Taming a Wicked Problem: Resolving Controversies in Biodiversity Offsetting

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Abstract

The rising popularity of biodiversity offsetting as a tool for balancing biodiversity losses from development with equivalent gains elsewhere has sparked debate on many fronts. The fundamental questions are the following: is offsetting good, bad, or at least better than the status quo for biodiversity conservation outcomes, and what do we need to know to decide? We present a concise synthesis of the most contentious issues related to biodiversity offsetting, categorized as ethical, social, technical, or governance challenges. In each case, we discuss avenues for reducing disagreement over these issues and identify those that are likely to remain unresolved. We argue that there are many risks associated with the unscrutinized expansion of offset policy. Nevertheless, governments are increasingly adopting offset policies, so working rapidly to clarify and— where possible—to resolve these issues is essential.

Key words

Biodiversity offsets; conservation policy; environmental ethics; environmental governance; no net loss.

Introduction

Biodiversity offsetting is a contentious conservation tool that aims to counterbalance losses of biodiversity in one place by generating equivalent biodiversity benefits elsewhere (Box 1; IUCN 2014). Following their genesis in wetland mitigation banking in the United States, the global reach of formal offset policies is growing (Figure 1). Industry is also increasingly seeking to generate social license to operate by using offsetting to help achieve no net loss of biodiversity, or even a net gain or net positive impact (ICMM and IUCN 2013, Aiama et al. 2015). Although this may sound like a win for conservation, views on biodiversity offsetting as a conservation approach range widely, from outright rejection (Walker et al. 2009, Spash and Aslaksen 2015) to qualified acceptance (Gardner et al. 2013), with scepticism and resistance also prominent in civil society discourse (FOEE 2014).

Concerns about the use of biodiversity offsetting range from fundamental ethical objections (Spash and Aslaksen 2015) to considerations of social equity (Mandle et al. 2015), issues of governance (Salzman and Ruhl 2000), and the many technical challenges associated with quantifying biodiversity losses and gains (Gonçalves et al. 2015). However, there is often little clarity over how concerns raised in both academic literature and public discourse fit within this spectrum of issues. Categorizing explicitly the full range of concerns around biodiversity offsetting allows identification of where targeted science can help resolve challenges, where political and other impediments require governance-related solutions, and where challenges are likely to persist because of fundamentally differing value systems.

In this synthesis, we classify and summarize the wide spectrum of commonly held concerns relating to biodiversity offsetting. First, we categorize these concerns by type and tractability (Tables 1 and 2). For each, we summarize avenues for reducing conflict over these issues but also identify issues that are likely to remain fundamentally unresolvable. Not all issues are yet prominent in current debates nor equally of concern across all offset contexts, but we suggest that most are of broad relevance. Tackling these challenges is crucial to judgements about whether biodiversity offsetting should be pursued and encouraged as a policy instrument and, if so, how to minimize the risks associated with biodiversity offsetting. The extent to which these issues can be resolved collectively determines the extent to which any given impact on biodiversity can be considered technically, socially, and ethically "offsettable" (Box 1).

Contested issues in biodiversity offsetting

We consider, in turn, the most controversial aspects of biodiversity offsetting under four broad categories:

1. Ethical challenges: are there fundamental ethical problems associated with trading losses and gains of biodiversity?
2. Social challenges: how do we capture the values held by society, and ensure these are reflected in the accounting of losses and gains in an offset trade?
3. Technical challenges: how effectively and confidently are we able to implement effective offset exchanges?
4. Governance challenges: what transparent, long-term governance arrangements can monitor policy compliance and effectiveness and minimize incentives to circumvent intended outcomes?

In the next section, we synthesize the main debates under each of these categories, and for each, we comment on the tractability of the problems (Tables 1 and 2).

Ethical challenges

The practice of offsetting raises questions about our rights and responsibilities toward the natural world. Does trading nature sit comfortably with belief in an obligation to protect biodiversity? Ethical questions are fundamental to many offsetting debates but have not been clearly articulated until recently.

