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The implications of environmental trading mechanisms on a future Zero Net Land Degradation protocol

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ABSTRACT

Despite many important success stories around the planet, there is general disappointment at the overall impact of the United Nations Convention to Combat Desertification (hereinafter: UNCCD) during its first 20 years, with soil degradation still a challenge for land managers throughout much of the world's drylands. Calls for a new protocol under the UNCCD that will ensure "Zero Net Land Degradation" (ZNLD) have gained momentum since the tacit endorsement of the concept at the 2012 Rio + 20 summit. There is great conceptual appeal to a framework that implicitly allows for development by balancing associated soil fertility loss with commensurate gains resulting from restoration activities. Trading programs which seek to reach "zero net" degradation of other natural resources have been in place for many years now internationally and offer an important basis for assessing the practical and theoretical problems that are likely to arise under a ZNLD framework. This article summarizes the relevant experiences garnered in "offsetting" regulatory schemes in the areas of wetland preservation, biodiversity, forestry, greenhouse gas emissions mitigation, real estate zoning, and conventional air pollution control. While many of these initiatives take place in environments with completely different climatic conditions, they offer important lessons for ZNLD advocates. Pitfalls in offset programs are identified in the areas of: *reliability of trades*; *clear quantifiable units of measure*; *equivalence given land heterogeneity*; *and delayed benefits*. The article contains a series of recommendations for land degradation offsets based on this diverse international experience. Proven implementation strategies should inform any future ZNLD policies as part of national and regional regulatory programs to combat desertification and arid land soil degradation.

1. Introduction: Zero Net Land Degradation in the context of environmental offsetting policies

On July 27, 2012, the U.N. General Assembly approved the fifty-three page declaration, "The Future We Want," negotiated at the recent Rio+20 summit on global sustainability: (U.N. 2012). Buried in section 206 of the sweeping vision and prescriptions for a healthier planet, in the chapter addressing *Desertification*, *land degradation and drought*, is a single sentence that represents tacit international approval for an entirely new strategy to combat desertification. After some resistance, the merits of a Zero Net Land Degradation (ZNLD), a strategy advocated by the UNCCD Executive Secretary, was thus acknowledged: "We recognize the need for urgent action to reverse land degradation. In view of this, we will strive to achieve a land-degradation-neutral world in the context of sustainable development" (United The United Nations, 2012).

In so doing, the international community embraced a more pragmatic approach to the vexing conundrum of land degradation in the drylands. A ZNLD strategy implicitly recognizes the failure of existing programs to abate the massive global trends in land degradation. Today roughly one-quarter of all lands on earth (Bai et al., 2008) and some 40% of croplands are affected by soil erosion (Foley et al., 2005). The UNCCD was designed in the hope that countries could rely on voluntary programs that employed a "bottom-up" strategy that would be driven by international assistance from "non-affected" developed countries to "affected" countries that lacked the resources to implement a clear National Action Program. After twenty years, many reasons can be given as to why the UNCCD has failed to achieve meaningful progress at the global level among countries affected by desertification. On the one hand, affected countries have not provided the "top-down" guidance that land managers and farmers needed to prevent land degradation (Tal, Gordon, 2010). The UNCCD was not successful in facilitating the integration of its objectives into existing or new national development plans whose provisions may even exacerbate the problem of land degradation (Stringer, 2008). Financial

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mechanisms created by the convention and subsequently by its Secretariat and those initiated by the affiliated Global Mechanism program were never sufficient to fund the necessary investment in land restoration (Tal and Cohen, 2007). Finally, the overall strategy articulated by the UNCCD includes land restoration, but in fact, the convention creates little incentive for countries to focus resources and regulatory attention on the potential to renew degraded lands.

