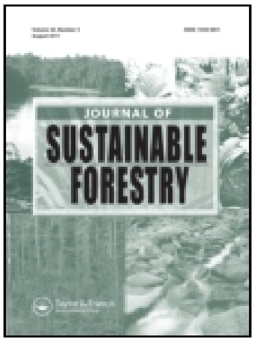

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Ecological Compensation to Address Environmental Externalities: Lessons from South American Case Studies

JOHN REID[1], AARON BRUNER[1], JEFFREY CHOW[2], ALFONSO MALKY[3], JOSÉ CARLOS RUBIO[4], and CRISTIAN VALLEJOS[4]

[1]*Conservation Strategy Fund, Sebastopol, California, USA*
[2]*Yale School of Forestry and Environmental Studies, New Haven, Connecticut, USA*
[3]*Conservation Strategy Fund, La Paz, Bolivia*
[4]*Conservation Strategy Fund, Lima, Peru*

Large development projects commonly cause damage to ecosystems, even after measures have been taken to avoid and reduce impacts on site. Governments are increasingly seeking to offset losses through ecological compensation programs to maintain overall levels of biodiversity and ecosystem services. The key to successful programs are criteria that reduce uncertainty and transaction costs while enhancing ecological equivalency. In South America, the government of Brazil, and Colombia have implemented compensation programs, and Peru has recently published broad guidelines and is developing detailed rules. Brazil emphasizes regulatory simplicity, which mitigates cost uncertainty, over ecological equivalence. Colombia has sophisticated methods for establishing ecological equivalence, but has yet to develop institutions necessary to reduce transaction costs. These experiences suggest a trade-off between rules that rigorously compensate losses with ecologically equivalent areas, and simpler approaches that have low transaction costs but may fail to ensure specific biodiversity goals. The success of Peru's system will depend on being practical enough to implement at scale and rigorous enough to deliver environmental benefits. We describe a series of mutually compatible recommendations to balance both needs. Ecological compensation is still a nascent effort in the neotropics and policy adjustments will be necessary as better information on success and failure becomes available.

Address correspondence to John Reid, Conservation Strategy Fund, 7151 Wilton Avenue, Sebastopol, CA 95472, USA. E-mail: john@conservation-strategy.org

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INTRODUCTION

Infrastructure and natural resource-related development projects commonly generate negative externalities, side-effects that impose costs onto people other than those voluntarily, directly involved in the development transaction. For example, in the tropics, dams dramatically alter ecosystems and impact human settlements (Sousa Júnior & Reid, 2010), while fossil fuel extraction can contaminate freshwater supplies and fishing grounds (Finer, Jenkins, Pimm, Keane, & Ross, 2008). The roads built for these and other development projects frequently induce deforestation (Laurance, Goosem, & Laurance, 2009), which in turn emits globally significant greenhouse gases (Le Quéré et al., 2009). Biologically diverse tropical forests are among the most heavily impacted ecosystem types, largely due to the forest loss that projects induce by increasing access for loggers, informal miners, and settlers (Chomitz, 2007; Geist & Lambin, 2002). Negative impacts occur when development projects within tropical forests cause the loss of valuable biodiversity and ecosystem services that often benefit the public at large.

Ecological compensation is a set of actions that mitigates losses by promoting restoration or conservation of ecosystems with similar structure and function elsewhere (BBOP, 2012). Also known as compensatory mitigation, biodiversity offsets, or compensatory conservation, it does not refer to financial compensation for social and economic impacts on affected communities. Ecological compensation has received increased attention in recent years as a national or regional regulatory instrument to help countries balance conservation and development objectives. Ideally, the objective of ecological compensation is to offset habitat damage from a development project after steps to first avoid and then reduce negative environmental impacts on-site have been exhausted (Quétier & Lavorel, 2011; Saenz et al., 2013b). A frequent goal of ecological compensation schemes is for offset activity to be ecologically equivalent to (i.e., no-net-loss) or exceed (i.e., net gain) the biodiversity and ecosystem services lost due to the development. Ecological equivalence occurs when the biodiversity and ecosystem service values lost due to development and gained via the offset are the same in nature and magnitude (Maron et al., 2012). The Business and Biodiversity Offsets Program (BBOP, 2012), an early promoter of ecological compensation, has adopted no-net-loss as a central principle. Although the International Finance Corporation (2012), the private sector arm of the World Bank which issues performance standards for compensation programs, does allow substitution of rarer or otherwise more valuable biodiversity features (i.e., "trading up"), most existing programs require ecological equivalency between ecosystem services, which are lost and offset (McKenney & Kiesecker, 2010; Quétier & Lavorel, 2011).

