Resource Paper : No Net Loss and Loss-Gain Calculations in Biodiversity Offsets

BBOP

Business and Biodiversity Offsets Programme

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About this Document

The Standard on Biodiversity Offsets ('the Standard') and accompanying supporting materials[1] such as **this Resource Paper**[2] have been prepared by the Business and Biodiversity Offsets Programme (BBOP) to help auditors, developers, conservation groups, communities, governments and financial institutions that wish to consider and develop best practice related to biodiversity offsets. They were developed by members of the BBOP Secretariat and Advisory Group during the second phase of the programme's work (2009 – 2012) and have benefited from contributions and suggestions provided by interested people during the public consultation process and by others who have joined us for discussions in meetings.

Best practice in biodiversity offsets is evolving, and the Standard and supporting documents such as this Resource Paper will be further refined based on more practical experience, feedback and discussion.

All those involved in BBOP are grateful to the companies who volunteered pilot projects in BBOP's first and second phases of our work and for the support of the donors listed overleaf, who have enabled the Secretariat and Advisory Group to prepare these documents.

BBOP is embarking on the next phase of its work, during which we hope to collaborate with more individuals and organisations around the world, continually to refine the standard based on experience and practice, and to learn from a wide range of experiences with biodiversity offsets in a variety of industry sectors and geographical areas. BBOP has already benefited from drawing on the experience and approaches of a the wide range of organisations, members and non-members alike, who are developing tools and mechanisms to apply the mitigation hierarchy, including delivery of biodiversity offsets. We hope their approaches and experiences will continue to inform and ultimately comply with the Standard as it is revised over time. . BBOP is a collaborative programme, and we welcome your involvement. To learn more about the programme and how to get involved please:

See: http://bbop.forest-trends.org

Contact: bbop@forest-trends.org

[1] The BBOP biodiversity offset standard, a set of resource papers, 'how-to' handbooks on biodiversity offset design and implementation, and an updated glossary, can be found at: **http://bbop.forest-trends.org/guidelines**.

[2] This paper was prepared by Toby Gardner and Amrei von Hase, with contributions from Theo Stephens, and Kerry ten Kate, and reflects comments received during the public consultation period. The material here builds on discussion documents produced by the BBOP Guidelines Working Group during Phase 2 of BBOP.

In addition to our fee paying membership, we thank those organisations that have provided financial support for BBOP's work[3] in its second phase:

[3] Endorsement of some or all of the BBOP documents is not implied by financial support for BBOP's work.

Contents

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, 2009a) and to support the interpretation and understanding of the Principles, Criteria and Indicators (PCIs) being developed for the BBOP biodiversity offset standard (BBOP, 2012a). The document specifically addresses Principle 4 (No Net Loss, 'NNL'), although the interpretation of NNL is relevant to most of the ten BBOP principles. The 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, 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.

The intended audience for this document is ecological specialists and technical consultants advising companies, governments and/or others wanting to undertake a biodiversity offset.

