foraging sites. We further recommend that, even when a habitat-quality score is proposed for use, if observational data is available on species usage of the site that indicates the site is higher value that assigned by the previous score, this should be reflected by adjusting the scoring scale accordingly.

We acknowledge that some species may be poorly captured by the recommendations provided, and for some species, no simple approach to develop an appropriate currency exists. We recommend that species experts are always consulted on the appropriate method in conjunction with the guidelines presented here and the assessment officer's considerations. The advice presented in this report, in particular surrounding the specific criteria for currency selection, represents a preliminary framework, and as such further work remains to validate it against case studies, and with representative stakeholders.

# 1. Introduction

The increasing pressure on our natural resources has resulted in conflicts between development and resource extraction, and biodiversity conservation. International best practice dictates that the mitigation hierarchy should be applied to minimise or ideally avoid this impact (BBOP, 2012; IUCN, 2016; McKenney & Kiesecker, 2010; US EPA and DA, 1990). As the final step in the mitigation hierarchy, biodiversity offsets may be required if impacts on biodiversity remain after avoidance and minimisation. Biodiversity offsetting involves doing beneficial actions in order to create a biodiversity gain at an offset site, which is then used to compensate for losses at the impact site. Usually, the goal of offsetting is to achieve at least no net loss – in other words, the impacted biodiversity is at least maintained (relative to a counterfactual scenario) when both the impact and the offset sites are considered.

Biodiversity offset policies and programs exist in over 100 countries (GIBOP, 2019). While the protection of biodiversity is a common goal, the specific biodiversity features that trigger the requirement for an offset differ among programs. In most cases, significant adverse impacts on threatened biodiversity are included among the triggers for an offset. In Australia, some State policy triggers include significant impacts on threatened species and ecosystems (Queensland, Western Australia, New South Wales), or significant native vegetation (Victoria, South Australia). Under the Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Environmental Offsets Policy (Australian Government, 2012), offsets are required where appropriate for significant residual impacts on protected matters (Matters of National Environmental Significance), and detailed guidance is provided for offsets on protected matters that are threatened species or ecological communities. Best-practice, including the EPBC Act Offset Policy, requires that offsetting is like-for-like – that is, that the biodiversity offset benefits the same biodiversity feature or element that is impacted.

To be able to meet the objective of (at least) fully counterbalancing impacts on particular biodiversity features, such as species or ecosystems, programs must define the currency that will be used to quantify losses and gains. The currency is sometimes called the unit of measure, index, indicator, or metric. It is the unit in which losses and gains for a particular biodiversity feature will be measured. Selection of an appropriate currency is crucial in order to 1) ensure like-for-like offsetting, 2) determine how much conservation action is required and how large the offset site must be to balance the loss at the impact site, and 3) evaluate if this action has been successful in counterbalancing the impact on the biodiversity feature in question. Measurement of losses and gains for the impacted biodiversity feature makes sense only if that feature is accurately represented by the selected currency and if the currency is adequately sensitive to the predicted losses and gains.

Currencies are used when:

- Describing the relative importance of a site for a biodiversity feature
- Estimating the total amount of loss a biodiversity feature is expected to be subject to due to actions at an impact site
- Estimating the total amount of gain a biodiversity feature is expected to receive due to actions at one or more offset sites
- Setting targets or milestones for the improvement or maintenance of a site, from the perspective of a biodiversity feature, over time
- Measuring the actual change in the value of a site over time for a biodiversity feature
- Comparing the value of a site for a biodiversity feature with what was estimated or predicted to occur.

An offsetting currency must meet several criteria. First, it must be ecologically relevant to the impacted feature, i.e. there is a meaningful correlation between what is being measured and the feature being offset (Bull et al., 2013; McKenney & Kiesecker, 2010; Noss, 1990). Second, increases and decreases in the value of the currency must be proportionate to increases and decreases in the value of the site for the relevant biodiversity feature. Third, it must be able to be measured at the site scale and be scalable for both small and more extensive sites. In practical terms, offset currencies must also be measurable within a reasonable time frame and at a reasonable financial cost for use in the approvals process. As offsets often occur in the context of government policies, operational constraints when conducting the evaluations are also important (Bezombes et al., 2017; Laycock et al., 2013).

There are several well established and widely accepted currencies in use for when the biodiversity feature impacted is a plant-based ecological community (Eyre et al., 2015; Oliver et al., 2021; Parkes et al., 2003). These currencies are typically benchmark-based composite indices. This means that they measure a series of aspects of the vegetation community, and each is compared to its ecosystem-specific benchmark value, before the elements are combined into a single value representing the condition of the community at the site (Oliver et al., 2021). The benchmark values for each component of the index can be determined based on expert elicitation (Dorrough et al., 2019), or measured values at sites considered to represent the most intact or best-condition examples of that vegetation community (Eyre et al., 2015; McNellie et al., 2020; Parkes et al., 2003).

While these vegetation-focussed currencies are effective and widely used for vegetation communities, they are also often assumed to function as a proxy for other features, such as habitat quality for particular species, or fauna in general, with the assumption that a high-quality vegetation community represents high quality habitat. However, there are many instances where this is inappropriate. A species may be found in several different ecosystems, thriving in certain environments but occurring at low densities in others. For example, Floyd's grass (*Alexfloydia repens*) is found in different vegetation communities, with either rich organic soils, clay-based soils or sandy soils. While the species will persist at low levels in clay-based and sandy soils, it requires a rich organic soil to flourish regardless of the condition of the vegetation community itself. Many fauna species will also use, or even depend upon, particular ecosystem components in heavily degraded ecosystems – such as hollow trees in agricultural land, meaning that the site is of a higher value than would be indicated by the vegetation community condition. For other fauna species, the site's value is also determined by non-vegetation factors such as depredation by foxes and cats. The condition of the vegetation community does not therefore necessarily correspond to into a site quality for a particular species.

In this report we provide guidance for selecting appropriate offset currencies for both ecological communities and individual species, with a focus on terrestrial systems. We develop rules of thumb for when it is preferable to use habitat quality as an offset currency, compared to when a direct measure of a species is more appropriate. For those species where habitat-quality scores are proposed as appropriate, we provide guidance on how to develop a suitable site-based score, and identify the circumstances under which information about species use of a site should be used to modify such scores (see Section 3.5 for more detail). We consider only solutions for best-practice, in-kind offsets, consistent with EPBC Act policy. Methods for estimating the amount of gain from management at the impact site, managing for uncertainty, and offset ratios are outside the scope of this work; we focus on providing guidance for selecting and developing appropriate currencies for use in gain calculations as part of a broader biodiversity offsetting approach. We acknowledge that some species may be poorly captured by the recommendations provided, and for some species, no simple approach to develop an appropriate currency is possible. We recommend that species experts are always consulted on the appropriate method in conjunction with the guidelines presented here.

