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Conservation Biology

Essay

Three ways to deliver a net positive impact with biodiversity offsets

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Abstract: Biodiversity offsetting is the practice of using conservation actions, such as habitat restoration, management, or protection, to compensate for ecological losses caused by development activity, including construction projects. The typical goal of offsetting is no net loss (NNL), which means that all ecological losses are compensated for by commensurate offset gains. We focused on a conceptual and methodological exploration of net positive impact (NPI), an ambitious goal that implies commitment beyond NNL and that has recently received increasing attention from big business and environmental nongovernmental organizations. We identified 3 main ways NPI could be delivered: use of an additional NPI multiplier; use of slowly developing permanent offsets to deliver additional gains after NNL has first been reached during a shorter offset evaluation time interval; and the combination of permanent offsets with partially temporary losses. An important and novel variant of the last mechanism is the use of an alternate mitigation hierarchy so that gains from the traditional third step of the mitigation hierarchy (i.e., onsite rehabilitation) are no longer be counted toward reduced offset requirements. The outcome from these 3 factors is that for the same ecological damage, larger offsets will be required than previously, thereby improving offset success. As a corollary, we show that offsets are NNL only at 1 ephemeral point in time, before which they are net negative and after which they become either NPI or net negative impact, depending on whether permanent offsets are combined with partially temporary losses or if temporary offset gains are combined with partially permanent losses. To achieve NPI, offsets must be made permanent, and they must achieve NNL during an agreed-upon offset evaluation period. An additional NPI-multiplier and use of the modified mitigation hierarchy will deliver additional NPI gains. Achieving NPI is fully conditional on prior achievement of NNL, and NNL offsets have been frequently observed to fail due to inadequate policy requirements, poor planning, or incomplete implementation. Nevertheless, achieving NPI becomes straightforward if NNL can be credibly reached first.

Keywords: alternate mitigation hierarchy, biodiversity offsetting, ecological compensation, net gain, net negative impact, permanence

Tres Maneras de Proporcionar un Impacto Positivo Neto con Compensaciones por Biodiversidad

Resumen: La compensación por biodiversidad es una práctica que consiste en usar las acciones de conservación, como la restauración, manejo o protección del hábitat, para compensar las pérdidas ecológicas causadas por las actividades de desarrollo, incluidos los proyectos de construcción. La meta típica de la compensación es la nula pérdida neta (NNL), lo que implica que todas las pérdidas ecológicas están compensadas por las ganancias proporcionales. Nos enfocamos en una exploración conceptual y metodológica del impacto positivo neto (NPI), una meta ambiciosa que implica un compromiso más allá de la NNL y que recientemente ha recibido una mayor atención por parte de los grandes negocios y las organizaciones no gubernamentales ambientales. Identificamos

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tres maneras principales mediante las cuales se podría proporcionar el NPI: el uso de un multiplicador adicional de NPI; el uso de compensaciones permanentes de lento desarrollo para entregar ganancias adicionales después de que primero se haya logrado el NNL durante un intervalo de tiempo más corto para la evaluación de las compensaciones; y la combinación de las compensaciones permanentes con las pérdidas parcialmente temporales. Una variante importante y novedosa del último mecanismo es el uso de una jerarquía alterna de mitigación de tal manera que las ganancias provenientes del tradicional tercer paso de la jerarquía de mitigación (es decir, la rehabilitación in situ) ya no se contabilizan para los requerimientos reducidos de las compensaciones. El resultado de estos tres factores consiste en que para el mismo daño ecológico se requerirán compensaciones mayores a las necesarias previamente, aumentando así el éxito de las compensaciones. Como corolario, demostramos que las compensaciones sólo alcanzan el NNl durante un punto efímero en el tiempo, antes del cual tienen un saldo neto negativo y después del cual se transforman en un impacto neto positivo o un impacto neto negativo dependiendo de si las compensaciones permanentes se combinan con pérdidas parcialmente temporales o de si las ganancias temporales de las compensaciones se combinan con pérdidas parcialmente temporales. Para alcanzar el NPI, las compensaciones deben volverse permanentes y deben llegar al NNL durante un periodo acordado de evaluación de compensaciones. El uso de un multiplicador adicional de NPI y de una jerarquía alterada de mitigación proporcionará ganancias adicionales al NPI. La obtención del NPI es completamente dependiente de la obtención previa del NNL; se ha observado con frecuencia que las compensaciones por NNL fallan debido a los requerimientos inadecuados de las políticas, la pobre planeación o la implementación incompleta. Sin embargo, llegar al NPI se vuelve una tarea sencilla si primero se puede alcanzar el NNL de manera verosímil.

