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Policy Development for Biodiversity Offsets: A Review of Offset Frameworks

Bruce A. McKenney · Joseph M. Kiesecker

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Abstract Biodiversity offsets seek to compensate for residual environmental impacts of planned developments after appropriate steps have been taken to avoid, minimize or restore impacts on site. Offsets are emerging as an increasingly employed mechanism for achieving net environmental benefits, with offset policies being advanced in a wide range of countries (i.e., United States, Australia, Brazil, Colombia, and South Africa). To support policy development for biodiversity offsets, we review a set of major offset policy frameworks—US wetlands mitigation, US conservation banking, EU Natura 2000, Australian offset policies in New South Wales, Victoria, and Western Australia, and Brazilian industrial and forest offsets. We compare how the frameworks define offset policy goals, approach the mitigation process, and address six key issues for implementing offsets: (1) equivalence of project impacts with offset gains; (2) location of the offset relative to the impact site; (3) "additionality" (a new contribution to conservation) and acceptable types of offsets; (4) timing of project impacts versus offset benefits; (5) offset duration and compliance; and (6) "currency" and mitigation replacement ratios. We find substantial policy commonalities that may serve as a sound basis for future development of biodiversity offsets policy. We also identify issues requiring further policy guidance, including how best to: (1) ensure conformance with the mitigation hierarchy; (2) identify the most environmentally preferable offsets within a landscape context; and (3) determine appropriate mitigation replacement ratios.

Keywords Biodiversity offsets · Mitigation hierarchy · Environmental compensation · Policy · Conservation planning · Mitigation replacement ratio

B. A. McKenney (✉)
The Nature Conservancy, 490 Westfield Road, Charlottesville, VA 22901, USA
e-mail: bmckenney@tnc.org

J. M. Kiesecker
The Nature Conservancy, 117 E. Mountain, Suite 201, Fort Collins, CO 80524, USA

Introduction

Human actions have altered about one-third to one-half of Earth's land surface (Vitousek and others 1997), causing considerable impacts to biodiversity. With global economic output expected to double over the next two decades (World Bank 2006), such impacts could increase dramatically. Tremendous investments are expected in energy, mining, and infrastructure sectors, among others. For example, the International Energy Agency (2007) forecasts more than $20 trillion in energy investments through 2030.

Biodiversity offsets are potentially a powerful tool for balancing conservation and development. Offsets seek to compensate for residual environmental impacts of project development, after appropriate steps have been taken to avoid and minimize impacts on site (ten Kate and others 2004). Countries including the United States, Australia, Brazil, Colombia, South Africa, Netherlands, Sweden, and United Kingdom have established or are developing offset policies to protect both species and ecosystems. The cumulative influence of advancing these regulatory and voluntary policies is large and growing, but interest in offsets is not restricted to governments. Multinational corporations such as Rio Tinto (2004) aim to have a "net positive impact on biodiversity" as part of their biodiversity strategy, and offsets will play an important role in meeting this objective.

With interest in biodiversity offsets increasing worldwide, we seek to strengthen the basis for policy development through a review of major offset policy frameworks in the United States, European Union, Australia, and Brazil. By comparing the goals, approaches, and key issues highlighted in these frameworks, and distilling important commonalities and differences, our aim is to provide guidance to countries that have not yet developed frameworks and to support improvements in existing policies. The frameworks selected for review include both established offset programs and rapidly emerging policies.

- US Wetlands Mitigation: This is the most mature of the offset frameworks reviewed, with its foundation in the section 404 amendments to Clean Water Act (33 U.S.C. § 1344). Wetlands mitigation aims to avoid and minimize impacts, and then offset residual impacts through compensatory mitigation that replaces wetland functions and values. Relevant policies include the US Environmental Protection Agency and Department of the Army (1990) memorandum of agreement on determining mitigation under section 404(b)(1) guidelines, federal guidance on wetland mitigation banking (US Army Corps of Engineers and others 1995), and regulations issued in 2008 governing compensatory mitigation for losses of aquatic resources (33 C.F.R § 325 and 332; 40 C.F.R. § 230).
- US Conservation Banks: Conservation banking is modeled after wetland mitigation, except that the objective is to offset adverse impacts to species, rather than replace wetland functions and values. California's Resources Agency and Environmental Protection Agency (1995) were first to issue guidance for conservation banking, followed by the US Department of the Interior (2003).
- EU Natura 2000: The Birds Directive of 1979 (Council of the European Communities 1979) and Habitats Directive of 1992 (Council of the European Communities 1992) underpin the effort to establish a network of Natura 2000 conservation sites throughout the European Union. The European Commission issued guidance on offsets in 2000 and 2001.
- Australian Offset Policies: Australian offset policies are developing rapidly. The federal government supports offsets under the Environment Protection and Biodiversity Conservation Act of 1999. At the state/territory level, offset policies have been developed in New South Wales, Victoria, Western Australia, South Australia, and Queensland, with most focused on offsetting the clearance of native vegetation. New South Wales has introduced BioBanking, a market-based offsets approach involving ecosystem and species credits (NSW DECC 2007).
- Brazilian Industrial and Forest Offsets: Brazilian federal legislation requires industrial developments to offset their environmental impacts through payments to the National Protected Areas System (Brazil Fed. Law 9985, Decree 4340). The system is still in its early stages of development, especially with regard to equivalency between industrial environmental impact and the benefits derived from offset payments. For Brazilian forest offsets, federal legislation requires that a minimum area of natural vegetation be maintained on private landholdings (Brazil Fed. Law 4771, Provisional Measures 2166/67). However, the legislation allows for off-site conservation offsets to compensate for natural vegetation clearing that exceeds the required minimum.

