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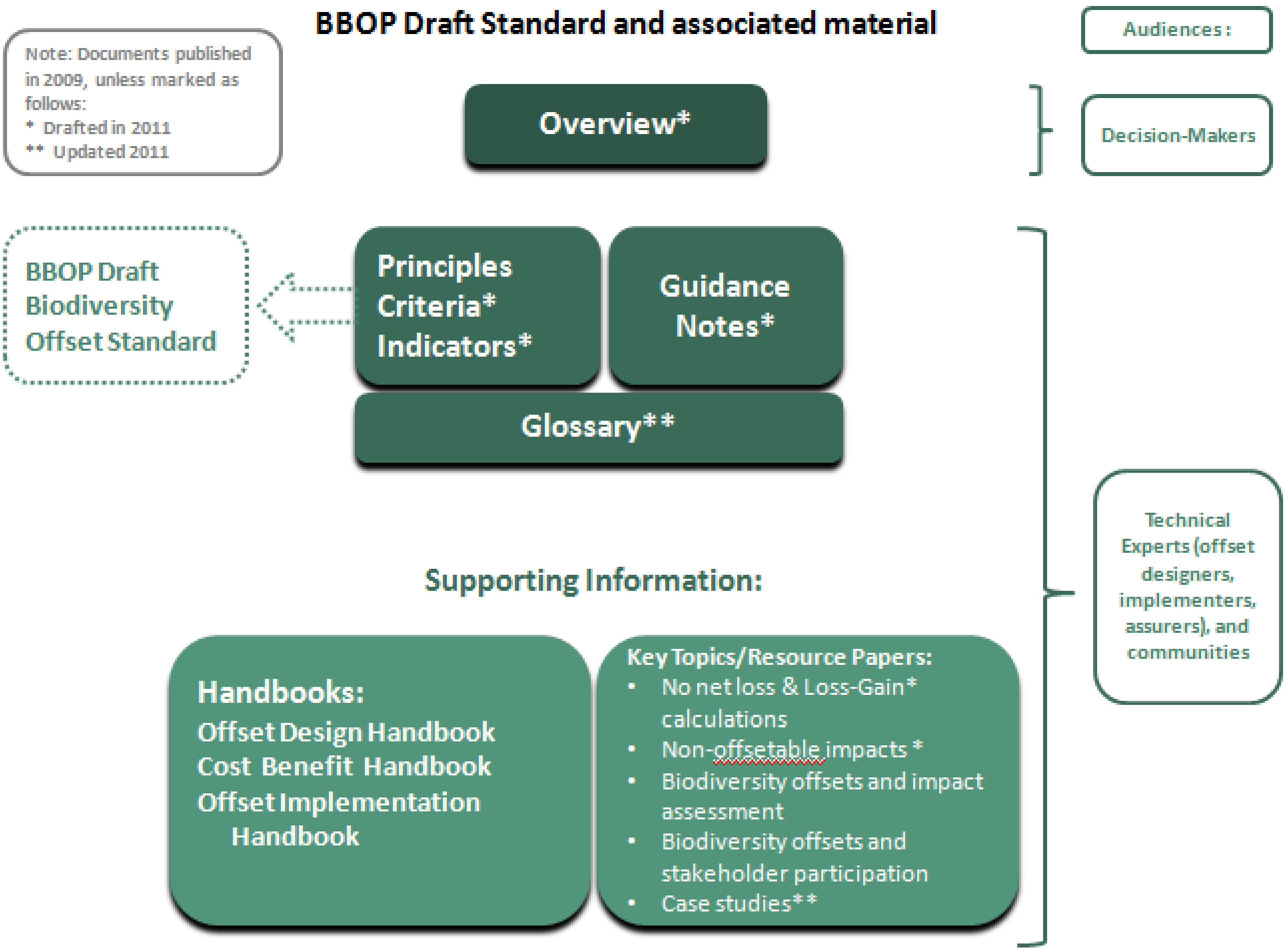
Date:	16-06-2011
Title:	Draft Resource Paper: **No Net Loss and Loss-Gain calculations in biodiversity offsets**
Audience:	**The intended audience for this document is ecological specialists and technical consultants advising companies, governments and others wanting to undertake a biodiversity offset.**
Abstract:	This document is one of two Resource Papers (the other is on Limits to what can be offset) written to update and complement information already published in the Offset Design Handbook (BBOP ODH, 2009) and to support the interpretation and understanding of the Principles and draft Criteria and Indicators (PCIs) being developed for the draft BBOP biodiversity offset standard (BBOP, 2011a). The document specifically addresses Principle 1 (No Net Loss, 'NNL'), although the interpretation of NNL is relevant to most of the principles. The draft paper outlines the key issues that need to be considered in working towards the goal of biodiversity offsets - a NNL or net gain outcome for biodiversity. It sets out a broad conceptual framework for loss/gain calculations (outlined by Stephens and von Hase, 2010), including a typology of currencies, considerations when selecting reference (or benchmark) conditions, and sources of uncertainty regarding the achievement of NNL and some responses to addressing these.
Next steps	Following comments received during the consultation period (15 June to 29 July) this draft will be improved, discussed with BBOP members and finalized as a 'Resource Paper' to accompany the PCIs and Guidance Notes to be published at the end of BBOP Phase 2.

Contents

[1] The BBOP Secretariat would like to acknowledge gratefully the financial support of the New Zealand Department of Conservation's Biodiversity Offset Programme in producing this work.

A note on related documents published by BBOP

Since BBOP was established at the end of 2004, it has produced a number of tools and products. The relationship between these is illustrated simply in the diagram below.



- All the documents from 2009 are available on http://bbop.forest-trends.org/guidelines/index.php.
- The other documents (such as this one) are under development, and once finalised in 2011 or 2012 will be available on the same website.
- The BBOP Principles, and now the draft Criteria, Indicators (PCIs) and accompanying Guidance Notes, are the core of BBOP's work to develop best practice for biodiversity offsets. These draft documents are currently available on http://www.bbopconsultation.org/pci/
- **The present draft paper addressing No Net Loss and Loss/Gain Calculations is one of two draft resource papers on key topics (the other being on 'Limits', i.e. Offsetable/Non-offsetable impacts). These papers will form part of supporting information intended to accompany and update existing guidance in the BBOP Handbooks. Please note that the present paper complements more detailed material (e.g. on loss/gain approaches, and currencies) in the BBOP Offset Design Handbook, Appendices and other Handbooks.**
- There is a set of questions to gather reviewers' opinions on the content of this paper. The questions are available at: http://www.bbopconsultation.org/pci/NNL_Questions.php. We would be grateful to any readers of this document prepared to send us a response to these questions by 29 July.

Guidance on No Net Loss and Loss-Gain calculations in biodiversity offsets

Overview

The concept of no net biodiversity loss lies at the heart of biodiversity offsetting. No net loss, in essence, refers to the point where biodiversity gains from targeted conservation activities match the losses of biodiversity due to the impacts of a specific development project, so that there is no net reduction overall in the type and amount of biodiversity present, over space and time. A net gain means that biodiversity gains exceed a specific set of losses.

Several countries have adopted no net loss or net gain as an overarching policy goal. For example, the United States has an explicit 'no net loss' goal for wetlands; other countries, states, financial institutions, or companies use terms such as 'net positive gain' of biodiversity, 'net positive impact' on biodiversity, or 'net environmental gain' to encapsulate similar policy goals.

The Business and Biodiversity Offsets Programme (BBOP) includes 'no net loss' or a 'net gain' of biodiversity in its formal definition of biodiversity offsets as *'measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no-net loss, and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity'.* Further, no net loss is the first of the ten Principles[2] for high quality biodiversity offsets. Interpretation of no net loss also encompasses the BBOP Principles 2-5, and it underpins Steps 4 to 7 of the offset design process, including the assessment of residual biodiversity loss due to a development project, the choice of loss-gain methods, review of potential biodiversity offset activities and assessment of biodiversity gains in any final design (see BBOP Offset Design Handbook; BBOP 2009a).

This resource paper covers three main topics, all of which are particularly relevant to the interpretation of criteria and indicators under Principle 1:

1. The meaning of no net loss of biodiversity and its relationship to BBOP principles
2. Approaches for quantifying biodiversity losses and gains
3. Dealing with uncertainty and risk in assessing biodiversity losses and gains

The paper attempts to identify underlying principles and guidance relevant to biodiversity offsets anywhere in the world. Nevertheless, the exact specification of a biodiversity offset requires careful consideration of various factors in the particular circumstances of the case, including characteristics of local biodiversity, human-use and cultural values of biodiversity, background rates of loss, ecological condition of potential offset sites, as well as legal, technical and socio-economic constraints on the kinds of offsets that can be applied. This will generally require the assistance of suitable qualified specialists and local expertise.

1. Balancing biodiversity accounts: understanding no-net loss and allied concepts

Central to the design of a biodiversity offset is a transparent quantification of the biodiversity losses and gains at matched development and offset sites. Evaluating gains relative to losses is challenging for two main reasons. First, biological diversity as a broad unifying concept is understood to encompass all forms, levels and combinations of natural variation, at all levels of biological organization (Gaston and Spicer 2004), as well as different kinds of human use and cultural values (BBOP 2009b). This means that compositional (e.g. individual species or species groups), structural (e.g. vegetation density) and functional (e.g. nutrient cycling rates) characteristics are all integral to the notion of biodiversity. As with any practical conservation problem, biodiversity offsets can only ever be measured and evaluated for a small, carefully selected, subset of biodiversity components (Caro 2010; Gardner 2010). Second, any given biodiversity offset project is characterised by a unique set of development impacts (defined by type, scale and intensity; see Step 4 of the offset design process; BBOP 2009a) and candidate offset sites (defined by geography, current ecosystem condition, and background rates of environmental impact; see Steps 6-7 of the offset design process; BBOP 2009a). The associated variation of local conditions is partly reflected in the multiplicity of procedures

[2] **No net loss:** A biodiversity offset should be designed and implemented to achieve in situ, measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity.

used around the world to assess loss of biodiversity (see below and Step 5 of the offset design process for some more common examples; BBOP 2009a). There is no one-size-fits-all approach. New methods are being developed and tested all the time, and a flexible, adaptive approach is necessary to achieve long-term conservation outcomes.
Despite this complexity, it is important that individual projects work from a set of common principles when designing offsets to achieve no net loss of biodiversity. Adherence to these principles, through the associated draft Criteria and Indicators that will become the BBOP standard on biodiversity offsets (BBOP, 2011a) provides assurance of best practice, and facilitates transparent and rigorous accounting.