Well established in the United States, Australia, and Europe, laws requiring development projects to incorporate ecological compensation are becoming increasingly prevalent in developing countries as well (Madsen, Carroll, & Moore Brands, 2010). Previous reviews (e.g., McKenney & Kiesecker, 2010; Quétier & Lavorel, 2011) outline the main design issues that must be addressed by environmental or biodiversity offset programs, but often focus on the United States, Europe, and Australia, where there is no longer an active agricultural frontier, institutions are highly developed, the scale of individual offsets is small, and monitoring is relatively easy. These conditions often do not apply in the developing tropics, even in relatively advanced countries such as those in South America.

Among developing countries, various forms of national ecological compensation programs exist in Mexico, Brazil, Colombia, Paraguay, South Africa, and China, though pilot projects and programs are in development in many others (Madsen et al., 2010; Villarroya, Barros, & Kiesecker, 2014). For comparative purposes we focus on Brazil, Colombia, as well as Peru, which is currently formulating its own ecological compensation system. Our attention is on these specific countries because they are neighbors, share similar colonial histories and ecosystems, and are considered highly biodiverse. Also, they are at relatively similar levels of economic development, with all three considered upper middle-income countries by the World Bank (2014). Moreover, while many countries enable ecological compensation, Brazil, Colombia, and Peru are among the few that explicitly require its implementation (Villarroya et al., 2014).

This commentary assesses the capability of ecological compensation policies in forcing development projects to internalize environmental costs. We propose a set of criteria, which fall under two general categories: characteristics related to reducing transaction costs, and qualities which would help ensure the effectiveness of compensation actions. Using these criteria, key to cost-effective implementation, we examine established ecological compensation policies in Colombia and Brazil, where environmental mitigation principles have been specifically outlined in legislation (Madsen et al., 2010). We then apply insights from the Colombian and Brazilian case studies to Peru, where ecological compensation policies were recently enacted, in order to inform their ongoing policy development process.

ASSESSMENT CRITERIA FOR ECOLOGICAL COMPENSATION SCHEMES

Criteria for Reducing Transaction Costs

Transaction costs are the costs of resources employed to define, establish, maintain, and transfer property rights (McCann, Colby, Easter, Kasterine, &

Kuperan, 2005). Transaction costs occur in the course of information collection, policy design, policy enactment and establishment, implementation and contracting, administration and monitoring, and enforcement compliance (Coggan, Whitten, & Bennett, 2010). Reducing transaction costs causes policy implementation to become more practicable by making compliance more attractive for firms and enforcement more affordable for regulators. Thus, to be cost-effective, an ecological compensation scheme should attempt to minimize transaction costs. Within the context of environmental regulation, complexity and uncertainty exacerbate transaction costs due to resources expended, by both regulators and those they regulate, to reduce or manage that uncertainty or complexity (Coggan et al., 2010). The following criteria constitute five ways by which transaction costs can be reduced for ecological compensation schemes, with several specifically addressing the uncertainty involved in the process.

First, rules for compliance ought to be relatively straightforward and unambiguous. Rule complexity or insufficient information about the specific responsibilities of the developer and regulator can lead to uncertainty, which in turn can increase transaction costs. Like any environmental regulation, overly complex or ambiguous rules pertaining to ecological compensation risk provoking resistance from developers while making compliance monitoring and enforcement more costly for public agencies.