Offset Policy Goals

For the frameworks reviewed, we find offset policy goals vary from "net gain" to "no net loss" to general statements about the need to address adverse impacts. In the US, the Water Resources Development Act of 1990 directs wetlands mitigation to seek "an interim goal of no overall net loss of the Nation's remaining wetlands base, as defined by acreage and function, and a long-term goal to increase the quality and quantity of the Nation's wetlands, as defined by acreage and function" (33 U.S.C. § 2317). Offset goals in Australia often go a step further calling for net environmental gains. Native vegetation regulations in New South Wales require that offsets "improve or maintain" environmental outcomes for relevant environmental values (NSW DNR 2005; NSW DECC 2007). The values include water quality, salinity, biodiversity, and land/soil degradation. Victoria's Department of Natural Resource and Environment (2002) calls for a reversal in the decline of native vegetation "leading to a net gain" while Western Australia's Environmental Protection Agency (2006) states "offsets should be used with an aspiration of achieving a 'net environmental benefit'."

Brazilian forest policy implies no net loss of habitat by requiring private landholders to retain a defined minimum forest/vegetation cover, with the minimum area requirement varying by region, such as 80 percent for Amazon Forest and 35 percent for Amazon Savannah (Brazil Fed. Law 4771, Provisional Measures 2166/67). Where a private landholder is not meeting the minimum area requirement, the policy allows for compensation through the establishment of off-site conservation offsets. States such as Minas Gerais and Paraná are developing systems to formalize the offset mechanism through crediting systems.

US conservation banking, EU Natura policy goals, and Brazilian industrial offsets do not directly address issues of no net loss or net gain. Conservation banking objectives are to offset adverse impacts to threatened and endangered species, but federal and state guidance do not specify *how much* such impacts should be offset. For the EU Natura 2000 network, the stated goal is to maintain overall (ecological) coherence of the sites (European Commission 2000). This goal appears open to wide interpretation, since it presumes the original network (when it is fully developed) will be coherent and that impacts will be measurable in a manner that allows for determinations regarding violations of "coherence." Brazilian industrial offset legislation defines no linkage between environmental impacts and the benefits of offset payments, therefore making it impossible to measure net difference in environmental values.

Mitigation Hierarchy

We find strong support across the frameworks for the mitigation hierarchy of: (1) avoiding impacts, (2) minimizing impacts, and then (3) offsetting/compensating for residual impacts. This approach was first established for US wetlands mitigation (US EPA and DA 1990), and policies in Australia and the European Union have adopted a similar mitigation hierarchy. Under US wetlands policy, the first step is to avoid adverse impacts "to the maximum extent practicable" (US EPA and DA 1990). An alternative is considered practicable "if it is available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes" (40 C.F.R. § 230.3(q)). Any unavoidable impacts should then be minimized "to the extent appropriate and practicable," after which, remaining impacts require compensatory mitigation (US EPA and DA 1990). The policies reviewed make clear that offsets are intended as an option of last resort, to be considered in addressing residual impacts after efforts to avoid and minimize have been undertaken.

In the first step of the sequence (avoidance), it is important to note that impacts to unique and rare habitats, special aquatic sites, and other critical environmental assets are generally prohibited; they must be avoided unless it is an exceptional case. In evaluating the proposed impact site against potential alternatives, the main criterion is which site represents the least environmentally damaging option. US wetlands policy notes that "compensatory mitigation may not be used as a method to reduce environmental impacts" to make a potentially avoidable project appear more acceptable (US EPA and DA 1990). Likewise, under Natura 2000 the European Commission (2000) makes clear that in considering alternative solutions for a proposed project, "other assessment criteria, such as economic criteria, cannot be seen as overruling ecological criteria." If project alternatives cannot be identified, rather than weighing potential measures for minimizing impacts, the European Commission first requires an assessment of whether there are "imperative reasons of overriding public interest, including those of a social or economic nature, which require the realization of the plan or project in question."

While offset policies are in consensus on following the mitigation hierarchy, quantitative guidelines for this decision-making process are lacking (Race and Fonseca 1996; Gibbons and Lindenmayer 2007; Burgin 2008) A key challenge for future application of offsets will be establishing a clear and defensible process for determining when offsets are an appropriate tool in conformance with the mitigation hierarchy, and when offsets should be rejected in favor of more intensive efforts at steps higher up in the mitigation hierarchy (avoid and minimize).