What values are important? Commentary about biodiversity offsetting can be classified as either biocentric (focusing on intrinsic values of nature) or anthropocentric (focusing on instrumental values of nature to humans; Justus et al. 2009, Sullivan and Hannis 2015). Most ethical objections to offsetting argue from a biocentric perspective that attempting to reduce nature to exchangeable units is a fundamental violation of its intrinsic value (Daw et al. 2015, Spash and Aslaksen 2015). Intrinsic value in the strict sense renders comparative valuation impossible (Justus et al. 2009); thus, offset exchanges seem to imply an acceptance of an anthropocentric philosophy and a focus on use or existence values. Although discussion of the instrumental values of nature for humans is prominent in the literature (Kareiva and Marvier 2012), evaluation of the impacts of offsetting on these values is limited. To facilitate open productive debate about the ethical dimensions of offsetting, it is necessary to make explicit whether concerns about compensating biodiversity loss relate to intrinsic values of nature or values related to human benefits and preferences. Some environmental philosophers argue that the natural world has intrinsic value at all scales from genes through to ecosystems (Rolston 1994). In this case, it appears that there can be no such thing as a "neutral" outcome from biodiversity offsetting, because any damage to individuals, species, or ecosystems affects uniquely valuable entities and carries moral weight.

Ethical basis for conservation Biodiversity offsetting can be seen as an example of the expansion of markets and market values into new areas of society, which can shift the ethical basis on which decisions are made (Sandel 2012). Ives and Bekessy (2015) argued that the shift from a traditional regulatory approach to effectively allowing biodiversity losses so long as offsets are required represents a substantial shift in the ethical basis for conservation. It has also been argued that offsetting may exacerbate environmental harm if it removes an important ethical valve regulating its destruction (Moreno-Mateos et al. 2015), potentially setting in train a slippery slope of increasing acceptability of harm (Ives and Bekessy 2015). Related is the question of whether offsetting works against engendering positive societal attitudes toward nature, by way of making harm to biodiversity more acceptable. These environmental and societal impacts can be addressed through targeted empirical research, although an informative study design is likely to be challenging. Nonetheless, comparisons could reveal (a) whether attitudes toward biodiversity impacts differ between regions in which offsetting is commonly implemented and otherwise -similar regions where it is not and (b) whether impacts permitted after the introduction of an offsetting approach tend to be of a type and scale that, without an offset, would not previously have been permitted.

Social challenges

If the principle of offsetting biodiversity is accepted as ethically valid, then the next set of challenges lies in capturing preferences: what is it that offsets ought to achieve, what sort of substitutions (taxonomic, spatial) are acceptable, and at what exchange rates?

No net loss compared with *what?* The concept of *no net loss* lies at the heart of offsetting, but the frame of reference against which this is to be achieved is rarely explicitly communicated in policy statements (Bull et al. 2014b, Gordon et al. 2015, Maron et al. 2015a). In reality, regulators rarely interpret *no net loss* to mean no biodiversity loss relative to before the impact; rather, it generally means maintaining some presumed trajectory of “background” decline (Maron et al. 2015a). Any offset exchange in which some offset benefit is considered to be generated by averted loss—that is, the protection or maintenance of existing biodiversity—implicitly presumes a frame of reference of biodiversity decline, because without this, there would be no losses to avoid. The unqualified use of the term *no net loss* can therefore be misleading to stakeholders and the public (Salzman and Ruhl 2010, Gordon et al. 2015, Maron et al. 2015b).

As long as this lack of clarity remains, the actual net consequence of offset trades are unlikely to match society’s expectations for no net loss of biodiversity. However, concealing the policy intent in this way might be perceived to benefit policy makers keen to use offset policy to release political pressure on governments from interest groups (Salzman and Ruhl 2010, Gordon et al. 2015). Requiring policies to state explicitly the frame of reference for no net loss—and indeed replacing the slogan with a more transparent descriptor—may improve accuracy of public perceptions, but it may prove politically unpalatable and therefore challenging to achieve.