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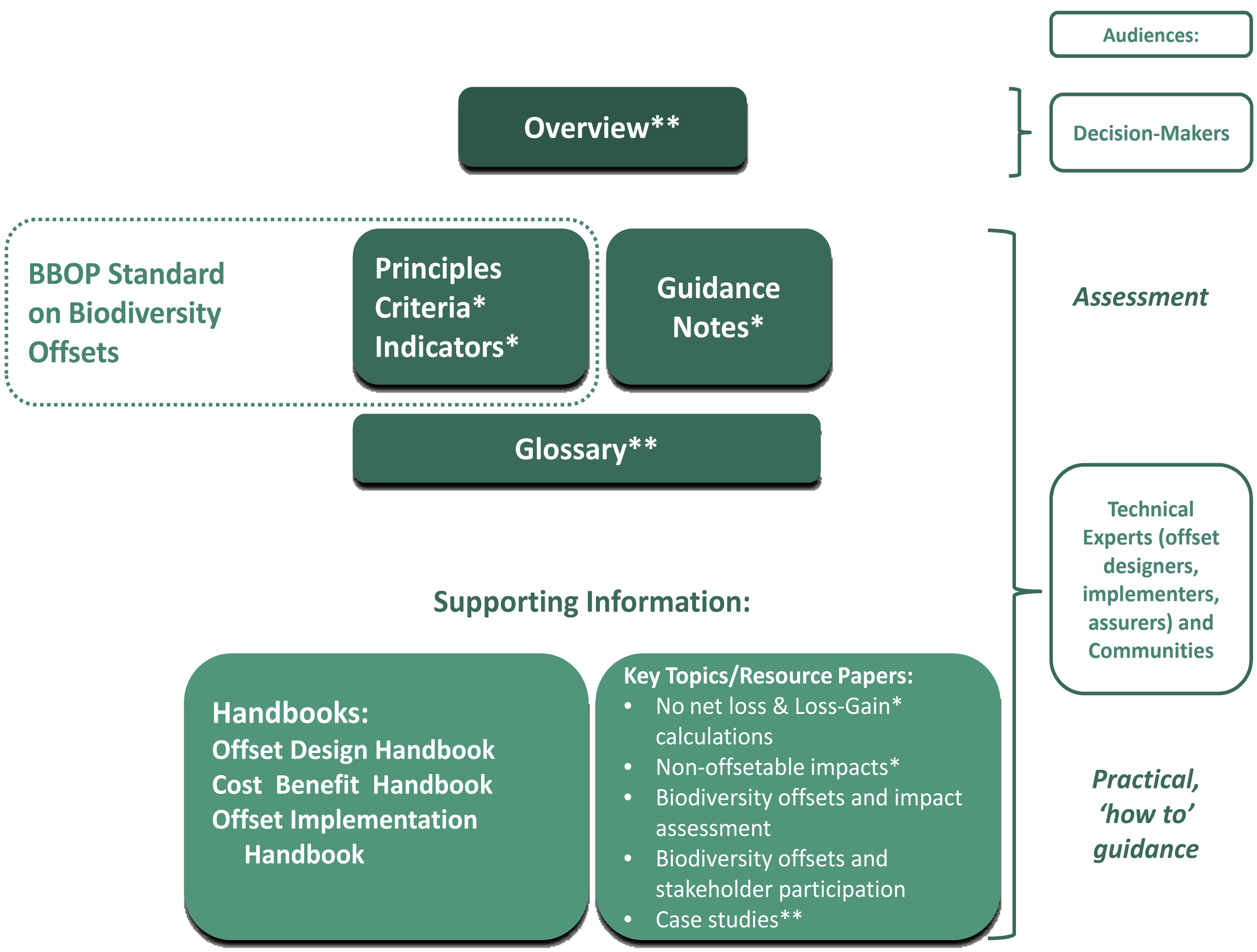
Related Documents Published by BBOP

Related documents published by BBOP include the Biodiversity Offset Standard and Guidance Notes, Resource Papers and the Glossary. The BBOP Principles, and now the Criteria, Indicators and accompanying Guidance Notes, constitute the core of BBOP's work to develop best practice for biodiversity offsets. Since BBOP was established at the end of 2004, it has also produced a number of other tools and products. The relationship between these is illustrated in Figure 1.

This document addresses 'Limits to What can be Offset' (Offsetable/Non-offsetable impacts) and is one of the resource papers on key topics (the other being on No Net Loss). These papers offer supporting information to accompany the Biodiversity Offset Standard and they complement and update existing guidance in the BBOP Handbooks. They are thus best read in conjunction with the BBOP Offset Design Handbook and Appendices (BBOP, 2009 a, c), the Cost Benefit Handbook (BBOP, 2009b), the Offset Implementation Handbook (BBOP, 2009d), and the BBOP standard (BBOP, 2012a).

Figure 1: BBOP Standard on Biodiversity Offsets and Associated Material

*Note: Documents published in 2009, unless marked as follows: * First prepared in 2012; ** Updated 2012*



All the documents listed in the diagram above (from 2009 and from 2012) will be available at:
http://bbop.forest-trends.org/guidelines/

Resource Paper: 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, amount and condition (or quality) of biodiversity 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'. No net loss is also the first of the ten BBOP Principles for high quality biodiversity offsets and it underpins several of the other Principles as well as the offset design process (BBOP, 2009a-c):

Principle 1: 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.

This resource paper introduces concepts and practices relating to no net loss of biodiversity and identifies some of the key issues relevant to biodiversity offsets virtually anywhere in the world. However, the specification of a biodiversity offset always requires careful consideration of context-specific factors, including characteristics of the local biodiversity, human-use and cultural values of biodiversity, background rates of loss, the ecological condition of potential offset sites, as well as legal, technical and socio-economic constraints on the kinds of offsets that can be developed. This will generally require the assistance of suitable qualified specialists and local expertise.