# 2. Selecting a currency

The most appropriate currency for reflecting a particular biodiversity feature will vary based on a range of factors including the type of feature and its ecology, and the ease with which the feature can be reliably detected, surveyed and monitored. Composite area x condition indices are well-established currencies for plant communities. For fauna and flora species, there are two broad currency categories: those that measure the population of the species (or some reliable proxy thereof), and those that measure the quality of its habitat. In the context of offsets, habitat-based metrics are more common than population-based equivalents (Marshall et al., 2020). While this will be in part due to practical reasons, we suggest that in many cases, using a currency that directly measures the species' density or abundance at a site is preferable and achievable (Section 2.2 and 2.3).

Policy requirements may place further constraints on the suitability of certain currencies. For example, offset policy guidance may specify that the assessment of a site (including to collect data to inform the currency to be used in comparing losses and gains) must be completed within a reasonable number of visits, and should be robust to inter-observer variability, providing the observers are suitably qualified (Australian Government, 2012; NSW Government, 2016). This may limit the use of currencies that would require frequent and long-term monitoring to obtain a clear understanding of the relative value of a site, and as such, poses particular difficulties in assessing species that are rare, cryptic or not reliably present on site. As well as being scientifically robust, to be useful in a policy setting, practicality of being able to apply the suggested methods to calculate and meet offset requirements must be considered (Carreras Gamarra et al., 2018; Laycock et al., 2013).

In this section, we step through the main ecological and practical considerations in identifying an appropriate currency type to use for a particular species or vegetation community. For species, we present this in the form of decision trees, and set out each step in the process below. The advice in this section, in particular surrounding the specific criteria for working through the currency selection decision trees in Figure 1 and Figure 2, represents a preliminary framework, and as such further work remains to validate it against case studies, and with representative stakeholders. The currencies discussed in this report are given in the context of calculating losses and gains to biodiversity for the purpose of calculating the required amount to offset. That is, for the purpose of trade. When the value of the chosen currency must then be monitored at the offset site, additional monitoring should also be carried out that is not constrained by the restriction of rapid assessment. Ideally, both the habitat and the species should be monitored to assess and refine the accuracy of the habitat currency as a proxy of empirical measures of species abundance.

The decision process we propose is aimed at identifying the most robust but practical currency representing a like-for-like (in-kind) trade, as required under the EPBC Act Offsets Policy [REF]. Like-for-like requirements are facilitated by ensuring currencies are reliable and repeatable measures of the value of a site to the particular species or vegetation community that is the focus of the offset. Careful currency selection also supports achievement of like-for-like in other ways. For example, offset policies (including the EPBC Act policy) includes a requirement that the value of the offset site must attain at least the same quality as the impact site. So, using an appropriate currency to measure quality in a consistent way at both impact and offset sites helps ascertain that such a requirement is met.

## 2.1 Offset currencies for vegetation communities

Losses and gains of a vegetation community are frequently quantified using a benchmark approach with a composite index that combines area and condition (Eyre et al., 2015; Oliver et al., 2021; Parkes et al., 2003). For terrestrial ecological communities in Australia, benchmark-based vegetation condition scores have been used to compute site-level condition relative to an undisturbed or 'best on offer' state for over two decades. Examples include 'Habitat Hectares' in Victoria (Parkes et al., 2003), the Keighery Score in WA (Keighery 1994), BioCondition in Queensland (Eyre et al., 2015) and the Biodiversity Assessment Method in New South Wales (DPIE, 2020). These methods involve measuring a range of vegetation community components, and comparing the values of those components with the relevant 'benchmark' - what would be expected at an undisturbed site of that particular vegetation type (usually based on data collected at undisturbed, reference sites – or expert opinion if such data are unavailable). The components are weighted and the weighted sum is scored against the benchmark for each component to give a numerical score for the condition of the vegetation community at the sampled site. For example, in the Habitat Hectares approach, large trees are weighted as up to 10% of the score, lack of weeds as up to 15% and leaf litter is worth up to 5%. Attributes weightings can vary according to the ecosystem; for example, under the BioCondition metric, large trees account for 15% of the score in woodland and mangrove ecosystems, but are not included in grassland or shrubland ecosystems (Eyre et al., 2015). The score's maximum is achieved when all components at the site in question reach benchmark levels. As such, the score is usually expressed as a percentage, or a score out of 100 or ten, depending on the system.

This condition component of the score is then used to weight the number of hectares affected by a development or an offset. This yields a currency in the form of area-weighted quality hectares, such that 10 hectares of best possible quality vegetation yields 10 quality hectares, but 10 hectares of 50% quality vegetation yield 5 quality hectares. In the context of the EPBC Act Offsets Assessment Guide, this type of currency is used during calculations when the row 'Area of community' is selected, in which the condition per hectare is input (rescaled if necessary to a 10-point scale).

Benchmark-based vegetation condition scores usually include similar elements. Most involve some measure of site spatial context, such as the extent of surrounding area that is native vegetation, or the proximity to important habitat corridors. The remainder of the score – usually the majority – comprises site-level condition measures that capture elements such as vegetation cover within different strata or growth forms, the prevalence of non-native species, native species richness and specific habitat components or functional attributes. The condition score is normally measured at a series of sample sites and combined with the context element of the score, before being applied as a weighting to the area of the site.

The main preconditions for the use of these benchmark approaches for vegetation communities include 1) a classification of vegetation communities, and 2) a set of benchmark values for each element to be measured for each community, representing the best possible value (or range of best possible values) each element could take. If these systems are not already in place, such benchmarks can be developed on a case-by-case basis, by identifying a series of 'reference' condition sites of the same vegetation type, and identifying the range of values for a standard set of components to be measured at each site (e.g. canopy cover or large trees). Challenges remain with achieving consistency in measurement among surveyors and among visits (Kelly et al., 2011; Morrison, 2015) and among-user variation has been estimated to be in the range of 15-18% (Gorrod & Keith, 2009). There are also risks such as substitution between components and potential functional losses caused by changes in patch size. On balance, however, appropriately designed condition x area indices, such as those in wide use in Australia, are currently the most suitable site-level proxy for the viability of ecological communities in Australia, and are therefore recommended as currencies for use in offset calculations.

## 2.2 Offset currencies for species

Sometimes, indices developed to describe the condition of vegetation communities are also used as proxies for the quality of habitat at a site for particular species, especially fauna species (DES, 2020; DPIE, 2020). However, this approach can fail to account for the particular ecological needs of each species, or the particular components or resources at a site that make it suitable for that species to thrive. Sometimes, there are more direct ways to identify the suitability of a site for a species – such as the prevalence or density of the species at the site. In other cases, a tailored habitat score might be required.