No net loss of what biota? Offsets require units or currencies of trade, derived from scientifically defensible proxies for the biota of interest. Ultimately, the appropriateness of a trade depends not only on ecological equivalence but also on what aspects of the affected biota are valued and in what ways by stakeholders (McKenney and Kiesecker 2010, Moreno-Mateos et al. 2015).

This challenge extends to establishing society’s willingness to accept exchanges among types of biodiversity, as well as through space and time (Bull et al. 2015). Exchanging a loss of a less-threatened species or habitat for a benefit to a more-threatened or higher-priority one has been proposed, an approach often referred to as “trading up” (Habib et al. 2013). In existing policies, however, “trading out of kind” (not necessarily trading up) is often permitted when like-for-like options (see Box 1) are exhausted (NSW OEH 2014). Addressing the question of whether and what exchanges among biota are appropriate and how they affect any social mandate to implement no net loss ultimately requires exchange rates that reflect societal values (at least at a particular place and time).

No net loss for whom? People assign a range of values to biodiversity. However, values that matter most to people often include cultural and spiritual values (Schultz et al. 2005). These are difficult to quantify (Schultz et al. 2005), change over time, and are rarely, if ever, accounted for in biodiversity offsetting assessments. Further, many values are inherently place based, so social equity issues can arise from offset sites being located far from where biodiversity is affected. For example, affected communities may lose recreation and environmental education opportunities and suffer from declines in the natural amenity and environmental health of the area (BenDor et al. 2007, Mandle et al. 2015). Such spatial exchange is intrinsic to biodiversity offsetting, so trade-offs with social equity are to some extent unavoidable.

Adequately capturing societal values related to biodiversity and ecosystem services is difficult (Daniel et al. 2012), and no currently used offsetting currency or biodiversity metric (Box 1) comes close to doing this. Reducing and reconciling this suite of values into one or more metrics that can permit the comparison of gains and losses—without undesirable substitutions among the elements of the metric—is fiendishly complex (Ives and Kendal 2014). Although valuation approaches can help progress this aspect of offsetting certain values, some, such as place-based and cultural values, are impossible to offset (as opposed to compensate for, which is a broader concept); therefore, in our view, developing metrics that capture all these factors is a fundamentally intractable problem.

Technical challenges

Technical challenges have received the most attention in the scientific literature, but most are far from being resolved.

Applying the Mitigation Hierarchy The importance of the mitigation hierarchy (whereby offsets are considered appropriate only after efforts to avoid and minimize impacts are first made) is recognized in almost all offset guidelines and policies. However, clear rules on when to move from one level to another along the mitigation hierarchy do not exist (IUCN 2014). Instead, developers and regulators decide on a case-by-case basis with little guidance or reference to past cases on whether an impact can or cannot be avoided and how much impact minimization is adequate before the residual impact can be considered unavoidable and therefore a candidate for offsetting (e.g., Kramer 2009). This creates a governance challenge as well as a technical one.

Clear and specific guidance on what steps can and should be taken to first avoid and mitigate impacts, as well as requiring these steps to be documented when submitting development applications for approval by regulators, would assist in ensuring offsetting is appropriately employed. Such clarifications to the mitigation hierarchy would need to balance recognition of the considerable variation in circumstances among particular cases of potential impact, with the need for reasonable and consistent expectations for avoidance and mitigation. Although offsets are considered the last step in the mitigation hierarchy, limits to what can be feasibly offset can also help define avoidance or "no-go" zones. However, such technical limits alone would be inadequate; avoidance should also be based on social acceptability of damage to a site, regardless of the potential for that damage to be offset.

Surrogates of biodiversity Strictly speaking, impacts on "biodiversity" can never be offset, because no two places will ever have identical biodiversity. Only losses and gains of more broadly defined surrogates of biodiversity can be validly exchanged. The fact that the persistence and value of any one component of biodiversity depends on relationships with other components of biodiversity, are dynamic, and respond to other environmental stressors further complicates the issue (Drechsler and Hartig 2011). Therefore, any surrogate employed as a currency is necessarily a crude simplification of the natural world, focusing on a few attributes that can be measured or estimated (such as the extent, condition, and type of vegetation or habitat type at a site).