Note: The aim of this paper is to help readers understand and interpret the Guidance Notes for auditors which accompany the biodiversity offset standard (BBOP, 2012a). The paper is not intended as a 'how to' guide on biodiversity offset design and implementation. For more step-by-step guidance on these topics please refer to the BBOP Offset Design Handbook (BBOP, 2009a), the Cost Benefit Handbook (BBOP 2009b) and the Offset Implementation Handbook (BBOP, 2009d).

The following sections cover three main topics:

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

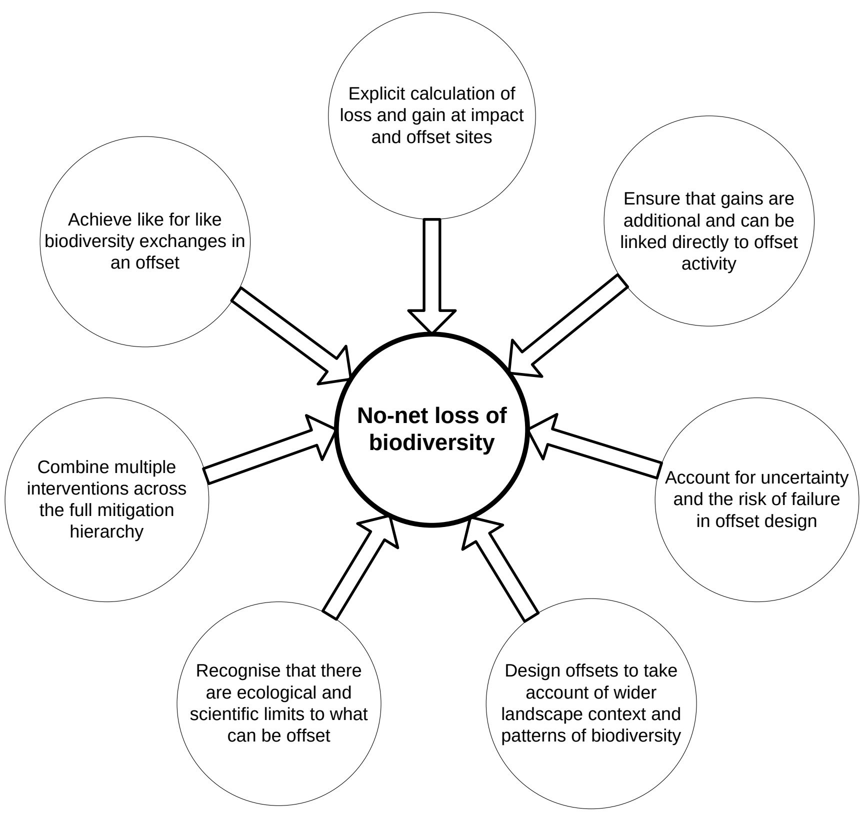
1. Balancing biodiversity accounts: Understanding no net loss and allied concepts

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 organisation (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) elements are all integral to biodiversity. As with any practical conservation problem, biodiversity offsets can thus 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) and candidate offset sites (defined by geography, current ecosystem condition, and background rates of environmental impact; see BBOP 2009a). The associated variation of local conditions is partly reflected in the multitude of procedures used around the world to assess loss of biodiversity (see section 2), and new methods are being developed and tested all the time. There is no one-size-fits-all approach - a flexible, adaptive approach is necessary to achieve long-term conservation outcomes. To assure best practice, however, .individual projects can work from a set of common principles when designing and implementing offsets to achieve no net loss of biodiversity. Here, the BBOP standard on biodiversity offsets (BBOP, 2012) offers a tool for transparent and rigorous accounting.

No-net loss is captured in the first of the ten BBOP Principles on Biodiversity Offsets but also requires explicit consideration of BBOP Principles 1-3 and 5**.** Specifically, a biodiversity offset is only likely to achieve no net loss when the following conditions have been met (see below and Figure 2):

Figure 2: Key ingredients of no net loss as the central target underpinning biodiversity offset

See text for more details of each contributing factor, and to which principle it relates.



1. **Biodiversity offsets are based on the explicit calculation of biodiversity losses and gains at matched impact and offset sites.** This 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 may be needed to account for different biodiversity components.