Second, an ecological compensation program should make available a robust and sufficiently diverse supply of compensation sites and actions. A robust supply of compensation options reduces the transaction costs for firms from having to establish or search for offset projects that comply with the regulation. Supply could be enabled with a local inventory (or, in the case of small countries, national inventory) of categorized compensation sites that are preapproved by the regulatory agency. Uncertainty and complexity arises partly from lack of information concerning the state of nature—i.e., the magnitudes of the habitat losses to development and of the offset gains (Quétier & Lavorel, 2011). Some supply strategies, such as a biodiversity offset bank, can help reduce uncertainties in ecological equivalence that arise due to time lags necessary for habitat restoration to occur (Bekessey et al., 2010). An appropriately but not excessively diverse array of ecosystem categories can accomplish approximate ecological equivalence while still ensuring that there are offset sites available in each category. Moreover, making public, private, and communal lands eligible for offset actions can increase the diversity of ecosystems available for compensatory actions, compared to an approach that narrowly defines allowable forms of tenure.

A third criterion is that ecological offset schemes should seek to minimize uncertainty pertaining to the costs of implementing habitat compensation. Developers, whether public or private, can more accurately budget for projects if regulatory costs are predictable. For example, predictability could be enhanced with a spatially explicit, public baseline study on the cost of compensation at sites in the inventory of categorized sites mentioned above.

Fourth, ecological compensation policies should encourage, or at least clearly enable, offset activities undertaken by a third party (i.e., offset providers)—separate from the developer and the regulating agency—with expertise in habitat restoration and conservation. A third party specializing in offset generation would have greater knowledge and experience, and thus encounter less biophysical uncertainty associated with ecosystem management.

Additionally, and similarly, ecological compensation policies should involve financial mechanisms and other intermediaries to facilitate transactions between potential offset buyers (i.e., developers) and sellers. Intermediaries can reduce transaction costs faced by buyers and sellers through the provision of information and services that are time and information intensive—such as negotiation, monitoring, and reporting (Coggan, Buitelaar, Whitten, & Bennett, 2013). Specialization would allow intermediaries to provide these services at lower cost than the buyers and sellers themselves, but only if transactions are sufficiently transparent.

Criteria for Environmental Effectiveness

The criteria above would influence downward the transaction costs and uncertainties related to ecological compensation policy, increasing the possibility of compliance. For a policy to be successful, however, it must be effective as well—i.e., fulfill the goal of offsetting, with ecologically equivalent habitat, the biodiversity and ecosystem services lost due to development. We propose five criteria that would enhance the effectiveness of a compensation scheme by helping to ensure ecological equivalence.

First and foremost, legally mandated ecological compensation must offset not only direct impacts of development projects, but also indirect impacts. Indirect impacts include damage that results from development, but is not directly caused by the developer. For example, road building through otherwise remote tropical forest induces further deforestation by increasing access to settlers and loggers (Angelsen & Kaimowitz, 1999; Chomitz & Gray, 1996, Soares-Filho et al., 2004). Moreover, many nonroad development projects—including dams, mines, and oil wells—may also require construction of access roads through formerly inaccessible forest areas. Generally, although indirect impacts vary greatly, their estimation is feasible (e.g., Gnansounou, Panichelli, Dauriat, & Villegas, 2008; Lenzen, Murray, Korte, & Dey, 2003).

Second, long-term finance mechanisms are necessary to help ensure that compensation activities continue for an appropriate period of time. Because many development impacts are irreversible, the no-net-loss concept requires that ecologically equivalent offset habitats be conserved in perpetuity as well.

Some offsets may require active long-term management and maintenance—such as invasive species control, maintenance of water control structures, and easement enforcement (McKenney & Kiesecker, 2010). A necessary condition for permanence is the availability of secure, dedicated funding that is equal in amount to the present value of the cost of all future compensation actions required for an ecologically equivalent offset (BBOP, 2009; Reid, 2013).