The following two sections present a decision tree to help guide the selection of an offset currency for when the offset is for a terrestrial species. By following through the questions in order, the user is guided to the recommended currency (based either on species abundance or habitat quality) as well as the proposed method for its calculation. The steps for determining the most suitable currency are similar for flora and fauna species. The key difference is the potential for fauna species to be highly mobile, as well as the potential for proxy measures of species density, such as tracks or scats. For flora species, an additional consideration is required regarding whether individuals can be easily distinguished (or whether, for example, the species is clonal).

## 2.3 Offset currencies for fauna species

Figure 1 shows the proposed process for selecting an offset currency for a fauna species and the proposed methodology for the calculation of that currency. Descriptions of each step are given in the remainder of this section. The two broad categories of currency for fauna species are: 1) a direct or indirect estimate of abundance, based on either direct surveys of individuals, or on some proxy of density such as scats or tracks; and 2) an estimate of habitat quality, based on an existing or tailored, species-specific approach. Rarely, a generic vegetation condition index will be a suitable proxy for habitat quality, and evidence would be required to support its use. Where a habitat scoring system is required, but does not already exist, Section 3 of this report provides a framework for its development.

When using the EPBC Act Offsets Assessment Guide, the row 'Area of habitat' is used when the selected currency is habitat quality (a quality weighted area currency), and the 'Number of individuals' row can be used if the currency is a direct or indirect estimate of abundance.

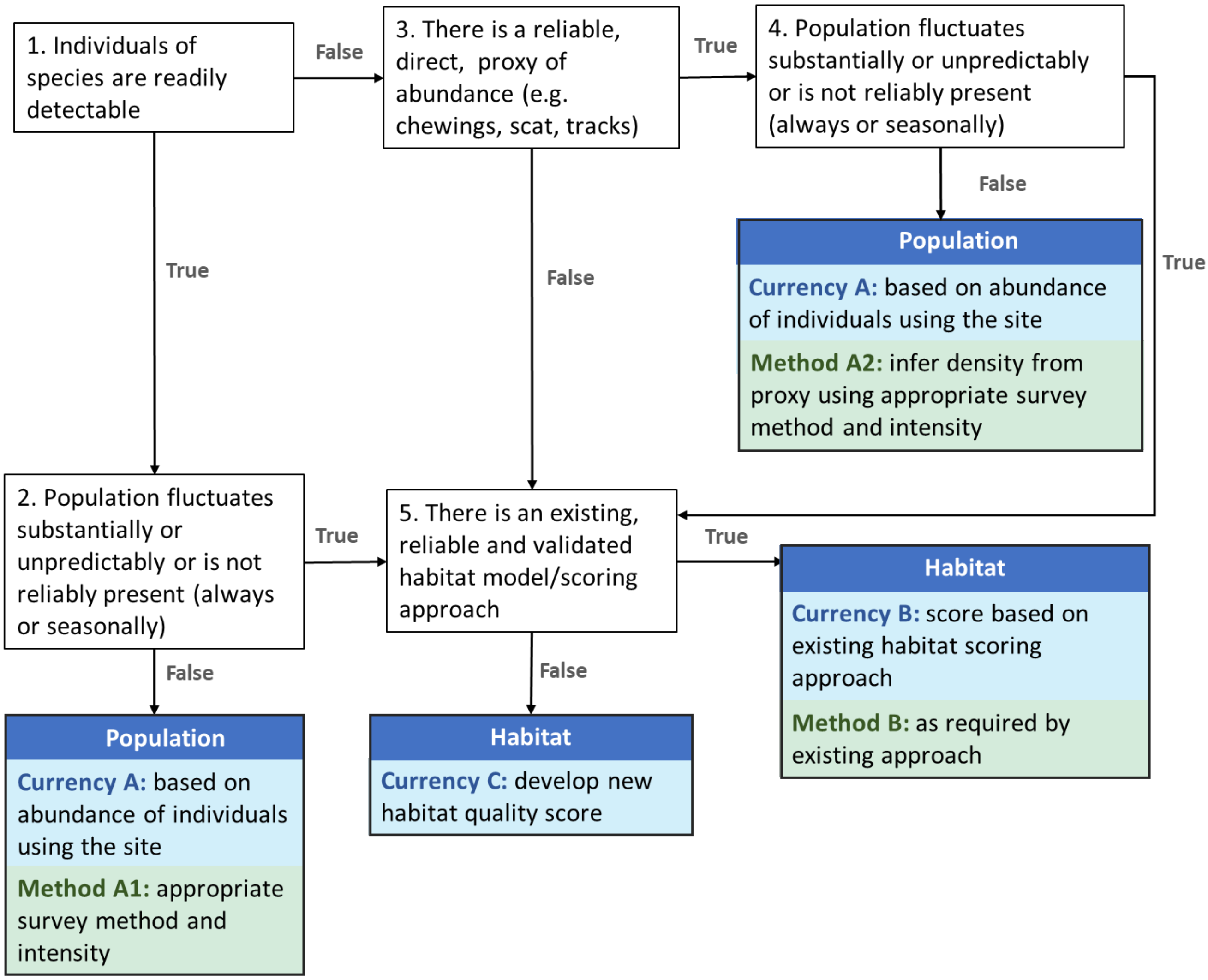


*Figure 1:* *Recommendations for selecting an offset currency for terrestrial fauna.*

### 2.3.1 Step 1: Individuals of species are readily detectable

The first decision in the process of identifying a suitable currency for a fauna species is whether the species can be reliably detected at a site when present. Some fauna species are readily detectable, but for other species the difficulty in detecting individuals makes directly estimating population size based on observation (including by sightings or trappings) unreliable. Examples of species that can be reliably detected include the Giant Burrowing Frog (*Heleioporus australiacus*) which calls predictably in suitable season, time of day and weather, and the Blue Mountains Water Skink (*Eulamprus leuraensis*), which can be seen predictably in suitable season and weather. This question should be answered as 'yes' if each unit of the species, or in an adequate sample of the species, has a reasonable chance of being detected at least once when appropriate survey effort, under suitable conditions and in the appropriate season is undertaken. A unit is defined in accordance with the target species e.g. an individual, a mature individual, a calling male. The required survey effort should be in accordance with standard methods as defined by published guidance (e.g. government survey guide, action or recovery plan, conservation committee) or as developed by species experts.