Palabras Clave: compensación ecológica, compensación por biodiversidad, ganancia neta, impacto negativo neto, jerarquía alterna de mitigación, permanencia

Introduction

Biodiversity is almost universally in a state of decline, and the rate of ecosystem degradation, which underlies much of biodiversity loss, is accelerating rather than stabilizing (e.g., Mace et al. 2018; IPBES 2019; IPCC 2019). Infrastructure development is one of the major causes for the ecosystem degradation and biodiversity loss (Maxwell et al. 2016), and it is projected that the next few decades will see an unprecedented further expansion of it (e.g., zu Ermgassen et al. 2019*b*).

Ecological losses from infrastructure development as well as from other anthropogenic land uses could potentially be curbed by a large-scale adoption of biodiversity offsetting (Rainey et al. 2015; IUCN 2016*a*; Willemen et al. 2020). Biodiversity offsetting (hereafter offsetting) is the practice of balancing ecological losses with ecological gains generated through actions, such as ecological restoration, establishment of new protected areas, or some form of habitat management (Gibbons & Lindenmayer 2007; McKenney & Kiesecker 2010; Wende et al. 2018). Habitat restoration is used to reduce past ecological degradation and thereby provides offset gains. Protected area establishment is a common form of so-called avoided (averted) loss offsets, which aim to provide gains via reduction of pressures that would lead to future habitat degradation or population declines unless addressed (Gibbons & Lindenmayer 2007; Maron et al. 2015). Similar to protection, habitat management operates by preventing or slowing the habitat deterioration that would occur without conservation action. Both protection and restoration come with complications, such as partial gains, time delays in the delivery of gains, leakage, and questions of additionality. Moilanen and Kotiaho (2018) provide a unified treatment of these underlying factors.

At least on paper, biodiversity offsetting seems to be an increasingly adopted policy tool. There are at least 37 countries with mandatory biodiversity offsetting policies for at least some infrastructure sectors or habitat types and a further 64 countries that recommend or enable voluntary offsets (zu Ermgassen et al. 2019*b*). Still, land use for biodiversity offsets is limited compared with the scale of human impacts on the world; in 2018, there were globally only just over 150,000 km^2 of variable-type offsets completed or in the process of being implemented (Bull & Strange 2018). Despite limited implementation so far, the relatively common global policy indicates that biodiversity offsetting can have an important role to play in minimizing losses or even delivering net positive biodiversity impacts to compensate for infrastructure development and land use. Negotiations are ongoing to include combined ecosystem restoration and no net loss (NNL) or net positive impact (NPI) for ecosystems in the global post-2020 global biodiversity framework (CBD 2020).

Offsetting is presently seen as the fourth stage of the so-called mitigation hierarchy in which ecological loss is first avoided altogether, then minimized by appropriate local project design, corrected by onsite rehabilitation (restoration), and finally offset offsite (e.g., IUCN 2016*b*; OECD 2016; Arlidge et al. 2018). The commonly stated goal of offsetting is NNL (i.e., ecological losses incurred by development are fully balanced by commensurate gains) (McKenney & Kiesecker 2010; Maron et al. 2018; Maseyk et al. 2020). Despite offset programs being increasingly adopted all around the world, there is wide variation in what an offset is taken to mean operationally (Bull & Strange 2018).

Although NNL is thought to be difficult to achieve, and many NNL policies have indeed been shown to fail their intended aims (Calvet et al. 2015; Lindenmayer et al. 2017; Bezombes et al. 2019; zu Ermgassen et al. 2019*a*), recently an appeal was made stating that a desirable outcome for economic development should be the even more ambitious goal of NPI for biodiversity. Net positive impact is gaining traction from businesses and conservation NGOs alike (Gibbons & Lindenmayer 2007; Rainey et al. 2015; IUCN 2016*a*; Bull & Brownlie 2017). Although an offset program that aims at NNL only compensates for the ecological losses, NPI aims to deliver more, to improve the state of the environment relative to its predevelopment state.