To address this challenge, Kiesecker and others (2009a) propose a framework for blending landscape-level conservation planning with application of the mitigation hierarchy. Their framework, referred to as "Development by Design," follows the basic principles of systematic conservation planning. Conservation planning is the process of locating, configuring and maintaining areas that are managed to maintain viability of biodiversity and other natural features (e.g., Pressey and Bottrill 2008). A conservation portfolio (= priority sites), the end product of conservation planning, is a selected set of areas that represents the full distribution and diversity of these systems (e.g., Noss and others 2002). Often ecoregional plans utilize an optimization approach automated with spatial analysis tools such as Marxan (Ball and Possingham 2000) that will facilitate the examination of development/conservation tradeoffs and mitigation recommendations (avoid versus offset). Proposed developments can be mapped and assessed relative to a conservation plan and the minimum viability needs of target species and ecological communities. Overlap between a conservation portfolio and proposed development may result in a "redrawing" of the portfolio to recapture habitat needed to ensure biodiversity goals are met. However, if minimum viability goals cannot be met through "redrawing" the portfolio, the proposed development would need to take further steps to avoid and minimize impacts, to the degree necessary to maintain the viability of the biological targets. The aim of this approach is to provide a goal-based, stakeholder-driven process that supports compatibility between development and conservation goals, guiding decision-making on where impacts to biodiversity may be offset and where they should be avoided or minimized.

NSW BioBanking takes a similar approach, applying irreplaceability and vulnerability criteria to support conformance with the mitigation hierarchy and identifying "red flag" areas where biodiversity conservation values are high and impacts should be avoided (NSW DECC 2008). Red flag areas are determined based on vegetation types and the estimated distribution remaining in the catchment management authority, the presence of critically endangered or endangered ecological communities, and the presence of threatened species. There may be some circumstances in which impacts to a red flag area are allowed. Considerations include satisfaction that all reasonable measures to avoid impacts have been taken, impacts are not to a highly cleared vegetation type of a size greater than four hectares, the site's contribution to regional biodiversity values is low, the viability of biodiversity values at the site is low, and other considerations (NSW DECC 2008).

Key Challenges to Implementing Offsets

Effective offset policies must address a number of challenging questions, including: What counts as an offset? How much does it count? Where should the offset be located? When does it need to be operational and for how long? How should risks be managed and what if the offset fails? We draw together these implementation challenges into a set of six methodological issues and compare how offset policies are attempting to address them (Table 1).

- Equivalence of project impacts with offset gains (in-kind versus out-of-kind)
- Location of the offset relative to the impact site (on-site versus off-site)
- "Additionality" (new contribution to conservation) and acceptable types of offsets
- Timing of project impacts versus offset benefits
- Offset duration and management
- "Currency" and mitigation replacement ratios

Our review finds an emerging consensus on basic principles for addressing these issues. But detailed guidance often remains elusive. In part, this reflects the difficulties associated with providing one-size-fits-all guidance for offset programs aimed at addressing complex impacts that vary with the local context.

Equivalence (In-Kind Versus Out-of-Kind)

As no two areas are ecologically identical, how can offsets best provide benefits that are "equivalent" to losses caused by project impacts? Are offsets required to be established on an "in-kind" basis, or is "out-of-kind" compensation possible?

"In-kind" offsets refer to compensatory mitigation that provides habitat, functions, values, or other attributes similar to those affected by the project, whereas "out-of-kind" offsets allow for different forms of compensation. Offset policies indicate a general preference for in-kind compensatory mitigation, with the European Commission (2000) calling for compensation under Natura 2000 that is in "comparable proportions" providing comparable functions and Western Australia's Environmental Protection Agency (2006) seeking "like for like or better." In Victoria, Australia mitigation must be "commensurate," with direct in-kind replacement only required where vegetation losses are of "higher significance" according to a grading system (Victoria DNRE 2002; Parkes and others 2003). For losses of lower significance, the program provides more flexibility and discretion to local planning authorities to determine whether out-of-kind mitigation should be supported to "optimise conservation outcomes." Brazil's forest offset system only requires an offset to be of the same ecosystem type (Brazil Fed. Law 4771, Provisional Measures 2166/67).

Until recently, US wetlands mitigation policy explicitly stated that "in-kind compensatory mitigation is preferable to out-of-kind" (US EPA and DA 1990). This preference was based on the premise that full and equivalent replacement of losses is best achieved by compensating with the same type of habitat, functions, and services, and that this is particularly important when the affected area is considered locally important (US Army Corps of Engineers 2002). Recent regulations express a less explicit preference for in-kind mitigation, focusing instead on identifying the most "environmentally preferable" mitigation for aquatic resources in the watershed, even if it is an out-of-kind option (33 C.F.R. § 332.3 [40 C.F.R. § 230.93]). However, similar to the approach in Victoria, Australia, the regulations call for in-kind mitigation where wetlands are of higher significance: "For difficult-to-replace resources (e.g., bogs, fens, springs, streams, Atlantic white cedar swamps) if further avoidance and minimization is not practicable, the required compensation should be provided, if practicable, through in-kind rehabilitation, enhancement, or preservation since there is greater certainty that these methods of compensation will successfully offset permitted impacts" (33 C.F.R. § 332.3(e)(3) [40 C.F.R. § 230.93(e)(3)]).