***If the statement in Step 1 is true, then proceed to step 2. If not is not true, and the species is difficult to detect, proceed to step 3.***

### 2.3.2 Step 2: Population at the site fluctuates substantially or unpredictably, or species is not reliably present

Even if the statement at Figure 1, Step 1 is true, and the species is readily detectable when present, some species are not reliably present at any given site – even the best quality sites within their range. While populations of all fauna species are expected to change over time, and in relation to environmental factors affecting resource availability, for many species this change in abundance can be relatively gradual and largely predictable. However, the abundance of some species fluctuates substantially at a given site on an unpredictable basis, and over short time frames. For example, some species such as the Plains Rat (*Pseudomys australis*), undergo 'boom and bust' cycles, where populations change by orders of magnitude in response to an environmental trigger. Other species, such as the Regent Honeyeater (Anthochaera phrygia) and Swift Parrot (*Lathamus discolor*) are highly nomadic, with individuals perhaps present at even very important sites only once in many years.

A site may only be sporadically used, and standard surveys may fail to detect individuals, and yet the site might still be valuable for the species persistence. As an example, specific conditions could be required such as seasonal or irregular flowering or fruiting events, or rainfall above a threshold. These conditions need to occur frequently enough that adequate surveys (including contingencies) can be undertaken (e.g. if a species occurs after once-in-five-year rainfall events, it might be ten years before the next suitable survey season). An example is the Green and Golden Bell Frog (*Litoria aurea*), which is readily detectable when present but metapopulations appear and disappear depending on environmental conditions and recruitment, so will often be absent in some years from high-value sites. For such species, basing decisions about the importance of a site on direct or indirect measures of species density alone are generally not appropriate.

Many species have moderately fluctuating populations at any one site, and the decision to use a currency based on population abundance or habitat quality depends on which is most likely to be more robust for the quantification of the offset exchange. In some cases, a different currency could be used for ongoing monitoring of gains at the chosen offset site, for example when environmental conditions are suitable for using an abundance currency for the offset exchange but not for subsequent monitoring over many years.

***If the statement in Step 2 is false indicating a non-fluctuating and reliably present population on site, then Currency A: Population abundance should be used. If the statement is true, continue to Step 5 to determine which habitat-quality score should be used.***

### 2.3.3 Step 3: There is a reliable direct proxy of abundance

For some fauna species direct detection from calls, trapping, or visual surveys is challenging, but reliable, ecologically-sound direct proxies for their abundance at a site are widely accepted. For example, these would include species for which scats or tracks are routinely used to generate a robust estimate of species abundance. Examples include Southern Hairy-nosed Wombat (*Lasiorhinus latifrons*), surveyed based on burrows, and Malleefowl (*Leipoa ocellata*) where mound nests are prominent features in the landscape and act as a proxy for abundance, and some mammals and reptiles where active burrows or the density of tracks on suitable substrates can be used.

The proxy of abundance should be as direct as possible, endorsed by species experts ideally in published advice or a species action or recovery plan, and more accurate than habitat proxies. 'Direct' proxies are defined here as a sign made by an individual. 'Indirect' proxies are habitat components required by the species (e.g. hollow bearing trees). While these are not suitable as direct proxies of abundance, they may be relevant in step 5, where a habitat-quality score is required.

***If the statement in Step 3 is false and there is no reliable direct proxy of abundance, continue to Step 5. If the statement is true, then continue to Step 4.***

### 2.3.4 Step 4: Population at the site fluctuates substantially or unpredictably, or species is not reliably present

A reliable proxy of abundance (and hence population density) is only useful in those situations where abundance itself is meaningful. As with Step 2, if a species fluctuates substantially in its abundance at a given site on an unpredictable basis, and over short time frame, or the species is not reliably present onsite for all or part of the year, then a measure of habitat quality might be a more suitable approach. Habitat quality measures are based on a simple species habitat model for application at the site scale. They are an attempt to estimate how important a site is to a species' viability more broadly through its support of a local population. If there is more direct information about how important a site is for a species, such as how many individuals use the site, a habitat-quality score does not need to be used as a proxy – instead information about a species' use of a site can be used directly to reveal the site's importance (as per Steps 1-3).

***If the statement in Step 4 is false, indicating a non-fluctuating and reliably present population on site, then use Currency A: Population, calculated with the proxy value. If the statement is true, continue to Step 5 to determine which habitat-quality score should be used.***

### 2.3.5 Step 5: There is an existing, reliable and validated habitat model/scoring approach.

For well-studied species, there may already be a widely accepted and robust method for scoring site-level habitat quality. In these rare instances, it is preferable to use these existing methods rather than developing a novel scoring system. When evaluating an existing habitat scoring system for use, it should be based on the species' particular habitat requirements, measurable at the site-scale, and increases and decreases in the habitat-quality score should reliably scale with increases and decreases in the importance of the site for the species.

***If the statement in Step 5 is true, use Currency B to employ an existing habitat-scoring approach. If the statement is false, then follow the guidance in Section 3 of this guide to develop a weighted, species-specific habitat scoring approach.***

## 2.4 Offset currencies for flora species

A decision tree to support the selection of an appropriate offset currency for a threatened flora species is shown in Figure 2. As with fauna species, the two broad categories of currency are an estimate of density, and an estimate of habitat quality, based on an existing or tailored scoring system. For some flora species, density can be measured by the area occupied, or by a combining this with some measure of the condition of the population within the occupied area. While the issues with highly mobile species that are considered for fauna species are not relevant for flora, the potential remains for the detectability of certain species to be highly temporally variable. Further, whether individuals within a species are easily distinguished is a key factor in determining a suitable currency. Figure 2 shows the decision tree for selecting the most appropriate currency, given the ecology and life history characteristics of the species. Descriptions of each step are given in the remainder of this section.