From a corporate perspective, the social license to operate can benefit greatly from well-managed and reported net positive environmental impacts (Richert et al. 2015; IUCN 2016*a*; OECD 2016). Despite the potential, and some initial enthusiasm for the implementation of NPI offset programs (Rainey et al. 2015), only 38 companies have made commitments to NPI policies for environment since 2001, and out of these just 26 still had active commitments in 2016 (de Silva et al. 2019). Moreover, an analysis of the sustainability reports of the top 100 global companies revealed that although 49% of these big businesses mention biodiversity, they in general give it limited treatment, and no company has reported quantitative outcomes of their activities for biodiversity (Addison et al. 2019; Smith et al. 2019). A conclusion that biodiversity impacts are underreported, and in most cases confined to generic or vague statements, has also been made recently (e.g., de Silva et al. 2019; Skouloudis et al. 2019; Weissgerber et al. 2019). One reason for the lack of uptake by these companies may be that a clear operational recipe is missing and thus there is significant confusion as to how--if at all--NPI can be achieved (Walker et al. 2009; Rainey et al. 2015; Bull & Brownlie 2017). We devised 3 ways to do so.

Three Ways to Achieve NPI with Biodiversity Offsets

Net positive impact can be achieved through the application of an NPI multiplier on top of the requirements for NNL through long-term gains that grow from slowly developing permanent offsets and through permanent offsets combined with partially temporary losses. A reduction in long-term losses can arise in 2 ways, from cessation of indirect impacts and from the use of the gains from the third step of the mitigation hierarchy (onsite restoration) toward NPI rather than for reduced NNL requirements. Before examining these routes to NPI, we reiterate that if NNL cannot be achieved for the project, neither can NPI. In this conceptual treatment, we assumed that offsetting efforts required to achieve NNL have first been successfully predetermined and account for all relevant considerations, such as partial restoration and avoided loss gains, time delays, leakage, simplified biodiversity measurement, uncertainty, etc. (Moilanen & Kotiaho 2018). (The common wisdom is of course, that offsets--for whatever reason--usually fail to achieve NNL.) Notably, the level of flexibility in space, time, and biodiversity allowed in the determination of NNL (Bull et al. 2015; Moilanen & Kotiaho 2018) has no bearing on the achievement of NPI. The same mechanisms apply irrespective of the degree of flexibility allowed.

The first and simplest mechanism of achieving NPI is to apply an area multiplier additional to the NNL offsetting effort, which then produces the given degree of NPI (Moilanen et al. 2009; Bull & Brownlie 2017; Moilanen & Kotiaho 2018). When the offsetting effort to reach NNL has been correctly determined, then applying an additional multiplier of, for example, 1.3 would produce 30% NPI relative to the original residual loss caused by the project. Application of a large enough multiplier is the most common reason for success of an NNL policy (zu Ermgassen et al. 2019*a*). Fundamentally, if the requirements for NNL are known, doing more will provide more than NNL, which implies NPI.

The second mechanism to deliver NPI is the use of slowly maturing permanent offsets to deliver long-term NPI. The desirability of permanent offsets has of course been pointed out many times (e.g., McKenney & Kiesecker 2010; van Oosterzee et al. 2012; Moilanen & Kotiaho 2018), but less so in the context of NPI. Net positive impact from this mechanism builds on a typical (hypothetical), monotonically increasing response of habitat condition to restoration measures (Figs. 1a & 1b). (Avoided loss gains typically develop slowly over years, just like restoration gains, so the logic of the figure also applies to avoided loss offsets.) As background, unless all offsets are a priori purchased from a habitat bank, an offset evaluation time frame has to be set, over which NNL is achieved, that appropriately accounts for the slow development of restoration and avoided loss gains (Moilanen & Kotiaho 2018). Unless set explicitly, such a timeframe will be adopted implicitly (e.g., via how much gain is assumed from habitat restoration). Because the evaluation period needs to be reasonable and not so long that societal credibility is lost (e.g., 20–30 years) but restoration benefits mature more slowly, habitat condition will in some cases continue to slowly improve after the end of the evaluation period. For example, forests take many decades or even centuries to fully mature. This means that the offset will generate further gains thereby transitioning to long-term NPI conditional on losses remaining stable or decreasing over time (Fig. 1b). The degree of NPI achieved via this mechanism can be estimated by dividing long-term average gains by short-term average

