Nordic Council of Ministers

Planning biodiversity offsets

TWELVE OPERATIONALLY IMPORTANT DECISIONS

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Twelve operationally important decisions

Atte Moilanen and Janne S. Kotiaho

TemaNord 2018:513

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ISBN 978-92-893-5406-6 (PRINT)
ISBN 978-92-893-5407-3 (PDF)
ISBN 978-92-893-5408-0 (EPUB)
http://dx.doi.org/10.6027/TN2018-513

TemaNord 2018:513
ISSN 0908-6692

Standard: PDF/UA-1
ISO 14289-1

Cover photo: unsplash.com

Print: Rosendahls
Printed in Denmark

NORDIC ECOLABEL
5041 0457
Ecolabelled Printed Matter
Rosendahls

Nordic Council of Ministers/Publication Unit
Ved Stranden 18
DK-1061 Copenhagen K
Denmark
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Foreword

When attempting to reconcile the needs of the society, economic activity, and nature conservation, it has numerous times been observed that natural and semi-natural habitats are a limited resource – in the Nordic region and elsewhere. Every development project, whether it is about construction of factories, mines, harbors, roads, railways, sports fields, skiing centers, shopping malls, new suburbs, or even individual houses or cabins, has negative environmental consequences. Harvesting wood, mining of crushed rock, clearing new agricultural fields, and many other forms of resource extraction inevitably reduce space available for biodiversity, thereby leading to reductions in availability of ecosystem services. These activities that cause environmental deterioration can on the other hand be seen as positive and important for the national and Nordic economy.

The situation is changing however. Pressures to stop and even reverse habitat degradation increase all the time. The Nordic countries have, for example, joined an international agreement (the Convention on Biological Diversity) to restore 15% of degraded environments by 2020. Consequently, there is an immediate need to find ways of stopping and reversing habitat degradation in the Nordics. One of these approaches is ecological compensation, which effectively means the use of habitat restoration and protection measures to compensate for ecological damage caused by construction or other ecologically harmful economic activity. Ecological compensation resembles the "polluter pays" principle, in which it is the responsibility of the polluter to compensate for the damage. Ecological compensation has not yet been widely used in the Nordic countries and its concepts, principles and methods are not well understood. A need for clear operational guidelines seems to come up in discussions repeatedly, expressed by businesses and administrators alike.

Soon after the completion of this report, the Terrestrial Ecosystem Group (TEG) of the Nordic Council of Ministers was introduced to the material. TEG has previously hosted Nordic workshops on the topic, and works to include issues regarding ecological compensation in the Nordic environmental cooperation. With this English translation

TEG and the authors wish to make the material available for a broader Nordic and international audience.

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Environment counselor	Chairperson
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Finnish Ministry of Environment	Nordic Council of Ministers

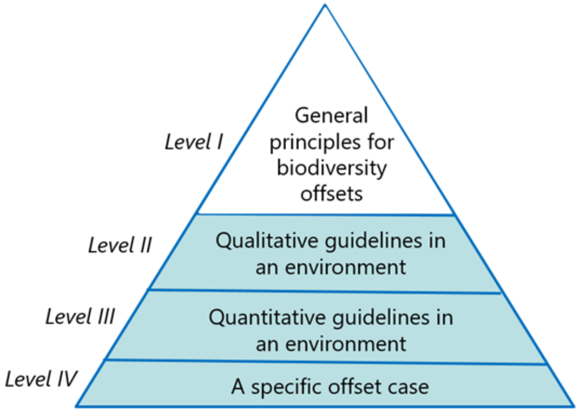
Foreword by the authors

This document has been translated and slightly adapted from the Finnish language original by the same authors, Moilanen & Kotiaho (2017). We should like to comment on the positioning of this work in the literature of the field of biodiversity offsetting.

Ecological damage caused by infrastructure projects or other economic or social activity can be compensated by restoring or protecting habitats. This process is called biodiversity offsetting. The purpose of this document is to review the concepts of offsetting and to summarise the operational decisions that effectively determine how well ecological damage becomes compensated. This document describes a framework that allows well-informed evaluation of biodiversity offsets. Factors treated cover the three major axes of ecology, biodiversity, space and time as well as a host of additional factors characteristic to the actions used for implementing offsets (see Table of Contents). The recommendations given in the text are from the perspective of environmental administration and organizations that oversee the credibility of offsets. This work does not offer an opinion about whether offsets should be allowed in the first place as a way of implementing nature conservation. Neither does it offer advice about how administration of offsets should be arranged or how the equality of stakeholders is ensured in offsetting.

The Figure below shows four levels at which offsets can be considered. Going from more general towards more specific, the first level is the criteria and decisions that should apply to any offsetting case. The simplest example of such a decision is whether offsets are required to be permanent or not. The second level is qualitative guidelines for decisions concerning some specific environment in some region: all level one questions are treated and qualitative guidelines are given. The third level is like the second, but more specific guidance is given about parameter values used in calculations. An example of such a decision is the length of the time frame used to evaluate losses and offset gains. The fourth level is a specific offsetting case, in which offsets may need to be implemented in several environments. Materials for levels I and II can be developed in advance and reused in new offsetting cases. Questions at levels III and IV require verification for each new offsetting case, which could imply significant work in design unless there are prior cases to use as credible templates. This document concentrates on the general operationally important decisions at level I. The risks of employing offsetting schemes are also treated briefly.

Figure 1: The four levels of design and implementation of biodiversity offsets



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Summary

Ecological damage caused by infrastructure projects or other societal activity may be compensated by restoring or protecting habitats. This process is called ecological compensation or biodiversity offsetting. Conceptually biodiversity offsetting resembles the “polluter pays” principle, in which the polluter compensates the damage it causes. Biodiversity offsetting can be considered at different hierarchical levels from general principles to individual offsetting cases. This publication focuses on the overarching ecological principles and implementation risks that are common to all hierarchical levels. This publication reviews the concepts of offsetting and summarizes a dozen operational decisions that effectively determine how well ecological damage becomes compensated. Factors treated cover the three major axes of ecology, biodiversity, time and space as well as a host of additional important factors characteristic to biodiversity offsets. The framework described here allows systematic and well-informed planning and evaluation of biodiversity offsets. The recommendations given in the text are drafted from the perspective of environmental administration and organizations overseeing the credibility of offsets.

1. Introduction

Biodiversity offsetting (ecological compensation, compensatory mitigation) is a process in which ecological damage caused by human activity is compensated by improving ecological condition elsewhere (e.g., Cuperus et al. 2001; ten Kate et al. 2004; Kiesecker et al. 2009a; Bull et al. 2013; Gelcich et al. 2017). Biodiversity offsets are the fourth step of the so-called *mitigation hierarchy*, in which negative ecological impacts are first avoided altogether, second minimized locally, and third reduced by habitat restoration in the impact area (ten Kate et al. 2004; Kiesecker et al. 2009b; IUCN 2016). Conceptually offsets resemble the "polluter pays" principle (Nash 2000), in which the polluter compensates the damage it causes. In biodiversity offsetting the actor who causes ecological impacts should do the compensation as well. According to the mitigation hierarchy, offsets should only be adopted when the options of the earlier steps of the mitigation hierarchy have been exhausted, and there is still some residual impact remaining. This document concerns the situation when it already has been decided that offsets may be acceptable in the project. Note however, that there may be habitats that cannot credibly be offset (e.g. Pilgrim et al. 2013). Offsets can be mandatory or voluntary, and especially voluntary offsets may be partial instead of fully compensating (Moilanen and Laitila 2015). Bonneuil (2015) reviews the history of the tightening and relaxation of environmental regulation (mostly in USA) 1960–1990, and documents how market-driven activity including offsets has become politically acceptable or even favoured way for conserving nature.

In this section, we review the most important concepts and principles of offsetting; we also provide examples of cases that are not true offsets. There are several large documents that review biodiversity offsets. BBOP (Business and Biodiversity Offsetting Program) is a coalition of large business and other organizations, who have the goal of promoting the use of biodiversity offsets (BBOP 2012). The International Finance Corporation performance standard 6 (IFC 2012a, 2012b) is guidelines developed by business to business about how to interpret offsets, also accounting for ecosystem services in the process. IUCN (the International Union for the Conservation of Nature) has developed guidelines from the perspective of environmental organizations, and they strongly emphasize adherence to the mitigation hierarchy (IUCN 2016). Common to these documents is that they describe well the goals of biodiversity offsetting, its position in the mitigation hierarchy, and many details worth considering during implementation. They do not however, in our opinion, make it systematically clear what are the factors and decisions that effectively drive the outcome of offsetting, and what perspectives might there be to these decisions. A previous report compiled by environmental consultancies and published in TemaNord, follows the BBOP presentation and reviews the state of offsets and surveys applications in the Nordic countries (Enetjärn et al. 2015). Focusing on cost efficient promotion of offsets, legal frameworks and Nordic collaboration, it concludes that "Nordic legislation does not support the use of environmental compensation and is not designed to achieve No Net Loss of biodiversity or ecosystem services." A lack of clear guidelines about the design and implementation of offsets in the Nordic countries was also identified.

Proceeding from a lack of clear guidelines, the aim of this document is to clearly describe and organise the operationally important decisions in the determination of offsets. The broad approach adopted is specification of offsets via multipliers: how large an area should be restored or protected to credibly compensate the loss of one (natural or semi-natural) hectare? Multipliers have been used in many on-the-ground offsetting cases. Here, we show how the total multiplier can be partitioned into several mostly independent components that can be systematically investigated individually.

Specifying offsets is fundamentally difficult, because there are many factors that should influence offsets. Biodiversity itself has thousands of dimensions, which makes it difficult to measure losses and to predict gains from offset action. Time delays characterize habitat restoration. Uncertainty is inherent in restoration, in the assumptions about environmental baseline trends, and in ecological concepts such as connectivity. Cost-efficiency may need attention. This document reviews the most important decisions in the design of biodiversity offsets in the order of space, time, biodiversity features, and characteristics of offsetting actions. In the end, we review briefly systemic risks that may reduce effectiveness of offsetting schemes. We also briefly review potential for fraud in the implementation of offsets and associated business.

Note

Use of biodiversity offsets inevitably requires use of partially subjective guidelines and case-specific decisions. Even in a well-informed process there will be political and technical challenges (Mann 2015).