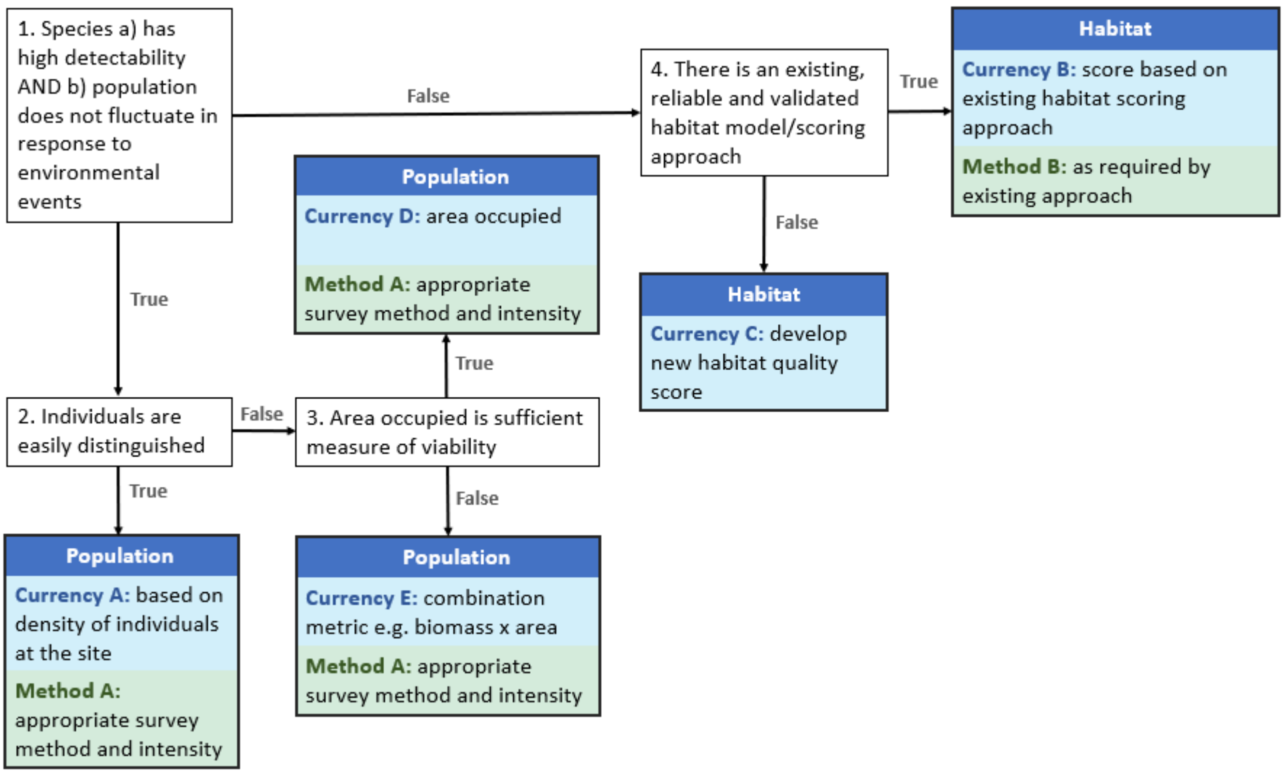


***Figure 2:*** *Recommendations for selecting an offset currency for terrestrial flora*

### 2.4.1 Step 1: Species has high detectability AND population does not fluctuate in response to environmental events

Step 1 comprises two statements, both of which must be true for this condition to be met. The first component is whether the species can be reliably detected. While this will be true for many plant species, some such as orchids, spend a large portion of the year underground. Additionally, individuals are not reliably detectable as not all plants will flower every year. Species with sparse populations covering a large area present similar detectability issues. For many plants, recent weather conditions and precipitation will be important factors to consider for detectability, as well as recency of major disturbance such as from fire, which may for example, prompt underground orchids to flower.

The second component for Step 1 is whether the species population on the site fluctuates significantly in response to environmental events. As described for fauna species in Section 2.3.4, some flora species operate on a 'boom and bust' cycle, where populations change by orders of magnitude in response to an environmental trigger, such as fire-dependant species. This 'boom and bust' category does not include those species which are present onsite, but are only detectable at certain times, such as plants that emerge after rainfall. Examples of species that would meet this criterion are long-lived, seed propagating trees such as Grove's Paperbark (*Melaleuca groveana*) and *Melaleuca irbyana*

***If the species is BOTH readily detectable and the population does not fluctuate unpredictably, proceed to Step 2. If one or both of these conditions are not met, proceed instead to Step 4.***

### 2.4.2 Step 2: Individuals are easily distinguishable

For many plant types, such as grasses or spreading ground-cover species, counting genetically distinct individual plants is not practical nor meaningful. This is also the case for those plants that propagate using runners or suckers, as opposed to seed-based recruitment. If the species has a morphology that enables individuals to be counted, this condition has been met.

***If the statement in Step 2 is true (individuals are easily distinguished), then the suggested currency is species abundance or density at the site. If the statement is false, then proceed to Step 3.***

### 2.4.3 Step 3: Area occupied is sufficient measure of viability

If individuals of a species are not readily distinguishable, such as with mat-forming grasses, an alternative currency might be the area covered by the species. An example of this category is Nabiac Casuarina (*Allocasuarina simulans*), a coastal shrub that propagates by suckers which therefore makes counting individuals challenging. Estimating or measuring the area covered by the species is simpler, and so area occupied is a suitable currency. In some cases, this measure might need to be expanded to include indicators of health, vigour, or biomass. Here a simple metric could be area occupied x biomass. As an example, Floyd's Grass (*Alexfloydia repens*) will form either a sparse or dense ground-cover, depending on the suitability of the site. Under those conditions, an area x density of cover score is a more informative, but still simple and repeatable measure.

***If the statement in Step 3 is true, then the area occupied is the recommended currency. If the answer is false, then a combination metric should be considered.***

### 2.4.4 Step 4: There is an existing, reliable and validated habitat model/scoring approach

For some plant species, individuals or occupied areas are not easily detectable, for example where the above-ground presence of the species fluctuates substantially among years in an unpredictable way. This includes many of the fire dependant species that have a 'boom and bust' response cycle. In these cases, survey information alone is unlikely to be reliable, for similar reasons as outlined in section 2.3.1. As such, a habitat proxy may be appropriate. For well-studied species, there may be an existing, robust method for scoring habitat quality. In these instances, it is preferable to use existing methods rather than specifying a novel scoring system. When using an existing habitat scoring system, a suitable proxy should be species-specific and evidence-based, such as those published in the peer-literature.

***If the statement Step 4 is true, use Currency B to employ an existing habitat-scoring approach. If the statement is false, then follow the guidance in Section 3 of this guide to develop a weighted, species-specific habitat scoring approach.***

# 3. Developing species-specific habitat-quality scores

For many species the most appropriate currency as indicated in the decision trees in Figure 1 and Figure 2 will be a measure of habitat quality. Examples include those species where a meaningful measure of abundance is difficult to obtain, or when a species' presence at a site is sporadic by virtue of its life-history traits (see Section 2). As discussed in Section 2, some existing approaches to habitat-quality scores used in offsetting rely on vegetation community condition indices. The condition of the ecosystem is therefore assumed to be a suitable measure of habitat quality for the target species. For many, however, this is unlikely to best represent the value of the site to the species. A species-specific habitat-quality score that considers the ecology of the species as well as the function of the site for the species (breeding, foraging, etc) would be more appropriate.

In developing a species habitat score, consideration should first be given to the components selected for assessment including if any are a limiting factor of site quality. Second, weighting and aggregation of multiple components into a single score should be clear and mathematically robust. Finally, if site-specific information can and should be used to adjust the score and/or scoring approach. Each of these considerations form part of the decision tree summarised in Figure 3 (designed to be followed when the decision tree in Figure 1 or Figure 2 results in decision for a currency based on a new species-specific habitat-quality score) and each is described further in this section.