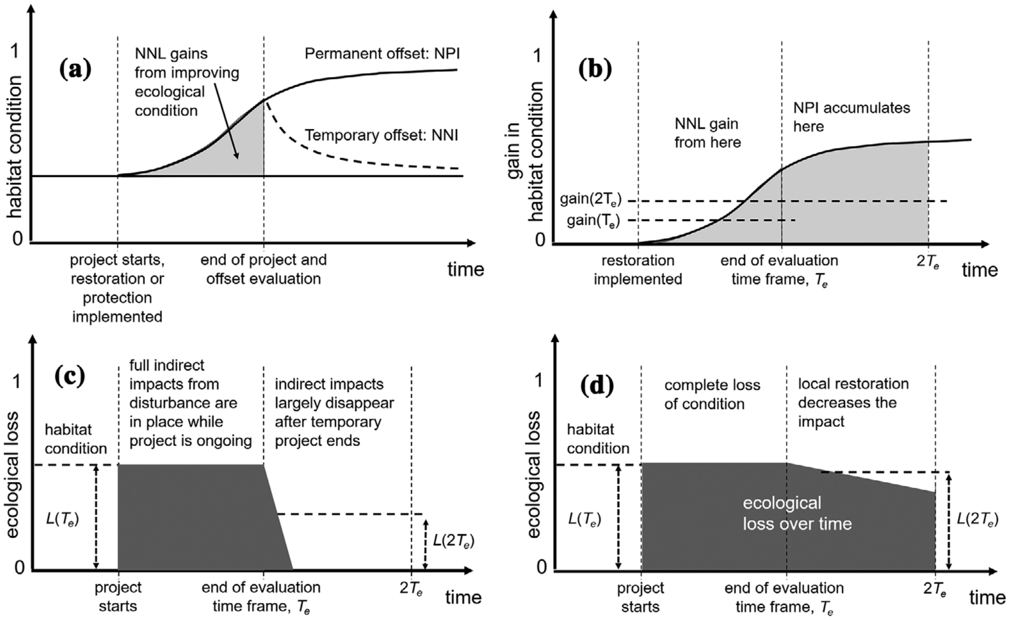

Figure 1. Illustration of restoration offset gains and the evaluation time frame: (a) habitat condition starts to recover and gains (gray area) accumulate after restoration has been implemented (permanence is critical for the long-term performance of the offset); (b) average offset gains (dashed lines) can be calculated over different evaluation periods (T_e)*, with gains transitioning from NNL to NPI over time; (c) permanent offsets can deliver NPI when coupled with partially temporary loses; and (d) local rehabilitation can also generate NPI via the reduction of average long-term losses, assuming that it is not allowed to reduce offset requirements.*

gains, marked in Fig. 1 with gain($2T_e$) and gain(T_e), respectively.

The third mechanism to deliver NPI is combining permanent offsets with (partially) temporary losses (Figs. 1c & 1d). For example, losses caused by indirect disturbance, such as noise, light, dust, human presence, etc., may decline quickly after the end of a temporary project, such as resource extraction (Fig. 1c), allowing for NPI to develop, again fully conditional on the permanence of the offsets and provided that all losses have first been offset to NNL inside the agreed-upon offset evaluation period. Of course, losses are effectively permanent for many types of projects, such as roads, dams, or expanded urban areas, largely precluding NPI via the second mechanism in these cases. The degree of NPI achieved via this mechanism can be estimated by dividing short-term average losses by long-term average losses, marked in Fig. 1 by $L(T_e)$ and $L(2T_e)$, respectively.

An important variant of the third mechanism to achieve NPI is reduction of long-term losses via a major transformation of the third step of the mitigation hierarchy. We propose that gains from local rehabilitation should not be deducted from the overall residual loss caused by the new development. In other words, they should not be counted toward reducing the residual impact counted from the direct footprint of the project. Local rehabilitation should nevertheless be implemented fully. As a consequence, all losses are first offset to NNL, and any later gains from local rehabilitation contribute toward NPI instead (Fig. 1d). Effectively, we recast local rehabilitation as a price to be paid toward NPI. What we propose is a reorganization of the mitigation hierarchy wherein its third stage becomes the last step and provides NPI rather than reducing requirements of NNL (Fig. 2). This change in how the mitigation hierarchy is perceived also reduces the significance of uncertainties inherent in local rehabilitation due to time delays or difficulties with the restoration of a significantly damaged habitat (Schoukens & Cliquet 2016). Additional action for NNL itself is shifted forward in time, allowing more immediate monitoring and verification of offset gains. Nevertheless, local rehabilitation is likely to recover only a fraction of losses, leading to a smallish degree of NPI only (Fig. 1d). As something to pay attention to, the requirements for the quality of local rehabilitation should not be significantly reduced if it is implemented for NPI instead of NNL.