The requirement for no-net loss is captured in the first of the ten BBOP Principles on Biodiversity Offsets. However, a robust interpretation of no net loss, as an overarching concept and as the basis for offset design, also requires explicit consideration of BBOP Principles 2-5**.** Specifically, a biodiversity offset is only likely to achieve no net loss when the following conditions have been met (see below and Figure 1):

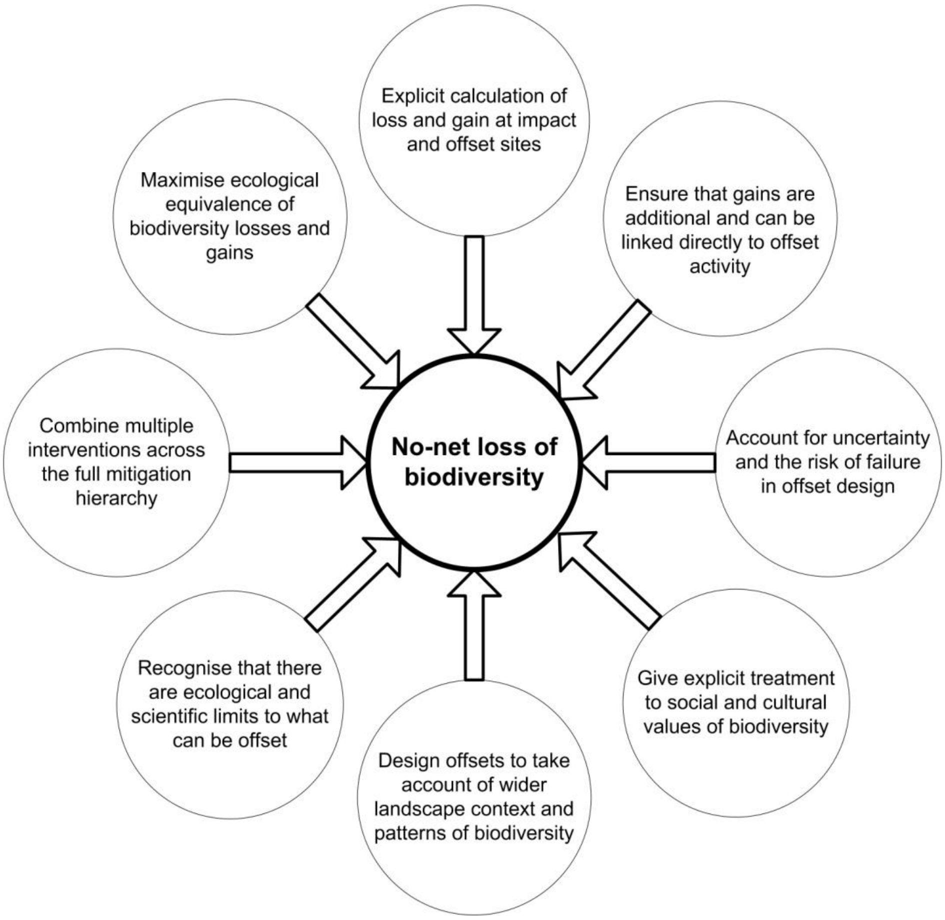


Figure 1: The key ingredients of no net loss as the central target underpinning biodiversity offsets. See text for more details of each contributing factor, and to which principle it relates.

1. **Biodiversity offsets should be based on the explicit calculation of biodiversity losses and gains at matched impact and offset sites**. This may seem self explanatory but the explicit calculation of biodiversity losses and gains is what distinguishes offsets from all other types of conservation activities. Irrespective of which biodiversity components are measured, it is impossible to demonstrate that gains match or exceed losses without going through this exercise. Multiple loss-gain assessments are often needed to account for different components (compositional, structural and functional, including intrinsic and cultural biodiversity values).

2. **Give explicit treatment to social and cultural values of biodiversity**. Values placed on biodiversity vary substantially among different stakeholder groups. Biodiversity conservation organisations often focus their efforts on conserving biodiversity for its intrinsic value, reflected through measures such as richness, population viability and endemism. However, local communities frequently place particular importance on certain biodiversity components (whether habitats, or certain species of plant or animal) for their use (e.g. medicinal plants, building materials, wild game, water resources) or non-use cultural values (e.g. recreation, sacred sites

and spiritually important species). Potential impacts on these biodiversity values, as well as opportunities for offsetting any such impacts, are not necessarily captured by general metrics of ecosystem condition or diversity and need to be given explicit treatment in any loss-gain assessment. Identifying social and cultural values invariably requires careful stakeholder engagement and participation (see BBOP Cost-Benefit Handbook, BBOP 2009c). Because of their high irreplaceability, it may not be possible to achieve no net loss with respect to some areas of particular cultural or spiritual significance (see also BBOP, 2011c: Limits to what can be offset).

3. **The biodiversity offset process requires every effort to be made to ensure that biodiversity gains are comparable, in ecological terms and from a conservation-priority perspective, to losses that occur as a result of the development project**. This is captured in the 'like-for-like' concept[3]and reflects the fact that different components of biodiversity cannot be viewed as substitutes (i.e. traded) for each other when seeking to secure no-net loss. In financial terms biodiversity is perhaps the ultimate *non-fungible asset*. Because biodiversity can vary so markedly between different locations, *in situ* conservation activities that provide additional on-the-ground[4] protection or benefits to the same and/or comparable habitats, species and populations impacted by the development offer the only means of ensuring that biodiversity gains match or exceed observed losses. Demonstrating that biodiversity offsets represent like-for-like exchanges requires careful selection of the *biodiversity metric or currency* that is used in loss-gain calculations (see below). The only exception to the like-for-like condition is where development activities can be shown to impact low conservation priority (i.e. common and non-declining, and/or well-conserved) components of biodiversity *and* where areas of high conservation priority (i.e. containing rare and/or declining populations or habitats) are available to provide an offset (e.g. through enhanced protection or restoration activities). This kind of exchange is termed 'out-of-kind' to reflect the change in type of biodiversity that is being offset and is only viable when clear improvements (often termed 'trading-up') in conservation outcomes are possible[5].

3. **Gains in biodiversity from conservation activities at offset sites need to be additional to those that would occur if no investment was made by the developer**. This condition is given by BBOP Principle 2, which also requires that activities at offset sites do not displace harmful activities elsewhere (i.e. guard against leakage). Biodiversity conservation gains can be achieved through interventions falling into two broad categories:

   a) Averted loss and/or degradation of biodiversity and improving protection status

   i. *Preventing further harm to biodiversity by tackling the drivers of background losses*. This relates to activities that will slow or stop known and ongoing environmental degradation, such as through the implementation of environmentally responsible natural resource management practices, and/or the strengthening or creation of reserve areas (to guard against identifiable threats such as vegetation clearance, timber extraction, fire encroachment, hunting etc). It can also include the provision of alternative livelihoods for people who undertake unsustainable levels of resource extraction (e.g. providing alternative protein sources to substitute for wild game). However, it is essential that any investment results in *measurable conservation outcomes* that are directly linked to the offset activity itself. Generalised 'structural' investments in local capacity building and environmental education may be important but they need to be shown to be clearly linked with actual biodiversity gains if they are to qualify as part of an offset package.
   ii. *Guarding against future threat***.** This refers to interventions that are designed to *avert known future risks* to biodiversity in areas that may currently be secure. One example of this would be a landowner who may have the legal right to cut down a forest on his land at any time in the future. Entering into a permanent conservation covenant or easement with the landowner could remove his right to do so and thus avert the risk. For an averted loss offset to make a defensible contribution to the goal of no net loss, it must be possible to show that any impending threats are highly likely to occur in the imminent future (and certainly within the timeline with the project), and are also likely to have a significant impact on local biodiversity.

   b) Positive management actions (restoration, enhancement) that improve biodiversity condition

   iii. This encompasses a wide variety of management activities that seek to improve the quality of biodiversity in sites with varying levels of degradation. Such activities can be divided into two basic

[3] 'Ecologically equivalent or representative (gains rel. to losses) are also commonly used terms to describe the concept of 'like for like'.
[4] On the ground refers to the relevant land- or seascape (i.e. is not limited to terrestrial ecosystems).
[5] Note that no scientifically defensible method has yet been developed to undertake these out of kind exchanges.

types: restoration and enhancement. Restoration refers to activities that specifically aim to return an area to its original (pre-disturbance) ecological condition prior to some anthropogenic impact. This may take the form of planting native species, removal of exotic and weed species, or ecological engineering to accelerate natural regeneration processes (e.g. inclusion of bird perches to encourage seed dispersal). Enhancement may in turn include similar activities (aimed at improving desirable ecological features or states), but it differs from restoration in that the goal is not necessarily to return a system to a specific 'prior' state (also see BBOP, 2011d: Glossary).