Simple metrics, usually a combination of the extent and quality of a habitat type, are often used as currencies in offsetting schemes for their ease of use and their facilitation of market liquidity (IUCN 2014, Salzman and Ruhl 2002). However, metrics that integrate multiple ecological components into a single index easily become black boxes—and outcomes for biodiversity are highly sensitive to the approaches used (Bull et al. 2014a). The inclusion and weighting of components is often arbitrary, and such composite metrics can conceal substitutions among these components, resulting in undesirable losses (Walker et al. 2009, Kujala et al. 2015).

Striking a balance between an easily calculated metric that does not reduce incentive to comply with or limit the functionality of the offset market, but that is comprehensive enough to ensure valued components of biodiversity are not lost in offset exchanges, remains a key challenge. This requires an adaptive policy approach and careful examination of the outcomes of multiple schemes and policies, but the ability to evaluate and compare outcomes relies on adequate and available data (see the *Measuring the outcomes of offsetting* section below).

Offset and counterfactual scenarios. Estimations of gain attributable to an offset action (and therefore the amount of biodiversity loss for which it can be exchanged) depend equally on assumptions about two scenarios: what would occur if the offset was done (the offset scenario) and what would occur if it was not done (the counterfactual scenario; Box 1). It is the difference between these two scenarios that represent the benefit from the offset action. However, there is almost always considerable uncertainty about both scenarios (Bekessy et al. 2010). The effectiveness of protection and, especially, restoration is frequently questioned (Maron et al. 2012, Curran et al. 2014). Robust evidence is limited, but commonly-applied restoration actions often produce novel ecosystems that differ from those they are intended to replace, and the adequacy of restoration to replace existing natural systems and biota is still debated (Maron et al. 2012).

The counterfactual scenario has an influence equal to that of the offset scenario in calculating the benefit of an offset but has received much less attention, and in many policies, it is not even explicitly considered (Maron et al. 2015a). The lack of focus on counterfactuals means that the substantial uncertainty of gains achieved by habitat protection goes unrecognized (see the *Capturing uncertainty and time lags* section, below). Although it is theoretically possible to estimate plausible counterfactual scenarios by projecting past rates of biodiversity loss into the future, in practice they are particularly challenging to derive, because by definition, they reflect a future that will never be observed. Such calculations are subject to considerable uncertainty in predictions of future development trends and anticipated impacts of climate change on biodiversity, and there may also be strong incentives to manipulate them (Salzman and Ruhl 2010, Gordon et al. 2015). Designing policy to force explicit and transparent assessments of the plausibility and consistency of assumptions made about both scenarios is key to addressing this challenge. Assumptions about counterfactual scenarios should be periodically revised to ensure they remain consistent with realized biodiversity trajectories to avoid inadvertently “locking in” or exacerbating biodiversity loss by overstating counterfactuals of decline (Gordon et al. 2015, Maron et al. 2015a).

Capturing uncertainty and time lags. Offsets typically involve trading relatively certain and immediate losses for less certain and potentially delayed gains (see also the *Offset and counterfactual scenarios* section above; Bekessy et al. 2010). A common practice is to use multipliers to make offsets more robust to potential overestimation of gains (BBOP 2012), but these are typically used in an *ad hoc* manner without clear justification (Laitila et al. 2014).

Recent studies have explored ways to include uncertainty and time lags in offset calculators in a consistent fashion through the use of, for example, time-discounting and bet-hedging strategies (Moilanen et al. 2009). Some evidence suggests that offset ratios robust to uncertainty and time delays are likely to be politically unrealistic (Moilanen et al. 2009, Gibbons et al. 2015), although this assumption relies on the political and legal context in which offsetting policy is developed and is yet to be systematically tested. Biobanking systems that provide already-established and measurable offsets—that is, acting as a savings bank—form an attractive alternative solution (Bekessy et al. 2010), with US wetland mitigation banking providing established examples. However, for certain biodiversity values, such as old-growth forests, and for averted-loss credits, the very long accrual time of such credits can be an economic limitation for offset providers (Gibbons et al. 2015). Carefully structured, stable policy that incentivizes the development of banks can help overcome this limitation.