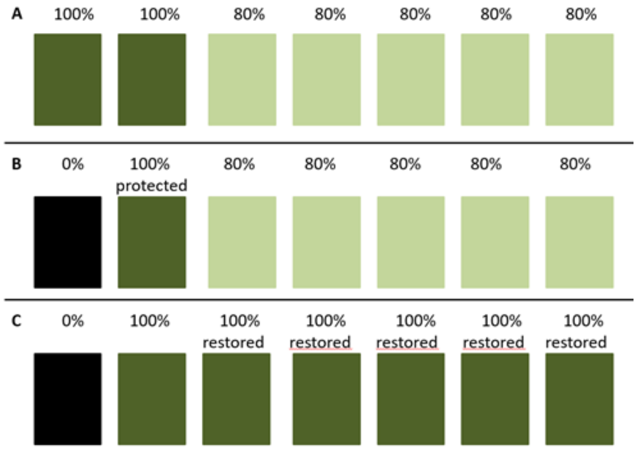
1.1 Important terms and concepts

We next introduce important terminology used in the context of biodiversity offsets and through this document:

- Biodiversity offsetting (ecological compensation), see above. This term is used for the process, in which actions are planned for compensating ecological damage. Usually the compensation is required to be complete, see no-net-loss, below. For clarity, note that the word "compensation" is in this document not used in the sense of monetary compensation to a person or organization.
- *Mitigation hierarchy*, also see above. First avoid, then minimize, then restore in the damaged area itself. Offsetting the damage outside the impacted area is the fourth step in the mitigation hierarchy.
- *Damage* (*habitat or land degradation*, *habitat loss*), any reduction in the ecological condition of an environment as consequence of anthropogenic action.
- *Offset* (*compensation*). Improving habitat condition by habitat restoration (restoration offset) or avoidance of future habitat degradation via protection (avoided loss offset), with the aim of offsetting damage that happens elsewhere.
- *Impact area*. An area or set of areas in which habitats (ecology, the environment) are completely or partially lost due to infrastructure projects or other human activity. Damage in these areas will need to be offset.
- *Compensation area* (offset area). An area or set of areas in which the compensation is implemented.
- *In-kind offset* (*like for like offset*). Offsetting so that biodiversity that is lost is compensated by gains for exactly the same biodiversity (species, habitats, etc.).
- *Out-of-kind offset* (*flexible offset*). Offsetting, in which gains are delivered for different biodiversity features than for those that suffer damage. An example would be offsetting forest loss by maintenance of herb-rich meadows.
- *Trading up* (Section 5.2). A form of flexible offsetting in which compensation is implemented in habitats that are generally considered to be more valuable for nature conservation than the habitat that is damaged.
- *No net loss* (NNL; Harper & Quigley 2005; Gibbons & Lindenmayer 2007) means that all ecological damage must be fully compensated, credibly and additionally

(Fig. 2). Another similar concept is land degradation neutrality (Safriel 2017). In the ecological sense NNL means that damage must be compensated for all species and habitats. If compensation is done only for, say, EU directive species, the offset is not necessarily ecologically NNL if losses are allowed for a host of more common species and habitats that have no conservation status.

Figure 2: Illustrating NNL



Note: (A) The landscape has seven areas: two in pristine state (habitat condition 100%) and five in slightly degraded state (condition 80%). (B) If one pristine area is lost and another protected as an offset, the outcome is not NNL. Because state B has a sum of 500% of habitat condition remaining compared to 600% in state A, one observes that 1/6 of condition-weighted habitat area has been lost. (C) For the outcome to be NNL, it would be required for example that there is a 20% restoration gain in five areas, which then compensates for the full loss of one pristine area (5*20% = 100%). This illustration is simplified, as only one metric of biodiversity is used and it is additionally assumed that restoration can return habitats into pristine state. The example also concerns a once-off restoration or protection action, not an environment that needs recurrent management.

Source: Moilanen & Kotiaho 2017.

- *Net positive impact* (*NPI*; *net gain*; Gibbons & Lindenmayer 2007; McKenney & Kiesecker 2010; Bull and Brownlie, 2017) means that there are more offsetting gains than losses due to development.
- *Partial compensation* (*limited loss offsetting*; Moilanen & Laitila 2015) means that offsets are implemented, but that they do not achieve NNL. If so, losses are limited

instead of fully compensated. In other words, compensation is only partial (see also Section 7). A related concept is *acceptable level of loss* (Enetjärn et al. 2015).

- *Flexibility* (substitutability, interchangeability, replaceability, fungibility; Bull et al. 2015; Section 1.3) How much flexibility is allowed in space, time and between biodiversity features when offsets are determined.
- *Permanence*. If damage is effectively permanent so should be also offsets (Section 3.1). Permanence can be guaranteed for example by setting the area under legally bindingly protection.
- *Time discounting*, net present value calculation. A computational method by which delayed gains may be valued lower than immediate gains.
- *Restoration offset* (Section 5.3). Compensation that is implemented by use of habitat restoration to improve habitat condition.
- *Avoided loss offset* (*averted loss offset*; Section 5.4). Compensation is implemented by protecting areas with the intention of stopping or reducing expected negative future impacts on the compensation area. Avoided loss offsetting only works if protection (or some other similar measure) has a positive net impact on habitat condition of the compensation area by slowing down damage, stopping it completely, or reversing the declining trend and leading to improvement in habitat condition.
- *Baseline of decline* (*counterfactual*; Section 5.6). Assumption against which the gains from avoided loss offsets are evaluated. For example, if an area is being degraded slowly, and this degradation stops due to protection, the difference between the declining baseline and stable state can be counted as a gain.
- *Leakage* (Section 5.5). Especially protection can lead to human pressures moving elsewhere. If pressures relocate instead of becoming neutralized, then NNL is not achieved at the landscape level. Leakage must be accounted for when avoided loss gains are evaluated.
- *Multiplier* (compensation ratio, offset ratio, mitigation ratio, replacement ratio; Dunford et al. 2004; Bruggeman et al. 2005; Moilanen et al. 2009; Bull et al. 2017; Section 6). A multiplier for area, by which effects of delays, trade-offs, uncertainties and flexibility are controlled.
- *Additionality* means that the compensation actions deliver gains that would not have been achieved otherwise (Section 5.1). If the same actions would already

have been done otherwise, then they do not deliver additionality. Consequently, the actions could not be counted as offsets. This effectively means that gains from restoration or protection activity cannot be double-counted for the benefit of multiple stakeholders.

- *Biodiversity feature*. A broad term for components of biodiversity, including species, populations, habitats, ecosystems, environments, ecological communities, ecosystem processes, and also possibly ecosystem services. Losses and gains will be measured for selected biodiversity features.

1.2 Examples of actions that are not biodiversity offsets

- One pristine area is destroyed. Another similar area of the same environment is protected as an offset. This is not an offset especially if the offset area was not under significant threat of habitat deterioration. Effectively, first there were two pristine areas and now there is only one (see Fig. 2). The newly protected area only provides compensation if it gains in condition after protection (and you cannot improve a natural state area). Also, some partial compensation is provided if there was credible expectation that habitat quality in the compensation area would have degraded in the absence of protection. In any case, several area units of small gains are needed to compensate for the complete loss of one area unit of habitat that is in natural or semi-natural state. Using an offset ratio of 1:1 provides only partial compensation.
- Vegetation is moved to a safe place from underneath an infrastructure project. (e.g. ecosystem hotel http://www.syke.fi/fi-FI/Tutkimus_kehittaminen/Tutkimus_ja_kehittamishankkeet/Hankkeet/Ekosysteemihotelli). This vegetation is later moved back. This is not an offset but rather minimization of impact in an earlier stage of the mitigation hierarchy. The condition of the environment has been reduced due to the infrastructure project and clearly NNL is not achieved.
- The damage to a population of a threatened species is compensated by creating replacement habitat for the species. This would generally be partial compensation, in which NNL is possibly achieved to the one species of interest but nearly all other parts of biodiversity would suffer. One species is but a minor

part of any ecosystem, and the business image value of such activity may be higher than the ecological effectiveness of the "compensation".

- One pristine hectare is destroyed, which is replaced by restoring a degraded hectare elsewhere. This is partial compensation. A partial gain on one hectare does not replace the complete loss of one pristine hectare. In some cases, NNL could be achieved via the restoration of many hectares.
- Assume there is an area that has been targeted for restoration as part of some national or international habitat restoration programme. If the same area is designated as an offset, then NNL is not achieved, as the area was already due to be restored for other reasons. Hence, additionality is not achieved and the net gain is zero. In other words, the gains from habitat restoration or protection should not be double-counted.

1.3 Flexibility is a fundamental consideration

The ecological reality of the World can be expressed in terms of three main dimensions: what biodiversity (features) you have where (space) and when (time) (Wissel and Wätzold 2010). Also, ecological losses and gains can be expressed through these dimensions: what and how much is lost where and when? What offsets gains are generated where and when? Associated to these questions is a fundamental concept of offsetting, flexibility: all offsets are flexible to some degree on a conceptual or operational level. This is explained next.

The requirement of in-kind NNL offsets is a great illusion of biodiversity offsetting. Because it is practically impossible to measure losses accurately and because offset gains are even more difficult to predict, it follows that claims of NNL for all species and habitats would usually be false. NNL would only hold in some simplified sense. Most often measurement of biodiversity is simplified significantly, as is done e.g. in the well-known habitat hectares approach (Parkes et al. 2003). In addition, populations may well have unique genetic features, but little or nothing would be known of losses and gains at the genetic level. When we examine the second main axis of ecology, space, we quickly realize that subjective decisions will need to be made about how near offset areas should be to the impact areas. With the time axis, we notice that ecological losses would often be rapid, but restoration gains would materialize with delays of decades, which implies flexibility in time. The conclusion is that offsets inevitably have flexibility in space, time and between features. Hence, all offsets are flexible to a degree, and the degree of flexibility allowed is an important but subjective decision.

Recommendation

Accept inevitable but well-justified flexibility in the implementation of offsets. Require elevated multipliers for higher flexibility.

1.4 Cost-efficiency is not a basic requirement for offsets

Cost-efficiency is a central concept of conservation biology (Carwardine et al. 2008), and it also influences design of offsets (Pouzols et al. 2012). The question is about how to produce highest gains for limited resources. It is important to realize that the requirement of NNL does not imply cost-efficiency. The offsets may be inexpensive and NNL, or they may be expensive and NNL. Both are NNL from the perspective of ecology and environmental administration. Nevertheless, it is clear the business paying for offsets would prefer them to be cost-efficient as offsets are a business expense (e.g. Spash 2015). Search for savings could result in the failure of offsets to deliver the expected gains. For example, when success of offsets was evaluated in Canada, it was found that less than 1/4 of offsets required had actually been implemented (Quigley & Harper 2006). Search for savings might lead to (i) reduction in the amount of offsetting required for NNL, (ii) implementation of offsets as cheaply as possible (and consequently somehow reducing certainty of success), and (iii) inadequate monitoring of offsets. Cost-efficiency should not lead to the offsets being implemented as something different than agreed upon during permitting.