The message for the second and third mechanisms is that permanent gains are critical for offsetting to achieve NPI. If offsets are permanent, it is likely that gains will continue to accrue through time, even if slowly, allowing the transition from NNL to NPI (Fig. 1a). However, combining permanent or semipermanent losses with temporary gains seems to ensure failure of the offsetting, leading to net negative impact (NNI) or net loss (Fig. 1a). For example, consider a 20-year temporary offset for a

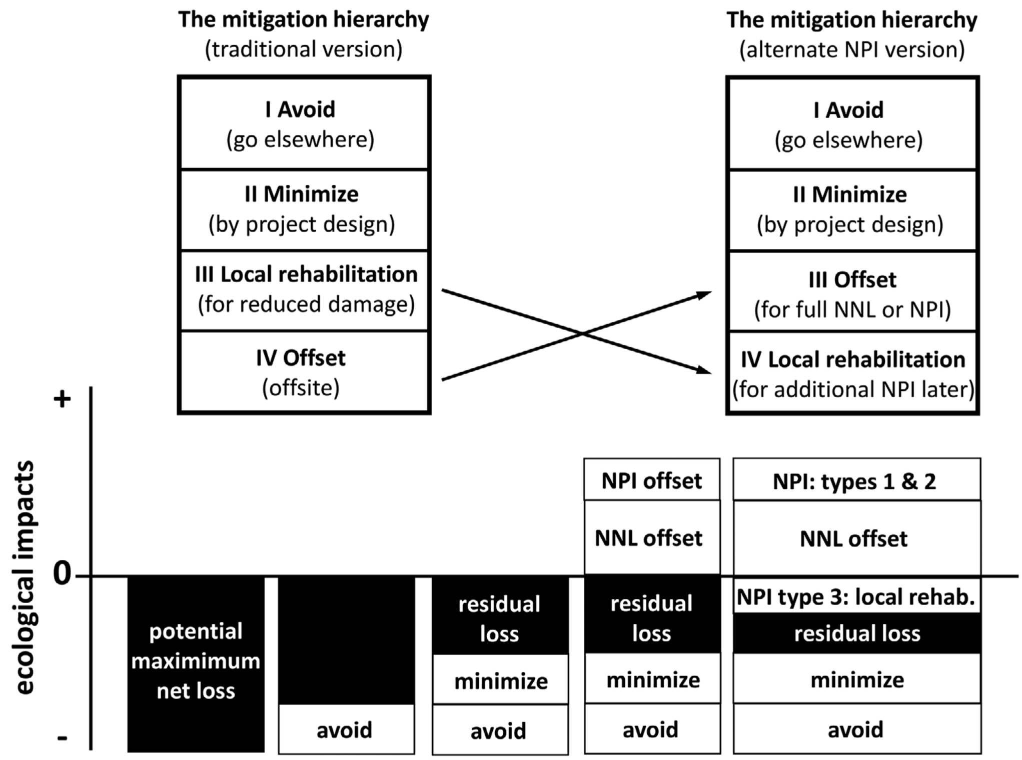

Figure 2. Revised mitigation hierarchy for impact avoidance, minimization, and offsetting in which gains from local rehabilitation are not deducted from the overall loss caused by the project and offsets provide no net loss (NNL) without reliance on local rehabilitation, which later contributes to net positive impact (NPI) (black background, loss of ecological function).

road or urban area that could exist effectively forever. An NNI from temporary offsets can even approach complete loss of ecological value if the offset is evaluated over a very long period, suggesting that all past, present, and future offset projects that use temporary offsets to offset partially or fully permanent losses are prime candidates for major failure of NNL. Interestingly, NNL itself occurs only at an ephemeral point in time: before this point offsets are net negative, at this point they have improved just enough in ecological quality to reach NNL, and after this point NPI follows with further maturation of gains, provided that the offset is permanent. Overall, the distinction between permanent and temporary is sufficient by itself to make the difference between potential long-term NPI and almost certain NNI, as illustrated in Fig. 1a. Of course, permanence alone cannot guarantee NPI. The area and quality of the offset needs to be otherwise adequate to achieve NNL inside the stated offset evaluation period. Relevant for selection of offset action, the requirement of permanence is a serious complication for offsets implemented via habitat management or maintenance because it is difficult to guarantee in perpetuity funding and permanence for on-the-ground operations that need repetition year after year and decade after decade (Norton & Warburton 2015).