Choosing which kind of offset activity is most likely to deliver measureable and additional conservation outcomes is best decided on a case-by-case basis, but should include consideration of the significance of the biodiversity in question, measurement of any background rates of biodiversity loss in the region, and at neighbouring sites, a near-term risk assessment, and a review of evidence of successful restoration activities in the same ecosystem (see also BBOP, 2011c). Usually a combination of distinct and complementary offset interventions needs to be adopted to deliver adequate biodiversity gains, to limit the risk of failure and to achieve the overall target of no-net loss.

4. **The offset design and implementation process should identify and account for uncertainty and risk that may undermine the potential for delivering conservation outcomes**. Irrespective of the choice of offset activity the process of securing measurable conservation outcomes is always subject to a certain level of risk of failure. Risks may stem from a lack of data and/or scientific uncertainty in the measurement of biodiversity loss and gain, failure in the implementation process itself (e.g. through use of untested restoration techniques; loss of funds for the offset work); or the occurrence of unexpected impacts (e.g. risk from fire or flooding). These risks need to be identified, and to the extent that is possible, accounted for in the offset design process through the use of offset multipliers and other techniques, recognising that multipliers are not always appropriate (see section 3).

5. **Achieving the target of no net loss of biodiversity is generally only possible when combining multiple interventions across the full mitigation hierarchy (BBOP Principle 3).** Biodiversity offsets should only be viewed as a final resort. Prior to considering an offset for a specific project every effort has to be made to avoid or prevent impacts from occurring in the first place (e.g. re-routing of pipelines to avoid the most sensitive areas). Where avoidance is impossible, impacts should then be minimised through mitigation measures (e.g. providing wildlife corridors to reduce impacts of roads), and investments to rehabilitate and restore on-site biodiversity in the development areas once they cease to be operationally active. Impacts on different components of biodiversity may be resolved most effectively at different stages in the mitigation hierarchy, depending on the type of threats involved and the conservation significance of the biodiversity in question. Such choices should be made as early as possible in the project cycle so as to avoid wasted investments or the potential for irreversible and non-offsetable impacts.

6. **Recognise that there are ecological and scientific limits to what can be offset (BBOP Principle 4).** Ecological limits to what can be offset are generally defined in relation to the concepts of irreplaceability and vulnerability. In essence there are certain components of biodiversity that, due to their rare and/or highly vulnerable nature, are very difficult, if not impossible to replace if they were to be lost. The clearest examples of this are critically endangered species that exist only in a small handful of sites and/or are in rapid decline across their range. It is not possible to offset impacts in such situations and avoidance is necessary to remain consistent with the goal of no-net loss (see previous point). Beyond the conservation status of the biodiversity in question there are also scientific and technical limits to what can be offset; due to a lack of suitable and quantifiable offset sites for averted degradation or averted loss offsets or a lack of tried and tested restoration techniques (BBOP, 2011c).

7. **Achieving like-for-like-or better biodiversity offsets that are also ecologically viable in the long-term requires consideration of the wider landscape context.** This involves integrating information on the wider land or seascape (e.g. land use – current and planned, etc.) and spatial data (preferably at a variety of relevant scales) on biodiversity into the offset design process. This is important for several reasons. First, some elements of biodiversity can only be measured relative to regional scales, as applies to many ecological or evolutionary processes (e.g. those relating to habitat connectivity) that should be accounted for in loss/gain exchanges (see section 2). Second, it is only possible to make a sound and cost-effective judgement about the most appropriate offset sites (i.e. those most likely to deliver like-for-like conservation outcomes) when choosing from a wide range of candidates in the neighbouring region. Second, conservation priorities are context specific, which means that the regional conservation significance of a particular biodiversity component (e.g. a plant

community) in a particular site needs to be evaluated relative to the presence or absence and condition of the same component elsewhere. Some conservation priorities are set at the global scale (e.g. the IUCN Red List, based on assessing species' vulnerability to threats and determining risk of extinction) but others are national or regional (e.g. country level Red Lists for species, conservation plans, and biodiversity action plans). For components of biodiversity that deliver cultural or human-use benefits the assessment of regional context is also important in efforts to achieve no-net loss. Finally, the long-term viability of biodiversity at offset sites (i.e. persistence of any biodiversity gains) depends critically on their connectivity to other landscape elements (e.g. through colonisation and dispersal processes) (Bennett 1998). All three of these landscape considerations are incorporated into the process of systematic conservation planning (Margules and Pressey, 2000; Moilanen et al. 2009, and see below).

2. Quantifying biodiversity loss and gain

The assessment of biodiversity losses and gains between impact and offset sites is the cornerstone of the offset design process. Choices about how loss-gain assessments are conducted relate directly to several key steps in the offset design process, from measurement of residual impacts (Offset Design Handbook Step 4) to choice of methods (Step 5), and the selection of most appropriate offset activities to ensure that biodiversity gains match or exceed the losses (Steps 6-7) (see Figure 2; BBOP 2009a). There is a wide range of published and unpublished approaches and methods for quantifying biodiversity offsets (see examples given in the Appendices of the BBOP Offset Design Handbook; BBOP 2009c; and below), and choosing between alternatives can be challenging.

There is no 'one-size fits all' solution for measuring biodiversity loss and gain, and individual solutions need to be tailored to fit local circumstances within a general guidance framework. Despite the large range of loss-gain methodologies in use, there are four basic components to a general framework that can be used to guide the selection of a suitable and defensible approach:

(i) the choice of biodiversity components and measures;
(ii) the choice of a currency for quantifying biodiversity exchanges;
(iii) the choice of an accounting model to define offset specifications; and
(iv) the availability of (or opportunity to collect) spatial information on patterns of biodiversity at the impact and candidate offset sites (Figure 2).

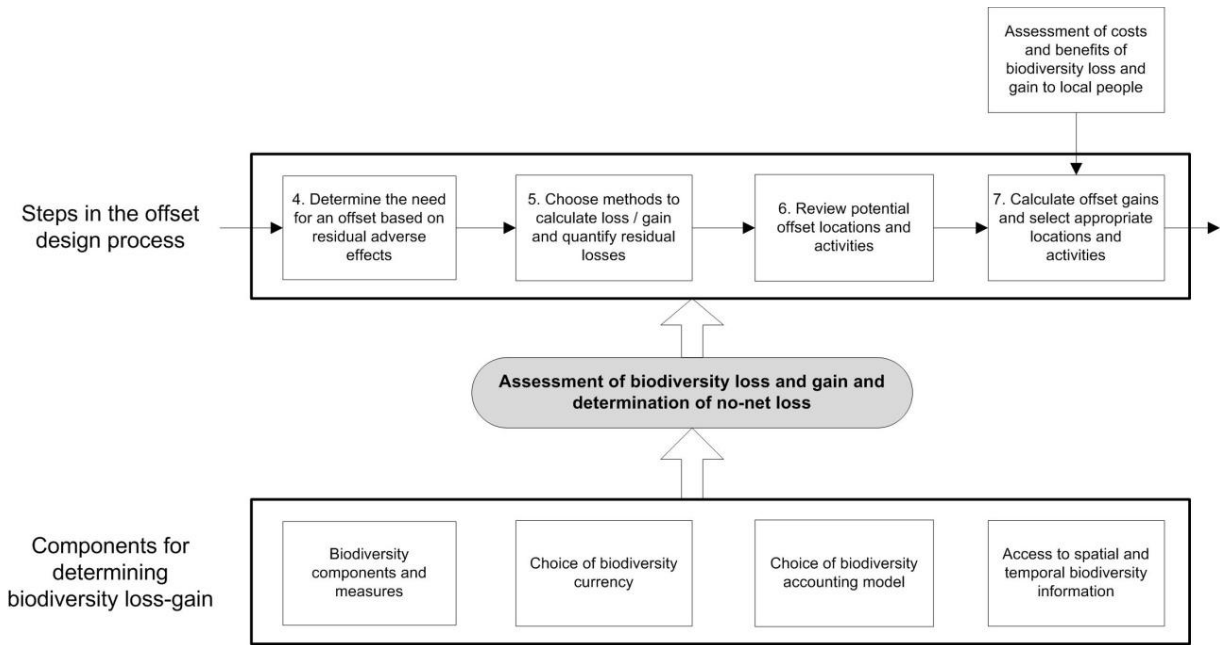


Figure 2. Relationship between a generic framework for determining biodiversity losses and gains and key steps in the offset design process. Choices regarding measured biodiversity components, currency, accounting model and questions of data availability need to be considered together.

2.1 Biodiversity components and measures

It is impossible to measure and account for all aspects of biodiversity when designing an offset. As such, offset design, like other practical conservation applications, relies upon surrogates or proxies that are intended to represent biodiversity more generally (Caro 2010; Gardner 2010). There are a number of important considerations when selecting suitable biodiversity surrogates (e.g. populations, species, vegetation and habitat types) and deciding on appropriate ways to measure the amount and quality or condition of affected biodiversity components (e.g. abundance, presence-absence, percent cover):

- Conservation significance (e.g. based on measures of irreplaceability and vulnerability/threat status) and the value of biodiversity to local and other affected people (i.e. ecosystem services including both cultural and use values);
- Resource and habitat requirements necessary to ensure the long-term persistence of affected biodiversity components;
- Ecological knowledge of the likely responses of different biodiversity components to different forms of human intervention;
- Geographic frame of reference, affecting the scale at which ecological evaluations need to be made;
- Timeframe of the proposed development project and associated biodiversity offset.
- Availability, quality, and spatial scale (extent and resolution) of existing data, and the feasibility of acquiring new data, to establish reference conditions for making assessments of loss and gain (see Section 2.2).