Recommendation

Do not accept compromise due to cost-efficiency, except if the question is about voluntary offsets. Note that the amount, quality and monitoring of offsets should be specified in such detail that search for savings will not lead to failure of offsets to deliver. If savings in implementation would lead to increased risk of failure, then this should be compensated for by an increased multiplier.

1.5 Factors influenced by topics treated in this document

Topics treated in this document influence in various ways different factors relevant for different actors or stakeholders associated with offsetting (environmental administration, the business causing impacts, implementer of offsets, etc.). Here, treatment is primarily from the perspective of an administrator or organization concerned with the environment:

- *Type of offset.* What species and habitats benefit from the offset. To what degree will the offset be in-kind compared to losses.
- *Options for offsetting*. How many alternatives will there be for implementing the offsets? If there are many options, it is likely that options will include ecologically promising areas where implementation of offsets is comparatively inexpensive.
- *Multipliers.* Many of the topics treated below will influence how high multipliers are needed for offsetting to be credibly NNL. Increasing the multiplier will naturally increase expenses.
- *Credibility.* How credible is it, that the compensation plan will really deliver NNL? For example, if offsets are not permanent, one may question the credibility of NNL.
- *Feasibility.* How easily, if at all, can offsets be implemented? For example, if in-kind compensation is required very close to the impacted areas, it is possible that NNL compensation simply cannot be delivered. (There may be insufficient areas for restoration / protection.)
- *Costs.* How much will the offsets cost? This does not necessarily interest the administration. Nevertheless, costs may have implications if the producer of the offsets aims at delivering NNL in the least expensive manner possible. Expensive offsets might make a project no go due to economic reasons, which might induce political pressure to give up on NNL.

1.6 Biodiversity offsets compared to habitat banks and offsetting funds

Biodiversity offsets are most often produced after the impact has occurred, for example using habitat restoration measures. The idea of a *habitat bank* is that the compensation has been generated in advance (e.g. Bekessy et al. 2010). In this case, a project that causes impacts can purchase ready compensations from the habitat bank. There are major differences between compensation (offset) that is generated after the impact compared to a habitat bank: uncertainties associated with the project will be quite different.

In a habitat bank, uncertainties that are associated with time and time delays (Section 3.2) disappear. However, it is generally not plausible that a habitat bank would have a large amount and wide range of habitats available in a restored and already recovered state. This implies that it will be common that in-kind compensation will not be available via the habitat bank, at least not nearby the impacted areas. A natural consequence will then be, that there will be pressure to allow increased flexibility between features when compensation is sought from a habitat bank. Whether it is desirable to allow this flexibility will be a case-specific question. Associated will be an increased need for flexibility in space as well. Yet another question is who decides about the flexibility allowed and the size of the compensation purchased from the habitat bank; will it be the habitat bank itself or some independent actor?

A third way of implementing ecological compensation is an *offsetting fund*, which operates so that who causes the impact will pay money to the offsetting fund. Then, public administrators utilize the fund in the best possible way to benefit nature conservation. Calvet et al. (2015) find major differences from the perspective of economic theory between post-hoc offsets, a habitat bank and offsetting funds. An offsetting fund should not be used to cover the normal operational expenses of environmental administration, because then additionality fails again and the compensation does not truly deliver the gains expected.

Recommendation

Allow the use of a habitat bank to deliver ecological compensation, but do not require that compensations must be generated a-priori by the habitat bank. Remember that with a habitat bank, uncertainties associated with habitat restoration are exchanged into an increased need for flexibility between features and in space.

1.7 Why be concerned about offsets?

Increasingly many countries are taking biodiversity offsets into use (Boisvert 2015; Bonneuil 2015). Nevertheless, suspicions are expressed and strong critique directed towards offsets (e.g. Spash 2015, Sections 7–8). This critique partially arises from irreconcilable differences in the worldviews of different stakeholders (Mann 2015; Sullivan & Hannis 2015). For example, it was found in United Kingdom that differences in worldview have led to differences in opinion that are almost impossible to bridge when offsets are taken to implementation (Lockhart 2015). Hence, it is plausible that offsets always will be a compromise, because of differences e.g. in how socio-political factors and costs of offsetting are valued. Commonly, the compromise will be about the short-term interest of stakeholders with flexibility (and losses) expected from nature. Also, due to the complexity of the topic, development of functional legislation and governance for offsets can be quite hard (Lukey et al. 2017).

Suspicions towards offsets are clearly justified based on scientific literature that has evaluated implementation of offsets. Such studies have been done at least in Australia, Canada and Sweden. It was observed in Australia that at maximum 37% of offsets led to any measurable ecological gain at all (May et al. 2017). This implies, that 2/3 of expected offsets completely failed to materialize. It was evaluated in Canada how well the mitigation hierarchy and offsets achieved NNL in 558 projects during years 1990–2011 (Poulin et al. 2016). The conclusion was, that despite attempts at offsets, the net loss of habitats was 99% of the ecological values of the impacted wetland environments. In Sweden, there has been an evaluation about ecological compensations in the context of transport infrastructure projects (Persson et al. 2015). The finding was that over 90% of communes had not used ecological compensations even once, and when compensations were used, they targeted small environments with a 1:1 offsets ratio, which clearly cannot deliver even close to NNL (Section 7). For offsets to succeed, losses and net gains need to be evaluated in a realistic manner, multipliers must be large enough, offsets must be implemented as agreed, and the maintenance of offsets on the ground must be monitored. If offsets open up impacts in environments that would otherwise remain untouched and if offsets then fail, then clearly the outcome is worse than nothing from the perspective of the environment and biodiversity (Bekessy et al. 2010; Spash 2015).

Recommendation

Clearly state the compromises inherent in societal decision making, and make visible the losses to nature that arise from these decisions. Require clear justification when habitats are to be degraded due to the needs of the society.

2. Decisions around space

2.1 The spatial context of evaluating offsets

Biodiversity offsets are unavoidably determined in some spatial context (frame of reference). The choice of this context and the consequences of the choice should be documented. The question is that offsets may be designed and evaluated e.g. at the context of a commune, region, country, continent, or the World. The reason why this may be important is that different biodiversity features (e.g. species, habitats) may be variably rare or common in different spatial contexts. A species could be common in Europe but rare in Finland, or vice versa (e.g. Brown 1984; Kotiaho et al. 2005; Päivinen et al. 2005).

The spatial context adopted may influence the evaluation of ecological losses and gains. It can be, for example, that only red-listed species require compensation by law but that common species can be treated more flexibly or even ignored. The spatial context may thus also influence what is considered as trading up (Section 5.2). In an offsetting project, several spatial contexts might be employed simultaneously. For example, ecosystem services (Section 4.2) might require evaluation from a rather local (collecting mushrooms) or global (atmospheric carbon sequestration) perspective.

The spatial context influences

- Which species and habitats benefit from offsetting? The effect is via influence on biodiversity measurement and possibly on what is accepted as trading up.
- The amount of options available for implementing offsets. The fewer options there are, the more difficult and expensive implementation will be.

Recommendation

Make a clear decision about the spatial contexts employed when bounds to flexibility are defined for species, habitats and ecosystem services.

2.2 Flexibility in space in the implementation of offsets

While the previous section was about the spatial context of evaluating gains and losses, this one is about spatial flexibility allowed in the implementation of offsets (Wilcox and Donlan 2007; Moilanen 2013; Bull et al. 2015). The question is simply how far from the impact areas are compensation actions allowed? Many ecosystem services should probably often be compensated rather locally. On the other hand, many commitments about biodiversity have been made at national levels, implying that compensation for biodiversity might be allowed comparatively further away from the impacts. If so, it is important to keep in mind that options for in-kind offsets might become reduced when moving between biogeographic areas, which implies an increased need for flexibility.

There are at least the following considerations about the choice of location for compensation areas:

- If offsets must be implemented very close to impacts, it is quite possible that NNL cannot be credibly achieved simply because large enough areas of the same habitat suitable for restoration or avoided loss simply do not exist.
- Flexibility in space influences significantly the number of potential candidates for offset action. With higher spatial flexibility, there will be more options, which implies lower per-area costs. If very little flexibility is allowed, costs may go up for example because more complicated restoration methods need to be used.
- Flexibility in space implies increased options for trading up as well.
- If offsets are implemented far from impacted areas, local stakeholders nearby impact areas may suffer from loss of place-based values.

Influences

- The number of options available for implementation of offsets. The more flexibility, the more options and the lower per-area costs.
- Acceptability of offsets from the perspective of locals living nearby impact areas.

Recommendation

Allow a degree of spatial flexibility. Consider the potential need for an increased multiplier (M_s>1) if elevated spatial flexibility is allowed. Note that credibility of NNL may be lost if compensation is required very close to the impacts.

2.3 About connectivity

Connectivity is not a primary criterion in the design of offsets, but as the topic no doubt will arise frequently, here are a few considerations. The area, quality and connectivity of habitats are primary variables of spatial ecology that define the population size (count of individuals) of a species in a landscape (Hodgson et al. 2011). Of these, area and habitat quality are primary because they determine the carrying capacity of the landscape (maximum population size), connectivity on the other hand influences how much of the carrying capacity is actually utilized (Hodgson et al. 2011). There is no area without habitat quality and there is no connectivity without habitat quality and area (see e.g. Kotiaho & Mönkkönen 2017). Connectivity (e.g. Laita et al 2011; Kool et al. 2013) is an operationally very difficult concept, because it is different from the perspective of different species. The importance and spatial scale of connectivity depend on whether the question is about plants or animals, is the movement on the ground or through air. Connectivity can be different from the perspective of animal home range, a local population, a metapopulation, or gene flow. Yet another question is landscape structure that allows range shifts of species following climate change. Due to the complexity of connectivity, it is not easy to account for it. Nevertheless, the following considerations might be good to keep in mind in case expert evaluation is used to account for aspects of connectivity:

- Connectivity is highest when there is a large continuous area of natural or semi-natural habitat.
- The influence of connectivity is highest when the landscape already suffers from fragmentation. If the landscape is highly connected or extremely fragmented, small changes in connectivity would have little additional effect on most species.
- Small offset areas might suffer from reduced ecological quality due to edge effects and problems with small local population sizes. Consequently, offset action would ideally be implemented on large and rather continuous areas, or in areas right next to natural or semi-natural habitats.
- It is beneficial if restoration offsets are implemented nearby high-quality protected areas. This is because the protected area may serve as a population source for species that recolonize the restoration area.
- If the loss of a large and ecologically high-quality area is to be compensated by many small areas, an increased multiplier K_C may be needed to compensate for loss of connectivity and the consequent additional negative impacts on biodiversity.