The ZNLD approach accepts the inevitability of additional desertification in the future that will be driven by the development that a growing population and economic expansion invariably produce. However, it addresses many of the shortcomings of existing UNCCD dynamics. To begin with, it creates a framework in which "development" and its implicit, associated economic benefits are linked to restoration commitments, presumably including financial commitments. There is an assumption that in order to reach an equilibrium state of degraded and restored lands, more prescriptive oversight will be required. Finally, the ZNLD's underlying orientation is also sanguine regarding the ability of restoration programs to rehabilitate soil integrity and improve land fertility (Tal, 2009; UNCCD, 2012).

For some time, the newer science of ecological restoration and the more traditional knowledge about rehabilitation and sustainable range management in arid and semi-arid regions have begun to inform land management strategies (Aronson et al., 1993). The results are impressive. For example, soil organic compounds typically increase by 35% as a result of reforestation and afforestation on cultivated lands in the drylands (Johnson, 1992). Accordingly, the ZNLD calls on countries to restore already degraded lands in order to ensure that the overall amount of degraded lands does not increase (UNCCD, 2011).

Zero net loss environmental strategies are no longer uncommon in myriad environmental policies adopted around the world. These programs implicitly embrace a flexible perspective that allows for the modest future losses of a natural resource to accommodate development as long as they can be "offset" by comparable or even greater restoration benefits. Programs exist on the state, regional and global level and are a sub-set of a growing number of ecological trading policies that have been called a "new economy of nature"(Daily and Ellison, 2002). These initiatives are alternatively called "mitigation programs" (U.S.) or "compensation programs" (EU).

The first country to adopt such an approach in addressing a conservation problem was the United States as it sought to address the steady disappearance of wetlands. By 1984, some 54% of U.S. wetlands had disappeared with considerable ecological ramifications (Robertson, 2000). Among the key ecosystem services provided by wetlands are flood control, filtration, nutrient reduction, wildlife habitat and recreation. In 1989, the U.S. federal government established a general policy through the enactment of amendments to Section 404 of the Clean Water Act (33 U.S.C. § 1344). While far from perfect, the system has contributed to stemming these negative trends and transforming large swaths of land into new or restored wetlands (National Research Council, 2001). The policy set out to balance any future loss with wetland mitigation and reclamation so that the total area of wetlands would either remain constant or increase. Even though 70% of wetlands are privately owned, in cases where damage to wetlands appears unavoidable due to infilling or draining, developers are required to "mitigate" the impact by enhancing alternative lands or replacing them (Zedler, 1996). While wetlands are characterized by a surfeit of water and stand in contrast to arid lands that face perennial water scarcity, the two ecosystems have similarities. Like dryland ecosystems, recreating wetlands or establishing new habitats, under a trading program with ecological integrity, is a long protracted process that may take many decades.

Since the inception of this initial offsetting program, additional "Zero Net Loss" frameworks have been employed in a range of environmental media. Forests are among the planet's most renewable resources with ecosystem services and natural grandeur restored after massive deforestation in America (Clawson, 1979), as well as in drylands across Israel (Tal, 2013). It is not surprising that forestry policies have also begun to apply no-net-loss methods: for instance, New Jersey requires replanting when trees are removed during development projects involving one-half acre or more; Maryland's *No Net Loss Reforestation Act* is based on a similar offsetting strategy (Maryland, 2009; New Jersey, 1993). Israel's forest agency has informally implemented a similar zero-net loss commitment.(KKL, 2013). Brazil has also adopted a "no net loss of habitat policy" which sets a minimum vegetative cover according to region (Brazil, 2001). Consequently, the Amazon Forest region has an eighty percent minimum cover standard, while the Amazon Savannah has only thirty-five percent (McKenney and Kiesecker, 2010). Clearly, the more arid the land, the more dispersed the tree cover should be in order to ensure sufficient water from reduced precipitation.

Fisheries are also given to "no-net-loss" frameworks. The Canadian Department of Fisheries and Oceans has enacted a long-term policy of requiring: "an overall net gain of the productive capacity of fish habitats" in its licensing program. Progress toward this objective is to be achieved through the active conservation of the current productive capacity of habitats, the restoration of damaged fish habitats alongside the development of habitats" (Canada Fisheries Act, 2012).