Finally, Table 1 summarizes the degree and timing of NPI produced by the methods described above. Only gains from an NPI multiplier (M_{NPI}) are generated simultaneously with the NNL offsetting. The other 2 forms of NPI can only be generated after the offset evaluation period ends, which could coincide with the end of the project. A real-world offset case will probably involve many types of impacts and different offset actions implemented in different environments. If so, the evaluation of project-level NPI requires aggregation over all impacts and their offsets.

Requirement that NNL be Achieved First

The major prerequisite for achieving NPI is that NNL be correctly specified first, meaning that all of the challenges of achieving NNL need to be solved before moving to NPI. We emphasize that, in general, failure of offsetting has been more the rule than the exception, and way bigger offsets (larger multipliers) are needed to achieve NNL than there is political will for presently. Failure of offsets can be attributed to insufficient policy requirements (i.e., lack of adequate specification and enforcement) (e.g., Curran et al. 2013; Spash 2015; Guillet &

Table 1. Timing and degree of net positive impact (NPI) produced by the 3 sources of NPI.[*].

Three NPI components	*Timing and degree of NPI, relative to NNL at the end of the offset evaluation time frame* (T_e)	
	by T_e	*by* $2 \times T_e$
NPI multiplier	M_{NPI}	M_{NPI}
Increased long-term gains from slowly developing permanent offset actions (Fig. 1b)	0	R_P
Reduced long-term losses combined with permanent gains, including reduced indirect losses from disturbance and local rehabilitation from the alternate mitigation hierarchy (Figs. 1c, d and 2).	0	R_L
With all components used	M_{NPI}	$M_{NPI} \times R_P \times R_L$

[*]See Fig. 1 for graphical explanation of $R_P = gains(2T_e)/gains(T_e)$ *and* $R_L = L(T_e)/L(2T_e)$.

Semal 2018), poor design (e.g., Walker et al. 2009; Gibbons et al. 2018; Moilanen & Kotiaho 2018), incomplete implementation of the offsets (e.g., Gibbons et al. 2018; Weissgerber et al. 2019), or even fraud (Moilanen & Kotiaho 2018). Several reviews have been conducted on the ecological outcomes of offset projects (e.g., Birkeland & Knight-Lenihan 2016; Theis et al. 2020; zu Ermgassen et al. 2019*a*). In their review of compliance with offsetting policy, Theis et al. (2020) conclude that although many projects are officially labeled a success due to their high compliance with legislative requirements, there is only a weak positive relationship between compliance and success in achieving good ecosystem function. This suggests that the policy requirements do not support credible ecological requirements for NNL (Moilanen & Kotiaho 2018).

The operational decisions that define the ecological success of a biodiversity offsetting project have been discussed in the scientific and gray literature (e.g., OECD 2016; Gardener et al. 2013; Grimm & Köppel 2019). Moilanen and Kotiaho (2018) grouped important offset design factors around objectives, characteristics of offset actions, and 3 well-known fundamental axes of the ecological reality: space, time, and biodiversity. The factors related to objectives are the degree of adherence to the mitigation hierarchy; the definition of NNL, including effect of uncertainty; and the desired degree of compensation relative to NNL. For the spatial axis, decisions to be made include the extent of the offset implementation area (how far from damage can offsets be implemented) and the spatial reference frame of biodiversity valuation (e.g., local, national, and continental), which influences, for example, what could be considered trading up. For the temporal axis, the decisions are whether the offset is temporary or permanent and what the offset evaluation period and strength of time discounting of delayed gains will be. For biodiversity, decisions include how biodiversity will be measured and whether or how trading up is allowed. For actions, additionality of actions, habitat restoration response functions, response of avoided loss action, baseline of avoided loss comparison, and leakage associated with avoided loss all need to be addressed. Gains and losses should be balanced accounting for at least these 15 design factors and quantities. Ignoring any of them during planning may lead to some unintended outcome or failure in offsetting. For instance, ignoring or underestimating time delays in restoration gains, leakage, or uncertainties can straightforwardly lead to offsets specifications that are in reality inadequate for achieving NNL.