The first three considerations capture something of the present-day ecological properties of a region while the remainder reflect practical constraints on ways in which offset assessments can be executed (see section 2.4). A rigorous assessment would make efforts to integrate and evaluate information on biodiversity patterns (compositional and structural elements such as populations, species and habitat types); ecological processes (biodiversity-mediated functional processes, e.g. plant-animal interactions, keystone species) and biodiversity components of particular importance to local and affected communities through their use or cultural values (i.e. ecosystem goods and services, see BBOP 2009c).

Once selected, these biodiversity components and associated measurements can be summarised within a Key Biodiversity Components Matrix (e.g. Table 9 in the Offset Design Handbook, BBOP 2009a; and Table 3 in the Lebateng BBOP worked example; BBOP 2009d; see also the resource paper on Environmental Impact Assessment and Offsets).

2.2 Biodiversity currencies

Once a set of biodiversity components and associated measures have been selected (see section 2.1) they need to be integrated into a suitable *biodiversity currency or metric*. This currency provides the basis for quantifying a development project's residual impact on biodiversity, and the nature and size of the offset required to compensate for the biodiversity affected. Since the choice of currency forms the basis of what is meant by loss and gain it is a critical factor in evaluating the potential for achieving no-net loss of biodiversity. This is both a strength, because it provides for the simplicity necessary to adopt a transparent accounting procedure (see section 2.3), and it is a weakness since anything that is not captured by the currency is at risk of being lost in the exchange.

Historically, the size and nature of an offset was ascertained using simple currencies such as area, measured in hectares (often on a 1:1 basis), or some proportion of the total financial investment made in a given investment project, via a formula that identifies a subset of biodiversity values (e.g. timber value on the land), or simply on an *ad hoc* basis determined by the investment a developer is prepared to make. However, the last 10-15 years have witnessed the development of more suitable metrics that endeavour to assess the nature, amount and quality of biodiversity that is likely to be lost and gained within a given project.

A good currency should capture the type, amount and condition of the biodiversity that is being lost and gained. It is often desirable or necessary for the overall offset design and accounting system (section 2.3) to include multiple complementary currencies that account for distinct biodiversity components (e.g. rare species and vegetation types, or intrinsic and cultural biodiversity values) and/or different geographic scales (e.g. site-level vs regional measures of biodiversity condition).

The following three questions can help to distinguish between different types of currencies: First, is the currency composed of direct or surrogate measures of biodiversity (type, amount, condition)? Second, does it include aggregated or disaggregated information on biodiversity (type, amount, condition)? Third, is it based on site specific or context dependent measures (biodiversity type, amount, condition)? A summary of this typology is given in Table 1. These choices in type of biodiversity currency are often correlated with each other (for example disaggregated currencies are frequently context-dependent) yet considering each of them separately can be a useful exercise.

Table 1. A 'typology' of currencies for biodiversity offsets

Choice in selecting a biodiversity currency	Explanation and examples
Direct or surrogate (proxy) measure?	In some situations direct counts or measures of biodiversity (e.g. number of individuals of a particular bird species) may represent a suitable currency in themselves, without requiring any form of recombination or modification. This may be the case where only this particular bird species is affected (e.g. losses through wind turbine strike). Direct measures of amount or condition have the advantage of ensuring that any losses and gains are not masked by changes in other variables, as may be the case when using indirect or surrogate based measures as the basis for a currency. Guarding against difficult to detect yet undesirable changes is particularly important when dealing with impacts on significant components of biodiversity such as threatened species. Direct measures of currency are necessarily disaggregated (they have a specific focus), but depending on how the component of biodiversity in question is measured they can be either site specific or context dependent. Because biodiversity is a multi-faceted and multi-scale phenomenon, currencies based on indirect or surrogate biodiversity measures (such as habitat complexity, vegetation type, certain condition measures, area) to simultaneously account for multiple biodiversity components have seen popular application in offset design. Surrogates need to be carefully designed and validated so that they may be representative of the underlying biodiversity, and do not mask important changes in this biodiversity. A particular problem in this regard is one of scaling: it is important to ensure that incremental changes in surrogate values reflect comparable changes in underlying biodiversity across the full range of values (Gibbons et al. 2009; and see below).
Aggregated or disaggregated?	Aggregated currencies (e.g. area and condition based currencies) combine and generalize information on multiple biodiversity components and include most surrogate measures. In principle they treat all constituent components equally (though some may be differentially weighted) and so may mask trade-offs between important or more difficult to conserve components for common or more easily conserved components (see McCarthy et al. 2004; and main text). By contrast, disaggregated currencies maintain the identity of individual biodiversity components (e.g. species, vegetation types) and are therefore more transparent, avoiding problems of trading between constituent parts. Examples of disaggregated currencies include complementarity and measures of persistence for individual biodiversity components. Disaggregated currencies may provide a basis for out-of-kind and trading-up exchanges (e.g. through the protection of endangered species in an offset site as compensation for impacts on common species), although methods for this are still under development. Of course aggregation is a relative concept; a currency which is dissagregrated at one level (e.g. variability in vegetation types) can be aggregated at another (contribution of constituent species within vegetation types).
Site specific or context dependent?	Currencies based only on site level information are useful when there is a poor understanding or lack of data on wider patterns of biodiversity. Site level-based currencies do not include any information on relative measures such as patterns of rarity, levels of threat and the extent to which particular losses and gains may contribute to regional conservation priorities. Commonly employed site level measures include area, species richness, counts of individuals, and measures of pressure (e.g. aggregated threat assessments such as are commonly used in freshwater contexts). By contrast context dependent currencies are able to assess the contribution of local biodiversity losses and gains to changes in conservation priorities at a regional scale (either through a contribution to the overall persistence of a given component, e.g. overall population growth rate; or to

regional patterns of biodiversity). Context-dependent currencies are generally also disaggregated and are essential where out-of-kind exchanges and trading up is being considered (i.e. offset low priority impacts through high priority gains). Examples include the (i) measurement of complementarity which can be used to assess dissimilarities among loss and gain sites, or identify the best combination of multiple offset sites that are necessary to achieve no-net loss; and (ii) persistence or susceptibility to loss which can be captured using a continuous measure of threat status and extinction risk (with the potential to combine both area and abundance measures). Both complementarity and persistence-based currencies have been used in conservation planning (see Pressey et al. 2007; Walker et al. 2008; Moilanen et al. 2009) but to our knowledge have yet to be applied to biodiversity offsets.

Table 1 provides some insight into the large array of currency options that are available or which can be adapted for calculating biodiversity loss and gain. Many of the more detailed approaches that rely on species-level information, or maps of regional biodiversity and patterns of threatening processes are difficult to implement in poorly studied parts of the world. Consequently, many existing biodiversity offset projects rely upon simplified and site-based surrogate measures, and in particular on different types of area x condition-based currency (e.g. the Habitat Hectares method employed in Victoria, Australia, see Parkes et al. 2003, and BBOP 2009a, 2009c and 2009d for a revised approach developed by the BBOP community). Condition is essentially a fractional measure of the relative (or perceived) intactness of biodiversity at a specific site relative to a reference site (assessed to be in 'optimal' condition). Condition can be measured directly at the species level (e.g. by comparing counts or abundance measures at impact, offset, and reference sites and averaged across all species that are measured) and/or using surrogates of biodiversity such as habitat and landscape structural indicators (for a detailed review of indicator concepts in biodiversity assessment and monitoring, see Gardner 2010). When used appropriately (taking certain caveats into account, see below), condition combined with a measure of area (e.g. hectares of vegetation lost or gained), i.e. condition x area currencies, can provide an ecologically meaningful guide to loss-gain assessments in offset design.

While condition x area currencies are popular in biodiversity offsetting there are at least four important considerations to keep in mind:

1. **Area alone is generally not an adequate currency for biodiversity offsets.** Area alone (e.g. 1 ha of deciduous forest) is a surrogate measure of the 'amount' of biodiversity affected, however it does not take into account any variation in quality or condition. This is problematic as human impacts are almost ubiquitous across the world and few potential offset sites are ever likely to be pristine. This means that the risk of 'trading down', where a high quality impacted area is offset by a substantially lower quality area of the same vegetation type, is high when area alone is used. This can undermines the ability to achieve no-net loss and illustrates a severe limitation in several current offset schemes (e.g. many wetland mitigation and conservation banking schemes in the United States and the Brazilian Codigo Florestal (Forest Code)) where exchanges are often calculated based simply on number of acres or hectares. Simple multipliers are frequently used to increase the size of the offset (e.g. 2x or 5x the impact area) as insurance against uncertainty in levels of ecological condition and other risks of failure in the offset process. Although appealingly simple, these multipliers are often of limited utility, as a large amount of a 'common and mediocre thing' does not equate to a small amount of a 'rare and good thing' (see section 3.2 for further discussion on multipliers).

2. **Assessments of ecological condition require selection of a reference or benchmark state yet this process can be highly subjective**. Measurements of ecological 'condition' or 'quality' can only be made with reference to some benchmark state that reflects a 'natural'/pristine or desirable condition (Noss 2004; Gardner 2010). The use of a benchmark aims to provide an objective framework, and a common reference point, for evaluating biodiversity losses and gains across impact and offset sites (the overall condition of the reference site must be equal to or greater than that of impact and of offset sites). To maximise the potential for a genuine like-for-like exchange it may often be necessary to employ multiple benchmarks for each of the biodiversity components that make up an overall offset package. Despite its intuitive application, the accurate measurement of a reference condition, and deviations from it, as a basis for judging offset performance and measuring biodiversity gains, is challenging and has confounded scientists working in natural resource management systems for decades (Lindenmayer and Hobbs, 2007). Gardner (2010) proposed five considerations or principles that can help when establishing a suitable reference condition for biodiversity assessment:

i. *Identify reference sites based on an independent understanding of prior human impacts*. The selection process should include an agreed set of minimal disturbance criteria, which may include historical records of human activity or areas that have made a substantial recovery from past disturbance. Where such information is not available it may be necessary to construct a 'virtual benchmark' which employs expert opinion and ecological knowledge to construct a best estimate of undisturbed conditions.

ii. *Accept the problem of shifting baselines.* For much of the world there is no such thing as a 'natural ecosystem' yet this should not necessarily impede our ability to measure losses and gains in biodiversity. With this consideration in mind Stoddard et al. (2006) developed a useful typology of different types of reference or benchmark condition, with each type being associated with different opportunities for conservation (Table 2). For many areas of the world that have already experienced long-term impacts from human activity the most appropriate reference site will be that which has been under the best possible conservation management for at least a few decades (the 'best attainable condition'; Table 2).