Although different offsetting contexts may yield different habitat-quality scoring systems, even for the same species, the most critical requirement is that the scoring system is used consistently within an individual offset exchange – between the impact and the offset site, and when monitoring changes through time at the offset site. We provide advice for developing scoring systems that could be applied for individual impact assessments and proposed offset exchanges, but sharing the experience of developing such habitat-quality scores for a single species across multiple cases is likely to yield commonalities and potentially allow for a standard approach to emerge for some species. Sharing of scoring systems also permits a default species-specific score to be adopted that can be modified as needed for site-specific considerations, for all future scoring systems for that species.

When the appropriate currency is a habitat quality score, in the context of the EPBC Act Offsets Assessment Guide, calculations are done withing the 'Area of community' row, in which the quality score per hectare is input (rescaled if necessary to a 10-point scale).

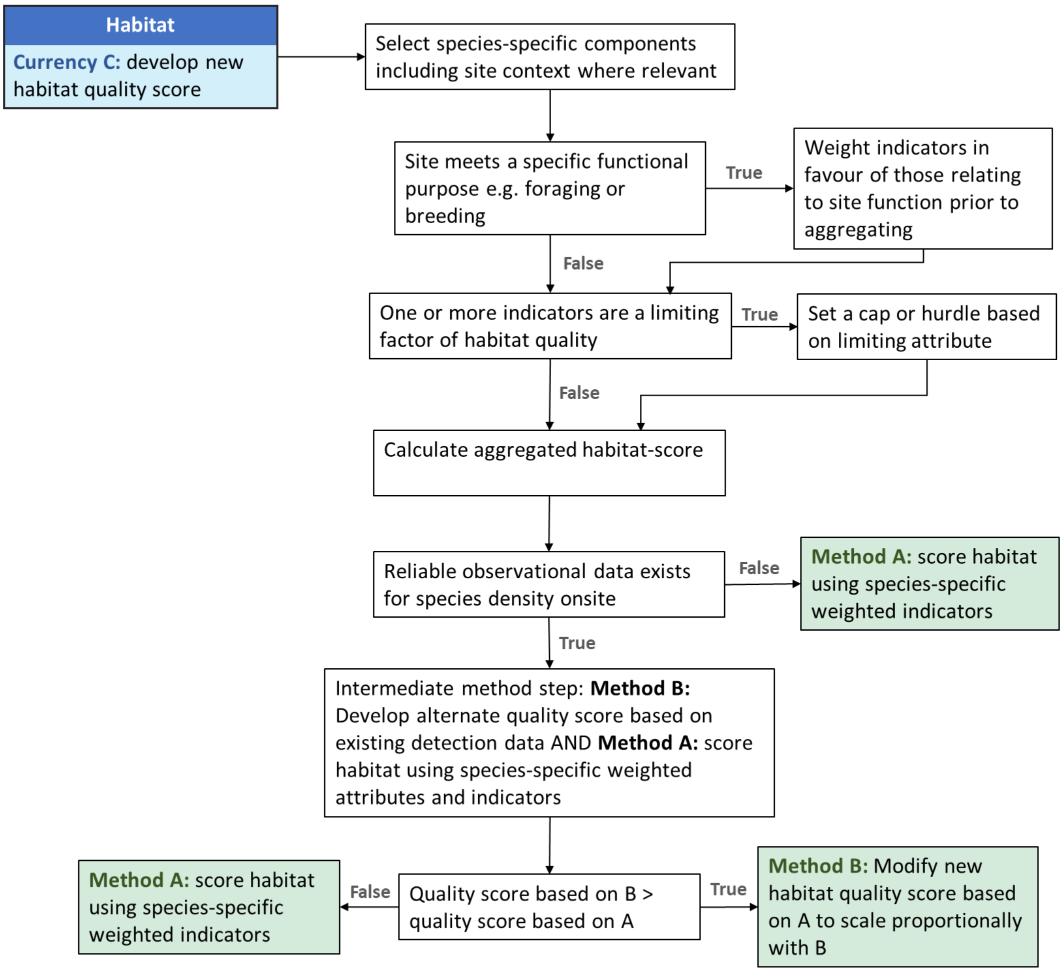


***Figure 3:*** *Steps for generating a weighted species-specific habitat score*

## 3.1 Step 1: Component and indicator selection

The first step is to select the components (i.e. the habitat parameter to be measured) and indicators (i.e. method of measurement) that will make up the habitat-quality score. The precise number of components required will vary between species, but for a species habitat-quality score it recommended that between three and five components be selected (Gregory, 2012). Components that cannot be modified by management actions, but affect the quality of the site (e.g. soil quality or presence of permanent water bodies) should still be considered, and could potentially be included as a cap to overall habitat quality (Section 3.3). Importantly, decisions about what components to include should be determined based on their importance to the species in question – not on their ability to be the subject of management actions. For fauna species, different sets of components may be appropriate where sites provide for distinct ecological functions, such as breeding or foraging. The selected components should be directly linked to the value of the site for the species and can represent both site-based components, as well as landscape or spatial context components (Table 1).

The estimation of potential loss and gain in an offset exchange involves both estimating the current state of a site (in this case, with respect to its current habitat quality for a particular species) and then estimating how that state would change in the future, under alternative scenarios (for example, if offset actions are done, or are not done). The habitat-quality score, therefore, should include only components that reflect its current condition. Components that may affect its future condition ought to instead be considered when estimating change in the habitat-quality score. For example, the presence of an important transformer weed that increases future fire risk causing expected future loss of hollow trees may be expected to reduce habitat quality for a hollow-dwelling species. However, if this is the only pathway of impact, the presence of the weed should not be included in the habitat-quality score (although it should be considered in estimating likely future changes to habitat quality). On the other hand, if the weed's presence reduces access to the ground layer for a ground-foraging species, it should be included as a component that affects current habitat quality.

***Table 1*** *Example components for measuring species habitat quality*

| Component | Scale | Examples of use |
|---|---|---|
| Connectivity | Landscape/ context | BioCondition (Eyre et al., 2015) |
| Fallen logs/Woody debris | Site-based | Habitat hectares (Parkes et al., 2003) Biodiversity assessment method (DPIE, 2020), BioCondition (Eyre et al., 2015) |
| Habitat structural complexity | Site-based | Saving our Species guidelines for estimating and evaluating species response to management (Mayfield et al., 2019) |
| Large trees | Site-based | Habitat hectares (Parkes et al., 2003) |
| Organic litter | Site-based | Habitat hectares (Parkes et al., 2003), BioCondition (Eyre et al., 2015) |
| Patch-size | Landscape/ context | Habitat hectares (Parkes et al., 2003); BioCondition (Eyre et al., 2015) |
| Tree canopy cover/height | Site-based | Habitat hectares (Parkes et al., 2003), BioCondition (Eyre et al., 2015) |
| Tree regeneration/ recruitment | Site-based | Biodiversity assessment method (DPIE, 2020), BioCondition (Eyre et al., 2015) |
| Understorey strata/ native grass cover | Site-based | Habitat hectares (Parkes et al., 2003), BioCondition (Eyre et al., 2015) |
| Undisturbed rocks | Site-based | Saving our Species guidelines for estimating and evaluating species response to management (Mayfield et al., 2019) |
| Weeds/non-native plant cover | Site-based | Habitat hectares (Parkes et al., 2003), BioCondition (Eyre et al., 2015) |

## 3.2 Step 2: Defining a scale for measurement of indicators

Once the components have been selected, each one requires a scale linking the value of the indicator to the quality of the site. For ease of comparison, each indicator should be ranked on a scale, for example from zero to five, or from zero to ten, with zero representing the component is absent and the maximum value representing a site where the component is at levels equivalent to the best on offer benchmark for that species. The simplest approach is to create a linear scale, in which each one-point increase in the score for the component represents an equal increment in the value of the indicator. An example is given in Table 2.