Accounting approach. Along with appropriate trading rules, accounting approaches must be designed to reflect the desired net outcomes of a given trade. Estimating equivalence in an offset trade requires drawing together information about the aforementioned technical elements—but this must be done in a mathematically appropriate way. For example, inappropriate “discounts” on calculated offset requirements undermine rigor and can result in even the best-run offset scheme failing to achieve no net loss. Crucially, impacts and offset proposals are still routinely assessed on a project-by-project or site-by-site basis, meaning that systemic failures of offset accounting and shortfalls in offset gains will be compounded across multiple trades and through time.

Estimates of both losses and gains in units of appropriate currencies should be adjusted for scenario uncertainty and time preference (Overton et al. 2013, Gibbons et al. 2015). We know of no government schemes that do all of this, although some approximate the process (e.g., Miller et al. 2015). More often, the approach used to calculate the equivalence (in kind and amount) of biodiversity losses and gains is complex and obscure or based on simple multipliers, with no suggestion of an explicit attempt to capture uncertainty, time lags, and additionality (Box 1; Bull et al. 2013), although guidance on these aspects is increasibly becoming available (Overton et al. 2013, Gibbons et al. 2015).

The key challenge of appropriate accounting systems lies in the translation to policy and implementation. Competing interests may oppose the transparency such an approach requires, and its appropriate use relies on integrity of operators (see the *Agency problems* section below). Strategic impact assessments are a tool used to consider cumulative impacts and, increasingly, cumulative net outcomes for biodiversity where offsets are involved (Kujala et al. 2015).

Governance challenges

The governance arrangements around biodiversity offsetting incorporate the rules, policies and institutions that guide the implementation of offsetting. Multiple actors, with differing objectives and interests, may be involved, including government, nongovernment organizations, the business community, and society at large.

Agency problems Like all environmental markets, biodiversity offsetting is exposed to agency problems because of asymmetric access to information between developers and regulators, uneven sharing of risks between these parties, and institutional incentives against the delivery of environmental outcomes (Eisenhardt 1989, Salzman and Ruhl 2000). For example, a developer may have an incentive to underdeliver offset obligations in order to reduce their costs when the regulator has limited capacity to monitor their activities for compliance. Similarly, there is an incentive to overestimate the conservation benefits from a potential offset site by assuming an implausibly negative biodiversity trajectory in the absence of the offset (Maron et al. 2015a; Gordon et al. 2015). These agency problems can be compounded as the number of actors increases, such as through the involvement of third-party offset providers. Without adequate oversight, there is a risk that the integrity of the offset transaction is diminished as the original biodiversity impact becomes more removed from the delivery of the offset.

There may also be an overt interest in maintaining a large and highly functional offset market, which would be constrained by high transaction costs if all offset trades were individually scrutinized (Salzman and Ruhl 2000). Direct or indirect political influence, pressure to make rapid decisions with limited information, and the use of bureaucratic discretion can all influence individual decisions made by policy administrators, which can cause policy to fail to meet its stated goals (Clare and Krogman 2013).

To mitigate against agency risks, independent oversight, legal accountability, and public scrutiny are paramount. Reducing transaction costs wherever possible (Coggan et al. 2013), using outcomes-based contracts to incentivize successful offset delivery, and ensuring offset risks are fairly shared between parties (e.g., through an insurance mechanism) can all improve the chance of sound offset outcomes. Fundamentally though, agency problems cannot be entirely eliminated (Eisenhardt 1989); therefore, transparent reporting of offset outcomes via a publicly accessible offset register is crucial (see the *Monitoring, evaluation*, *and reporting* section below).

Trust fund models Increasingly, in-lieu fees paid by developers are being used in place of direct provision of offsets. A trust fund into which multiple developers pay may lower transaction costs and allow offsets to be more strategically located. However, offset funds managed by government authorities risk being absorbed into consolidated revenue, or used to fund existing conservation initiatives leading to cost shifting (Pilgrim and Bennun 2014, Githiru et al. 2015, Gordon et al. 2015, Maron et al. 2015b). Risks to sound governance of trust funds could be managed with an independent and effective fund administrator, impervious to political interference, and with requirements for the mandatory tracking of funds through to the benefits they deliver (reported against the impacts they are intended to offset).