In the early 1980s, academics began to advocate the concept of "Transferable Development Rights (TDRs) as a market-based approach to land conservation (Carpenter and Heffley, 1981; Mills, 1980;). The models proposed that development rights be transferred from one property to another while establishing conservation easements (development restriction) as compensation on the former. Higher density and economically optimal real estate development is enhanced, relative to the outcomes in existing inflexible zoning regulations. These systems are conceptually and functionally similar to the ZNLD mechanisms envisioned – even as the context is completely different.

Offsets are typically attained under statutory frameworks through formal or informal permitting procedures that allow development that leads to clearance of natural ecosystems and habitats, contingent upon alternative habitat being preserved or created with a comparable conservation value. Germany was the first country to adopt an "offset program for biodiversity," implementing its Eingriffsregelung policy as early as 1976. Biodiversity impacts from development are assessed with regards to the entire affected ecosystem, estimating their capacity and the impact on natural scenery. The policy stipulates that any offsetting take place in two locations containing the same ecological habitats. In 2010, the program was expanded to allow for "habitat banking," even as voluntary banks had already been established. All sixteen of the Länders (German states) have already adopted local legislation which reflects different approaches to calculating damages and associated costs (Bakker, 2012). France and Sweden have also begun to integrate no-net-loss biodiversity programs into their national strategies (UK, 2011). A variety of regulatory programs have been established in the Australian jurisdictions, with a particular focus on offsetting any clearance of native vegetation (New South Wales, 2007). It is worth noting that the Australian programs are ambitious and typically go beyond replacement, calling for "net gains" in native vegetation (Victoria, 2002; Western Australia, 2006).

Globally, the Kyoto Protocol of the UN Framework Convention on Climate change contains several trading mechanisms. Perhaps the most prominent one is the "Clean Development Mechanism"

(CDM) program which allows developing countries to offset the carbon emissions of developed countries that cannot meet the targets set under the Kyoto agreement (UNFCC, 2013). The EU includes trading alternatives as part of its biodiversity strategy (EU, 2011). Several commentators have identified "common ground" between climate change adaptations and combating desertification at the policy level, even as case studies at the local level in Southern Africa revealed that mutually supportive links between these two programmatic objectives are poorly developed (Stringer et al., 2009).

Conceptually, most offsetting programs are predicated on the notion that the resource being protected is, to some extent, renewable. Relying on the resilience of biological systems, damage can be sustained in one place because anticipated gains in another will compensate for the loss. To demonstrate the point, even though it may be technologically possible, due to the prohibitive expenses, the rehabilitation of aquifers is extremely rare. This makes a "zero-net loss" program for ground water protection an unworthy regulatory strategy. The second assumption involves the availability of a damaged environmental asset that can be restored or a resource that can be improved to compensate for any ecological losses.

ZNLD attempts to take these concepts and apply them to the problem of land degradation. While soil itself is not a renewable resource using conventional time horizons, soil fertility, functionally, can improve with appropriate management practices and restoration strategies.Naturally, restoration processes in the drylands are particularly slow, and soil systems typically are less resilient and less quick to recover than forests, fisheries or even biodiversity (Cortina et al., 2009). Nonetheless, experience suggests that sustained interventions can produce effective results (Blum, 1998; Curry and Good, 1992; García et al., 2004).

Unlike other environmental media, where trading is allowed under the assumption that the resulting environmental damage usually is reversible, a ZNLD strategy recognizes that the fertility of many lands lost to degradation or development probably will never return. Yet, in a planet where land degradation is already so pervasive, the second condition –the wide availability of lands where restoration interventions can produce positive quantifiable outcomes- – makes it possible to accept additional losses.