***Table 2:*** *Example of a stepped, categorical approach for mapping indicator values to component scores (from zero to ten) where the maximum count is estimated at 30.*

| Component score | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Indicator value range | 0 | 1-3 | 4-6 | 7-9 | 10-12 | 13-15 | 16-18 | 19-21 | 22-24 | 25-27 | 28-30 |

While the stepped based approach illustrated in Table 2 is widely applied (Eyre et al., 2015; Parkes et al., 2003) and may be a sufficient translation for many components, there are some instances where other methods may be more suitable. For example, where a wide range of values results in a coarse scale, small changes in a value near the boundaries of each category can result in large changes to the score (Gorrod & Keith, 2009). In these scenarios, a continuous score, scaled according to the minimum and maximum known values, may provide better representation. Linear approaches to scaling may also be unsuitable in instances where small changes at one end of scale have more effect than at the other. For example, where a threshold is reached beyond which increases or decreases are negligible. For this scenarios, alternative non-linear functions can be applied to score the component (Oliver et al., 2021).

## 3.3 Step 3: Inclusion of hurdles and caps for limiting site quality

*Hurdles*

For a given species, it is possible that a sufficient density of one component is essential for a site to be of any value for that species. In such cases, that component acts as a habitat constraint and should be used as a hurdle (or threshold), to prevent consideration of inappropriate sites that intrinsically lack the required component being used as offsets. Assessing this component independently also avoids time being spent on assessing offset sites that lack basic requirements and are therefore unsuitable. One example is connectivity; some species require structural connectivity of habitat to be able to use a site, and for such species, a connectivity hurdle might be required before a site's quality is further considered. Similarly, for species at risk due to particular threats, such as vehicle strike, sites where that threat is present and cannot be mitigated should be excluded from further consideration as an offset, to ensure a precautionary approach.

*Caps*

In some cases, one component limits the value of a site, such that increases in other components only add to the site's value when that one component is present at high levels. For example, the density of denning sites might set a maximum potential value of a site for an arboreal mammal, such that additional habitat components can only add to the habitat quality of the site up to the level of suitability determined by the availability of denning sites. In these situations, the habitat-quality score should be capped at the value for that component, i.e. the maximum score a site can receive is determined by the value of that component.

## 3.4 Step 4: Weighting and aggregating indicators

Once the scores have been defined by experts for the individual indicators, they then need to be aggregated into a single habitat-quality score. It should be considered whether some of the indicators are relatively more important to the species in question than others, and if so, to specify those weightings. A key limitation with many existing habitat-quality scoring systems is that all components are equally weighted, or have fixed weights that do not vary among species (DES, 2020; Eyre et al., 2015; Oliver et al., 2021). For example, the Queensland Government Guide to determining terrestrial habitat quality (DES, 2020) calculates habitat quality as the sum of four equally weighted functional components; foraging, shelter and breeding, mobility, and threats. Requiring all four components to be equally weighted regardless of the species or habitat type in question is likely to be inappropriate for many species, resulting in the ecological value of a site for a species being inaccurately reflected in the scoring. Among species and sites, each of these components might contribute differentially to species viability, ranging from zero to 100% influence (when considered at a site level).

Below we show how the various components of the habitat-quality score come together to yield a site score (Figure 4).

- **Cap:** Whether this indicator sets a cap on the overall score.
- **Indicator score:** Score (from 1-10 in this example), calculated based on the key.
- **Weighting:** Weight for this indicator between 0 and 1, where the weightings sum to one.

From these values, the following values can be calculated;

- **Weighted indicator score:** Indicator score, scaled according to weight.
- **Weighted habitat score:** Final score out of ten for this biodiversity feature, based on weighted indicators.
- **Unweighted habitat score:** Final score out of ten for this biodiversity feature, based on unweighted indicators.
- **Capped habitat score:** The lowest individual score of any capped attributes.

The weighted habitat score (for the site) is the sum of the weighted indicator scores. When the values of the weights themselves add to one, then is the equivalent of a weighted average. By comparison, the unweighted score is the average value of the unweighted indicator scores.

| | Cap? | Weighting (0-1) | Score (0-10) | Weighted score | Weighted habitat score (0-10) | Unweighted habitat score (0-10) | Capped habitat score (0-10) |
|---|---|---|---|---|---|---|---|
| Indicator 1 | No | 0.2 | 10 | 2 | **6** | **7** | **4** |
| Indicator 2 | No | 0.1 | 8 | 0.8 | | | |
| Indicator 3 | **Yes** | 0.7 | 4 | 2.8 | | | |

Indicator name | Cap | Weighting | Indicator Score | Weighted indicator score | Weighted habitat score | Unweighted habitat score | Capped score

*Figure 4: Example approach for weighting and aggregating indicators into a species-specific habitat score, including a capped component. In this example.*

The example in Figure 4 illustrates the impact of species-specific weighting for three indicators. In this example, the weighted algebraic mean of the indicator scores is lower than standard mean value due to the low value of Indicator 3, which carries 70% of the score. This indicator also sets a cap for the habitat score, further the reducing the overall score to two.

## 3.5 Steps 5 and 6: Inclusion of species' use of site

Habitat scores are appropriate for species for which species density or abundance data are not reliable (see Section 2.3 and 2.4). However, in some circumstances where gaps exist in our knowledge of the species' ecology, there is a risk that the proposed scoring system scores a site too low compared to the species' known use of the site. In these cases, any species density or abundance data, even if opportunistic and unreliable, can still inform the habitat scoring, while retaining a precautionary approach. For example, a site from which there happens to be records of relatively large numbers of individuals should receive a relatively high habitat score - but the absence of such a record should not preclude a site being assigned a relatively high habitat score, because of the already-identified unreliability of presence data. We present a way in which such data can, when suitable, be used to inform the development of a habitat-quality scoring approach and inform site habitat scores. We show how the scoring system can be rescaled and the adjusted scoring system used to recalculate the habitat-quality score for both the impact and offset sites. That is, both the impact and the offset site are assessed based on the same, revised, scale.