Recommendation

Pay attention to connectivity if impact areas and offset areas are clearly different from the perspective of connectivity. If so, an additional multiplier may be needed.

3. The time dimension

3.1 Permanence of offsets

Whether offsets are permanent or not influences both multipliers and how credible the offsets will be seen (McKenney and Kiesecker 2010; van Oosterzee et al. 2012; Laitila et al. 2014). Permanent compensation is gained from, e.g., permanent protection as opposed to a temporary conservation contract. A once-off offsetting action should be preferred to an action that requires regular repetition (habitat management). It would be reasonable to take negative impacts as effectively permanent: this clearly is the case in most infrastructure projects. Conceptually, one might argue that permanent damage could be compensated for with a very large temporary offset. Nevertheless, if offsets are temporary, their evaluation becomes hard: how should one value an uncertain temporary offset?

Influences

- Primarily credibility of the offset. Evaluation of temporary offsets is even more challenging than evaluation of permanent offsets.
- Possibly actions allowed. Recurrent habitat management is not a reliable offsetting action, if there is risk that the action will be discontinued in the foreseeable future.

Recommendation

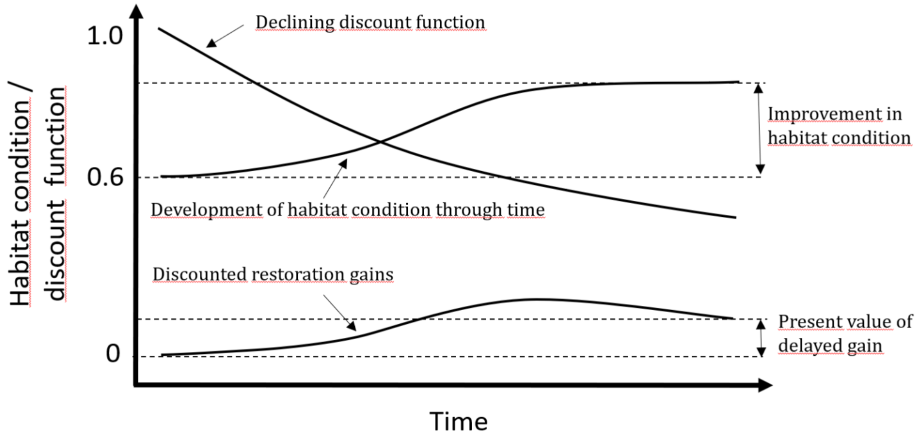
It is generally best to avoid temporary offsets. This reduces uncertainty and makes both the calculation of offsets and monitoring more feasible.

3.2 Time discounting and net present value calculation of delayed offsets gains

Time delays and associated time discounting are most obvious for restoration offsets, but also avoided loss offsets will take time to generate gains. The situation is often such that impacts happen very quickly, within a few years of the project commencing. On the other hand, offset gains may take decades or even centuries to mature fully (see Kotiaho & Mönkkönen 2017). This could be the case for example for forest, where maturation to old-growth forest takes at least many decades. In such environments, impact avoidance would generally be much easier than restoration (e.g. Vesk et al. 2008).

If the impact is effectively immediate but offsets gains are delayed, fair balance requires time discounting and net present value calculations to be employed. Why is this so? Just like in economics, an immediately available benefit (offset) should be perceived as more valuable than a significantly delayed one; this could be e.g. due to increased uncertainties implied by long time delays. If this assumption is accepted, then the inevitable consequence is that time discounting and net present value calculations should be used (Carpenter et al. 2007; Moilanen et al. 2009; Overton et al. 2013; Laitila et al. 2014). For fairness, it should be stated that time discounting could apply also to impacts in addition to gains, but because impacts from construction projects usually happen almost immediately at the beginning of the project, one could just as well skip the calculation. Below there is a schematic of time discounting (Figure 3).

Figure 3: Schematic of discounting delayed restoration benefits



Note: A degraded area (condition ~0.6) is restored. The recovery of the environment happens with a delay, with an approximately 0.3 improvement in condition at the end of the evaluation time frame. Discounted gain is calculated by multiplying the expected improvement with the declining discount function, meaning that the discounted benefit becomes reduced. The average discounted improvement (say *b*) over time will be used in the calculation of a multiplier. If the ratio is calculated for the loss of pristine habitat, then the multiplier = 1/*b*, which usually would be much greater than 1.

Source: Moilanen & Kotiaho 2017.

At least the following considerations are associated with time discounting offsets:

- Time discounting should be used routinely for delayed offset gains.
- There are inevitable subjective decisions associated with time delays: the length of the time frame of evaluation and the time discounting coefficient (percentage).
- If the time discounting percent is (for parity) required to be as large as return on investment usually required in business, then offset gains decades in the future have effectively no value. Even a couple percent yearly discounting leads to almost complete perceived loss of value after a few decades. This could effectively prevent the use of offsetting in a habitat that is slow to recover after restoration.
- The discounting percent for biodiversity should probably be lower than that used in business, especially for permanent offsets.

- In a habitat bank the offset has been generated in advance and time discounting is therefore not needed.

Influences

- Primarily multipliers and therefore costs.
- Credibility in the sense that credibility is harmed if the negative influence of time delays is not openly accepted.

Recommendation

Require time discounting of delayed gains, producing a multiplier M_T. Impacts need not be discounted if they take place very quickly compared to gains.

3.3 The time scale of evaluating losses and gains

Evaluating NNL means that the balance of losses and gains can be evaluated, which is a fundamentally quantitative question. If time discounting is used due to delayed offset gains (pervious Section), it is operationally necessary to decide what the time frame of calculations is. If the time frame is short, like a decade or two, then restoration benefits have little time to mature and the multiplier will become relatively large. If time discounting is strong, the influence of later years diminishes, and the influence of the time frame likewise becomes reduced. A suitable time frame of evaluation would be a subjective case-specific decision, and we suggest that something like 20–50 years might make general sense.

Influences

- Multipliers, and hence costs.
- Short time frame leads to high multipliers. If the time scale is short but offsets permanent, NNL offsets may turn into NPI in the long run. Hence, shorter evaluation interval is better for biodiversity.

Recommendation

Require clear statement of the time frame of evaluation. Note that when offsets are required quicker, a comparatively larger area is needed to produce NNL.

4. Biodiversity features

Important note

While measurement of biodiversity is difficult (see below), the real challenge in offsetting is realistic prediction of offset gains following habitat restoration or avoided loss in offset areas. Observing present-time biodiversity still is much easier than predicting what there will be in the future.

This section discusses measurement of biodiversity and ecosystem services, which is one of the greatest challenges of offsetting. There are many species and habitat types. Even if Northern Europe is comparatively species-poor at the global scale, a typical hectare still hosts at least hundreds of species. Species are not substitutable by each other (Salzman & Ruhl 2000), and biodiversity cannot be measured using one metric only (Purvis & Hector, 2000; Mateos et al. 2015). On the other hand, estimating reliably the population size of even one species is difficult and predicting changes in populations is even more difficult. Understanding the demography and genetic composition of local populations requires major work, time, and resources. Consequently, biodiversity offsets can be made operational on the ground only if simplifications are allowed in the measurement of biodiversity (Quétier & Lavorel 2011; Maron et al. 2012; Bull et al. 2013). On the other hand, excessive simplification can lead to failure in representing biodiversity in a balanced manner, thereby leading failure of NNL (Bernhardt et al. 2005; Walker et al. 2009; Bekessy et al. 2010). The risk of failure will be greatest for specialist species that have very specific habitat requirements. Specialist species are also more often threatened than common species (Kotiaho et al. 2005; Mattila et al. 2006; 2008).

Hanford et al. (2017) studied how well a simplified (one-dimensional) biodiversity metric covered species occurring in the area. They arrived at the conclusion that the metric did not work. The problem was that a single metric failed to adequately describe the variable habitat requirements of various species groups. While there are computationally credible ways of handling multiple dimensions of biodiversity in offsetting (e.g. Pouzols et al. 2012; Mandle et al. 2016; Masyek et al. 2016), availability of data for model parameterization quickly becomes an obstacle.

Recommendation

Allow simplified measurement of biodiversity as an unavoidable fact. Simplified measurement and consequent uncertainty may nevertheless need further compensation via an increased multiplier.

4.1 Measurement of biodiversity

Below, we discuss measurement of biodiversity: from what species and habitats information is gathered, what kind of information is collected, how is this information obtained and from what areas is data needed? These tables are not supposed to be an exhaustive treatment of biodiversity measurement (which is topic for a thick book). Rather, their purpose is to make clear how difficult and broad the subject is. We omit references to the almost endless scientific literature that would be available for this topic.

Table 1: What species to survey?

Level	Strengths and weaknesses
All species	This would be ideal. However, getting reliable information about the presence of all species is very hard and very impractical if not impossible for organisms that are rare, small, cryptic, otherwise difficult to detect, or which move between areas in time. Unrealistic requirement.
Threatened species	Frequently small population sizes, which does not help accurate estimation of occurrence, population size or distribution.
Threatened species group-level occurrences	As above, but collected by group, such as "number of red-listed plant species." Easier and more reliable measurement than for individual species.
Indicator species	Assumed to indicate high-quality habitats and the presence of other interesting species as well. Often chosen so that the indicator is easy to observe and identify. The perhaps most used alternative in surveys, but the performance of the indicator species is often poorly studied (see Halme et al. 2009).
Key-stone species	Often common species that are thought to be important for ecosystem structure and function.
Just a single species	It is possible that legislation requires offsets for only one (threatened) species. It should be recognized that this is not even close to ecological NNL, because one species is just a tiny fraction of an ecosystem.

Selection of species or species groups for survey is not a trivial decision, and case-specific considerations may need to be accounted for. It is relevant that the occurrence of many species is correlated, and indicator species and group-level information can be utilized to get a decent overview. Some species might be interpreted as surrogates for other species.

Recommendation

Consider the possibility of operating on environments / habitat types (and their condition), because they are feasible to survey. Habitat types are surrogates for large numbers of species. Simplified measurement can possibly be compensated for with a multiplier.

Table 2: What kind of information to collate?