Third, compensation activities should constitute new and additional contributions to ecosystem conservation, determined against an appropriate baseline, which takes current and expected threats to the offset site into account (McKenney & Kiesecker, 2010). This concept of additionality is identical to that used in carbon offset projects to ensure that offsets are credited only for emissions reductions that would not have occurred in the absence of the project. Because one must posit a counter factual baseline, establishing additionality can be undermined by uncertainty in the expected success of the compensation action. However, options are available to manage this uncertainty. For example, compensation actions could cover areas comfortably in excess of the impacted site, determined by high offset ratios (Moilanen et al., 2009).

Complicating additionality concerns are temporal dynamics such as time lags, which occur when the development impact occurs before the offset gain is realized, or when the generation of ecological equivalency takes place long after the initial offset action (Quétier & Lavorel, 2011). Consequently, compensation policy should incorporate these temporal dynamics. Timescales of centuries may be required for the establishment of conservation habitat comparable to some ecosystems (e.g., old growth forests) (Morris, Alonso, Jefferson, & Kirby, 2006), which renders re-creation infeasible and necessitates other compensation strategies such as restoration of degraded areas or conservation of threatened areas. Also, offset ratios could be calculated such that they incorporate uncertainty in the effectiveness of restoration action, correlation between success of different compensation areas, and time discounting (Moilanen et al., 2009). Because some temporal deficits may be impossible to compensate, other strategies mentioned above, such as conservation banking and selecting appropriate baselines which incorporate expected threat and uncertainty of success, can also help resolve this issue (Quétier & Lavorel, 2011).

Finally, an effective ecological compensation program would require efficient monitoring of impact sites and compensation activities not only for compliance enforcement, but also for program evaluation (Quintero & Mathur, 2011). Offset activities can fail to meet their ecological equivalence objectives even when technically compliant to regulation (e.g., Matthews & Endress, 2008). Monitoring should therefore include periodic review of project success rates in order to improve offset program design.

ECOLOGICAL COMPENSATION POLICIES IN BRAZIL AND COLOMBIA

Brazil is one of the most biodiverse countries in the world (Giuletti, Harley, De Queiroz, Wanderley, & Van Den Berg, 2005), with renowned species-rich areas including the Amazon, Cerrado, and Atlantic forest. The Brazilian ecological compensation system for industrial development projects was established by the National Protected Areas Systems Law (Federal Law 9985, Decree 4340, Section 36) in 2000. The law requires developers to pay a fee, equal to a percentage of their initial investment, into the Protected Areas System (Sistema Nacional de Unidades de Conservação, SNUC) through the Environmental Compensation Fund (Fundo de Compensação Ambiental, FCA; Madsen et al., 2010). Versions of the system exist at both the federal and state levels. The federal system currently sets the ceiling for payments at 0.5% of capital costs. When less sensitive areas are impacted, the percentage may be lower. For projects under state jurisdiction, the percentage varies and can be substantially higher. Pará State, for example, has a maximum of 2% (Pinto, Vedoveto, & Veríssimo, 2013). These funds are used solely for existing protected areas, unless a protected area itself is directly affected by the development work (Madsen et al., 2010). Also, the Brazilian Forest Code (Federal Law 4771, Provisional Measures 2166/67) requires private landowners to maintain a minimum area of natural vegetation. However, a landowner may purchase off-site conservation offsets from other landowners to compensate for clearing that exceeds the required minimum (McKenney & Kiesecker, 2010). Only the Forest Code requires that compensation be of the same ecosystem type, unless the industrial development project directly impacts a protected area, in which case that protected area is the beneficiary.