For impacts to species, US conservation banking guidance calls for mitigation measures that "fit within the conservation needs of the species," rather than focusing on replacing the exact (in-kind) functions and values of specific habitat adversely affected by a project (US DOI 2003). But mitigation must support the affected species; conservation benefits "for one group of species cannot be used to offset impacts to a species not part of the group." Likewise,

Table 1 How offset policies in the United States, European Union, Australia, and Brazil address key implementation issues

Key issues	US wetlands mitigation	US conservation banking	EU natura 2000	Australian native vegetation offsets	Brazilian industrial offsets	Brazilian forest offsets
Equivalence	Most environmentally preferable option, in-kind for difficult-to-replace resources	In-kind for species; must support conservation needs of the species	Comparable proportions and functions	"Commensurate" or in-kind (especially for losses of high significance)	No preference	Same ecosystem type
Location	Same watershed	Same service area (US FWS); provides best long-term benefit to species	Same biogeographic region in the same Member State; same bird migratory path	Adequate geographic link between losses and offsets; closer to on-site when losses are high significance	No preference, but if impacts are to a protected area, offset must benefit that protected area	Same watershed
Additionality and types of offsets	Must be additional; prefer restoration; allow establishment, enhancement, and preservation	Must be additional; no specific constraint on type of offset	Must be additional; re-creating habitat, or in exceptional cases proposing a new site	Must be additional; full range of offset types allowed	No requirement; supports funding of Brazil's protected areas system	Must be additional to required conservation area on any private landholding
Timing	Before first credit is sold/debited, need to have secured site, approved mitigation plan, and assurances	Offset must be operable at time first credit is sold	Offset must be operable at time when project damage is effective	Flexible; timing is factored into scoring	Offset payment required prior to environmental permitting	Offset is retroactive, addresses land clearing that has already occurred
Duration	Self-sustaining; preservation must be permanent	Perpetuity only	Perpetuity preferred	Perpetuity preferred; in place as long as on-site impacts	Perpetuity preferred	Perpetuity preferred
Currency and offset ratios	Based on lost aquatic resources; at least 1 to 1 ratio by acreage or linear foot	Based on species and habitat values, at least 1 to 1 ratio for area supporting nest site or family group	Based on impacts to species, habitat, and functions	Based on assessment methodology in NSW; "Habitat hectares" framework in Victoria	Commensurate with impacts (minimum payment of 0.5% of total capital costs of project)	Defined ratio of 1 to 1

Natura 2000 requires that offsets for birds be along the same migration path and "accessible with certainty by the birds usually occurring on the site affected by the project" (European Commission 2000).

It is worth noting that despite the trend toward greater acceptance of out-of-kind offsets, as evidenced by policies in the United States and Australia, there is little to no support (legal, regulatory, or otherwise) for "very out-of-kind" forms of mitigation such as funding for conservation training and education. Indeed, US federal guidance on the use of in-lieu-fee arrangements for wetlands specifically rejects such approaches to offsets, noting that "funds collected under any in-lieu-fee arrangement should be used for replacing wetlands functions and values and not to finance non-mitigation programs and priorities (e.g., education projects, research)" (US Army Corps of Engineers and others 2000). Brazil's industrial offsets may be the only exception here, as the types of environmental impacts are not linked to the objectives of conservation expenditures made with offset payments (Brazil Fed. Law 9985, Decree 4340).

Location of Offset Relative to Impact Site (On-Site Versus Off-Site)

Do offset benefits need to accrue to the local geographic area affected by project impacts? What if a proposed "local" offset provides considerably less environmental benefit than other more distant proposed alternatives?

While offset frameworks are in broad consensus that mitigation benefits should accrue to affected areas, guidance differs on how proximate offsets need to be to an impacted site. Until recently US wetlands mitigation policy called for compensatory actions to "be undertaken, when practicable, in areas adjacent or contiguous to the discharge site" (US EPA and DA 1990). This approach was criticized for encouraging reactive, piecemeal mitigation projects with high failure rates, and for inadequate consideration of the watershed context (National Research Council 2001), as mitigation approaches at this scale may increase benefits (McAllister and others 2000).

Wetlands mitigation regulations issued in 2008 drop the preference for on-site compensatory mitigation in favor of using a watershed approach "to the extent appropriate and practicable" (33 C.F.R. § 332.3(c) [40 C.F.R. § 230.93(c)]). Under a watershed approach, compensatory mitigation should be located within the same watershed as the impact site, and where it can most successfully replace lost functions and services. The approach should take into account watershed scale features such as aquatic habitat diversity, habitat connectivity, relationships to hydrologic sources, land use trends, ecological benefits, and compatibility with adjacent land uses (33 C.F.R. § 332.3(b) [40 C.F.R. § 230.93(b)]).

For US conservation banking and Australian native vegetation offsets, location decisions are similarly linked to the overarching conservation goal. Conservation banking guidance supports off-site banks where they are environmentally preferable or where on-site measures are not practicable (US DOI 2003). The priority in bank location decisions is to provide for the long-term conservation of habitat and species. In practice, banks are sited within a "service area" defined by the US Fish and Wildlife Service based on physical and ecological attributes such as watersheds, soil types, species recovery units, and/or species and population distributions (US FWS 2006). In Victoria, Australia the need for on-site mitigation for native vegetation impacts varies based on the quality of the vegetation proposed for clearance. Although the program calls for "an adequate geographic link between losses and offsets," it only requires offsets to be "as close as possible" when "higher significance" vegetation is affected (Victoria DNRE 2002; Parkes and others 2003). For vegetation losses of lower significance, local planning authorities have discretion to determine whether off-site mitigation would be preferable.