Level	Strengths and weaknesses
Genetic	Informs about the ability of a population to adapt to changing conditions following e.g. climate change. Genetic information is usually not available. Also, intrapopulation genetic diversity and species diversity within a community are often positively correlated, due to the parallel influences of environmental characteristics such as area, connectivity, and environmental heterogeneity on both levels of diversity (Vellend 2005; Kahilainen et al. 2014). Therefore, it might be argued that species level information might be adequate for practical purposes.
Population size	Useful information but somewhat difficult to evaluate reliably. If estimated, then probably only for selected threatened or indicator species.
Index of population size	More coarse estimate of population size. Useful nevertheless.
Group-level occurrence	Group-level information for e.g. "threatened birds". Much easier and more reliable to estimate than species-specific information.
Presence only	Observations of species presence without information about abundance; species-list information. Can be used in statistical species distribution modelling. Useful for understanding losses in the impact area. It is difficult to reliably predict changes in species presence (gains) following habitat restoration.
Presence absence	More useful than absence-only information e.g. in statistical modelling. It is however generally difficult to ascertain that a species does not occur in an area. Is the species absent or did it just go undetected?

Table 3: How to get information about species?

Method	Explanation
Direct observation	Very obviously useful information, but on-the-ground high-resolution survey of many species across large areas is work-intensive, slow and expensive.
Species-habitat association	Most species have association with a certain kind of habitat or micro habitat. Habitat types may be relatively easy to map by ground observation or remote sensing. Thus, if (i) species-habitat associations are known a-priori, (ii) a habitat mapping exists, and (iii) species presence in the general area has been observed, it may be possible to derive sensible species distribution information directly from habitat associations. This is quite practical and can be done without modelling.
Statistical species distribution models	These are statistical models that link species occurrences to environmental variables. This is possible if environmental background variables exist and there are sufficient observations to make model fitting credible. Of course, technical capacity for doing the models is needed as well.
Spatial population models	Dynamic models that link spatial data about the environment with the population dynamics of the species (births, deaths, dispersal, possibly interactions with other species). Constructing these models requires a lot of information even for a single species.

Habitat mapping. Habitat mapping is the easiest way to start survey of biodiversity. Habitat types are comparatively easy to survey either on the ground or by interpretation of remote sensing data, but the mapping is inaccurate for individual species. This is because species may have specific requirements that go beyond general habitat type. If habitat mapping is adopted, it is very important that additional information is obtained about human impacts as well. This is because the degree to which habitats are degraded influences two very important components of offsetting: it impacts both what gains can be expected from habitat restoration and what can be expected from avoided loss. For example, drainage reduces the condition of a peatland. Forest management reduces the biodiversity of a forest. Some types of habitat degradation can be countered with habitat restoration. Avoided loss may be more appropriate for habitats that still are in comparatively good condition. Knowledge of habitat types and their ecological condition is a useful starting point for understanding the distribution of biodiversity.

Recommendation

Think about offsets first at the level of habitat types and their condition. Consider species-specific requirements carefully. Offsets will become operationally impossible if species-level information requirements are not kept moderate.

4.2 Ecosystem services (ESS)

As is obvious from the name, biodiversity offsets were originally developed for the compensation of lost biodiversity. However, there is no reason why offsets could not be used for compensating lost ecosystem services as well – after all, ecosystem services arise from biodiversity (Jacob et al. 2016; IFC 2012; Gaia and Pellervo 2017). Nevertheless, it may be good to design offsets for ecosystem services separately from biodiversity. This is because there are considerations such as accessibility that may be relevant for ecosystem services but not for biodiversity. It is a conceptually important distinction that compensation for biodiversity is done for the sake of biodiversity itself, whereas compensation of ecosystem services is done for the sake of people. Mixing these two things may lead to loss of NNL from the perspective of biodiversity, as biodiversity does not automatically become offset in a balanced manner as a by-product of offsetting ecosystem services.

The utility value of ecosystem services between locations is influenced by demand, which is different from biodiversity. For this reason, loss and compensation of ecosystem services should be examined together with local stakeholders (e.g. IFC 2012). Accounting for connectivity requirements is even more difficult for ecosystem services than for biodiversity (Kukkala & Moilanen 2017). As with biodiversity, maintenance of ecosystem service supply requires sufficiently large and well connected ecological networks. Additionally, it is important that supply and demand meet with ecosystem services such as recreation, berry picking or hunting. Compensation locally is not important for every ecosystem service though: for example, loss of carbon sequestration from the atmosphere can obviously be compensated further away.

It is important to realize that full compensation of ecosystem services does not guarantee NNL for biodiversity. The same concern does not hold the other way around: if biodiversity is offset fully and in kind, then there should be no reduction in ecosystem service supply generated by biodiversity. Of course, the location of ecosystem service supply could change, which influences accessibility and how well supply and demand meet.

Recommendation

Require offsets to be determined separately for biodiversity and ecosystem services. Synergies can be sought in the implementation of offsets. Comparatively local offsetting of ecosystem services would be generally desirable, but offsetting of biodiversity could possibly be allowed further away.

4.3 From what areas is information about biodiversity and ESS needed?

The negative ecological impacts should obviously be evaluated from the impact areas and their neighbourhoods, as dust, noise, night time light, hydrological effects, and ecological edge effects and loss of connectivity can extend beyond the area of direct impact. The offsets however, can be implemented further away. Due to this reason, information might be needed from a rather large area, which can be problematic. Table 4 below summarizes why information is needed from elsewhere than the area of direct impacts. This topic has major consequences for measurement of biodiversity: understanding the impact areas thoroughly is not very useful for offsetting if there is only very limited information from the offset area candidates. Also, losses in impact areas can be measured on the ground, but potential future gains in offset areas need to be predicted, which introduces additional uncertainty.

Table 4: From what areas is information needed?

Area	Why might data be needed from this area?
General area of development	If information is available from the general area where impacts are expected to take place, it may be possible to minimize impacts by positioning development so that ecological losses are minimized. Useful information.
Area of direct impact	Information is needed so that it is known what biodiversity and ecosystem services need to be replaced. Essential information.
The neighbourhood of the impact area; area of indirect impacts.	This information is needed when evaluating indirect effects that spread outside of the area of direct impacts due to noise, light, dust, pollution, hydrological effects etc.
The offset areas	Needed when estimating potential offset gains. Includes uncertainties, leakage and baseline assumptions described elsewhere in this document.
Offset area candidates	Needed if offsets areas are to be chosen from amongst a larger number of candidates. May increase cost-efficiency.
Neighbourhood of offset area candidates	The offset areas interact with their surrounding via, e.g., spatial population dynamics. The condition of the surrounding areas may, e.g., influence recolonization of offset areas by species that have disappeared locally.
The entire landscape	Useful if evaluating landscape level effects including ecological networks and connectivity. Can also be utilized in ecological impact avoidance when positioning of infrastructure is designed.
National-scale information	May help understand broader scale rarity and commonness of biodiversity features. Features that are rare in a broader context are those that should probably be emphasized in evaluations. Such information may be available from red lists of species and habitats.

As we see, it would be beneficial if information about biodiversity would be available from a broader area than just the impact and offset areas. This is a major requirement. Because accurate survey of biodiversity over a large area is (prohibitively) difficult, time-consuming, and expensive, biodiversity measurement will most likely end up being simplified, which then returns to questions about the credibility of offsets.

Recommendation

Implement offsets in stages. Evaluate losses and gains first using coarser information. Do more accurate surveys for impact and offset areas only after alternatives for areas have been limited to a small number.

5. Offset actions

5.1 Additionality

Permanence, additionality and leakage are central concepts of carbon offsets (van Oosterzee et al. 2012), and so they are also for biodiversity offsets. Additionality means that one cannot count gains from (conservation) actions that would have been done in any case (= double counting is not allowed). If an area is to be restored due to prior commitments, it cannot be a restoration offset for a construction project. If an area has already been protected, and it cannot therefore be harmed, the area cannot be counted as an avoided loss offset, as there are no pressures to remove. Likewise, offsets should not be counted towards national environmental goals (IUCN 2016; Maron et al. 2016). This is because offsets are meant to compensate the negative impacts of an infrastructure (etc.) project, and offsets would not usually improve the state of the landscape as a whole. An exception to the rule could be a situation where offsets credibly produce NPI, in which case the improvement over NNL could potentially be counted towards something else.

As an anecdote, let us mention the situation in which a new impact is targeted on an area that has previously been designated as an offset. In this case, the area needs to be offset twice, once as itself, and another time because it already is compensation for past damage. Unless this is done, it is possible that area A is compensated with area B; then B is lost and compensated with area C, then C with D and so on. Such chaining leads to the outcome, that many areas have been lost but only one offset area remains – landscape condition has gone down step by step. Hence, there is no way that NNL has been maintained.

Recommendation

Require justification that documents additionality for offset actions proposed. If additionality is missing, an area/action is not an acceptable offset. If additionality is met only partially, then the value of the offset should be proportionally reduced.

5.2 Trading up

Trading up means swap of impact areas into offset areas of some other habitat type, which are thought to be more valuable from the perspective of biodiversity conservation (Habib et al. 2013). Flexibility is needed in trading up as impacts and gains happen for different sets of species. It is an inevitably subjective decision whether trading up is allowed and what multipliers are used in the action.

Influences

- Type of offset: what is lost and what is gained as replacement.
- Feasibility. If trading up is allowed, then there most likely will be many more options to choose from, which should increase overall feasibility and reduce per-area costs of offsetting.
- Credibility. Depending on the case, credibility might be harmed or enhanced.
- Multipliers. These will likely be different from in-kind compensation. A small multiplier might be acceptable, but we do not recommend a multiplier < 1 to be accepted even if trading up.
- Costs. Costs will much depend on the environment in which action is taken. Increased options would usually lead to reduced costs because it is reasonable for businesses to pick the least expensive option to implement offsets.

Recommendation

Allow trading up when the trade achieves clear gains for biodiversity conservation. This is a subjective decision though. Pay attention to sufficient multipliers being maintained.

5.3 Characteristics of restoration offsets

Generating offset gains via habitat restoration is the first of the two main ways of doing offsets. Restoration ecology is a science of its own. Habitat restoration progresses so that the abiotic or biotic conditions of the environment change following the restoration action. Then the response of the ecological community and natural succession start slowly moving the habitat closer to the natural state. There may be significant time delays and uncertainties associated with habitat restoration. Spake et al. (2015) reviewed the recovery of species groups in temperate forests. They concluded that return of old growth forest characteristics takes 90–180 years depending on the species group, when the aim is to achieve 90% of what is in an original old growth forest.