Like Brazil, Colombia is rich in biodiversity (Saenz et al., 2013a). In contrast to Brazil, the Colombian ecological compensation system, a licensing program mandated by the national environment legislation *Decreto 1753*, sets the compensation requirement on an area basis. The developer is required to conserve or restore an area that is similar ecologically, but 4 to 10 times larger than the impact site. The multiplier is calculated with an algorithm that includes the impacted ecosystem's rarity, degree of representation in the protected areas system, the share of its original extent remaining, risk of conversion, and status as primary or secondary vegetation. The National Environmental License Authority (ANLA) determines the developer's requisite offset size and location (Villarroya et al., 2014). Created with help from The Nature Conservancy (Saenz et al., 2013a), the manual for this system was recently approved in 2012 (Resolución 1517 de 2012; Ministerio de Ambiente y Desarrollo Sostenible—Colombia, 2012). Before this new system was established, development projects were required to offset their impacts by reforestation close to the impact site, based on a simple calculation of trees per hectare. However, protection periods for offset sites were brief and little attention was paid to ecological equivalence (Saenz et al., 2013a). Moreover, monitoring was lacking and there exists no information on the previous program's effectiveness (Madsen et al., 2010). Hence, there are no fully implemented projects by which to judge the success of Colombia's ecological compensation efforts, but it remains an important case study nonetheless and potentially a model for other offset programs in South America.

Table 1 summarizes and compares the key characteristics of Brazil and Colombia's ecological compensation programs for development impacts according to the criteria described in the previous section. In general, Brazil appears to meet most of the criteria for reducing uncertainty and transaction costs. Brazil's system for development impacts provides regulatory clarity by requiring a payment that is a specific percentage of measureable capital costs. Brazil's policy also ensures that developers always have a supply of offsets available for purchase, since compensation fees are not attached to specific lands or activities and instead channel into a more general conservation fund. Furthermore, except for the caveat that those funds support the Protected Areas System, Brazil essentially places no geographic boundary on the expenditure of development offset funds (McKenney & Kiesecker, 2010). By capping payments at 0.5% of investment, Brazil's program also minimizes uncertainty regarding compensation costs. Moreover, since payments are channeled into the Protected Areas System via the Environmental Compensation Fund, offset actions are implemented by a government agency that specializes in conservation.

However, in practice there also have been severe bottlenecks in compensation financing, with only 10% of available funds disbursed in 2008 (Pinto et al., 2013). Although developers usually pay the requisite funds, administrative problems have prevented them from being efficiently spent on priority activities for protected areas (Madsen et al., 2010). Recent figures provided by the Brazilian Institute of Environment and Renewable Natural Resources, Brazil's environmental licensing agency, suggest that the situation is improving: The volume of compensation funds directed for specific uses rose sharply from R$10 million in 2011 to over R$274 million through November of 2013 (Antônio Celso Borges, personal communication, April 11, 2014).

Brazil's compensation system meets few of the criteria for enhancing ecological equivalency. Except for protected areas directly damaged by a development project, environmental impacts—direct and indirect—are completely decoupled from the objectives of conservation expenditures made with the offset payments (McKenney & Kiesecker, 2010). This disconnect is in spite of the fact that provisions for indirect impact exist in Brazil's general policies regarding environmental impact assessment (Villarroya et al., 2014). Because payments are based on the project's capital cost rather than

TABLE 1 Comparison of Ecological Compensation Policies of Brazil and Colombia According to Select Criteria

	Brazil	Colombia
Criteria to reduce uncertainty and transaction costs		
Straightforward and unambiguous rules	Strong: Firms can use a simple formula or pay the maximum 0.5%.	Moderate: Additional effort is required to calculate the habitat multiplier, but the algorithm is well-defined.
Robust supply of compensation sites	Strong: The supply of compensation action is not limited.	Strong: A wide array of public and private sites qualifies as offsets.
Predictable compensation costs	Strong: The costs are capped at 0.5%.	Weak: Offset selection criteria do not include compensation costs.
Compensation implemented by third party experts	Strong: The funds are channeled to the Protected Areas System.	Weak: The policy only specifies that the developer is responsible for implementation.
Efficient, transparent financial channels and intermediaries	Moderate: Developers generally pay their fees to the Compensation Fund but fund disbursement has been slow.	Weak: Traditional contracts are used and are not necessarily transparent.
Criteria to enhance effectiveness and ecological equivalence		
Direct and indirect impacts compensated	Weak: Neither direct nor indirect impacts are linked to compensation.	Moderate: Direct impacts are offset; indirect impacts are mentioned in assessment rules but not compensation algorithm.
Long-term financing assured	Weak: The environmental fund is not an endowment.	Weak: No endowment or guarantee is required. The offset only needs to last the duration of the development project.
Compensation new and additional	Weak: Compensation funds are for managing existing protected areas rather than establishing new ones.	Moderate: Additionality is indirectly considered in the offset ratio algorithm but is not explicitly mandated.
Correction for time lags	Weak: There is no time lag correction.	Weak: There is no time lag correction.
Project monitoring	Moderate: Compensation funds are used for protected area monitoring.	Strong: Monitoring must be done at both impact and compensation sites as long as impacts last.