Other offset frameworks note geographic boundaries for locating offsets, but provide less guidance on location decisions. The European Commission (2000) requires Natura 2000 offsets to be in "the same biogeographical region in the same Member State" while Brazil's forest offset system calls for offsets to be within the same watershed (Brazil Fed. Law 4771, Provisional Measures 2166/67). Brazil's industrial offsets place no geographic boundary on the expenditure of offset funds, unless the industrial development impacts a protected area, in which case the protected area becomes the beneficiary (Brazil Fed. Law 9985, Decree 4340).

"Additionality" and Acceptable Types of Offsets

To what degree must offsetting activities represent genuinely new and additional contributions to conservation? What types of offsets activities (e.g., restoration, protection) can be undertaken to deliver compensatory mitigation?

"Additionality" refers to the need for offsets to provide a new contribution to conservation, additional to any existing values. This is a widely held principle of the frameworks reviewed. For example, US conservation banking guidance states unambiguously that "land used to establish conservation banks must not be previously designated for conservation purposes (e.g., parks, green spaces, municipal watershed lands)" (US DOI 2003). Offset regulations in New South Wales, Australia call for offsets to be "additional to actions or works carried out using public funds or to fulfill regulatory obligations"

(NSW DNR 2005). And in Brazil, a landowner offsetting the forest-clearing liability of another landowner must maintain conserved areas that total the minimum required conservation land for the parcel (e.g., 20 percent) plus additional conservation land equal to the liability.

Under the additionality requirement, several types of offsets are deemed acceptable compensation. For Natura 2000, compensatory measures can consist of re-creating habitat, or in exceptional cases proposing a new site. Native vegetation programs in Australia allow for a wide array of compensation, including re-vegetation, regeneration, restoration, enhancement, removal of threats, improved management (e.g., control of weeds), avoidance of further permitted impacts (e.g., stock grazing), and protection. Rather than a specific compensation mechanism, US conservation banking relies on a "range of strategies" including "preservation, management, restoration of degraded habitat, connecting separated habitats, buffering of already protected areas, creation of habitat, and other appropriate actions" (US DOI 2003).

Wetlands mitigation favors restoration over other compensation options "because the likelihood of success is greater and the impacts to potentially ecologically important uplands are reduced compared to establishment, and the potential gains in terms of aquatic resource functions are greater, compared to enhancement and preservation" (33 C.F.R. § 332.3(a)(2) [40 C.F.R. § 230.93(a)(2)]). Restoration is divided into "re-establishment" (i.e., returning natural or historic functions to a former wetland with a resultant gain in wetland acres) and "rehabilitation" (i.e., repairing natural or historic functions of a degraded wetland with a resultant gain in wetland functions but not acres). If restoration is not possible, wetland establishment, enhancement (e.g., water quality improvement), and preservation may be acceptable forms of compensation. Wetland preservation, however, is only an allowable option when the wetland resources proposed for preservation provide physical, chemical, or biological functions important for the sustainability of the watershed, the resources are under threat of destruction or adverse modifications, and the site will be permanently protected (33 C.F.R. § 332.3(h) [40 C.F.R. § 230.93(h)]).

Timing of Project Impacts and Offset Benefits

As some offsets will require a number of years before ecological maturity brings full benefits, when does an offset need to be operational – before, concurrent with, or following project impacts?

In principle, the frameworks reviewed call for offsetting activities to be operational and proven *prior* to allowing project impacts. For example, the European Commission (2000) makes clear that under Natura 2000 "the [compensatory] result has normally to be operational at the time when the damage is effective on the site concerned with the project unless it can be proved that this simultaneity is not necessary to ensure the contribution of this site to the Natura 2000 network." Likewise, US conservation banking guidance states "at the time the first credit in a bank or phase of a bank is sold, the land within the bank or its phase must be permanently protected through fee title or a conservation easement, with any land use restrictions set in perpetuity for the land legally established" (US DOI 2003). The aim of requiring effective offsets prior to project impacts is to safeguard against a temporal loss of conservation values. Project impacts cause immediate and certain losses, whereas the conservation gains of an offset are uncertain and may require many years to achieve. Indeed some habitat features and systems take decades or more to develop and mature, with the risk that they may never provide an equivalent conservation value as what was lost (Burgin 2008).

While anticipatory approaches seek to ensure no temporal losses of values when compensating through offsets, they can also create some significant disincentives to developing offsets in the first place. First, if offsets are to compensate on a like-for-like basis, the anticipatory approach requires offset developers to foresee project impacts before they have occurred, which can be difficult for projects that are complex with a potentially wide range of impacts. Second, the anticipatory approach can impose substantial upfront costs for banking approaches if there is no ability to raise funds by releasing credits early (prior to the offset being operational). Offset planning, establishment, management, and operating costs must be borne for perhaps years before the offset meets specified performance standards (e.g., vegetation measures, hydrology criteria) and can be applied as compensation for impacts.