For example Maron et al. (2012) and McAlpine et al. (2016) discuss habitat restoration as an offsetting method. They find that restoration of each environment has its own characteristics. How well the environment recovers will depend on the degree to which the abiotic and biotic conditions have been altered (Maron et al. 2012; McAlpine et al. 2016; Elo et al. 2016). Certain kind of habitat degradation is comparatively easy to restore: removing pressures, removing alien species, or adding specific resources for individual species (bird boxes) are comparatively easy actions to take. On the other hand, a significantly altered environment is unlikely to return to the original natural state if the species community has already mostly changed to something else. A chemically altered environment may be practically impossible to restore. The EU court of justice has recently stated restoration uncertainty as reason why local restoration action cannot be relied upon when expected environmental damage is evaluated in Natura 2000 areas (Schoukens & Cliquet 2016).

Habitat restoration has certain characteristics that would apply to most restoration cases:

- Habitat restoration almost always involves time delays (Zedler & Callaway 1999; Hilderbrand et al. 2005), which should be accounted for when multipliers are calculated (Section 3.2).
- There can be additional uncertainties about the overall success of restoration in the first place (Suding 2011; Halme et al. 2013). These can be accounted for with an additional multiplier.
- One restored hectare does not offset one lost hectare in its natural- or semi-natural state, and the associated multiplier needs to be evaluated realistically. If restoration improves the habitat with a proportion x on the scale of zero (completely degraded habitat) to one (pristine), then the multiplier is $1/x$. As restoration usually only recovers a minor fraction of full quality, this multiplier would usually be much greater than 1. As an extreme example, if bird nest boxes are added to a forest, they will represent only a tiny fraction of the ecological

value compared to the total ecosystem of a pristine forest. The multiplier needs to be evaluated separately for each habitat, degree of degradation and restoration measure.

- Generalist species, ecosystem function and ecosystem services will likely recover easier than specialist species, which may need very specific conditions. The full original ecological community may be impossible to recover, as some species may have gone regionally extinct.
- Generalist species, specialist species, ecosystem function and ecosystem services will likely recover at different rates.
- One approach to evaluating restoration gains is to use logic that is based on evaluation of impacts of structural changes in the habitat (Kotiaho et al. 2015; 2016a).
- When selecting restoration areas, one should seek synergies in the restoration of biodiversity and ecosystem services, accounting for accessibility, connectivity and other such factors as needed. Connectivity to pre-existing high-quality conservation areas is of benefit for the recovery of a habitat.
- The offset area can be both restored and protected. Protection may be needed to ensure the permanence of the offsets.
- In some cases, restoring a protected area can provide additionality. This could be so if the protected area benefits from restoration, but the restoration would not realistically be done except as an offset (Mustajärvi 2017).
- Evaluating benefits from restoration offsets inevitably requires a decision about a reference state in relation to which both habitat degradation and effects of restoration are evaluated. This state would most obviously be the natural state (Kotiaho et al. 2016a, b), and only for a good reason any other state. If the reference state is not the natural state, then there are endless options for other subjective choices, which is not good.

Let's for the sake of illustration assume that the condition of the impact area is 80% of the pristine natural state and that this area is completely lost. Let's also assume that offset areas are in state 40% and that restoration raises their condition to 60%. If so, then four hectares of restoration are needed to compensate for one hectare of loss. Also, this multiplier may need to be increased, as 60% condition areas may not be able to support as demanding specialist species as 80% condition areas are. Furthermore, if there is uncertainty about overall success of restoration in the first place, an additional multiplier may be needed: if restoration only works 50% of the time, then this uncertainty multiplier would be 1/0.5=2, leading to an overall multiplier of 2 x 4 = 8. Note that this is a simplified example and does not account for all components of the total multiplier (Section 7). For example, time delays should semi-automatically result in an additional multiplier.

Multipliers may be different for different components of biodiversity and ecosystem services. If this is the case, the total multiplier should be at least the largest of these. Depending on availability of areas suitable for the restoration of biodiversity and species, different biodiversity and ecosystem services may need to be offset in different locations. If so, the efforts required to meet NNL become larger. Again, not damaging natural environments in the first place is much easier than restoring them after impacts.

Recommendation

Prefer restoration actions of which there is operational experience and which are known to work more or less reliably. Uncertainties become elevated if new restoration methods are trialled in the context of offsetting.

5.4 Characteristics of avoided loss offsets

Avoided (averted) loss offsets rely on the reduction of pressures (threats) in the offset areas for example via protection measures (e.g. ten Kate et al. 2004; Gibbons & Lindenmayer 2007; BBOP 2012). There are major uncertainties associated with avoided loss offsets, including leakage (relocation) of pressures elsewhere, leading to reduced gains (Section 5.5). Uncertain assumptions about baseline trends also need to be made (Section 5.6). Additional issues to keep in mind include:

- As with restoration offsets, avoided loss offsets produce gains that per area unit only fractionally replace loss of pristine habitat. Usually the credible baseline for the avoided loss area is not immediate complete loss in the absence of protection, but rather, a slow decline might be a fair average expectation. Consequently, the avoided loss multiplier is >>1.

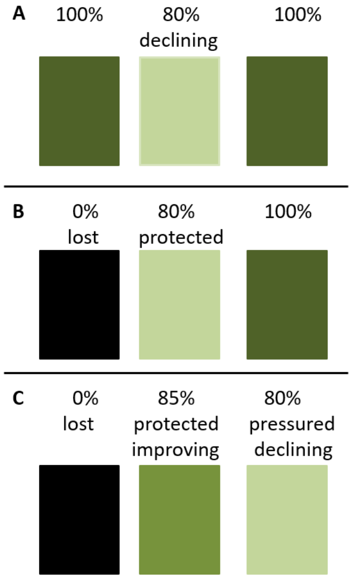
- Avoided loss offsets may be better in producing gains for specialist species than restoration offsets. This is because avoided loss is applicable also to areas that still are in good ecological condition and that still retain populations of specialist species. In comparison, specialist species may have already disappeared from restoration areas and their return may be uncertain.
- Restoration and avoided loss offsets can be combined as appropriate.

There are significant differences between restoration and avoided loss offsets in terms of where uncertainties are. With restoration, there is always uncertainty about time delays and restoration success. With avoided loss, there is uncertainty about how much loss is really avoided, i.e. how much does the situation improve compared to not protecting the area. Leakage is another source of uncertainty for avoided loss offsets.

5.5 Leakage of pressures in avoided loss offsets

The idea of avoided loss offsets is that protection (or some other measure) leads to reduced pressures (threats) in the area, and habitat condition then starts recovering or declines less than it otherwise would have. It is a special risk in avoided loss offsets that pressures leak. This means that pressures move elsewhere instead of being cancelled (Ewers & Rodriguez 1998; Virah-Sawmy et al. 2014; Moilanen & Laitila 2015). If all pressures leak to a similar location than the offset site, the landscape level net gains from avoided loss become zero. No real compensation takes place and the only net effect is the loss of the impact areas. Computationally, if a fraction p of pressures leak, one needs an additional multiplier of $M_L=1/p$ to achieve NNL (Moilanen & Laitila 2015). This calculation can be modified to account for the case that pressures leak to areas that have different habitat condition than the offset areas. It is especially serious if pressures leak to areas that are in fact of higher ecological quality than the avoided loss areas themselves. The schematic below illustrates leakage.

Figure 4: Relocation of pressures; leakage



Note: (A) To begin with there are three one-hectare areas, two in full natural condition and one under pressure that has already lost some condition i.e. has degraded. Condition weighted total area is 2.8 ha. (B) One area is lost to development and the area under pressure is protected. Protection removes the pressure from the protected area and stops the degradation. Condition-weighted area is now 1.8 ha. (C) Even when habitat condition in the now protected area improves a bit after protection, pressures do not disappear but rather they only relocate. As a consequence, the third area starts losing condition. The condition-weighted area is now 1.65 ha. Almost half of condition-weighted area has been lost even when the offset was done by protecting an area of the same size as what was lost. NNL is not met. Meeting NNL requires that the condition-weighted area of the landscape is not reduced. This example illustrates yet another reason why a 1:1 avoided loss offset ratio will usually not reach even close to NNL.

Leakage should be evaluated always when avoided loss offsets are used. Leakage could be significant e.g. for forest environments, if the offsetting leads to no reduction in forest use pressure, which could be the case if a fixed amount of wood is harvested every year regardless. (The quality difference between the offset site and typical harvested forests would be a significant factor in evaluating the impact of leakage.) On the other hand, leakage would probably be a lower risk for e.g. peatlands in Finland, as peatlands are not under pressure in the same way as forests. However, it should be noted that if there are no pressures that can be expected to degrade habitat condition in the offset area, then there also are limited opportunities for avoided loss. Evaluating leakage is not easy. Setting aside and protecting one area may also move pressures from the protected type of a habitat into another; pressures could also move from one administration (country) to another, making leakage difficult to detect (Moilanen & Laitila 2015). If leakage is evaluated only locally, it is quite possible that pressures move outside the study area and thus are not detected. In addition to avoided loss offsets, leakage can be a problem with combined restoration and avoided loss offsetting (often restoration areas need also protection to ensure permanence).

Influences

- Feasibility, negatively.
- Multipliers, increase and thereby increase costs as well.
- Credibility of offsets, negatively.

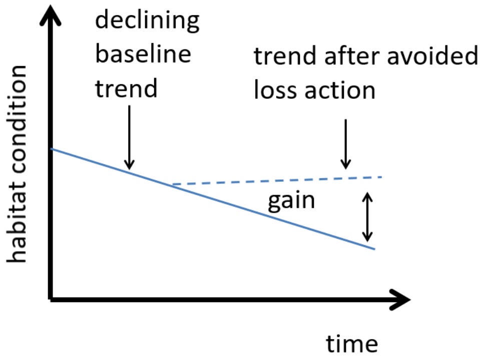
Recommendation

Require evaluation of the possibility that pressures are not cancelled by protection (or other similar measure) but simply relocate elsewhere. Leakage leads to (at least partial) loss of offset gains, and it thus is a serious but difficult to evaluate phenomenon.

5.6 Baseline trend assumptions in avoided loss offsets

Avoided loss offsets rely on the assumption that protection has a positive effect on the future of the offset area, by stopping a decline or even leading to improvement in condition. It is assumed that the improvement follows from reduction of pressures in the area. The amount of avoided loss gains need to be calculated from the difference between the improved future expectation and the declining baseline trend. This means that the assumption about the baseline trend strongly influences the gains estimated from an avoided loss offset (Bull et al. 2014; Maron et al. 2015; Figure below).