2. **Give explicit treatment to social and cultural values of biodiversity**. Values placed on biodiversity vary substantially among different stakeholder groups. Conservation organisations may focus their efforts on conserving biodiversity for its intrinsic value, measured in terms of richness, population viability and endemism. 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 components, and opportunities for offsetting such impacts, need to be given explicit treatment in offset design. Identifying social and cultural values of biodiversity, and assessing the costs and benefits to indigenous peoples and local communities of the project's residual impacts and of the offset options requires careful stakeholder engagement and participation even where these communities do not have legal title to the land or formal land ownership (see Cost-Benefit Handbook, BBOP 2009b). 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, 2012c: Limits to what can be offset).

3. **The biodiversity offset process needs to ensure that biodiversity gains are comparable - in ecological terms, from a conservation-priority perspective, and to local stakeholders - to losses that occur as a result of the development project***.* This is captured in the 'like-for-like' concept[4] 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. The same applies to different values placed on biodiversity (see above). In financial terms, biodiversity is perhaps the ultimate *non-fungible asset* because it can vary so markedly between different locations and over time. Conservation activities that provide additional on-the-ground[5] protection or benefits to the same and/or comparable habitats, species and populations can ensure 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* 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 species populations or habitats) can be improved through 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[6].

4. **Gains in biodiversity from conservation activities at offset sites need to be additional to those that would occur if no offset investment was made by the developer***.* This condition is given by BBOP Principle 5, 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 several interventions falling into two broad categories:

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[4] 'Ecologically equivalent or representative (gains rel. to losses) are also commonly used terms to describe the concept of 'like for like'.

[5] On the ground refers to the relevant land- or seascape (i.e., is not limited to terrestrial ecosystems).

[6] Note that no scientifically defensible method has yet been developed to undertake these out of kind exchanges.

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 includes activities that will slow or stop known and ongoing environmental degradation, such as implementing environmentally responsible natural resource management practices, and/or strengthening or creating protected 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). It is essential that any investment results in *measurable conservation outcomes* resulting directly from the offset activities. General 'structural' investments in local capacity building and environmental education may be important but to qualify for an offset package they need to produce clear and relevant biodiversity gains.

ii. *Guarding against future threat***.** This refers to interventions designed to *avert known future risks* to biodiversity, for example where a landowner has 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 shown that any impending threats are highly likely to occur in the imminent future (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:

i. This encompasses a wide variety of management activities that seek to improve the quality of biodiversity on sites with varying levels of degradation. Such activities can be divided into two basic 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, 2012d: 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. This should include consideration of the significance of the biodiversity in question, measurement of 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, 2012c). Usually a combination of 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.

5. **The offset design and implementation process should identify and account for uncertainty and risks 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).

6. **Achieving the target of no net loss of biodiversity is generally only possible when combining multiple interventions across the full mitigation hierarchy (BBOP Principle 1).** Biodiversity offsets, as the last step in the mitigation hierarchy should only be viewed as an option of final resort. Prior to considering an offset for a specific project appropriate measures need to be taken to avoid impacts (e.g., re-routing of pipelines to avoid the most sensitive areas). Where avoidance is not achievable, 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.

7. **Recognise that there are ecological and scientific limits to what can be offset (BBOP Principle 2).** 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 (and because they are needed to meet biodiversity conservation targets – i.e., are highly irreplaceable), would be very difficult, if not impossible to replace if they were to be lost. The clearest examples of this are critically endangered species or ecological communities that exist only in a small handful of sites offering the right habitat requirements and/or which are in rapid decline across their range. Often it is necessary to avoid impacts on these biodiversity components to remain consistent with the goal of no-net loss (see previous point). Beyond the conservation significance and status of the affected biodiversity there are other limits to what can be offset, for example 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 (please refer to the Resource Paper on limits to what can be offset, BBOP, 2012c).

8. **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., spatial data on land use and tenure, biodiversity, etc.) with the offset design process. This is important for several reasons. First, some elements of biodiversity that need to be included as part of an offset can only be measured relative to regional scales (many ecological or evolutionary processes, for example those relating to habitat connectivity). 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 long-term conservation outcomes) when choosing from a range of candidates in the neighbouring region in the context of other land use pressures and associated opportunities or constraints, and costs or benefits for conservation. Third, conservation priorities are context specific: the regional conservation significance of a particular biodiversity component (e.g., a plant community) at a 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, for example through colonisation and dispersal processes (Bennett 1998). Systematic conservation planning for land- and seascapes incorporates these kinds of considerations (Margules and Pressey, 2000; also Faith et al., 2001; Faith and Walker, 2002); Moilanen et al. 2009). This can (and wherever possible should) form a sound basis for developing individual and aggregated biodiversity offsets in a regional context. 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).