For these reasons, offset policies for Australian native vegetation and US wetland mitigation tend to take a more flexible approach to the timing of project impacts and offset benefits. For example, in Victoria, Australia temporal issues are factored in as another element subject to scoring, depending on when offsets are initiated (Victoria DNRE 2002). Under the BioBanking scheme in New South Wales, biodiversity credits are issued and can be sold on the open market once a BioBanking agreement has been approved (NSW DECC 2007). US wetland mitigation policy is somewhat more restrictive in that it only allows for credit releases in accordance with the achievement of specific milestones. Before an initial allocation of credits can be sold, a wetland bank/offset project must have a secured site, an approved mitigation plan, and other assurances need to be in place. Additional credits can be transacted as the bank/offset achieves ecological and performance-based milestones (e.g., construction, planting, establishment of specified plant and animal communities) set out in its credit release schedule. This schedule should reserve a significant share of the total credits for release only after full achievement of ecological performance standards. Factors in determining a credit release schedule include the mitigation approach (e.g., restoration) and nature/amount of work, likelihood of success, and aquatic resource types and functions (33 C.F.R. § 332.8(o)(8) [40 C.F.R. § 230.98(o)(8)]). In light of this guidance, advance credit release is very common for US wetland mitigation banking. Environmental Law Institute (2002) estimates about 90 percent of US wetland banks sell some credits before achieving *any* performance standards.

Offset policies that allow for the immediate or phased release of credits, such as NSW BioBanking and US wetland mitigation banking, may not adequately address time-lag and uncertainty issues. To achieve "no net loss" outcomes, Moilanen and others (2008) suggest incorporating uncertainty in the effectiveness of restoration actions, correlation between success of different offset areas, and time discounting in the calculation of offset ratios. They find that when these factors are taken into account, offset ratios should be much higher to avoid net losses in conservation values.

Offset Duration and Management

What is the appropriate operable period for an offset – in perpetuity or equal to the duration of project impacts? What types of requirements, management, and assurances are needed?

Offset protection in perpetuity assumes project impacts are irreversible, whereas finite protection assumes there is potential to reverse damage at the project site. Our review finds consensus among the frameworks that offset protection in perpetuity is preferable, but in some cases offsets may be operable for only the duration of project impacts. For example, offset regulations for native vegetation in New South Wales, Australia call for offset benefits to "persist for at least the duration of the negative impact of the proposed clearing," though "permanent conservation measures are given greater value than other management actions" (NSW DNR 2005). US conservation banking policy provides no possibility of finite protection, requiring banks to "safeguard in perpetuity the species or habitat conservation values upon which the credits are based" (US DOI 2003). US wetlands mitigation regulations require offsets to be "permanent" if the compensatory action is preservation alone. For restoration, establishment, and enhancement actions, regulations call for offsets to be "self-sustaining once performance standards have been achieved" (33 C.F.R. § 332.7(b) [40 C.F.R. § 230.97(b)]). Where such offsets require active long-term management and maintenance (e.g., prescribed burning, invasive species control, maintenance of water control structures, easement enforcement) and/or long-term financing mechanisms, the responsible party must provide it.

As offsets are generally intended to operate for either the long-term or in perpetuity, the frameworks are in consensus on a number of management and compliance measures, including the need for management plans, performance standards, securing site tenure, restricting harmful activities, monitoring, legal and financial assurances, adaptive management, and contingency and remedial actions in the event of offset failure (US DOI 2003, European Commission 2000, 33 C.F.R. § 332.4(c)(2-14) [40 C.F.R. § 230.94(c)(2-14)]).

"Currency" and Mitigation Replacement Ratios

What is an appropriate "currency" or uniform trading unit to support compensation for project impacts with offset benefits? Given differences in ecological quality and other factors, on what basis can mitigation replacement ratios be established?

Offset policies support establishing a currency (debit/credit unit) that incorporates values associated with ecological functions, quality, and integrity, rather than basing currency simply on land area. With a currency established, mitigation replacement ratios can be determined, reflecting the number of credit units that must be provided through an offset to compensate one unit of loss at the project site (e.g., 3 to 1 ratio).

While currency and mitigation ratios are distinct concepts, policies often conflate them, adjusting mitigation ratios to reflect "quality" issues not accounted for in the currency unit. For example, wetlands mitigation requires a "mitigation ratio greater than one-to-one where necessary to account for…differences between the functions lost at the impact site and the functions expected to be produced by the compensatory mitigation project…" (33 C.F.R. § 332.3(f)(2) [40 C.F.R. § 230.93(f)(2)]). Mitigation ratios may be tailored based on a range of factors including the chosen compensation mechanism (e.g., restoration, preservation), equivalence of the offset (in-kind versus out-of-kind), conservation significance (unique versus common), location (on-site versus off-site, in/out of watershed, eco-region, or service area), temporal lags between project impacts and offset maturity, and risks of offset failure.

US offset guidance calls for the incorporation of ecological values, but allows for offset transactions based on land area alone. For example, US conservation banking calls for credit units that reflect "a species' or habitat's conservation values," with these values based on biological criteria, habitat types, and management activities (US DOI 2003). However, this guidance also allows that "in its simplest form, one credit will equal one acre of habitat or the area supporting one nest site or family group."