Monitoring, evaluation, *and auditing* Without evaluation, it cannot be known whether offsetting is leading to no net loss of target biota, nor can the need for ongoing improvements be identified. Although some assessments of offset programs exist, the lack of empirical evaluation of projects and policies is a key challenge to the success of biodiversity offsetting (Bull et al. 2013). There are technical challenges in measuring the outcomes of any impact or conservation intervention, because in addition to long time delays, there are issues of natural variation, challenges of achieving good replication, appropriate controls, and adequate statistical power (Ferraro 2009). The full costs of an offset exchange or scheme include monitoring and auditing for the life of the offset(s)—not just for the offset establishment phase. Therefore, structuring a scheme so that funds are available for these activities is essential, but this rarely occurs and it remains a significant governance challenge. Lack of resources or institutional capacity to monitor and evaluate policies is an ongoing challenge for regulating agencies (Brown et al. 2013). There may also be a disincentive for both industry and regulators to evaluate and report on findings, because public scrutiny can be financially or politically costly (Keene and Pullin 2011).

Clear audit guidelines, outcomes-based contracts, and other performance incentives (such as withholding payment until it is known that offset works have been completed or outcomes achieved) can reduce transaction risk (Eisenhardt 1989). Peer monitoring and wider public participation in the process are all approaches for maintaining adequate scrutiny. Guidance is lacking on the design of a monitoring program that would be able to demonstrate whether or not an individual offset, or offset program as a whole, has been successful in offsetting impacts.

Conclusions

Our review demonstrates that there is a considerable breadth of challenges that need to be addressed in order to respond to societal concerns around the uptake of biodiversity offsetting. We outline the key issues to be resolved and the barriers to that resolution (Tables 1 and 2). Both supporters and opponents of offsets broadly agree on the suite of technical and governance challenges that must be met for offsets to fulfil their promise, but disagreement persists on whether these challenges make biodiversity offsetting unacceptable. Barely any empirical evaluations of offset schemes exist, and none addresses all of the elements we summarize here. Now that many mandatory and voluntary schemes have been in place for over a decade some evaluation should be possible, but adequate information is often lacking because of monitoring and reporting failures.

The large catalogue of issues we have identified highlights the importance of employing a precautionary approach to permitting environmental impacts and moving to the use of offsets only after avoidance and minimization options have been truly exhausted (BBOP 2012). Ultimately, the exploration of these issues will help clarify the limits to the appropriateness and feasibility of offsetting from not only a technical perspective (Maron et al. 2012, Pilgrim et al. 2013) but also in terms of social acceptability (Daw et al. 2015) and its legitimacy as a form of conservation finance (Pilgrim and Bennun 2014, Githiru et al. 2015, Maron et al. 2015b). Although these limits are being explored, offsetting should be implemented with caution; biodiversity exchanges likely to fall short of the standard of an offset should be recognized as such (and perhaps be termed *compensation* rather than *offsets*), and *no-go zones*, in which damage is considered unacceptable regardless of the potential for offsets, should be delineated and respected.

Nevertheless, biodiversity offsetting is an increasingly widespread policy adopted by governments and companies worldwide. Immediate practical steps to improve policy and practice where possible are needed urgently. Notwithstanding some of the fundamentally intractable ethical problems and more difficult social problems we have identified (Table 1), the growing literature on biodiversity offsetting identifies a number of actions that can be readily implemented to address key technical and governance problems and minimize some of the risks of offsetting perversely becoming a further threat to the persistence of biodiversity (e.g., BBOP 2010, Bekessy et al. 2010, IUCN 2014, Gordon et al. 2015). We summarize several of these key actions in Box 2. Therefore, although satisfactory resolution of many of the challenges we describe herein will take time, we echo calls for these steps to be taken now by those responsible for offset policies within both government and the private sector.