Table 2. A typology for defining different reference condition or benchmark states under varying levels of human disturbance. Adapted from Stoddard et al. (2006)

Term	Description
Reference condition for ecological integrity	Reserved for the traditional concept of the reference condition as a completely natural or intact state
Minimally disturbed condition	A measure of condition in the absence of significant human disturbance. The concept of a 'minimally disturbed condition' accepts that some level of disturbance is almost inevitable for most of the world, and provides what is often the best approximation of the reference condition for ecological integrity.
Historical condition	This term describes the condition of a system at some point in its history (e.g. pre-human arrival, pre-Columbian, pre-industrial).
Least disturbed condition	Least disturbed condition is found in conjunction with the best available physical, chemical, and biological habitat conditions given today's state of the landscape. It is ideally described by evaluating data collected at sites selected according to a set of explicit criteria defining what is least disturbed by human activities (e.g. contemporary landscape assessments of structural complexity, and/or historical records of human land-use and management).
Best attainable condition	Best attainable condition is equivalent to the expected ecological condition of least-disturbed sites if the best possible management practices were in use for some period of time. It represents what may be a *reasonable goal* for conservation activities. This is a somewhat theoretical condition determined by the convergence of management goals, best available technology, prevailing use of the landscape, and public commitment to achieving environmental goals.

iii. *Match impact sites to the most appropriate benchmark when selecting amongst offset candidates*. It can often be useful to collect data on a variety of potential benchmark conditions and then compare each candidate reference site against the characteristics of the impact site in order to find the most appropriate match for evaluating like-for-like exchanges. If an impact site is large, and encompasses a variety of ecosystems, more than one reference condition is likely to be needed for designing an offset.

iv. *Recognise that ecosystems are highly dynamic.* Ecosystems are in a constant state of natural flux as they undertake cycles of disturbance and recovery, confounding attempts to define benchmark conditions robustly using data from a single time period. This is a difficult problem to deal with (McCarthy et al. 2004) but it can be tackled with information on historical trends and/or comparisons across multiple, similar sites. It may also be necessary to include disturbance regimes (e.g. due to fire, cyclones, or biotic variables etc.) as part of the benchmark state itself.

v. *Include information on landscape context*. As discussed previously the long-term ecological viability of any given site depends critically on its interaction with other components of the wider landscape, and consideration of this context dependency is necessary when determining reference conditions.

3. **Surrogate-based biodiversity currencies need to be carefully scaled against changes in the underlying biodiversity components of conservation concern.** It is vital that currencies based on surrogates of biodiversity (e.g. area of a particular vegetation type x condition) are consistently scaled against changes in biodiversity values, so that an incremental change in the currency reflects the same change in constituent biodiversity values at both high and low ends of its range. The most famous type of scaling factor is found in the use of the species-area exponent *z* to adjust for the fact that a doubling of habitat area is unlikely to be associated with double the number of species (i.e. area and species are not linearly scaled). Similarly, changes in condition are also unlikely to have a linear relationship with changes in biodiversity, and may need to be scaled. Ideally this scaling factor would be calibrated using direct observations of (multiple) species across different impact and benchmark sites, or would otherwise need to be developed based on expert opinion, for example.

4. **Wherever possible, context dependent information that can inform on rarity or irreplaceability of specific biodiversity components should be included in the currency**. Unless currencies include some measure of irreplaceability, there is a danger of allocating low values to degraded yet highly irreplaceable and/or threatened biodiversity (Bekessy et al. 2010). This is problematic as many of the world's most important (for conservation) ecosystems are in a degraded state.

In conclusion there is no such thing as the perfect biodiversity currency for offset projects. **Once a set of key biodiversity components representing pattern, process, and ecosystem services has been identified, it would be highly desirable to capture their values through currencies that are based on direct, disaggregated (and thus transparent) and context dependent measures.** Employing direct and disaggregated currencies reduces the risks and uncertainties that are common with surrogate and aggregate measures (e.g. due to masking of contrasting responses), while context dependency ensures that landscape considerations and wider conservation status measures and targets are incorporated. **However, given our limited knowledge and understanding of much of biodiversity, it is inevitable that some intelligent surrogate measures are also employed. These provide a quantifiable bet-hedging strategy for capturing changes in biodiversity components that are either unknown or too difficult or costly to assess directly.** As discussed above, caution is needed when applying such simpler approaches. It is particularly important to resist the temptation of 'spurious certainty' – where misleading or meaningless measurements are used to guide management just because they are available and allow for a satisfyingly quantitative assessment. The risk of not capturing biodiversity adequately in the assessment of loss and gain can be reduced by applying multiple and complementary currencies that take account of known conservation priorities and available data. Risks can be further reduced by focussing investments on the most tried and tested interventions to provide biodiversity gains at offset sites, and using methods for addressing uncertainty and risk. Since offset currencies are undergoing a process of continuous improvement, data from new field projects can provide invaluable feedback for testing and developing methods.

2.3. Biodiversity offset accounting models for balancing losses and gains

Accounting is fundamentally a process for estimating the net balance, or equity, in exchanges. The concept of financial accounting is well understood, and biodiversity offsets aim to deliver a comparable level of rigour to the quantification of biodiversity losses and gains among impact and offset sites. Biodiversity accounting in offset design is only possible when losses and gains are quantified using the same currency units (and derived from the same underlying measurements of biodiversity). The core output from the accounting model is the offset specification – i.e. assessment of offset sites and activities that can deliver equal or greater gains in biodiversity as that which is known or expected to be lost from the offset site (a process encompassed by Steps 4 through 7 of the offset design process; see BBOP 2009a).

The term 'accounting model' need not infer complex mathematical models and detailed spreadsheets, as even simple models can be useful. A relevant example is the species-area relationship which provides a well established model for interpreting changes in area of habitat, and which could be used as a basis for very rudimentary offsets (not-withstanding the significant limitations of using area alone as a currency for like-for-like exchanges; see above). There is a range of measuring systems or accounting models that are or could be used in biodiversity offsetting, dealing with different levels of biodiversity (from populations, species and habitats) and incorporating varying levels of complexity (see Appendices to the BBOP Offset Design Handbook 2009c, Cochran et al., 2011). One approach of low-to-medium complexity which has seen particularly widespread application is the pragmatic Habitat Hectares method (Parkes et al. 2003; or derivates from it), which employs area x site-specific surrogate measures of vegetation as the currency of exchange, and balances losses and gains through a simple tabulation of changes in individual components (e.g. vegetation type, area, connectivity) of the overall index.

Loss-gain calculations that include context-dependent spatial information on patterns of irreplaceability require more sophisticated approaches. Here matching biodiversity lost at an impact site with the most appropriate (i.e. most likely to deliver like-for-like exchanges and result in a no-net loss or net-gain of biodiversity while also being cost-effective to implement) offset site(s) requires a systematic conservation planning approach. Systematic conservation planning approaches can make a significant contribution to effective offset design by simultaneously integrating information on the spatial variability in both biodiversity benefits and implementation costs among different offset candidates (Kiesecker et al. 2010; Moilanen et al. 2009). A variety of different conservation planning software programs exists to help guide this exercise, for example MARXAN, C-Plan, Zonation and others (e.g. see Ball et al., 2009).

Salzman and Ruhl (2000) point out that equity in an exchange of biodiversity varies according to type, time and space. This underlines the complexity of biodiversity accounting compared to financial accounting, which only needs to be concerned with equity in time (discounting) as dollars have a set and consistent value across space. In an ideal world, an offset accounting model would account for changes in all three dimensions (type, time, space) to ensure the delivery of no net loss. The majority of existing methods account in some way for exchanges in type and across space between impact and offset sites, yet to our knowledge no published methods also account for changes over time.

Although it is impossible to guarantee that a biodiversity offset delivers truly like-for-like biodiversity benefits, several considerations are important to address problems of equity:

1. **Equity in the type of biodiversity**. This refers to the notion of ecological equivalency or like-for-like that is central to achieving no-net loss of biodiversity within the offset process. Demonstrating like-for-like exchanges is challenging because biodiversity is a quintessentially non-fungible asset – no two components of biodiversity are identical, and there are no universally accepted methods for objectively determining equity in an exchange of dissimilar biodiversity (e.g. pandas for blue whales). Instead, rigorous offset design requires that careful attention is paid to choosing a biodiversity currency or currencies that adequately capture any significant changes in valued biodiversity components. In addition, restrictions or '**exchange rules'** are needed that limit exchanges which would undermine the delivery of no-net loss. A variety of exchange rules can be used to improve the integrity of an offset, including:

    i. *Limits on exchanges that involve biodiversity components of known conservation importance***.** This highlights the point that there are limits to what can be offset (Principle 4, BBOP, 2011c). Rules can be set that prevent the exchange of threatened and endangered components of biodiversity for other, less threatened components – i.e. 'trading down' (though the reverse may be permissible'' – trading losses of common species for gains in threatened species). Biodiversity components of particular conservation importance should be dealt with individually in the biodiversity accounting process to ensure that any changes can be easily assessed.

    ii. *Limits on declines in ecological condition between impact and offset sites*. One problem with area x condition based currencies (such as Habitat Hectares) is that increases in area may be allowed to compensate for decreases in condition (i.e. to the extent that the currency rules allow area and condition to be exchangeable). This could easily result in a significant drop in biodiversity conservation value, if a large area of very low condition were offered in exchange for a smaller area of excellent ecological condition. Such risks may be limited by applying an exchange rule which requires that key indicators of ecological condition either do not change significantly or can only increase between impact and offset sites (i.e. insisting on like-for-like or trading up, and now allowing 'trading down').

    iii. *Limits on what is considered substitutable within aggregated surrogate currencies*. McCarthy et al. (2004) highlight the importance of this in identifying possible weaknesses in the state of Victoria's Habitat Hectares method (Parkes et al. 2003) by showing, for example, that increases in some components of the index (such as volume of dead wood) can mask potentially negative changes in others (e.g. loss of live trees). This kind of problem can be solved, at least in part, by establishing exchange rules that set minimum values (and possibly upper limits) to key components that make up any aggregated currency.