Likewise, US wetlands mitigation regulations require compensatory mitigation to be sufficient, to the extent practicable, to replace lost aquatic resource functions. The amount of compensatory mitigation should be determined based on a functional, condition, or other suitable assessment method. If one of these methods is not used, a minimum one-to-one acreage or linear foot compensation ratio must be used. Where necessary, mitigation ratios should be adjusted to greater than one-to-one based on the method of compensatory mitigation (e.g., preservation), likelihood of success, differences between functions lost and functions expected to be produced by the offset, temporal losses of aquatic resource functions, difficulty of restoring, establishing, or enhancing the desired aquatic resource type and functions, the distance between the affected aquatic resource and the offset site, and risk and uncertainty associated with offsets that have not been implemented before project impacts occur. The rationale for the required replacement ratio must be documented in the administrative record for the permit action

(33 C.F.R. § 332.3(f) [40 C.F.R. § 230.93(f)]).

With no regulatory endorsement of a specific functional or condition assessment method for wetlands mitigation, and a broad range of factors to consider in establishing mitigation ratios, several US states have simply established defined wetlands mitigation ratios based on the type of compensatory action. These can vary widely from state to state. For example, Ohio's ratio is 1-to-1 for wetlands restoration and creation and 2-to-1 for enhancement and preservation actions, whereas New Jersey's ratio is 2-to-1 for restoration actions and Michigan's ratio is 10-to-1 for preservation (Environmental Law Institute 2002). Brazil has taken a similar approach for forestry offsets, establishing a set mitigation ratio of 1-to-1 for all forestry offsets. For industrial offsets, Brazil requires a minimum payment of 0.5 percent of total capital costs of development to support offsets commensurate with impacts.

Whereas the other offset frameworks reviewed make no endorsement of a particular assessment method, guidance in Victoria, Australia supports a specific approach for determining offsets called the "habitat hectares" method (Parkes and others 2003), and this has also been adapted within the NSW Biobanking assessment methodology (NSW DECC 2008). The "habitat hectares" approach involves comparing remnant native vegetation to a benchmark for the same vegetation existing in a mature and long-undisturbed state. Based on an assessment of site conditions and the landscape context, component scores are developed as a basis for estimating the overall habitat quality, which is then multiplied by the area of the site to establish the number of habitat hectare units (Victoria DNRE 2002; Victoria DSE 2008).

Discussion

Our review of offset policy frameworks in the United States, European Union, Australia, and Brazil finds much consensus on offset goals, the importance of adhering to the mitigation hierarchy, and approaches for addressing key challenges to implementing offsets. While this congruence provides a sound foundation from which to develop policy for biodiversity offsets, several issues require further guidance, including how best to: (1) ensure conformance with the mitigation hierarchy; (2) identify the most environmentally preferable offsets within a landscape context; and (3) determine appropriate mitigation replacement ratios.

First, while offset frameworks emphasize the importance of the mitigation hierarchy—avoiding and minimizing impacts before proceeding to compensatory mitigation—there is little guidance on how this critical sequence should be followed to ensure projects conform to it. Guidance tends to focus on avoiding impacts to "difficult-to-replace" and "high significance" resources, but ultimately provides wide discretion to regulatory authorities on decisions about when to avoid, minimize, or offset. A chief concern about advancing biodiversity offsets is that, if not implemented according to the mitigation hierarchy and a set of standards, the approach could provide a "license to trash" —development in areas where impacts should have been avoided or more effectively minimized. To safeguard against this concern, more effective policy guidance is needed for determining whether projects conform to the mitigation hierarchy. Such guidance should incorporate science-based criteria—irreplaceability and vulnerability – as put forward under approaches by Kiesecker and others (2009a) and the NSW BioBanking scheme (see "Mitigation Hierarchy" discussion above).

Second, policy guidance on issues of equivalence and location is trending away from strict requirements for in-kind offsets located as close to impact sites as possible, in favor of identifying the most environmentally preferable offset options within the watershed or landscape. While these changes in policy could improve conservation outcomes, some further guidance in needed. For example: What criteria should be applied in determining when out-of-kind offsets represent a "trade up" in conservation benefits compared to in-kind options? To what extent are criteria and standards needed for watershed/landscape planning, to ensure more pro-active approaches to conservation-development conflicts and cumulative impacts? Within a watershed or landscape context, what approach should be taken for offsetting ecosystem service impacts, given that service benefits tend to be tied closely to location (e.g., non-timber forest products, water services) and people benefitting from such services are unlikely to find it adequate compensation if offsets are located far from the impact site?

To address these issues, offset frameworks need to move beyond encouraging a landscape/watershed approach to making this planning a *requirement*, especially for landscapes where future impacts are projected to be significant. Incorporating landscape planning (e.g., Margules and Pressey 2000; Pressey and Bottril 2008) into mitigation decisions offers numerous advantages over a traditional project by project approach. Landscape plans allow practitioners to consider the cumulative impacts of current and projected development. This can guide which step of the mitigation hierarchy should be applied (i.e. avoidance versus offsets) and ensure that, rather than piecemeal activities, mitigation is consistent with broader conservation goals to maintain large, resilient ecosystems that support healthy wildlife habitats with sufficient connectivity and benefit human communities.