The Offset Design Handbook Appendices (BBOP 2009c) summarise a variety of approaches and methods used in different parts of the world for ascertaining biodiversity loss and gain, including, for example:

- The US Fish and Wildlife Services: Habitat Evaluation Procedures (HEP)
- US wetland and stream assessment methods in practice
- The European Birds and Habitats Directives
- Victoria (Australia): habitat hectares method
- Western Australia: Net Environmental Benefit
- South Australia: Significant Environmental Benefit (SEB) methods
- Western Cape (South Africa): Biodiversity offset guidelines
- REMEDE Toolkit – Resource Equivalency Method
- New Zealand: Risk Index Method
- New Zealand: Averted Risk Formulae

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 (see Figure 3 below; and BBOP 2009a). There is a wide range of published and unpublished methods for quantifying biodiversity offsets (please see the textbox above, and Cochran et al., 2011 and references therein), and choosing between alternatives can be challenging. It is important that defensible approaches to measuring biodiversity loss and gain are selected and tailored to fit local circumstances (see e.g., Tanaka, 2008, BBOP 2009e), and that they consider each of the key issues set out below as part of the following steps:

(i) the choice of biodiversity components and measures (e.g., breeding pairs of a threatened bird species);

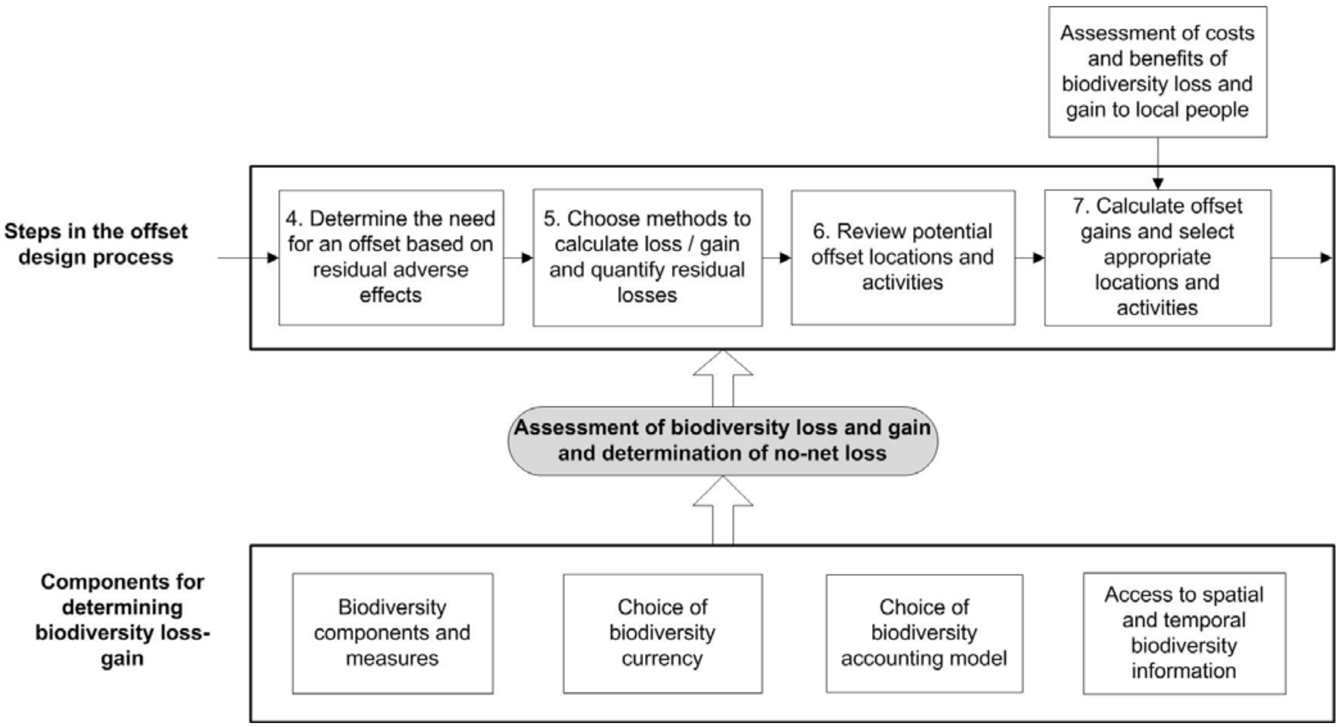
(ii) the choice of a currency to quantify biodiversity exchanges (e.g., area of vegetation x ecological condition);

(iii) the choice of an accounting model or system based on the chosen currencies and integrating various other considerations in order 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 3).