its impacts, ecological equivalency is not ensured. The funds need not be used to conserve or restore the same ecological functions and assemblage of species impacted by the project. Neither does the program fund additional habitat conservation or account for any time lags. Instead, funds are applied toward solving land tenure issues; revising or implementing management plans; monitoring the protected area; and conducting research in the protected area and its buffer zone (Madsen et al., 2010).

The system does have some advantages for ecological management. Although financing is not necessarily assured, compensation actions must take place in public protected areas, which are designated for conservation in perpetuity and require an act of Congress in Brazil to degazette or change (Law 9985, Article 22, Section 7). Therefore, permanence is enhanced because population and economic pressures are less likely to reverse conservation actions in formally protected areas than they are in unprotected lands (Bruner, Gullison, Rice, & Da Fonseca, 2001; Villarroya et al., 2014). Also, despite its drawbacks, the system succeeds in allocating substantial funds for conservation. Pinto et al. (2013) estimated that in Pará alone, as much as R$2.2 billion (~US$1 billion) in compensation payments were generated by projects licensed from year 2000 to2014.

Colombia's ecological compensation program is more complex, with potentially higher implementation costs. Nevertheless, this system reduces regulatory uncertainty by utilizing existing spatial ecosystem data in a predefined algorithm to identify the appropriate location and size of offset sites, based on the geophysical characteristics of the development project (Saenz et al., 2013a). Developers potentially have access to diverse compensation options due to the comprehensiveness of the spatial database, based on remote satellite imagery, and a regional landscape-level approach to site selection. Although the ANLA determines the developer's requisite offset size and location, the program does not include a forum of exchange to facilitate transactions between offset buyers and sellers. The offset selection criteria also neglect to explicitly include restoration and conservation costs and thus fail to mitigate uncertainty regarding compensation costs. Although the developer is responsible for implementing offsets, Colombia's system does not address the issue of third party sellers, though third parties with expertise in ecological compensation may yet emerge over time. Similarly, the system currently includes no financial mechanisms or intermediaries to reduce transaction costs, though these may yet develop as the program matures.

Colombia explicitly sets no-net-loss as a goal of its compensation system (Villarroya et al., 2014). Thus, the strength of the Colombian system is in its potential to provide ecological equivalence in its offsets. The comprehensiveness of the spatial database and algorithm allows the ANLA to assign offsets, which are roughly commensurate to the developer's direct ecological impact. Only direct impacts are explicitly considered in the compensation algorithm, though indirect impacts are mentioned in the assessment rules.

The algorithm also implicitly incorporates some additionality concerns by considering historical loss rates, using the average over the previous 6 yr as the baseline. However, loss rates are but one characteristic among several which the algorithm weighs to generate the compensatory multiplier, which suggests that a commensurate offset selected by a developer may not necessarily be additional in all cases. Otherwise, the algorithm ignores additionality as well as time lags, shortcomings, which its authors acknowledge and suggest, should be incorporated into future iterations of Colombia's ecological compensation framework (Saenz et al., 2013a). The system also lacks any guarantee of long-term funding or other mechanism to ensure permanence of compensation actions. Importantly, permanence is undermined by the requirement that the offset last the duration of the development project only, rather than the duration of its impact (Villarroya et al., 2014). However, the assessment manual does call for monitoring at the impact and offset sites for the entire duration of the impact (Mouthon, Blanco, Acevedo, & Miller, 2002).