As the very large range of contested elements of the approach attests, biodiversity offsetting is not a panacea, and there are severe risks associated with its unguided expansion, as well as some intractable issues that will not be solved even with the best policy design. Regardless of the criticisms, it seems unlikely that the uptake of offsetting will dissipate as more and more governments move to develop policy frameworks enshrining the approach. Therefore, resolving the issues we identified in this article is essential to minimizing the risks to biodiversity from offsetting policy.

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Box 1. Key concepts and terms associated with biodiversity offsets

Like for like: Gains and losses are of the same type of biodiversity and are measured using the same metric

Biodiversity metric: A surrogate measure of biodiversity used to measure the quantity of losses, gains, and their equivalence.

Offsetability: The likelihood that an offset for a given impact is likely to replace fully the affected biota; contingent on all risks discussed herein being managed adequately.

No net loss: An outcome in which the total amount of some target biota does not decline below the level expected under some counterfactual scenario.

Counterfactual scenario: The scenario (e.g., a biodiversity trajectory) expected to occur in the absence of some defined action or set of actions (such as an impact and an offset).

Mitigation hierarchy: The process by which environmental impacts from development are avoided, unavoidable impacts are then minimized, and residual impacts are then offset.

Additionality: The requirement that an offset benefit consists only of gains that would not otherwise have occurred and that are fully additional to the expected scenario without the offset.

Box 2. Priority actions for improving transparency and effectiveness of biodiversity offset policy.

1) Develop and embed in policy clear and specific guidelines for how to implement the avoidance and minimisation steps in the mitigation hierarchy, along with examples and a requirement to document the steps taken.

2) Provide an explicit statement of the frame of reference against which offset goals such as 'no net loss' are to be achieved, in order to increase transparency, clarity for developers, and public acceptance, and ensuring counterfactual scenarios are both consistent with this frame of reference and periodically revised.

3) Encourage more strategic approaches to offsets in situations where multiple offset trades are likely, and create policy structures and incentives to generate a supply of banked offset credits to help reduce uncertainties and time lags.

4) Establish independent oversight and auditing of offset schemes to improve transparency and effectiveness of governance and equitable sharing of costs and risks between parties.

5) Allow free public access to a register that describes how offset sites are meeting their promised outcomes to encourage scrutiny of policy effectiveness.

Table 1. Summary of the key contested ethical and social issues in biodiversity offsetting. Tractability of both scientific and implementation elements of each issue is coded from High to Low: **H** = Approximate solutions exist or are easily discoverable; **M** = Solutions are in theory empirically discoverable, but unknown/uncertain/very hard to learn about (scientific) or unlikely to be put in place because of the political and governance context (implementation); and **L** = Issue is fundamentally intractable.

Challenge	**Tractability**		**Response needed**	**Barriers**
	Scientific	Implementat-ion		
Philosophical/Ethical				
What values are important?	**L**	**L**	Continuing societal debate	Fundamentally unresolvable value judgement about competing philosophies

Challenge	Tractability		Response needed	Barriers
	Scientific	Implementat-ion		
Ethical basis for conservation	**M**	**M**	Carefully designed evaluation of effect of offset-type policies on development approvals and social acceptance of impacts	Diverse and changing value sets for biodiversity
Social				
No net loss compared with what?	**M**	**M**	Explicit statement of frame of reference in all cases, and provision to periodically revise this baseline in light of better knowledge	Frames of reference describing ongoing biodiversity decline unpalatable
No net loss of what?	**M**	**M**	Explicit statement of targeted biota and/or processes in all cases, and elicitation of willingness to substitute among targets	Diverse views on acceptable levels of inclusiveness and substitutability.

Challenge	Tractability		Response needed	Barriers
	Scientific	Implementat-ion		
No net loss for whom?	**M-L**	**M**	Broad and deep social impact assessments designed to identify stakeholders and capture value sets	Fiendishly complex to identify relevant valuers, and to quantify and weight diverse and changing value sets. Place-based values cannot be offset; their loss could at best be compensated.