In practice, when considering the form of ZNLD initiatives, it is important to recall that environmental trading programs have not always produced the intended results and surely are not universally successful. For instance, the EU's "emission trading system" that was to serve as a model for future global markets in the service of greenhouse gas reductions has suffered greatly as a result of the economic slowdown. Indeed, rather than encourage improved environmental performance, several factories have begun to move back from natural gas to coal, reflecting the drop in carbon prices (from 30 to 7 dollars/ton) in the market (Reed, 2013). The sulfur dioxide trading program, under the U.S. Clean Air Act, is credited with dramatically reducing SO_2 emissions and, with it, acid rain across the U.S. Even so, twenty years after its enactment, the SO_2 market has completely collapsed, with experts recently concluding that "the demand for federal SO_2 allowances has been virtually eliminated" (Schmalensee, Stavins, 2012). If ZNLD initiatives are to avoid similar fates, it is well to consider the considerable experience accrued in comparable natural resource offsetting frameworks.

Ultimately, even though the ZNLD rationale is conceptually gratifying (as the other articles in this section highlight), if offset programs are not designed properly, ZNLD programs can produce an environmental debacle—allowing catastrophic damage with no counter balancing environmental gains. Indeed, existing offset programs have been disparaged by critics as a "license to trash." Lessons emerging from these initiatives, therefore, are particularly instructive in the context of land degradation and new international strategies.

2. Lessons from existing offset programs

Based on critiques from existing offset regimes, it is possible to identify problematic dynamics that may cause ZNLD initiatives to fail to produce a positive environmental balance. These pitfalls are divided into the following categories:

- *Reliability of trades;*
- *Clear, quantifiable units of measure;*
- *Equivalence given land heterogeneity; and*
- *Delayed benefits.*

Each of these categories will be assessed with an eye to designing effective ZNLD programs in the future.

2.1. Reliability

Perhaps the most common critique of offsetting programs is that the trades are simply unreliable. Despite promises, too often offsets involve "paper calculations" that never actually take place. For instance, according to a 2008 review of seventy-six wetland mitigation projects, two-thirds reportedly did not adequately restore the area required under the trade or create an alternative wetland site (Matthews and Endress, 2008). A Canadian study found fault with a full 86% of the offsets involving the development of alternative fish habitats (Harper and Quigley, 2005). This kind of problem can be expected in programs that involve dryland restoration as the renewal process will be lengthy, making verification of a mitigation project for a restored dryland system a very long-term regulatory commitment.

Part of the problem is often political. In the area of wetlands trading, it is only natural that lobbyists for interest groups work to influence trades or even receive exemptions from offsetting projects altogether. Given the amount of profits associated with real estate development or logging old growth forests, the incentives to seek political interference are great. In the restoration of desertified lands, models presented by land developers will tend to inflate the pace and the extent of the renewal process. Predictions of restoration effectiveness in the drylands, in general, are extremely difficult because of foreseen threats (e.g., flashfloods or wildfires) and unforeseen threats. Indeed, evidence from Australia and the Mediterranean suggests that soil loss and degradation after wildfires may be more severe than was previously thought (Moody et al., 2013; Nyman et al., 2011).

Another factor that increases uncertainty is climate change, which is expected to affect many dryland regions dramatically (Bautista et al., 2010). Whether land managers should introduce species or ecotypes characteristic of regions with lower precipitation in anticipation of drier conditions or replace the original vegetation is a dilemma that will need to be considered by land managers at the local level (Vallejo, 2009). Fires in the Mediterranean basin are already beginning to reflect the climate change scenarios that anticipated more severe and frequent fires in areas where droughts will be far more common. This is one of the reasons why Israel chose not to pursue "carbon credits" through afforestation as a developing country within the Kyoto protocol's CDM trading system (Tal, Gordon, 2010). A variety of adaptation measures can reduce their future impacts and increase the likelihood of restoration (e.g., resprouting woody species, increasing the diversity of species in post-fire reforestation projects and improving water availability and water-use efficiency for introduced seedlings) (Duguy et al., 2013). But even the best models cannot anticipate what the actual effect on restoration efforts will be with any real confidence.