Figure 3. Relationship between a generic framework for determining biodiversity losses and gains and key steps 4-7 in the offset design process (see BBOP 2009a)

Note: 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 intended to represent biodiversity more generally (Caro 2010; Gardner 2010). The following are important considerations when selecting suitable biodiversity surrogates (e.g., populations, species, vegetation and habitat types) and ways to measure their amount and condition (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 affected people (i.e., ecosystem services including both cultural and use values);
- Resource and habitat requirements to ensure the long-term persistence of affected biodiversity;
- 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 undertaken (see section 2.4). A rigorous assessment would make efforts to integrate information on biodiversity patterns (compositional and structural elements such as populations, species and habitat types); ecological processes (biodiversity-mediated functional processes, e.g., species-specific habitat requirements, 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 2009b).

Once selected, these biodiversity components and associated measurements can be summarised within a Key Biodiversity Components Matrix (see BBOP 2009a Table 9).

2.2 Biodiversity currencies

Once biodiversity components and associated measures have been selected (see section 2.1) they are 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 their habitats, and vegetation types or ecosystems) and/or different geographic scales (e.g., site-level versus regional measures of biodiversity condition).

The following questions can help to distinguish between different types of currencies:

- Is the currency composed of direct or surrogate measures of biodiversity (type, amount, condition)?
- Does it include aggregated or disaggregated information on biodiversity (type, amount, condition)?
- 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 selecting a 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 and habitat suitability 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 generalise information on multiple biodiversity components. 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, but may make it harder to find offsets that deliver the precise amounts of each of the 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 disaggregated 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) as well as to regional biodiversity offset site selection problems (Faith et al., 2011; Faith and Walker, 2002).

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 currencies (e.g., as used in the Habitat Hectares method used in Victoria, Australia, Parkes et al. 2003; in BBOP 2009e; as part of Habitat Evaluation Procedures, HEP, developed by the US Fish and Wildlife Service, 1980; and in HEP derivatives, e.g., Tanaka, 2008).

Condition is essentially a fractional measure of the relative (or perceived) intactness of biodiversity at a specific site relative to a reference site or suite of sites (assessed to represent some kind of '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 (whether of vegetation, of habitat for a particular species, or of ecological functions). 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 undermine 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 Forest Code) that base exchanges 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), to consider time lags between impacts and offset delivery, and 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 a desirable condition relating, for example, to accepted conservation goals (Noss 2004; Gardner 2010). The benchmark is to provide an objective framework, and a common reference point, for evaluating biodiversity losses and gains across impact and offset sites. To maximise the potential for a genuine like-for-like exchange it may be necessary to employ multiple benchmarks relevant to the biodiversity components that make up an overall offset package. Despite its intuitive application, the establishment of appropriate reference conditions 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 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 disturbance criteria relevant to the specific regional and ecological context. This may draw on historical records of human activity or areas that have made a substantial recovery from past human disturbance, or – where relevant - areas with desirable levels of disturbance (for example, in regions where certain traditional agricultural practices help to maintain or promote species of conservation concern). 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, or alternatively of suitably 'disturbed' conditions (see ii below: the concept of shifting baselines).

ii. *Accept the problem of shifting baselines.* For much of the world there is no such thing as a 'natural, pristine 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', a desirable condition for a region to achieve specific agreed conservation aims; 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	This 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 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	This 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 (including offset) activities. It 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 provide information 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 important 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 a process for estimating the net balance, or equity, in exchanges; the concept of financial accounting is well understood. Biodiversity offsets aim for a comparable level of rigour to the quantification of biodiversity losses and gains among impact and offset sites. This is only possible when the same currency is used for losses and gains (derived from the same underlying biodiversity measurements). The core output from the accounting model or system is the offset specification which details the offset sites and activities that can deliver no net loss or net gain relative to predicted impacts.

The term 'accounting model' need not imply 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 (but see limitations above). There is a range of accounting models that are or could be used in biodiversity offsetting, dealing with different biodiversity components (from populations, species and habitats), relying on various currencies, and incorporating different levels of complexity and rigour (see review by Cochran et al., 2011). Approaches of very low complexity that rely on measures of area alone (e.g., of wetland impacted) in combination with simple multipliers often lack adequate rigour and defensibility. Therefore, approaches of medium complexity are often chosen, such as the US's Habitat Evaluation Procedures (HEP, and derivatives) and others used in wetland assessments in the US, as well as Australia's Habitat Hectares (Parkes et al. 2003) and New South Wales Bio-banking methods (e.g., Gibbons et al., 2009). These approaches may already include context-dependent spatial information on biodiversity, or they can be integrated into systematic conservation planning or similar processes to ensure that issues relating to the landscape context are considered in the offset specification (see also section 1).