Table 2. Summary of the key contested technical and governance issues in biodiversity offsetting. Tractability of both scientific and implementation elements of each issue is coded from High to Low: H = Approximate solutions exist or are easily discoverable; M = Solutions are in theory empirically discoverable, but unknown/uncertain/very hard to learn about (scientific) or unlikely to be put in place because of the political and governance context (implementation); and L = Issue is fundamentally intractable.

Challenge	**Tractability**		**Response needed**	**Barriers**
	Scientific	Implementation		
Technical				
Applying the Mitigation Hierarchy	**H**	**M**	Ensuring offsets reflect full replacement cost; Develop clear guidelines on mitigation hierarchy application	Incentives to reduce focus on mitigation hierarchy
Surrogates of biodiversity	**M-L**	**M**	Examine preferences for and ecological consequences of substitution among elements in composite metrics; improve biodiversity monitoring and build more	Conflict between realism in biodiversity surrogates used as currency, and market size & liquidity; Limited data on both

Challenge	Tractability		Response needed	Barriers
	Scientific	Implementat-ion		
			comprehensive datasets; examine societal acceptability of tradeoffs between market function and robustness of currency	biodiversity and societal preferences, both of which are dynamic
Offset and counterfactual scenarios	**M**	**M**	Explicit statement of scenario assumptions including counterfactuals; develop robust, standard approaches for deriving appropriate counterfactuals	Incentive to manipulate scenarios is hard to eliminate and transparency around assumptions often unpalatable; many different yet similarly valid approaches to developing scenarios; counterfactual scenarios (in the case of protection) and offset scenarios (in the case of restoration) both vulnerable to manipulation

Challenge	Tractability		Response needed	Barriers
	Scientific	Implementat-ion		
Capturing uncertainty and time lags	**M**	**M**	Place a levy on offsets to reinvest in learning to reduce uncertainty around interventions; develop appropriate discount rates that reflect time preference for biodiversity; develop strong supporting policy for a 'savings bank' approach where feasible	Factoring in uncertainty and time lag often leads to very onerous offset requirements; time lags means certain types of credit will accrue very slowly, making a 'savings bank' approach challenging and an unattractive investment without strong supporting policy
Accounting approach	**H**	**M**	Encourage transparency in offset calculation; ensure impact assessment approaches link with offset calculation approach	Increased transparency often unpalatable

Challenge	Tractability		Response needed	Barriers
	Scientific	Implementat-ion		
Governance				
Agency problems	**M**	**M**	Incentivise compliance (minimise transaction costs, outcomes-based contracts, risk severance); increase capacity for monitoring & evaluation; independent auditing; enhance public participation and scrutiny.	Increased scrutiny of offset trades is politically unpalatable. Incentive to under-deliver offset obligations, or to accept poor trades cannot be entirely eliminated.
Trust fund models	**H**	**M**	Development of robust methods for estimation of the replacement cost of biodiversity; systems to track funds to ensure original impacts are compensated for; independent control and oversight.	Risk of funds being absorbed into consolidated revenue; mismanagement of funds; increased transparency may be politically unpalatable; concerns about move away from “like for like”.

Challenge	Tractability		Response needed	Barriers
	Scientific	Implementat-ion		
Monitoring, evaluation and auditing	**M**	**M**	Design of monitoring and evaluation programs to evaluate offset outcomes at site and policy level; database infrastructure to store and share information on offset outcomes; independent oversight and public scrutiny of policy effectiveness.	Lack of incentive and/or capacity to evaluate; oversight and transparency may be politically unpalatable

Figure 1. The dark shading shows (a) countries known to have national policy in place or under development that requires or enables biodiversity offsets (n = 69); (b) EU countries, therefore subject to directives requiring no net loss for Natura 2000 sites (n = 28); (c) countries containing subnational regions that have their specific no net loss policies (n = 5); and, (d) countries in which development projects are eligible for funding from the International Finance Commission (IFC), so that offsets can be required under IFC Performance Standard 6 (n = 136). Note that other lenders, including different development banks and the Equator Group, can also require adherence to Performance Standard 6. Sourced from database maintained by Wild Business Ltd; see http://www.wildbusiness.org/research/