Another critical factor that will make it difficult to ensure the future benefits of present land restoration efforts is the critical interface between social and physical drivers of degradation. Over the years, farmers and pastoralists of the drylands have adapted to the vicissitudes of local "socio-ecological" systems, which increasingly involve political-economic contexts beyond their control. Thus, for example, world agricultural markets and even consumer preferences for different fiber and food products can completely alter the economic realities and exigencies of rural dryland communities (Easdale and Domptail, 2014). A broad range of "indirect" drivers involving a range of social conditions – from the status of women to land tenure systems –may constitute the underlying cause of practices that contribute to land degradation (Adeel et al., 2005; Tal, 2013). The evolution of such factors is exceedingly hard to predict. Yet, this does not mean that they can be ignored. The UNCCD's underlying strategic orientation of "bottom-up" engagement of local communities remains a significant challenge that will need to be addressed by land managers if implementation of a ZNLD framework is to be effective over the long run. It will not happen if there is not fundamental change in the actual behavior and practices of farmers, shepherds and developers in affected countries.

Legal arrangements can, however, help increase reliability and prevent empty promises. For instance, in his review of New Zealand's "no-net-loss" biodiversity trades, Norton argues that a key to ensuring the actual implementations involves requiring consenting authorities to create formal frameworks to guarantee implementation. These guarantees must be sufficiently robust (or protracted) to see that the anticipated benefits are actually attained years in the future. In cases that arose in New Zealand, the Environmental Court intervened to impose such safeguards on an approved biodiversity offset. For instance, in one case where virgin bush was to be destroyed to create a land fill, the court required such measures as:

- Registration of a covenant against the title that establishes a legal protection in perpetuity at the alternative bush site;
- Establishing permanent fencing in the protected bush and removal of all domestic grazing animals;
- Submission of a restoration plan within two years with annual reporting of progress;
- Transplanting and propagation of seedlings of rare tree species; and
- Ensuring public access to the new site for recreational, educational and scientific uses (Norton, 2009).

It is easy to imagine a ZNLD restoration plan with similar provisos.

To ensure implementation and the attainment of environmental benefits, conventional financial mechanisms can be employed. For example, long-term escrow accounts could be created to ensure that long-term land restoration projects are realized, much as they are required now to ensure implementation of toxic cleanups (U.S. EPA, 2012). If developers cannot capitalize on this level of commitment, they can be required to take out a long-term environmental indemnification policy with the private insurance sector (Monti, 2002).

Utilization of such financial mechanisms might make sense when offsets are proposed by real estate developers or by other enterprises with proven economic capacity to cover the costs of environmental damage (e.g., fishing companies). When land restoration in desertified areas is required in developing countries, frequently there will be no "deep pocket" available from whom such guarantees can be demanded. In cases where public lands are deforested, irresponsibly cultivated or salinized by poor water management by scores of individuals, in a "tragedy of the commons" dynamic, it may be impossible to identify the many parties who have contributed to the land degradation, much less make them pay for an offset project.

Effective dryland land restoration is not merely an exercise in preservation and frequently requires intensive intervention and investment (Tal, 2009). In the absence of a responsible developer, it is not clear that trades involving soil rehabilitation will always be realistic. Here the international community (e.g., the Global Environmental Fund) should consider the creation of a special financial mechanism. Its mandate would be to support the necessary land rehabilitation or management activities associated with ZNLD initiatives, in the event of insolvency.

2.2. Units of measure

Some environmental media readily lend themselves to offset programs, as the units of trade are straight forward. Hence, the setting of carbon dioxide equivalencies (the emissions that are equal to the amount of CO_2 that would have the same global warming potential) has allowed for the establishment of markets and a range of trading frameworks world-wide (Kruger and Pizer, 2004; Tal, 2009). Indeed, even the lay public is capable of computing their personal CO_2 equivalents via on-line calculators (U.S. EPA, 2013).