Figure 5: Schematic of the influence of the baseline trend in avoided loss offsetting



Note: The environment (habitat, etc.) has a slowly declining background trend. After protection, the decline stops or habitat condition could even start improving slowly. The offset gains are calculated from the difference between the original declining trend and the new trend after protection. Note that the baseline trend is inevitably based on an uncertain estimate about what is expected to happen into the future. There could be variants of this calculation. One would be to evaluate gains between the present condition and future expected condition, i.e., a declining trend assumption would not be allowed, and only real improvement in condition following protection would be counted.

There are several things to pay attention to:

- If the offset area candidate is high-quality environment, there may be reasons why the area has maintained its quality so far (e.g. poor accessibility). The same reasons might maintain the area into the future as well, implying that there is no declining baseline to improve via protection. If so, additionality fails and avoided loss offsetting brings no true gains.
- It was observed in a study done in Australia that the baseline decline had on average been estimated five times steeper than what scientific evaluation about the baseline later found (Maron et al. 2015). Additionally, assumptions made about the baseline have frequently been demonstrably false (Maron et al. 2013). These observations point to overt optimism in the evaluation of avoided loss gains.
- The estimate of baseline trend may depend on the time frame used to evaluate the trend, and the trend may be different in different habitats (Sonter et al. 2017).

- When evaluating the baseline trend, only natural processes and external human influences like climate change should be accounted for. One should not include effects of construction activity before the offsetting project. If they are included in the baseline estimate, use of offsets ensures that the past trend of increasing construction continues unabated into the future. This is because losses and gains balance around the declining trend, not around a stable state.
- To reduce uncertainty and speculation, it may be desirable to only allow avoided loss gains to be calculated between the present state of the area and an improving future state. It is a subjective decision whether speculative declining trends are allowed in the first place.
- Avoided loss gains should be time discounted just like restoration gains. This naturally increases the multiplier.

Influences

- Multipliers, and hence costs.
- Credibility and feasibility, especially for specialist species.

Recommendation

Require justified evaluation of the avoided loss baseline trend. Note that this estimate is one of the most uncertain ones in offsetting, and scientific literature has found evidence as to declines being overestimated easily, leading to failure of NNL.

6. Joint multipliers

It is important for nature that (i) the mitigation hierarchy is used and impacts are first avoided before offsets are adopted, (ii) offsets are requested to be large enough both in area and in quality so that NNL is plausible, (iii) offsets are implemented as agreed, which may be an issue when savings are sought, and (iv) implementation and maintenance of offsets is monitored. Keeping track of offset projects requires resources as well, and this should probably be done by a governmental administrator.

In this document, we have described several factors that should influence multipliers. These factors are largely independent from each other, meaning that their effects are multiplicative (i.e. should be multiplied by each other to get total multiplier). As a consequence, the multiplier for a natural or semi-natural area can become seemingly high. This is ecological realism, because complete loss of one very good hectare certainly requires minor improving action over a large number of hectares for the gains and losses to balance out (= NNL).

Joint multipliers should consider at least the following components (see also Section 9):

- (i) Restoration offsets
  - $M = M_R * M_T * M_U * M_B * M_S * M_X * M_C$, in which
    - M is the joint multiplier
    - M_R is multiplier arising from the only partial recovery that follows habitat restoration
    - M_T is multiplier for delayed gains, based on time discounting. It can be calculated together with M_R by time discounting the gains over time recovery function, to estimate mean discounted gain over time. It is also possible to separate effects of partial recovery and time delay
    - M_U is a possible uncertainty multiplier compensating for possibility of complete failure of restoration

- M_B is a possible multiplier compensating for rare and threatened species when measurement of biodiversity is simplified
- M_s is a possible multiplier from elevated spatial flexibility allowed
- M_X is a possible multiplier for trading up exchanges
- M_C is a possible additional multiplier compensating for changes in connectivity.

- (ii) Avoided loss offsets
  - $M = M_A * M_T * M_L * M_B * M_S * M_X * M_C$, in which
    - M is the joint multiplier
    - M_A is multiplier arising from the only partial (compared to complete loss) gains that come from avoided loss; this includes effects of baseline assumptions
    - M_T is multiplier for delayed avoided loss gains, based on time discounting
    - M_L is multiplier for leakage
    - M_B is multiplier compensating for rare and threatened species when measurement of biodiversity is simplified
    - M_S is multiplier from elevated spatial flexibility allowed
    - M_X is multiplier for trading up exchanges
    - M_C is additional multiplier compensating for changes in connectivity.

Multipliers can be different for different things to offset, habitats, generalist species, specialist species, individual species, ecosystem function, ecosystem services, etc. In addition, these multipliers are different for different restoration or avoided loss actions. If the impact areas cover multiple habitats, separate calculations are needed for each – but doing separate calculations for all species is not feasible or sensible. Simplification in measurement of biodiversity will be practically unavoidable. If effects are evaluated for many different biodiversity features and actions, the combination of multipliers can be made into a very difficult exercise if features are impacted by multiple actions simultaneously. In any case, the multiplier for an environment has to be at least the maximum across those calculated for different components of biodiversity and ecosystem services. If it is not, then at least one component of biodiversity or ESS will fail NNL. (It is another matter if flexibility in biodiversity is actively allowed.)

If for example the multiplier for specialist species is 10, and for generalist species 5, then the multiplier of 10 is needed for NNL. Typically, one would expect that the multiplier for the loss of a natural-state habitat would be >10 and possibly even several tens, if restoration or avoided loss can only produce minor improvements for the habitat. If the honestly evaluated multiplier for NNL is greater than what can be afforded due to socio-political or economic reasons, it is correct to admit that the compensation is only partial, not NNL. There is no problem if voluntary offsets are partial, but also then a false impression of NNL should not be allowed. Partial offsets bring challenges to communication: how is it prevented that gains are not overly emphasized over losses in corporate communication? There may be risk of greenwashing.

Recommendation

Require justified reasoning for multipliers in different environments. When the joint multiplier becomes very high, businesses may try to negotiate reduced multipliers. If this request is accepted, then communication in terms of NNL should not be allowed as the question is about partial compensation.

7. Systemic risks

When considering biodiversity offsets, one should recognize that the approach increases the possibilities and profits of doing business (Walker et al. 2009; Bekessy et al. 2010; Spash 2015). New possibilities for business, new jobs and new paths of influence are generated. Business is made easier by reducing environmental regulation (Bonneuil 2015; Spash 2015) and the costs of offsetting are sunk into the cost of doing business. That is, after the costs of offsets have first been minimized. Even if a single offset project would be credibly NNL, there may be indirect negative effects that reduce the net benefits of offsetting schemes at the level of the society and the environment (Gordon et al. 2015; Ives & Bekessy 2015; Spash 2015; Levrel et al. 2017):

- Voluntary nature conservation may become reduced when the new possibility for profiting from conservation becomes public knowledge (Gordon et al. 2015).
- False public confidence in biodiversity offsetting, when offsets seemingly almost by definition guarantee NNL (Gordon et al. 2015).
- Replacement of other mechanisms of nature conservation when new market-based mechanisms take hold (Gordon et al. 2015).
- Utilitarian ethics replace ethical-moral arguments in the relationship between people and nature (Ives & Bekessy 2015). Economic logic is used as justification for actions that degrade our environment. Maintenance of the environment for future generations cease to be reason for withholding action that degrades the environment. Rights of species become reduced (e.g. Apostolopoulou & Adams 2017).
- Tipping points of the global ecology and consequent major global as well as existential risk (to the humankind) are difficult to evaluate and put price upon. All action that ultimately promotes the degradation of the environment contributes to these risks.
- Reduced importance given to place-based values (Gordon et al. 2015; Apostolopoulou & Adams 2017; Levrel et al. 2017). The environment always

deteriorates at the impact area and its close vicinity. Local people can suffer irreplaceable (non-economic) damage. Ecosystem services become redistributed as they disappear from one area and are restored elsewhere (Levrel et al. 2017). Losses are born and benefits gained by different people and stakeholders.

- Overestimation of declining trends in avoided loss offsetting (Gordon et al. 2015; Maron et al. 2015). If the benefits of avoided loss offsetting are evaluated against a declining baseline, it is a consequence of NNL offsetting that opportunities for reversing declining environmental trends are lost. This happens because projects that degrade the environment have offsets calculated against the declining trend, with the implication that the trend becomes cemented. If benefits from avoided loss offsets are furthermore overestimated (because the declining trend is overestimated), the decline of the environment becomes even steeper than before.
- Financialization of nature brings potentially significant but difficult to evaluate long-term risks. Taking biodiversity offsets into use is a big step in this process (Spash 2015).
- Use of partial compensation to benefit (greenwash) the image of a business. This is a risk when compensation is only a small fraction of ecosystem-level NNL.
- Fraud that takes advantage of difficulties in designing, implementing and monitoring offsets (next section).
- Overall economic activity becomes increased. Environmental damage though the life cycle of new products would not typically be accounted for in offsets.

Despite all risks it remains possible that biodiversity offsets will lead to a better outcome compared to the present practise, in which no compensation at all is required from everyday small-scale activity that incrementally degrades the environment. Taking offsets into use may produce both restoration and avoided loss benefits, and it may also guide activity towards environmentally less damaging practises. A lot will also depend on how the regulation of offsets is implemented in legislation and administration.

8. Potential for fraud

This is speculation into a topic of which there is scarce information available. Biodiversity offsets may involve significant potential for fraud. An important motivation for adopting offsets is the desire to increase economic activity: industries gain new opportunities to utilize natural resources, environmental consultants, traders, certifying officials, the financial sector, other middle men and land owners gain new opportunities for business (Spash 2015). From the perspective of a business causing impacts, offsets are a cost of business that must be minimized. It follows that there will be pressures to produce offsets as inexpensively as possible, and many things could go wrong from the perspective of NNL. One can identify at least the following opportunities for fraud:

- Biodiversity is difficult to measure and changes in biodiversity can only be predicted with uncertainty. Measurement errors and uncertainties can be large in estimates of population sizes and in particular population trends. Overly optimistic (fraudulent) interpretation of data may lead to underestimation of ecological damage and overestimation of offset gains. If it later turns out that compensations were not in fact NNL, then are there any realistic chances of holding anybody responsible for the outcome? It will be easy to blame failure on e.g. the weather or vagaries of spatial population dynamics.
- How is it verified that offsets are implemented as agreed and that they stay permanent? What happens e.g. if monitoring finds that offsets have not been implemented as agreed, but the company implementing offsets has e.g. already (fraudulently) gone bankrupt?
- If trading up is allowed further away (say in a tropical country), then how is implementation of offsets monitored and how is it ensured that the same offset is not (fraudulently) sold multiple times? How can additionality and lack of leakage ever be verified?