Comparisons between the Brazilian and Colombian ecological compensation schemes might suggest that there exists a fundamental tradeoff between regulatory simplicity and robustness in ecological equivalence. Brazil's straightforward rules regarding how compensation funds are generated may reduce uncertainty, transaction costs, and resistance to compliance by developers, but such simplicity results in a dearth of ecologically equivalent outcomes. In contrast, Colombia's geographically comprehensive algorithm for calculating appropriate offset ratios likely helps its system achieve ecological equivalency, but may also necessitate the creation of new market institutions, financial mechanisms, and other intermediaries to reduce transaction costs for offset buyers and sellers. However, the mitigation of uncertainty and transaction costs need not be mutually exclusive with robust ecological equivalence. The development of Peru's ecological compensation program may offer an opportunity to better balance these two objectives.

ECOLOGICAL COMPENSATION DEVELOPMENT IN PERU

Like Brazil and Colombia, Peru is a megadiverse country and a global center for species richness (Rodríguez & Young, 2000). Peru still possesses large continuous tracts of tropical rainforest, but has experienced significant ecosystem damage due in part to economic development of its frontier (Naughton-Treves, 2004; Oliveira et al., 2007). Mining, transportation infrastructure, energy generation, and natural gas extraction are major drivers of forest and wetland degradation and loss (Bovarnick et al., 2010). Moving toward better stewardship of its natural capital, Peru enacted the 2005 General Law on the Environment (Ley No. 28611), in which Article VIII specifically mandates the internalization of environmental costs from development.

The National System for Environmental Impact Evaluation (Sistema Nacional de Evaluación de Impacto Ambiental, SEIA) requires the mitigation of development impacts and ecological compensation for unavoidable residual damage. The SEIA does not specify the standards and criteria developers must follow to compensate their impacts. In 2011, the Ministry of Environment began analyzing policy options for specific rules, focusing in particular on the method for calculating a developers' financial obligation for compensation (Ministry of the Environment—Peru, 2011). In 2012, the Ministry invited public participation in the policy process through a series of workshops (Ministry of the Environment–Peru, 2013). The next year, the Ministry published draft compensation guidelines for developers on how to fulfill the SEIA's compensation requirements. Based on comments from experts and stakeholders, this draft was revised and published as a final Ministerial Resolution on December 5, 2014.

The resolution calls for an ecological compensation scheme with the following key characteristics: development impacts should be compensated by conserving or restoring ecologically equivalent areas; compensation actions should take place at least until project closing and continue if impacts persist; financial mechanisms should exist to ensure long-term implementation; and compensation activities should offset both direct and indirect impacts. These principles leave considerable room for interpretation and are voluntary during a pilot phase that will produce final, detailed rules in the form of two manuals developed by the Ministry of the Environment (Ministry of the Environment—Peru, 2014).

A POSSIBLE PATH FORWARD

Peru's challenge is to create a system that avoids the uncertainty and complexity that can exacerbate transaction costs while still meeting a basic standard of long-term habitat conservation and restoration to counterbalance losses to development. Although Peru's offset regulation development, with its emphasis on ecological equivalence, seems to follow the Colombian strategy more than the Brazilian system, the policies of both neighbors have important advantages that should be considered as Peru formulates detailed rules. The following recommendations attempt to combine the simplicity, straightforwardness, and predictability of Brazil's approach with Colombia's emphasis on scientifically robust ecological equivalency.

First, the government should invest up-front in generating and organizing the information that the system will require. As was accomplished in Colombia, a detailed ecosystem database, combined with scientifically robust selection methodology, would help Peru choose priority compensation sites that are compatible with national biodiversity conservation plans. Spatially explicit, best estimates of restoration and conservation costs could also be included in the database and selection algorithm. Developers could then more easily include compensation costs into overall project feasibility assessments.

Similarly, accounting that incorporates additionality and time lags should be folded into the offset and site selection algorithm, as suggested by the authors of the Colombian system (Saenz et al., 2013a). Applying time discounting for time lags, and a standardized scoring system for additionality, would be relatively simple and transparent to implement as long as the system strikes a pragmatic balance between pursuing exact ecological equivalence and allowing developers a set of practical choices. Employing such a consistent methodology could not only enhance ecological equivalence, but also eliminate uncertainty and transaction costs that come from more ad hoc, subjective approaches by reducing project-level analytical expenses and by narrowing the area of potential disagreement between developers and regulators.