Other environmental media are far less given to uniform characterization. For instance, calculating compensation for habitat loss in an attempt to prevent net loss of biodiversity is far more complex. Even when two wetlands appear the same, they may, in fact, have very different levels of nutrient cycling or species composition. Nonetheless, the broad range of ecosystem services and contrasting levels of these services produced on seemingly similar lands have not stopped international and domestic offset efforts (Daily and Ellison, 2002). Procedures to estimate analogous environmental benefits have been established. For example, Victoria Australia adopted a grading system to rank the significance of vegetative losses, which it uses to determine whether an offset is "commensurate" or not. The system distinguishes between "high-significance" and "low-significance losses"—with greater flexibility allowed for the lower impact cases and little tolerance for highly significant areas that would be developed (Victoria, 2002).

Establishing criteria for measuring progress in preventing land degradation and restoring degraded drylands is particularly difficult because there is a broad range of opinions regarding the operational objectives of programs to combat desertification and how to characterize them. The Millennium Assessment from 2005 remains the scientific document with the broadest scientific consensus regarding appropriate strategies for combatting desertification. The report links desertification to the loss of ecosystem services. Accordingly, combating desertification is not just about the prevention of erosion and the loss of soil fertility or organic matter, but it also requires preserving provisioning services (e.g., food, forage, fuel, building materials, and water for humans and livestock, for irrigation, and for sanitation) and regulating services (e.g., pollination, carbon sequestration, etc.), as well as the less quantifiable cultural services, in the drylands (Adeel et al., 2005).

Given the general desire to simplify as much as possible in trading programs, a ZNLD system will most likely adopt "bottom-line" indicators for trades that involve easily measurable parameters in the soil. But there may well be situations where even these will vary. For instance, if soil salination poses the greatest challenge to soil fertility and future ecosystem service production, then it might come to dominate restoration specifications. Even when a unit is relatively clear, it is still a challenge to reach a level of specificity sufficient for the credible enumeration of environmental compensation. Forest loss is relatively simple to characterize and measure (even if "forest quality" is a far more challenging variable). Notwithstanding, in New Jersey, if a developer wishes to receive an offset credit for clearing forestlands, a detailed plan is required that must include:

- Tree species and size;
- Quantity of trees;
- Methods of planting;
- Management of the trees;
- Maps;
- Color photos; and
- Scaled landscape drawings.

Only following such detailed documentation can an offset be translated into quantifiable units and reviewed for evaluation, after which an offset may be granted (New Jersey, 1993).

Tree cover is easier to translate into objective units than "land restoration," especially in the drylands where the relationships between land cover and biodiversity and soil integrity are different than in more temperate regions. In China, an evaluation of afforestation on degraded lands after forty years revealed marked improvement in vegetation structure and species diversity (species richness, Margalef index, Shannon–Wiener index, and Sorensen's similarity index), soil nutrients (organic carbon, total nitrogen, extractable ammonium nitrogen, available potassium, and available phosphorous), and soil anti-erodibility indexes (water-stable soil aggregates, mean weight diameter, and the ratio of soil structure dispersion) (Jiao et al., 2012). Clearly, a trading program in the drylands would need to determine which of these criteria is most salient for restoring arid, semi-arid and dry sub-humid lands before it could ascertain whether or not newly restored lands sufficiently balance lands that were "forfeited" forty years earlier as part of a ZNLD program.

During its first fifteen years, implementation of the UNCCD was hindered by an inability to reach a consensus definition for benchmarks and indicators of land degradation. Recently, progress has been made in this regard (Orr, 2011). The ability to articulate and measure soil degradation (and rehabilitation) can be utilized as part of the international oversight in future offsetting programs. Nonetheless, the U. N. convention must continue to build on this work in order to reach a far greater level of specificity to make for replicable assessments and effective implementation.