As an example, consider the case where the species in question is only ever sporadically present at even the most important sites. As such, a habitat quality-score is chosen for the currency to estimate losses and gains. In this case, the habitat quality of an impact site was rated as score of 2/10 based on a species-specific habitat-quality score developed using the method described above. However, observational data are available that shows the site is sporadically visited by flocks of up to 50 birds. These are very large numbers for this species; sites across the species' range are only known to attract a maximum of about 60 birds. The fact that the site attracts close to the maximum number of birds known from any site suggests that it is an important site for the species – even though the habitat score suggested the site was poor quality.

This additional information, indicating that the site is of higher value to the species than is represented by its habitat-quality score, compels us to re-assess the previously devised scoring scale in terms of what makes a high-quality site. The habitat-quality scoring scale should therefore be revised in such a way as the impact site is now rated to better reflect its importance to the species, in this example, an 8/10. This revision should consider what features of the site have been scored inappropriately, and the indicators, their scoring scale and weighting adjusted accordingly. For example, on the original scale, a given indicator with a value of 14 might score a five on the scale from one to ten. If this feature was considered an important factor in the species' documented use of the site, we might adjust the scoring such that a value of 14 now scores an eight, rather than a five. Scales and weightings for other indicators may also be adjusted, and new indicators added, before they are re-aggregated into the final habitat-quality score.

The new scale should then be applied to re-assess the relevant offset site such that both sites are now scored according to the new scoring system (Table 3). This allows for the opportunistic, but crucial, information from the species' site usage to be used to sense-check, and adjust the scoring scale based on our updated understanding, but also allows for monitoring to continue to be done in a currency type appropriate for this species – habitat quality – because of the unreliability of sighting data for this species.

We provide an example of how this approach could be used to adjust habitat scoring approaches below. Importantly, a lack of data showing use of a site by species whose presence or detectability at a site are highly variable, should not be used to adjust site quality scores.

***Table 3:*** *Possible scenarios for combining observed site usage by species with existing habitat scores (scored on a scale from 0 -10)*

<table>
<tr><th colspan="3" rowspan="2"></th><th colspan="2">Original score</th><th colspan="2">Revised score</th></tr>
<tr><th>Impact site</th><th>Offset site</th><th>Impact site</th><th>Offset site</th></tr>
<tr><td rowspan="8">Scenarios</td><td rowspan="2">1. No species density data or lower score suggested by species density data</td><td>Habitat-quality score</td><td>2</td><td>3</td><td rowspan="2">2</td><td rowspan="2">3</td></tr>
<tr><td>Score based on species density data</td><td>1</td><td>No data</td></tr>
<tr><td rowspan="2">2. Higher score based on species density at impact site</td><td>Habitat-quality score</td><td>2</td><td>3</td><td rowspan="2">8</td><td rowspan="2">9</td></tr>
<tr><td>Score based on species density data</td><td>8</td><td>No data</td></tr>
<tr><td rowspan="2">3. Higher score based on species density data at offset site</td><td>Habitat-quality score</td><td>2</td><td>3</td><td rowspan="2">5</td><td rowspan="2">8</td></tr>
<tr><td>Score based on species density data</td><td>No data</td><td>8</td></tr>
<tr><td rowspan="2">4. Higher score based on species density data at both impact and offset site</td><td>Habitat-quality score</td><td>2</td><td>3</td><td rowspan="2">5</td><td rowspan="2">8</td></tr>
<tr><td>Score based on species density data</td><td>4</td><td>8</td></tr>
</table>

**Scenario 1:** Species not observed at the site, or species observations suggest lower habitat value than the habitat-quality score suggests.

No changes are required to the habitat-quality scoring system. The site-usage data is known to be unreliable and represents the minimum use of the site, so the original calculated habitat-quality score is therefore the best available information.

**Scenario 2:** Species data at the impact site indicates higher habitat value than the habitat-quality score suggests.

Data representing the species' use of the impact site indicates that the rating of this site in this case should be raised from a score of two out of ten to a score of eight out of ten. Once the key features causing the scoring discrepancy have been identified, the scale used to calculate the scores for these indicators should be adjusted to reflect this more reliable information about site importance by changing their weightings or scoring scale. Alternatively, additional components may need to be added that better describe the value of the site. The offset site should then be re-scored according to the new scale.

**Scenario 3:** Species data at the offset site indicates higher habitat value than the habitat-quality score suggests.

The observed species density at the offset site indicates that the site quality should be raised from a score of three to a score of eight. As with Scenario 2, the habitat-quality scoring system used should be adjusted to reflect this more reliable information about site importance (in this instance at the offset site), and the new method used to recalculate the score of the impact site.

**Scenario 4:** Species data at both the impact and the offset site indicates higher habitat value than the habitat-quality score suggests.

The scale should be adjusted based on the observed density of the species for whichever site would yield the highest proportional increase. In this case, the larger gain results from rescaling based on the observational data at the offset site. The impact site should be re-assessed according to that scale.

This method is more suited to offset gain calculation systems that are best practice, and critically, which do not allow overstatements of gain from averted loss. The approach is appropriately precautionary only when other aspects of the offset gain calculation are consistent with best practice, but risks of applying this approach are elevated is a large part of the 'gain' is estimated to be simply from maintaining already-existing habitat. As with the currency selection, the framework proposed here is still conceptual and has yet to be validated against case study examples. We are aware of several cases for which suitable data are available and future work should look to confirm this approach prior to its application.

# 4. Summary

For biodiversity offsets to be effective, the currency used to measure ecological equivalence at the impact and offset site must be closely correlated with the viability of the biodiversity feature being impacted. For vegetation communities, use of a composite area x condition method is a well-established and useful approach. When the impacted feature is a threatened species whose abundance onsite can be meaningfully estimated, then the currency should be based on direct or indirect measures of abundance. However, for other species, a species-specific measure of habitat quality is required.

We provide general guidance on the development of suitable species-specific habitat quality indices for use as offset currencies. Next steps in the testing and further development of this approach could include identifying the categories into which species that commonly trigger offset requirements fall, and investigation into whether generic habitat-quality scores for particular species are viable. Although the identification and development of species-specific currencies for measuring losses and gains in offset exchanges is largely unavoidable when individual species are the focus of offsetting, there are ways to streamline and normalise the approach used. Variation in the scoring approaches developed among sites, species, and offset trades is not necessarily problematic, as long as the approach used is based on sound principles, good evidence and expert advice, and is applied consistently between the impact and offsets site, and within a site over time.

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