Where possible such threshold values should be justified through validation against actual biodiversity data in reference sites.

iv. *Requirements for minimum landscape context conditions at offset sites*. Offset sites that have not been designed to account for composition and structure of the wider landscape may not prove ecologically viable in the long-term. Rules can be set that require offset sites to be of a minimum size, and be characterized by a minimum level of connectivity with neighbouring patches of the same vegetation type.

2. **Equity in space.** Biodiversity patterns and processes vary significantly from place to place due to variability in biogeography and the type and intensity of human activities. Geographic distance is thus often used as a relatively useful proxy of ecological equivalence (since closer often means more similar). Cultural values of biodiversity in particular may also only be meaningful across a limited spatial extent, depending on the distribution of local people who derive such benefits and are affected by projects and offsets. Spatial exchange restrictions that take the broader regional context into account and/or which limit the distance over which impact and offset sites can be separated (e.g. certain orders of watershed, biogeographic regions or centres of endemism, zones of occupation by certain traditional or indigenous peoples) are often used (e.g. in USA wetland mitigation banking systems such regions are often called service regions) to help ensure that an offset is more likely to achieve the goal of no-net loss. Accounting systems that integrate measures of biodiversity at a variety of scales (e.g., at site level, landscape level – to capture habitat connectivity, for example - and regionally) provide a means of integrating spatial equity in biodiversity exchanges (see Gibbons et al., 2009 for example, for the system being used in New South Wales, Australia).

3. **Equity in time.** Unless the biodiversity gains from an offset are delivered before the development impact occurs, it is inevitable that losses at the impact site will exceed any biodiversity gains from offset activity for a period of time. This temporal mismatch or lag between losses and gains increases the risk that certain biodiversity components may not be maintained. This may be due to the failure in the offset activity itself (e.g. restoration is unsuccessful), or as a result of time-delayed ecological cascade effects (e.g. changes in or loss of key ecological processes such as seed dispersal or nutrient cycling, degradation or loss of habitat needed for the persistence of certain species) or due to the impact of unexpected hazards such as fire, flooding and disease for which provision has not been made. These risks of failure in the delivery of biodiversity gains from offset activities are further compounded by the fact that conservation benefits received in the future are worth less to people (whether through use, cultural or existence values) than the same benefits received today. This issue of discounting the value of future benefits is a recognised phenomenon in economics but to date has seen little consideration in biodiversity offsetting (but see Gowdy et al., 2009, for a review of discounting relative to biodiversity value).

One approach to the problem of dealing with equity over time is to integrate the concept of 'Net Present Biodiversity Value' into the biodiversity accounting model (Theo Stephens, *personal communication*). Financial accountants use Net Present Value to estimate equity in the exchange of gains and losses over time. The same concept may be adapted for the measurement of biodiversity losses and gains. Essentially, the method requires a biodiversity currency, specified time intervals and a discount rate:

- The discount rate is a composite measure of our willingness to accept the exchange of certain loss today for an uncertain gain in the future. It comprises four components: time preference, the balance of supply and demand, default risk, and inflationary (or deflationary) expectations.
- The currency reflects the 'amount' of biodiversity lost due to project development impacts and gained from any offset activity (see previous) and is predicted for each time interval.
- Time intervals need to be chosen that are meaningful to both the project life-span and the expected biodiversity recovery rates.

The Net Present Biodiversity Value of the gains and losses over each time interval is estimated and summed over a time period. A positive sum of Net Present Biodiversity Value indicates that the no-net loss target has been met for the specified time period. As in financial accounting, the Net Present Biodiversity Value is sensitive to the discount rate, which must be carefully chosen and justified (see Stephens and von Hase, 2010, and not that further work on this is currently being developed, G. Ward, *personal communication*).

2.4. Assessing no net loss of biodiversity: putting theory into practice

As outlined earlier, assessing biodiversity losses and gains as part of an offset project is a multi-step, iterative exercise. Decisions regarding biodiversity components and currencies as well as the choice of accounting model(s) require joint consideration across Steps 4-7 of the overall offset design process (Fig. 2 and BBOP 2009a). A wide range of biodiversity offset systems and loss/gain methods have been (and continue to be) developed, involving varying levels of complexity, data requirements and differences in the number of components of the loss-gain assessment process that are explicitly accounted for (see BBOP 2009a, 2009c for a detailed listing). Different methods have also received different levels of field testing.

Ultimately the choice of offset design reflects a balance between applying scientific rigour and transparent accounting on the one hand, and finding pragmatic solutions given certain technical and socio-economic constraints of specific situations. Beyond the considerations set out earlier, the choice of methods for measuring patterns of biodiversity loss and gain is strongly influenced by a number of practical considerations, including:

1. **Data availability.** This includes the availability of appropriate biodiversity data (including historical information at the impact site as well as spatial and temporal-trend information for candidate offset sites), and associated information on conservation priorities and ecological dependencies for key biodiversity components. Where data are lacking, relevant information may need to be collected. Peer-reviewed expert opinion can often provide a valuable complement to existing data provided it makes a standardised and systematic contribution to the offset design process

2. **Geographic scale of reference for biodiversity loss-gain assessments.** Opportunities for achieving 'like-for-like' exchanges depend not only on the quality of existing data sets (or possibilities for collecting new field data) but also on the geographic scale of the offset assessment (see Gibbons et al., 2009). Access to excellent data from a limited spatial scale of analysis (e.g. restricted to the project site) facilitates the rigorous assessment of biodiversity loss and gain. However, this needs to be complemented with local and regional information (often at a less detailed level) which enables finding and evaluating adequate offset site/s and activities. More detailed assessment is then required at the candidate offset sites to verify their appropriateness, and validity.

3. **The project time-frame.** Practitioners working on voluntary biodiversity offsets generally need to fit into companies' planning timelines, which may be a challenge when they are very tight or unpredictable.. Where offsets are required by law it is important to ensure that the time requirements for offset design and delivery are integrated with planning timelines and consent processes. The endpoint for offset calculations (i.e. delivery of biodiversity benefits) needs to be defined clearly. **It is critically important to specify when 'no net loss' will be considered to have been achieved for a specific project.**

4. **Socio-economic costs of offsetting.** This includes not only the financial cost of different offset options to the developer but also the financial and social costs that may be borne by local people living in the project and offset areas (including impacts on economically and culturally significant biodiversity). These concerns need to be fully integrated into the offset design process in order for proposed offsets to be both economically viable and socially sustainable in the long-term. Detailed discussion of cost-benefit comparisons necessary to make such evaluations is presented in the BBOP Cost Benefit Handbook (BBOP 2009b).

5. **Compliance of offset design and implementation with national legislation (where this exist) and/or conformance to the BBOP Principles, Criteria and Indicators.** Irrespective of the recommendations of the most up-to-date science, many countries already have some relevant policy and legal guidelines that need to be adhered to, including for example on priority biodiversity components, conservation targets, limits to what biodiversity may be impacted, duty of care, laws on environmental and social impact assessment (see BBOP: ODH, 2009a), . In addition, BBOP has developed Principles, Criteria and Indicators that effectively provide a draft international standard on biodiversity offsets (see BBOP, 2011a).

3. Insuring against failure: dealing with uncertainty and risk in biodiversity exchanges

Due to the complexity of biodiversity, along with relatively limited scientific understanding, and relatively low priority for investment when set against other societal values, the practice of biodiversity conservation is associated with significant levels of uncertainty and risk (Moilanen et al. 2009; Walker et al. 2009). Biodiversity offsetting is no exception. **In practical terms it is impossible to 'prove' that a no-net loss (or a net-gain) of biodiversity has been achieved through offset activities and many existing projects are likely to fall significantly short of achieving this goal**. Many offsets involve certain biodiversity losses in exchange for uncertain, spatially and temporally disjunct gains. Moreover, and irrespective of the quality of baseline information that is available, losses and gains will always, at some level, be biologically dissimilar. Careful consideration of areas of uncertainty is therefore important, as is identifying best-practice approaches to minimising risk and delivering defensible biodiversity offsets that have a good chance of achieving no-net loss. Where risks and uncertainty of outcomes are high, data are lacking, and/or the biodiversity in question is of particular conservation significance, a precautionary approach (accompanied by long-term monitoring and funding) is needed to provide assurance in offset delivery (see Resource Paper on 'Limits to what can be offset'). This section briefly reviews the main sources of uncertainty in biodiversity offsetting, and provides some recommendations for best practice responses.