As ZNLD programs move from the theoretical to the operational phase, there are innumerable parameters that might be used as indicators to show successful soil restoration and successful offsetting activities. These include: total organic C, water soluble C, carbohydrates, total N content, Protease-BAA and β-glucosidase aggregate stability and bulk densities. Soil enzyme activities and labile carbon fractions have also been identified as particularly sensitive indicators of the improvement in soil quality resulting from revegetation (Izquierdo et al., 2005). Ants have even been used as a proxy for successful soil restoration (Andersen and Sparling, 1997). ZNLD programs will have the benefit of the many years of ambivalence and agitation over agreeable standards under the UNCCD for measuring the degree of land degradation. But in order to facilitate a ZNLD offsetting program and make it accessible world-wide to local decision makers and developers, the "perfect," scientifically replicable unit of measure for land degradation will have to give way to a simple and clear one. For dryland systems, there is considerable support for prioritizing "slow" variables, for both social and biological progress, which are better able to characterize long-term trends and are less given to fluctuations (Carpenter and Turner, 2000). At the same time, making sure that ZNLD standards are easily measured at the local level will be crucial to ensuring that offsetting is taken seriously and leads to a balance or net gain of healthy lands.

2.3. Equivalence and land heterogeneity

A related problem common to offset programs involves environmental heterogeneity: not all fishing grounds, wetlands and, of course, drylands are created the same. Ecosystem composition may be very site-specific, differing dramatically across regions. This causes problems. In establishing a "no overall net loss in wetlands" as a statutory objective in 1990, the American Water Resources Development Act included a qualitative and a quantitative component to the process. Wetlands mitigation is to be 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). Yet, in retrospect, such language constitutes a vague and unsatisfactory mandate.

Dutch highway planning agencies employ a relatively simple approach when approving "compensation" trades to ensure biodiversity: The first step assesses the degree of equivalency of habitats or species (in-kind versus out-of-kind compensation). If they are not sufficiently similar, developers are required to seek an alternative location, with ecological values on the "compensation" site that are commensurate with the development site (Cuperus et al., 1999).

The proximity of the compensation site to the degraded one is one of the conundrums relevant to future ZNLD programs. Existing offset policies have sought to create new wetlands in the vicinity of the damaged site, but in practice, this has not always been possible. For instance, in order to meet program expectations, some wetlands off-sets, established in the proximity of a damaged site, proved to be forced, inappropriate and ineffective. This experience led to greater flexibility in regulatory design and approval of more distant wetlands in offset programs, as long as they were within the same watershed. According to biogeography theory, trading several small heterogeneous wetlands in a given watershed for one large homogeneous wetland will probably support a richer diversity of species and larger populations producing a net gain for biodiversity. But how far away should such an offset be allowed? Brazil has a broad "watershed" approach to compensatory sites for its biodiversity offset framework. Several regulatory agencies have come to rely on "mitigation banking" which allows for the compensating wetlands to be located further away (Robertson, 2004). Biodiversity banks have been proposed for trading where specific "valued" aspects of an ecosystem can be identified and replaced through new conservation initiatives.

In general, a distinction is often made between "in-kind" offsets—where mitigation creates habitats, functions or values comparable to lands affected by a project–and "out-of-kind" offsets where the compensation may take an entirely different form (McKenney and Kiesecker, 2010). While "in-kind" offsets are preferred, there will be cases where a trade-off, either in the quality or quantity of restored lands, makes sense.

Out-of-kind flexibility may be particularly compelling should an "additionality" criterion be included in a ZNLD program. A variety of trading initiatives have come to require that an environmental offset offer new "additional" benefits beyond an existing baseline level of environmental assets (Gillenwater, 2012). For example, rather than a one-size-fits-all compensation mechanism, Australian native vegetation programs allow a broad menu of land management options. Developers can choose between 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, assuming that they will generate environmental returns greater than those lost by land development (McKenney and Kiesecker, 2010).