One reason offsets fail ecologically seems to be that offsets do not apply to all types of losses. Another is an imbalance between the evaluation of biodiversity losses and biodiversity gains such that the location, nature, and extent of impacts are well documented, whereas expected gains are predicted in a comparatively vague and uncertain manner (Weissgerber et al. 2019; zu Ermgassen et al. 2019*a*). This imbalance is in part unavoidable because losses concern observable biodiversity and can be measured on the ground, whereas the gains will only occur in the future and thus can ever only be estimated or projected with uncertainty. Nevertheless, we believe that the science of restoration ecology is mature enough to provide the means to project the gains with reasonable and sufficient accuracy, at least in many ecosystems (IPBES 2018). Thus, the imbalance in operationalization is a failure that can be addressed by increased emphasis on capacity building to allow competent estimation of gains in planning. If policy developers, consultants, planners, etc., were knowledgeable about the operational requirements of successful offsets, the harsh critique of biodiversity offsetting per se might be answered. Investing in proper knowledge transfer would likely build capacity and result in more successful offsets.

The Alternate Mitigation Hierarchy

As a core component of this work, we propose an alternative to the traditional mitigation hierarchy (e.g., IUCN 2016*b*; Arlidge et. al. 2018) that is used to position offsetting in the broad scheme of environmental impact avoidance at the beginning of pretty much every publication about offsets (Fig. 2). First, although we do not at all disagree with the 2 first steps of the mitigation hierarchy, we are skeptical about their functionality. Step one, avoidance, can certainly be implemented by moving a project such as a road into an ecologically less harmful location, and land-use planning tools for doing this are readily available (e.g., Kareksela et al. 2013). Nevertheless, we believe that economic activity is generally encouraged and that cancellation of projects is uncommon. It has indeed been found that there is often a failure to avoid impacts (Phalan et al. 2017) and that environmental impact assessments rarely find significant impacts, which then allows projects to go ahead despite some environmental impacts (Murray et al. 2018). Step 2 is minimization of impacts, for example, via planning or technical solutions. Project impacts seem to be reduced to the level of compliance with environmental regulation (Theis et al. 2020), but it is questionable whether businesses are willing to invest substantial extra money into reducing impacts even further. Putting these initial misgivings aside, our main argument here is about the third level of the mitigation hierarchy, local rehabilitation. We propose that it should become the last step in the hierarchy and that its role be recast into a time-delayed source of (ideally mandatory) NPI rather than allowing it to be counted toward the reduction of the original residual impacts of the project that need to be offset (Fig. 2).

There is a logical inevitability that the transformation of the mitigation hierarchy would improve offset performance, subject to appropriate regulation and checks to ensure proper implementation. First, because local rehabilitation would no longer count toward the reduction of projected losses, more offset action would be required to produce the gains needed for NNL. Second, more conservation action would be brought forward in time. Increased offsets can be implemented immediately or even purchased from a habitat bank, which could be decades earlier than rehabilitation during or after the end of the project. Third, uncertainty would be reduced because there would be less concern about the feasibility, reliable implementation, overall success, and verification and durability of restoration effort in a significantly damaged impact area far in the future during or after the end of the project. Moreover, there is the risk of any project extending from what was expected originally, thereby delaying further the delivery of gains from local rehabilitation. Hence, there are multiple reasons for giving up the practice of allowing local rehabilitation to reduce the size of the offset needed. In other words, we propose adoption of the alternative mitigation hierarchy in Fig. 2 that moves toward NPI. We also propose that NPI be compulsory, as the price paid for the privilege of the offsets being allowed in the first place, implying full commitment to local rehabilitation on top of initial NNL and NPI offsets that should be permanent.

From NNL to NPI

Although NNL has been discussed extensively, there is not that much literature focusing on the transition from NNL to NPI. In one of the earliest treatments, Bull and Brownlie (2017) argue that achieving NPI is fundamentally different from achieving NNL and that moving from one to the other presents significant challenges that will be less trivial than often thought. They support this position with 4 lines of arguments, which we do not find influence our reasoning: first, NNL and NPI have distinct underlying conservation philosophies; second, there is uncertainty in achieving NNL; third, appropriate frames of reference may depend on the case; and fourth, stakeholder expectations of NNL and NPI may differ. We considered each of these arguments.