Salzman and Ruhl (2000) point out that equity in biodiversity accounting varies according to type, time and space, whereas financial accounting is only 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 but few deal with 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**. Demonstrating equivalent (or like-for-like) exchanges is challenging because no two sets or 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 biodiversity 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 equivalence, including:

    i. *Limits on exchanges that involve biodiversity components of known conservation importance (e.g., of high irreplaceability or vulnerability)***.** This highlights the point that there are limits to what can be offset (Principle 2, BBOP, 2012c). Rules can be set that prevent the exchange of irreplaceable, or threatened biodiversity for components of lower irreplaceability or threat status – 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 some area x condition based currencies 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 by identifying possible weaknesses in the state of Victoria's Habitat Hectares method (Parkes et al. 2003), for example, in situations where increases in some attributes (such as volume of dead wood) mask 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 characterised by a minimum level of connectivity with neighbouring patches of the same vegetation type (Gibbons et al., 2009).

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 at least for a period of time (see Sheldon et al., 2005; Bendor, 2009). Any temporal mismatch or lag between losses and gains increases the risk that certain biodiversity components cannot be maintained at all. This may be due to the failure in the offset activity (e.g., restoration is unsuccessful), or as a result of the non-linear nature of biodiversity and time-delayed ecological cascade effects (e.g., loss of key ecological processes such as seed dispersal or nutrient cycling, degradation or loss of habitat and critical resources needed for the persistence of certain species, e.g., Maron et al., 2010) or due to the impact of unexpected hazards such as fire, flooding and disease for which provision has not been made.

A common approach to addressing certain aspects of equity over time is the use of simple multipliers (see also Section 3.2): these are applied to assess the required 'gains' to be delivered by a specific offset, with the size of the multiplier varying according to the length of the time lag between losses and gains (e.g., see selected wetland assessment methods in the US: Bardi et al., 2006 in Florida; Sheldon et al., 2005; Hruby, 2011 in Washington State). This approach does not, however, address the problem where temporal delays lead to critical resource shortages over time that may result in irreversible biodiversity loss (see above). This is best addressed by providing a successful offset ahead of any impacts taking place (see e.g., Bekessy et al., 2010).

Some methods also integrate discount rates – commonly applied in economic valuation - to address issues relating to equity over time (e.g., in Habitat Equivalency Analysis, HEA). It has also been proposed to integrate the use of a discount rate and the concept of 'Net Present Biodiversity Value' (NPBV) in the accounting model for biodiversity offsets. Essentially, this 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. In financial settings, it comprises four components (although not all of these would necessarily be used when discounting is applied to assess biodiversity loss and gain, e.g., see TEEB, 2010, Denne and Bond-Smith, 2011): 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 NPVB of the gains and losses over each time interval is estimated and summed over a time period. A positive sum of NPVB 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. This must be carefully chosen and justified – still an area of considerable debate (see Gowdy et al., TEEB 2009; TEEB, 2010 offer recent critical reviews of the use of discounting with regards to biodiversity and ecosystem services valuation; Denne and Bond-Smith, 2011 for an analysis relative to biodiversity offsets in a New Zealand context).

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 (Figure 3 and BBOP 2009a). A wide range of biodiversity offset systems and methods have been (and continue to be) developed, involving varying levels of complexity, data requirements, levels of field testing, and differences in the number and type of components explicitly accounted for in the loss-gain assessment Ultimately the choice of offset design reflects a balance between applying scientific rigour and transparent accounting, 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 provide an international standard on biodiversity offsets (see BBOP, 2012a).

3. Insuring against failure: Dealing with uncertainty and risk

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 and 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:** 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 as to 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, 2012c).

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 and due to the non-linear nature of biodiversity, 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 and risk. Particular emphasis needs to be placed on the precautionary principle where risk and uncertainty are high (see also BBOP 2012c) to limit the chances of a bad outcome. 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 BBOP 2009a; 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. Another way of establishing multipliers in offset specifications is relative to known or estimated margins of error, for example where confidence levels can be constructed using available data distributions for a particular biodiversity measure and projections of offset gains.