A consistent metric or standard should also be developed for indirect impact estimation as well. Peruvian environmental impact assessment regulations already mandate consideration of indirect impacts (Supreme Decree 019-2009-MINAM, Annex IV), thus their centrality to compensation plans should be reiterated in the final rules. Policy makers could opt for a predictive model based on spatial analyses of historical land use change (e.g., Chomitz & Gray, 1996) or could simplify the methodology further by establishing a standardized set of offset multipliers based on the specific type of infrastructure development and a very limited set of biophysical factors that determine indirect impacts (i.e., flat terrain vs. mountains).

Additionally, the government should facilitate participation by a wide range of third party compensation providers, including public protected areas, private reserves and indigenous communities. In the short term, Peru could partially emulate the Brazilian model by using public protected areas as a ready supply of offset sites with clear property rights and known conservation gaps (Servicio Nacional de Areas Naturales Protegidas [SERNANP], 2009). In the longer term, Peru must establish the institutions, intermediaries, and mechanisms necessary to facilitate transactions between developers and private offset sellers.

Such systems could include a habitat banking program, which fits into Peru's existing compensation framework (Bovarnick et al., 2010). A fee-based system, like Brazil's, could allow developers to pay into an ecological compensation fund managed by a third party rather than undertake or contract for offset actions themselves. Unlike Brazil's program, however, the fee must be appropriately scaled to the cumulative direct and indirect impact of the development project and funds must be directed toward ecologically equivalent offsets. The management of larger natural areas offers economies of scale (Armsworth, Cantú-Salazar, Parnell, Davies, & Stoneman, 2011), for example, in management, monitoring, and risk allocation. By taking advantage of these economies of scale, a habitat banking system would reduce transaction costs and, consequently, the costs per offset credit for the developers (Bovarnick et al., 2010). Other options also include a mixed system of in-lieu fees and on-the-ground compensation actions, giving developers more ways to meet compensation obligations.

FINAL CONSIDERATIONS

The incorporation of many of these recommendations in ecological compensation policy requires a wider landscape-level perspective on development and offset activities, timing of offset generation, measurement of biodiversity and ecosystem services, consistent accounting procedures and rules for calculating losses and gains, transparent institutions and intermediaries, forecasting of future changes to natural habitats, and approaches to managing risk (Gardner et al., 2013). The enterprise of ecological compensation is still relatively new—having been developed in the United States in the 1990s—and programs which incorporate all of these considerations are rare (Madsen et al., 2010). Conservation outcomes from offset programs in developed countries have been inconsistent (Bull, Suttle, Gordon, Singh, & Milner-Gulland, 2013), despite their advantages in terms of available data, strong institutions, and monitoring capacity. Nevertheless, attracted to the flexibility and perceived simplicity of ecological compensation as a way to balance development with conservation, governments and nongovernmental organizations continue to draft new policies across the developing regions of Central and South America, Africa, and Asia. Most of these have yet to yield empirical results that permit evaluations of cost-effectiveness. While there have been a number of pilot projects in developing countries, many of these have been voluntary offsets involving relatively small areas (BBOP, 2009; Madsen et al., 2010). Therefore, while informative for project-level conservation or restoration methodology, they are not necessarily instructive for the formulation of country-level compensation policy. Consequently, many ecological compensation programs—including those in Brazil, Colombia, and Peru—will require periodic monitoring and evaluation in order to refine and improve policy design.

We hope that these recommendations can contribute to the elaboration of appropriate ecological compensation rules in Peru, leading to the effective internalization of environmental costs, stronger protection for species and habitats, and more socially beneficial development choices overall. If this process is successful, it could benefit other forested countries worldwide as they look for models for their own conservation goals, and the regulations and institutions necessary to achieve them.

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