The first argument revolves exclusively around the in-kind and out-of-kind offsets and the degree of flexibility allowed (Bull & Brownlie 2017). Overall, the distinction between in-kind and out-of-kind biodiversity is an illusion created by the accuracy, or lack thereof, with which biodiversity is measured. Taken to the extremes, every individual and ecological community is unique and thus irreplaceable in the fully in-kind sense (Moilanen & Kotiaho 2018). Our argument is that doing more than required for NNL will provide NPI irrespective of the degree of flexibility allowed in the NNL offset or in the additional actions done for NPI. It would be perfectly reasonable to allow elevated flexibility for additional actions that are made with the intention of delivering NPI.

The second argument rests on the claim that meeting the NNL objectives already requires overcompensating for losses, which makes it difficult to specify how large the gains should be to meet the NPI objectives (Bull & Brownlie 2017). According to the present reasoning, if the level of compensation needed for NNL is known, the transition to NPI is straightforward (e.g., by applying the NPI multiplier). We reiterate that the major prerequisite for achieving NPI is that the gains required to achieve NNL are first correctly specified, which naturally accounts for relevant uncertainties. If this is not the case, the problem is not with the transition from NNL to NPI but rather with the specification of NNL itself.

The third argument is based on the fact that the choice of reference frame (ecological baseline; counterfactual) can significantly influence the gains expected (Bull & Brownlie 2017). Consequently, case-specific estimates of gain and the level of compensation needed for NNL will be affected. Although this is a fact, in an offsetting project, the gains needed for NNL and NPI both depend on the same residual loss caused by the development. The choice of reference frame in no way affects the feasibility of any of the 3 NPI mechanisms we described.

The fourth argument is about public or stakeholder perception of the credibility of NPI objectives (Bull &

Brownlie 2017). We do not see public perception as a fundamental ecological or logical principle that defines what can be achieved with offsetting. Certainly, stakeholder support and broad acceptance can generate ownership that facilitates good design, implementation, and monitoring of offsets, but it does not influence, for example, the ability of habitat restoration to deliver ecological gains needed for NNL or NPI.

Based on the reviews cited above, it is nevertheless clear that true problems exist with inadequate policy requirements, design, and implementation of offsets. Therefore, a major challenge for biodiversity offsetting, be the objective NNL or NPI, seems to be knowledge transfer and capacity building so that understanding in the scientific community is communicated to society and operationalized in the implementation of the offsets. Also, businesses would be required to accept the comparatively large offset area requirements and costs that arise when accounting for partial additionality, partial and delayed gains for restoration and protection, time discounting, leakage, uncertainty, additional NPI requirements, and possible extra multipliers that compensate for flexibility in space or biodiversity (Moilanen & Kotiaho 2018). The requirement for truly permanent offsets, as presented here, would also cause problems in contexts where legislative or administrative practices do not support permanent land allocation to conservation or the application of other effectively permanent mechanisms. That said, legislation is a human construct and can be changed to allow permanent offsets if there is the public desire to do so.

Overall, the present argument emphasizes how NNL and NPI are unavoidably dependent on the period over which the balance of losses and gains is evaluated (Fig. 1), meaning that questions of time (i.e., offset evaluation period), development of gains, permanence, and time discounting become of primary importance for offset success (for further discussion of these in the context of achieving NNL, see Moilanen and Kotiaho [2018]). For simplicity, we presented material without the complication of time discounting, which can, however, be implemented in calculations that apply standard time-discounting techniques (Laitila et al. 2014; Moilanen & Kotiaho 2018). Our argument and Fig. 1 are presented in terms of aggregate gains in relation to aggregate losses. In on-the-ground planning, calculation of aggregate loss needs an intermediate step to account for the size and quality of area affected and fractional ecological losses therein. Likewise, estimation of gains needs to account for the size of offset area and fractional gains therein, plus all the other factors summarized by Moilanen and Kotiaho (2018). As a final caution, there are some environments, such as slowly maturing late successional ecosystems, for which credible offsetting may be impossible if anything close to in-kind is required (Pilgrim et al. 2013). This means that the ability of offsetting to deliver NNL and NPI in a credible manner has to be examined case by case.

Once the requirements for NNL have been specified and once it has been verified that adequate implementation options exist (which will not always be the case), the transition to NPI becomes simple enough. Offsetting is only one part of the solution to global environmental problems. Nevertheless, within its scope, it should be made as good a tool as possible.

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