3.1. Sources of uncertainty in the assessment of biodiversity losses and gains

There are at least five sources of uncertainty in offset design, and biodiversity loss-gain calculations, that can contribute towards uncertainty in outcomes and put at risk a developer's ability to achieve the target of no-net loss. These need to be explicitly acknowledged and addressed in biodiversity offset design (ways of dealing with specific risks/elements of uncertainty are set out below):

1. **Biodiversity losses are not all accounted for in designing and implementing an offset:** This may be because only a limited set of impacts is taken into consideration, or because only some biodiversity components have been considered (e.g. relevant socio-economic and cultural values are not assessed and only a subset of 'intrinsic' biodiversity values are included in the design and implementation). This compromises the goal of no net loss of biodiversity, which by definition should encompass all project impacts and biodiversity values.

2. **Impacts on some components of biodiversity cannot be offset:** This is captured under Principle 4 (Limits to what can be offset). It is often the case that some impacts may be difficult or impossible to offset. This may be for a variety of reasons, including ecological, socio-cultural, legal and financial reasons. In these cases, it is important to remove the uncertainty of whether or not impacts may be non-offsetable (e.g. by undertaking additional in-depth biodiversity / ecological / social studies; assessing aspects of project design and predicted impacts, etc.) and undertaking relevant actions to respond to the findings (see BBOP, 2011c).

3. **Dissimilar biodiversity between impact and offset sites.** Since it is impossible to measure everything, biodiversity offsets must rely, at least in part, on surrogate measures as a currency for exchange (Section 2.1). Surrogates inevitably provide an imperfect estimate of changes in underlying biodiversity values, and can mask potentially important losses and gains.

4. **Uncertainty in offset performance** due to a lack of data, such as on baseline patterns of biodiversity and regional conservation priorities, and limited ecological information on the likely responses of selected biodiversity components to both impact and offset activities.

5. **Uncertainty in the ecological system** itself, including indirect impacts from secondary extinctions, ecological cascades, time-delayed ecological processes, natural disturbance regimes (e.g. disease and fire) and stochastic ecological dynamics.

6. **Uncertainty in offset implementation success.** This may come from the impact of unexpected threats, such as climate change, invasive species, fire and floods that put at risk the ability of even the well designed offsets to succeed in delivering measurable conservation outcomes. In addition uncertainty in offset implementation can come from technical uncertainty in the implementation of offset activities themselves (for example through the use of poorly tested restoration methods, or failure to identify the most important threats in need of mitigation for averted loss offsets). There is also a risk of corporate financial failure or loss of political will to deliver stated commitments after impacts have already occurred.

7. **Time delays in offset delivery**. This kind of uncertainty comes from the fact that development impacts on biodiversity are certain (or close to being certain) whilst gains from offsets are (usually) only fully delivered at some unknown point in the future.

3.2. Insuring against uncertainty and risk in biodiversity offsets

There is a variety of ways of dealing with the different sources of uncertainty in implementing a biodiversity offset. Dissimilarity in biodiversity between impacts and offsets is best dealt with through careful selection of the measures and currencies used to account for changes in biodiversity, as well as the use of exchange rules to prevent undesirable and unexpected outcomes (see section 2.3). Uncertainty associated with a lack of data or understanding can be addressed through adequate investment in field work and research.

By contrast, uncertainty in the ecological system itself, uncertainty in offset implementation, and time-delays associated with offset delivery are most commonly dealt with through the use of **multipliers** (see Step 7 in the BBOP offset design process; BBOP 2009a; and see Moilanen et al. 2009). Multipliers are grounded in the precautionary principle and serve to increase the basic size of an offset (as set by the underlying biodiversity currency and associated accounting model), thereby helping to account for concerns that the offset may not be sufficient to deliver a no-net loss outcome. There are at least three types of commonly applied multipliers in biodiversity offsetting:

1. **Generic risk-aversion multipliers.** These multipliers attempt to deal with the risk of offset failure or underperformance due to uncertainty in the ecological system, and uncertainties in offset implementation and long-term viability. It often makes sense to identify different multipliers to address specific risks. For example, if there is only a 50% chance of seedlings maturing into adult trees in a restoration project then it makes sense to double the number of seedlings planted to achieve the desired outcome, rather than simply increasing the size of the area where restoration is undertaken. Often in practice, however, generic multipliers (frequently linked to area) are employed to bundle together a variety of concerns about uncertainty in offset outcomes. The size of generic-risk multipliers is often linked to the conservation significance of the target biodiversity in question. This is the case for the state of Victoria Habitat Hectares method (Parkes et al. 2003; and Victoria Department of Sustainability and Environment 2002) which requires an increase in offset size ranging from 2x for habitats of 'very high conservation significance' (as defined by state level guidance) to no increase for low priority habitats.

2. **Time-discounting multipliers.** This kind of multiplier is calculated through the discounting procedure and estimation of 'Net present biodiversity value' and then applied to the basic offset recommendation from the non-temporal accounting model (see section 2.3). The size of time-discounting based multipliers can be enormous when dealing with offset activities that take a long time to deliver biodiversity gains (such as ecological restoration of highly degraded habitats; Moilanen et al. 2009).

3. **'End-game' or conservation outcome multipliers.** These multipliers are essentially aimed at ensuring that landscape or regional-scale conservation goals are met and they can help ensure that already threatened ecosystems or habitats do not become more threatened as a result of development impacts. Thus, where a biodiversity component is of particular conservation importance (e.g. limited in spatial extent), or where a specific conservation target (such as '30% remaining' or 'at least 5000ha') has been set, 'end-game' multipliers can be applied. The size of the multiplier depends upon the amount of the biodiversity component that remains, its current conservation status, and a decision about what represents an acceptable level of accumulated loss across the landscape scale (see Brownlie et al. 2007; BBOP 2009c).

The advantage of multipliers is that they tend to be easy to understand, implement, and audit. Yet in practice, they are difficult to calculate accurately and thus do not meet with broad agreement. Where uncertainty is high, multipliers may need to be very large (e.g. an order of magnitude increase in basic offset size) if they are to provide adequate protection against failure to deliver no-net loss (Moilanen et al. 2009). Moreover, **multipliers are not a silver-bullet solution and are inappropriate for dealing with many types of risk**. Thus, area-based multipliers cannot account for the risk that an offset activity may fail (as opposed to falling short of achieving complete success). If a restoration project uses untested techniques and fails to secure any measurable biodiversity benefits, increasing the size of the offset area will contribute little towards improving the chance of success. Despite these concerns, multipliers have been inappropriately used in this context by existing offset programs (e.g. United States wetlands mitigation banking). Another example of inappropriate use of multipliers is the application of discounting approaches when there are significant risks of offset failure (e.g. species extinction) or impoverishment of local people (through diminished access to biodiversity-mediated ecosystem services) due to time-delays. Finally, it is not always clear how multipliers concerned with reducing different types of risk should be combined (e.g. additive or multiplicative) within the overall offset specification.

Alternatives to using multipliers to limit uncertainty and spread risk include stepping back and employing more rigorous methods for calculating biodiversity losses and gains (e.g. see Gibbons et al., 2009), using multiple and complementary biodiversity currencies and accounting models, and selecting a larger, more varied portfolio of offset sites and activities. For example, combining restoration-based offset activities with averted loss offsets can help limit the risk of offset failure. **Averted loss offsets that reduce or halt ongoing or expected background threats to biodiversity may often provide more assured and immediate benefits than restoration-based offsets. This is especially true for highly complex, species-rich ecosystems (e.g. tropical rainforests) or slowly regenerating systems that respond to periodic, unpredictable abiotic events (e.g. rainfall in desert systems) where there is little, if any, evidence that full habitat restoration is possible within meaningful time scales (Gardner et al. 2007)**.

Nevertheless averted loss offsets are themselves not free from uncertainty, especially where this relates to practical considerations of implementation success (i.e. factors independent of ecological considerations). Aside from the concerns about permanence that are relevant to any offset program (e.g. through the potential for management failure and/or occurrence of unexpected negative impacts on offset sites in the future) offset developers need to demonstrate that the condition of additionality has been satisfied (see Fig. 1).

Averted loss offsets are made possible through the abatement of background threats to biodiversity that are independent of the planned development project. Benefits can be measured as a positive deviation from background rates of loss following the start of the offset. However, measuring this marginal gain is confounded by uncertainty in the extrapolation of historical background loss rates into the future (Fig. 3A), and/or uncertainty in predicting the likely effectiveness of any offset activity to abate the background threats (Fig. 3B). Moreover, it has to also be demonstrated that there is no risk of leakage, where threats that have been abated at the offset site are simply diverted elsewhere. It is also important to reemphasise that averted loss offsets will always permit some level of accumulated loss at the landscape scale (whereas restoration offsets, *provided they work perfectly and precede the impact*, are uniquely able to ensure no-net loss at both project and landscape scales).