Harnessing landscape planning can also improve offset site selection and conservation returns. Kiesecker and others (2009b) propose adapting systematic conservation planning to identify offset opportunities in the highest priority areas for conservation. The approach involves developing a series of rules (offset goals) for selecting offset sites that would meet the conservation needs of impacted biological targets (i.e. size, condition, landscape context). Then using a site-selection algorithm (i.e. Marxan, Ball and Possingham 2000), offset sites that would best meet conservation goals are identified at increasing spatial extents. This is done from a landscape perspective, including consideration of landscape integrity and future potential impacts. Rules can be designed to ensure that the offset portfolio captures the necessary landscape-level conservation requirements, such as connectivity, corridors, and buffer zones of the intended conservation targets. From this portfolio of possible offsets, sites can then be selected for implementation that best support conservation goals.

Third, where offsets are implemented, policy guidance on mitigation replacement ratios is often inadequate. Broadly speaking, guidance on replacement ratios falls into three categories: (1) pre-defined ratios, such as those based on the type of conservation action (e.g., 1-to-1 ratio for restoration, 5-to-1 ratio for preservation); (2) ratios determined based on a specified assessment method (e.g., "habitat hectares"); and (3) subjectively determined ratios based on the discretion of regulatory authorities after multiple considerations, such as conservation actions, probability of success, temporal losses, and uncertainty and risk factors, among others.

All three approaches are problematic. While pre-defined ratios may simplify the offsets implementation process, there is little reason to believe they deliver no net loss outcomes on a regular basis. Given variations in ecosystems, types of impacts, and possible offsets, pre-defined ratios may result in under-compensation or over-compensation, but the achievement of no net loss outcomes is more likely coincidence than by design. To illustrate, consider two possible restoration offsets. The first offset involves the application of an untested restoration approach, and it will be many years before conservation values are delivered, if at all. The second offset uses a well-accepted restoration approach that can deliver conservation benefits effectively and rapidly. Under offset policies using pre-defined replacement ratios for restoration actions, the same ratio (typically a ratio of 1-to-1 for U.S. wetlands mitigation, but it varies across states) would be applied to both projects, despite the marked differences in likely conservation benefits.

Reliance on a single assessment method to determine ratios seems similarly inadequate for addressing the wide range of possible impacts and offset opportunities. Consider that for wetlands mitigation alone there are dozens of sophisticated assessment methods (Bartoldus 1999). These multiple assessment methods have been developed over time for a variety of reasons—to address different wetland types, in response to scientific advancements, and to meet demands for more practical, cost-effective, and timely assessments. Policies that endorse a specific assessment method are likely to constrain innovation and limit the potential for determining ratios that deliver no net loss outcomes.

Lastly, subjectively determined ratios based on professional judgment (of regulators and others) is too often an ad hoc and opaque process. This makes it difficult to ascertain the degree to which decisions are science-based and unbiased. Moreover, since the approach lacks a structured and transparent framework, it is often not time- and cost-efficient.

A more structured, transparent, and defensible accounting framework is needed that takes into account ecological context and other important factors. Our review suggests such a framework focus on three key offset elements: (1) "additionality" (the extent to which an offset provides a new contribution to conservation); (2) probability of success (the likelihood that offset actions will deliver expected conservation benefits); and (3) time-lag to conservation maturity (how long it will take for offset actions to deliver conservation at a maturity level similar to what was lost at the impact site).

A transparent framework with specific guidance on quantitative approaches for incorporating these three factors would be a significant improvement over current practices. For additionality, the framework should take current conditions and threats into account, using a baseline that reflects an expected background rate of loss for the offset site. This would support quantitative estimates of additionality for both restoration *and* protection offsets, with protection benefits based on prevention of the expected background rate of loss.

Likewise, incorporating probability of success into offset accounting would ensure a more realistic appraisal of how restoration and protection offsets contribute to no net loss outcomes. The success of conservation actions can vary greatly, depending on the ecosystem, restoration techniques, management, and other factors. Where experience with conservation actions is comprehensive, probability of success can be estimated with some accuracy, and where experience is more limited, a ranking process might be employed (high, medium, low probability). Incorporating probability of success will create incentives for implementing effective offsets over offset actions with high risks of failure. It will also encourage offset planning that includes monitoring, legal and financial assurances, adaptive management, and other measures to increase an offset's estimated probability of success (as this will in turn increase the offset's value in the accounting framework).

Finally, it may take many years or decades before conservation actions reach maturity. This time-lag represents a loss for biodiversity; it should be accounted for in estimates of offset benefits (Moilanen and others 2008). This involves estimating the time to maturity of a conservation action and applying a discount rate – a commonly used method for estimating the present value of future benefits. This approach will create appropriate incentives for offsets, making conservation actions that promise benefits far into the future less attractive than offsets delivering more immediate benefits. Likewise, there will be strong incentives to avoid impacts to natural systems that require very long periods for restoration, as offsets for these impacts would likely have a very high replacement ratio, making them more expensive to implement.

Policy guidance on mitigation replacement ratios needs to be strengthened. We recommend an accounting framework that incorporates additionality, probability of success, and time to conservation maturity. A more quantitative approach would be a marked improvement over current practices, could help address concerns about offsets not providing sufficient compensation for losses (Race and Fonseca 1996; Ambrose 2000; National Research Council 2001), and would align incentives to support offsets that truly deliver on no net loss goals.

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