- Potential for windfall profits if measurement of biodiversity is changed. Advance knowledge of the forthcoming change in measurement would be something that could be utilized to unfair advantage.
- Biodiversity is much more difficult to understand than money. If financial markets are developed for biodiversity, is it possible that investors could be tricked into paying for non-existent biodiversity? Biodiversity Ponzi schemes?
- Threats on species or populations could be purposefully exaggerated so that avoided loss benefits become overestimated, which then reduces costs of offsetting.
- Regulatory capture. Influencing regulations for personal benefit with the expense of the environment. Or, purposeful misreporting by the financial officer of a business doing offsets. These could lead to adverse environmental outcomes.
- Could speculation on biodiversity (structured biodiversity investment instruments and vehicles, etc.) lead to undesirable results from the perspective of nature?

It can be said that the potential for fraud is greater than usual in the context of biodiversity offsets business. Poor measurability, difficult valuation, complexity of determining offsets, difficulty of monitoring, and potentially large monetary interests might plausibly attract fraudulent activity.

9. Summary tables of important decisions

These tables collate from previous chapters the important questions of offsetting, separately for restoration offsets and avoided loss offsets. The tables can be combined if the offset is a combination of restoration and protection, as could well be the case. All questions in the table should be evaluated for each habitat type in every offset project. There are two reasons to do so. First, if any of these questions is ignored, the chance of failing NNL increases. Second, the transparency of the offsetting process demands that all important decisions are actively and visibly treated. For example, the potential of leakage must be documented as evaluated, even if it turns out not a problem in the particular case. In addition to decisions about the important operative questions, a large amount of additional information may be needed about impact and offset areas, including about the type, amount and condition of habitat impacted and presence of selected species. The national governmental environmental administration should be the primary actor when principles for evaluating offsets are decided, at least if offsetting is mandated by law.

Table 5: Important questions in restoration offsets

Factor to account for	Question / explanation
Spatial context	What spatial context (e.g. country, Europe) is used when rarity and threat status of species and habitats is evaluated? Several spatial contexts could be used as relevant.
Area of implementation	How far from impact areas is implementation of offsets allowed? Some distance in km, county, country, etc.?
Multiplier for elevated spatial flexibility	A multiplier may be set if elevated spatial flexibility is allowed.
Permanence	Is the impact permanent or temporary? If permanent, the same should be required from offsets. Permanent offsets can also be required for temporary impacts, in this case balancing time discounted losses and gains.
Time scale	Over how many years is parity of losses and gains evaluated?

Factor to account for	Question / explanation
Time discounting	What time discounting coefficient (and function) is used?
Measurement of biodiversity	Decide the biodiversity features for which losses and offsets are measured? In addition, it may be specified how measurement is done, in terms of habitat area, individual counts or what?
Multiplier for changes in connectivity	How are changes in connectivity evaluated? If a large area is replaced by several small, a multiplier may be needed.
Measurement of ecosystem services	Decision about what ecosystem services are accounted. Also, is both supply and demand or only supply accounted for.
Multiplier for simplified measurement	Multiplier that compensates for the fact that simplified measurement leads to increased uncertainty about NNL for individual species.
In-kind vs. trading up?	If trading up is allowed, then what is up? There may be several options allowed for trading up.
Multiplier for trading up	What multiplier is used for trading up? An important but subjective parameter.
The recovery function for habitat restoration	A function that describes the expectation for habitat improvement over the time scale of evaluation. The function starts from a degraded state, and following restoration starts moving closer to natural state. Depending on the case, a separate function may be needed for different habitats, species and ecosystem services, conditional on restoration action taken. Simplification will most likely be needed.
Multiplier for restoration offset	Multiplier by which it is accounted for that one hectare of restoration does not compensate for one hectare of loss. Calculated from the recovery function of the previous item and time discounting.
Multiplier for restoration uncertainty	Uncertain restoration success may be accounted for either via lower gains in the recovery function or by an additional multiplier.
Additionality	Confirm that the offsets actions described are additional, and that partial lack of additionality is accounted for in calculations.

Table 6: Important questions in avoided loss offsets

Factor to account for	Question / explanation
Spatial context	see Table above
Area of implementation	see Table above
Multiplier for elevated spatial flexibility	see Table above
Permanence	see Table above
Time scale	see Table above
Time discounting	see Table above
Measurement of biodiversity	see Table above
Multiplier for changes in connectivity	see Table above
Measurement of ecosystem services	see Table above
Multiplier for simplified measurement	see Table above
In-kind vs trading up?	see Table above
Multiplier for trading up	see Table above
Baseline trend assumption of the avoided loss offset	Document assumption about baseline and about the gain evaluated with respect to the baseline
Multiplier for avoided loss	Calculated by time discounting the gain evaluated in the previous item (if the gain is delayed)
Joint multiplier for restoration and avoided loss	If both are used simultaneously, quantify the improvement for the joint action and calculate multiplier (using time discounting when appropriate)
Leakage	Justify what happens to the pressures stopped by protection. Do they disappear or do they relocate, fully or partially? If they relocate, a multiplier is needed.
Multiplier for leakage	Calculate multiplier accounting for fraction of pressure that relocates and estimate of where the pressures move to.
Additionality	see Table above

Conclusion

It would be excellent if it was possible to offer a ready-made, detailed and reliable method for determining offsets, but there are many reasons why this is not possible. There are many subjective decisions that need to be made when offsets are decided. For example, subjective decisions need to be done about the measurement of biodiversity and the time frame of evaluating effects. Differences in data available influence what calculations are possible. There are unavoidable uncertainties inherent in offsetting, for example about the likelihood of restoration succeeding. Information about species distributions is always uncertain and incomplete. The demand for ecosystem services may change in the future. Due to reasons such as these, it is inevitable that some uncertainty will remain and that subjective decisions need to be made in offsetting. Furthermore, implementing, monitoring and maintenance of offsets is not going to be easy.

In this work, we have addressed a dozen (or so) operative decisions that are central in deciding how well offsets will eventually satisfy NNL. These decisions cover the three major axes of ecology, biodiversity features, space and time, as well as several topics about restoration and avoided loss offsets. If at least these factors are evaluated systematically and independently, it is possible that NNL might be reached. If any of these considerations is ignored, intentionally or by accident, it is likely that NNL will fail in some respect. On the other hand, there is no 100% guarantee of NNL in the broad sense even if all these questions are addressed: for example, the indirect life-cycle impacts of new products would not usually be accounted for in offsets. Taking offsets into use might even lead to hard-to-evaluate changes in behaviour of land owners.

NNL is primarily a question of ecological reality and the perspective of this document has therefore been about the ecologically credible determination of NNL offsets. Several topics relevant for offsetting activity have been ignored, including:

- Are there environments in which losses and offsets can never be allowed?
- What should be the national guidelines about allowing offsets at all?

- Before adopting offsets, it might be desirable to develop more detailed guidelines for some more common environments, e.g. in Finland this could be for common and widespread environments such as forests and peatlands (Fig. 1, levels II–III).
- How should the legal, administrative and governance mechanisms for planning, implementing and monitoring offsets be implemented?
- How should (almost inevitable) loss of place-based values be compensated to people nearby impact areas?

To conclude, we hope that this document has clarified the perception the reader has about biodiversity offsets, risks associated with their use, and about operationally important decisions, many of which are subjective, in the use of offsets. We thank those from the Finnish Ministry of the Environment, the Ministry of Agriculture and Forestry, Parks and Wildlife Finland (Metsähallitus), the Finnish Association for Nature Conservation, University of Helsinki, the terrestrial ecology group (TEG) of the Nordic Council of Ministers, and others who have provided feedback on this document.

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Referat

Ekologiska skador som uppstår i och med ett byggprojekt som har skadliga konsekvenser för miljön eller av annan samhällelig verksamhet kan kompenseras genom restaurering av livsmiljöer eller med skyddsåtgärder. Denna process benämns ekologisk kompensation, och kompensationsåtgärderna innebär gottgörelse av skada. Ekologisk kompensation påminner begreppsmässigt om principen ”förorenaren betalar,” som innebär att förorenaren ersätter den skada denna orsakat. När det gäller ekologisk kompensation ska den aktör som orsakat försämrat naturtillstånd gottgöra försämringen. Ekologisk kompensation kan studeras på olika nivåer, allt från allmänna principer till enskilda fall av gottgörelse. Denna publikation fokuserar på allmängiltiga ekologiska principer för planering av gottgörelse, oberoende vilken nivå det gäller, och på möjliga risker med implementeringen. Publikationen redogör för de centrala begreppen inom ekologisk kompensation och för flera operativt viktiga beslut som i väsentlig grad bestämmer i vilken utsträckning den ekologiska skadan kan gottgöras i verkligheten. Publikationen ger verktyg att planera och bedöma gottgörelserna på ett systematiskt och motiverat sätt. De frågor som behandlas omspänner tre huvudaxlar inom ekologin – biodiversitet, tid och plats – samt en mängd viktiga faktorer som är kännetecknande för ekologisk kompensation. I texten presenteras rekommendationerna ur perspektivet hos den aktör som övervakar att gottgörelserna är trovärdiga och genomförbara.

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Planning biodiversity offsets

Ecological damage caused by infrastructure projects or other development activity may, in some cases, be compensated by restoring or protecting habitats elsewhere. This process, which resembles the "polluter pays" principle, is often called biodiversity offsetting or ecological compensation. The frequently-cited goal of offsetting is ecological no-net-loss, which means that all ecological losses must be fully balanced by corresponding ecological gains produced by offsetting actions.

This publication reviews the principles of offsetting and summarizes a dozen decisions that effectively determine the credibility, feasibility and costs of offsets. These decisions cover the three major axes of ecology, biodiversity, space and time as well as additional considerations inherent to implementation of offsets via habitat restoration and protection measures. Compensation will necessarily take place some distance away from the damage, it will come with uncertainties and a time delay, and lost biodiversity will never be replaced by exactly the same thing, which means that up-front treatment of the degree of flexibility allowed should be fundamental to any offsetting project.

As ecosystems are different, the twelve design questions described here should be systematically addressed when offsets are suggested for a new type of environment. Doing so will facilitate well-informed and transparent design and evaluation of biodiversity offsets.

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