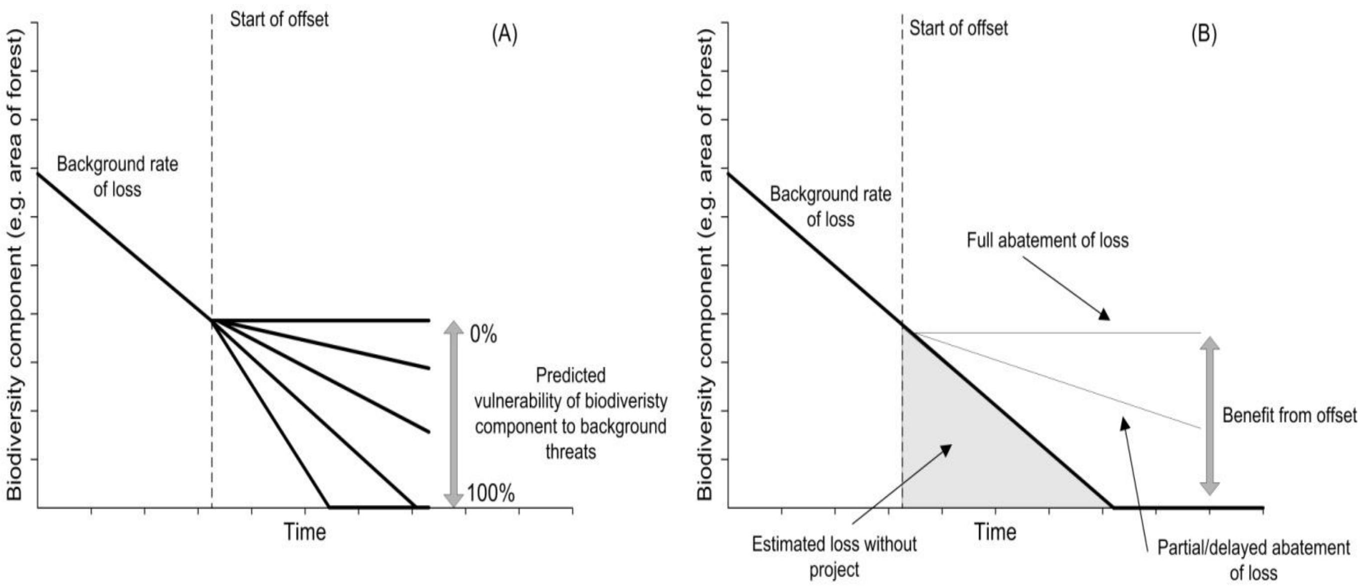


Figure 3. Conceptualising additionality in averted-loss offsets given uncertainty in predictions of background rates of biodiversity loss (A) and the effectiveness of offset activities to fully abate background impacts (B).

A 'gold standard approach' to ensuring that an averted loss offset will deliver measurable and sufficient biodiversity benefits to achieve no-net loss is where the offset is secured *before* the impact occurs (Bekessy et al. 2010). This approach can equally be applied to restoration offsets (where offsets are not allowed to be traded against impacts until they have reached ecological maturity) as averted-risk offsets (see also Resource Paper on

'Limits', 2011). Both options can lead to the idea of biodiversity banking (Carroll et al. 2007) where pre-established offsets can be offered as exchanges on an open market place. While conservation banking can provide an interesting solution to some offset problems it is still necessary to demonstrate that additionality has been achieved, the condition of like-for-like exchange has been met for a given offset site, and that any biodiversity benefits can be secured into the long-term.

Conclusion

The considerations discussed in this paper on no net loss and biodiversity loss-gain calculations can go some way towards ensuring that best practice measures have been implemented for a specific project, and that there is a reasonable likelihood that necessary biodiversity benefits can be secured. It is important to remember that offsetting should be seen as a last resort, and as the last step in the mitigation hierarchy. Careful attention should always first be paid to opportunities to avoid and mitigate the impacts before they occur. Ongoing theoretical and practical work on biodiversity offsets is vital to provide feedback on which methods and approaches are most suitable, and under which circumstances. Only through a continuous process of adaptation and improvement will it be possible to further close the gap between no net loss as an overall conservation policy and the present, significant and cumulative losses of biodiversity that result from development projects.

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Appendix A: Annotated checklist to help assess the delivery of no net loss in biodiversity offset design

The concept of no net loss of biodiversity lies at the heart of biodiversity offsetting. It encompasses all of the first five BBOP Principles and underpins Steps 4 to 7 of the offset design process, including the assessment of residual loss, the choice of loss-gain methods, review of potential offset activities and assessment of biodiversity gains in any final design. Evaluating whether no net loss of biodiversity will be or has been achieved requires consideration of both theoretical and practical issues relevant to a particular context. Assessing the likelihood of success in achieving no net loss of biodiversity can be aided through consideration of the following annotated checklist of criteria for success which together summarise the guidance provided in this paper. The first three criteria underpin the first BBOP principle, the remainder re-emphasise Principles 2-5 and 8 in the context of achieving no-net-loss.

1. Biodiversity losses/gains at impact and offset sites need to be measured using explicit, transparent methods

i. The design of biodiversity loss and gain calculations should include a clear choice of biodiversity measures and currencies, and the explicit presentation of the accounting model used to quantify exchanges and the assumptions made about biodiversity type, location and time;

ii. The selection of biodiversity measures for loss-gain calculations needs to be based on theoretical considerations (e.g. how best to capture the biological diversity at a particular site in a metric), data availability, prior ecological knowledge, and a clear definition of the geographic and temporal scales of the development activity in question;

iii. Cultural values of biodiversity require separate, explicit attention within an overall assessment to ensure that the needs of local people are given adequate consideration;

iv. Multiple biodiversity measures, currencies and accounting models are almost always needed to adequately capture losses and gains for a wide range of key biodiversity components.

2. Maximise efforts to ensure the ecological equivalence of biodiversity losses and gains

i. The selection of biodiversity currencies should consider whether candidate metrics represent direct or indirect measures of the affected biodiversity, aggregate multiple biodiversity components/measures into a single value, and whether they are site specific or context dependent. Currencies that are based on direct, disaggregated and context dependent measures of the amount and condition of affected biodiversity provide a more accurate and transparent foundation for biodiversity loss/gain exchanges. These currencies require better, more comprehensive data to be collected, or available. Good offset design tends to include a combination of direct and indirect currencies, and does not rely only on aggregated and site specific measures (such as area, or area-condition metrics);

ii. A systematic and independent assessment of biodiversity benchmark (reference) sites is needed to calibrate measures of losses and gains. Benchmark sites may frequently represent the best available biodiversity condition and it is often necessary to employ different benchmarks to assess changes to different components of biodiversity. A benchmark may represent a real site, or a hypothetical reference point (e.g. in cases where a real site is inaccessible);

iii. The biodiversity accounting model used as the basis for designing an offset and to derive offset specifications should be clearly identified and explained, and assumptions about equity in biodiversity exchanges with respect to type, space and time should be clearly stated;

iv. A clear set of exchange rules that help minimise the risk of non like-for-like exchanges occurring should be identified. These rules should include limits on impacts to critically important biodiversity components, limits on changes in condition between impact and offset sites, and limits on what can be bundled within a single aggregated currency (and therefore presumed to be exchangeable)

v. Where employed, out-of-kind biodiversity offsets should be based on the demonstration of a clear opportunity for improvements in the conservation of high priority biodiversity at offset sites over impact sites (i.e. 'trading up). Clear reasoning for the basis for the exchange needs to be provided as there is currently a lack of a widely accepted and scientifically defensible methodology.

3. Account as much as possible for uncertainty and the risk of failure in offset design

i. Identify and systematically (and where possible specifically) address the main areas of risk to offset delivery, i.e. dissimilarity in resident biodiversity between impact and offset sites; scientific uncertainty in loss and gain of biodiversity; failure of implementation process; threats to offset permanence through unexpected future impacts and ecosystem dynamics; and time-delays in delivery of biodiversity benefits.

ii. In addition to the careful selection of biodiversity measures and currencies for exchange, and investment in additional research where *a priori* data and understanding are lacking, uncertainty in offset delivery can, under certain circumstances, be reduced through the careful application of multipliers.
iii. The use of multipliers to account for generic risks in offset delivery can be linked to the conservation significance of the biodiversity components in question. Multipliers are not suitable for situations where there is a risk of total delivery failure.
iv. Recognise and where possible quantify risks of offset failure due to time-delays in delivering biodiversity benefits. Risks include failure of the offset activity, time-delayed ecological cascade effects, the impact of unexpected hazards, and diminished importance to stakeholders of future gains over immediate losses. It may be possible to mitigate time-delays through discounting. Yet if there are significant risks of non-delivery, the safest approach is to secure biodiversity benefits before the impact has occurred.
v. End-game multipliers can be used where national or regional conservation targets exist for protecting minimal areas of habitats and ecosystems, especially where these are recognised as threatened.

4. Demonstrate that gains are additional and can be directly linked to the offset activity (BBOP P2)

i. Give priority to opportunities for preventing further harm to biodiversity or avoiding imminent threats (averted loss offsets) versus restoration activities.
ii. Demonstrating successful offset performance requires monitoring. Biodiversity monitoring programs require two layers of indicators in order to be effective – direct measures of biodiversity that can report on the conservation performance of the offset activity, but also indirect measures that link changes in valued biodiversity with changes in the management activities themselves (e.g. reduction of logging intensity, installation of fire breaks, increase in number of guard patrols, planting of native trees etc)

5. Combine multiple interventions across the full mitigation hierarchy (BBOP P3)

i. The most effective approach to minimising risks to biodiversity offsets is to maximise the avoidance of harm to the most sensitive elements of biodiversity from the outset. All offset projects should be initiated with a rigorous assessment of the relationship between different biodiversity components, expected threats from different development activities, and the cost-effectiveness of interventions at different stages of the mitigation hierarchy

6. Recognise that there are ecological and scientific limits to what can be offset (BBOP P4)

i. Check for the likelihood of non-offsetable impacts on certain biodiversity components by evaluating biodiversity impacts with respect to local, regional and international criteria of irreplaceability and vulnerability, as well as local cultural values of biodiversity. Undertake steps to limit the risk of incurring non-offsetable impacts (see BBOP, 2011c)

7. Design offsets to take account of wider landscape context and patterns of biodiversity (BBOP P5)

i. Integrate landscape-level considerations (measurements) into loss/gain calculations and the accounting system.
ii. Make the most of conservation and landscape planning tools and approaches to locate offset sites and activities most effectively within the wider landscape.
iii. Evaluate a wide range of candidate offset sites to maximise equivalence with losses at impact sites, and where necessary maximise complementarity amongst multiple offset sites.
iv. Evaluate connectivity between offset sites and the wider landscape using a combination of satellite images, available data on ecosystem condition, and long-term monitoring.

8. Maintain an adaptive approach to offset design that is open to the incorporation of new data, biodiversity currencies and accounting techniques (BBOP P8)