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 some existing offset programs (e.g., in methods used as part of 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.

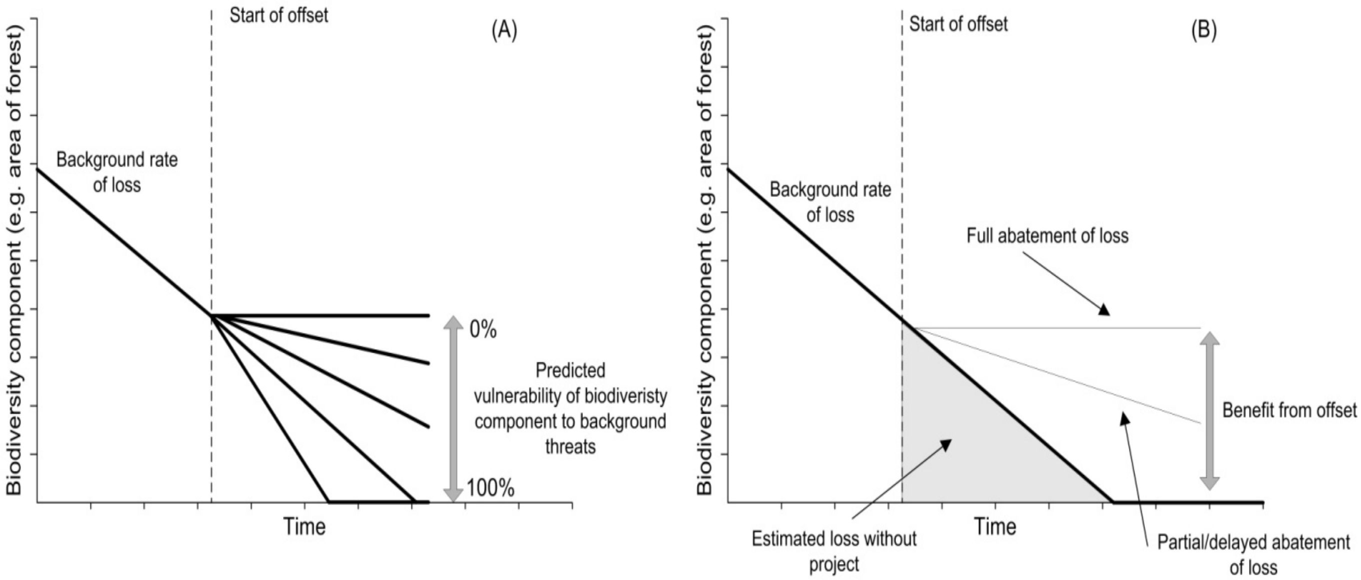
Alternatives to using multipliers to limit uncertainty and spread risk include stepping back and employing more rigorous methods for calculating biodiversity losses and gains (e.g., see Gibbons et al., 2009), using multiple and complementary field-tested biodiversity currencies and accounting models, 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 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 Figure 2).

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 (Figure 4A), and/or uncertainty in predicting the likely effectiveness of any offset activity to abate the background threats (Figure 4B). Moreover, it has to also be demonstrated that there is little 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 4. Additionality in averted-loss offsets given uncertainty in predictions of background rates of biodiversity loss and the effectiveness of offset activities to fully abate background impacts

The figure conceptualises 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). Part A illustrates that the background rate of biodiversity loss estimated for the period prior to the implementation of an offset is an uncertain predictor of future changes in biodiversity that occur irrespective of any offset activity (i.e., the rate of background loss may increase or decrease). Note that changes in biodiversity are rarely linear as shown in this simplified example. Part B illustrates that there is also uncertainty in the relative effectiveness of any offset intervention (even if we can confidently estimate the baseline scenario).



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 to averted-risk offsets (see also BBOP 2012c). 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 or better 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 an option of 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 1-3, 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. Socio-economic and 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 capture losses and gains adequately for a wide range of key biodiversity components.

2. Maximise efforts to ensure the net balance 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, provided they cover sufficient and representative biodiversity components. 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 P5)

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)

iii. Combine multiple interventions across the full mitigation hierarchy (BBOP P1)

iv. 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.

5. **Recognise that there are ecological and scientific limits to what can be offset (BBOP P2)**

   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, 2012c).

6. **Combine multiple interventions across the full mitigation hierarchy (BBOP P1)**

   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.

7. **Design offsets to take account of wider landscape context and patterns of biodiversity (BBOP P3)**

   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)**