Several proposals have been proposed to increase the likelihood of a "fair" trade in offsetting programs. For instance, biodiversity experts in Finland have prepared an uncertainty analytic framework for calculating "robustly fair offset ratios" that guarantee a high probability of producing as much conservation value in the offset area that is lost. The reliability of models that project future biodiversity in restored areas is ultimately dependent on the quality of data available and the levels of uncertainty (Moilanen et al., 2008). The problem of uncertainty can, to some extent, be overcome by increasing the "mitigation ratio" beyond a one-to-one trade in land area. For example, if the soil restoration benefits in a ZNLD offset are indeterminate, an area two or more times the newly degraded site can be required. Several U.S. states have applied such ratios for restoration offsets (e.g., New Jersey 2-1 for restoration actions; Ohio 2-1 for enhancement and preservation actions; and Michigan, a lopsided 10-1 in favor of preservation) (McKenney and Kiesecker, 2010).

Even with improved analytic decision methods for projecting ecological benefits, it remains difficult to ensure that the new wetland, habitat, fishing ground or forest contains equivalent or even comparable characteristics to the one being destroyed. As the *Sierra Club*, the leading American conservation organization, argues:

> *"It's easy to measure acreage, so that's what they do, but the real key is ecological function. Does one acre of newly created wetland (forest) compensate for the loss of an acre of mature wetland (forest) with complex hydrologic and ecologic linkages?"* (Sierra Club, 2005).

Clearly the answer to this rhetorical question is "no." There will invariably be cases when unique and rare habitats are involved for which appropriate matches are unavailable. In these cases, most existing national and international offset policies typically call for the rejection of proposed development plans or projects (European Commission, 2000; McKinney and Kiesecker, 2010).

Projecting the likelihood of successful land rehabilitation in a ZNLD framework is even more fraught with uncertainty as the process of soil restoration is more prolonged, and soil types and conditions can often be completely different (Tal, 2010). On a physical level, heavier soils will typically take far longer to reestablish themselves than lighter soils. Sandy soils may be less vulnerable to water runoff, but are more prone to wind erosion. It may not always be possible to have restored lands, in a ZNLD offset, contain an identical soil type or comparable permeability, density, porosity, acidity or nutrient and retention levels. On the conceptual level, if soil degradation is to be assessed by the loss of associated ecosystem services, than disparate communities will tend to define these services differently. The interface between subjective human values and myriad geographic needs and the physical dimensions of land fertility makes the establishment of a uniform format for evaluating tradeoffs even trickier. Yet, operational regulations can help guide managers in considering essential differences in lands before such offsets can be approved.

For biodiversity "offsets," as mentioned, the rarity and uniqueness of especially sensitive habitats mean that not all proposed development sites can be replaced. In order to address such dynamics, a "mitigation hierarchy" has emerged, which characterizes many offset programs. Typically, the hierarchy involves a three-step process of first considering the possibility of "avoiding impacts"; then requiring a "minimizing of impacts"; and only then allowing for offsetting compensation for residual impacts (McKenney and Kiesecker, 2010).

Presumably, special sensitivity is less common when compensating for land degradation and fertility. Nonetheless, ZNLD programs should establish a clear set of decision-rules to determine if lands are of special value or contain fertility for which no alternative tracts are available for restoration. In such cases, the "avoid" and "minimize" options should be imposed.

2.4. Delayed benefits

Restoration of renewable natural resources is a protracted process. Indeed, one study suggests that it will take at least forty years to fully restore the ecological integrity and carbon content of a wetlands system (D'Angelo et al., 2005). In drylands, ecological restoration may take far longer. For instance, only after forty years has China begun to evaluate the relevant benefits of its afforestation program in Loess soils, with results still highly preliminary (Jiao et al., 2012). When undisturbed, natural wetlands are removed, any ecological gains from restoration are considered to be a gamble that may (or may not) pay off in the future. Soils, however, operate on an entirely different "geological" time scale. An entire science, "Pedogenesis," evolved to characterize the slow processes that lead to soil formation. It can take hundreds of years to produce a centimeter of soil. Nonetheless, rehabilitating the biological productivity potential of degraded lands is surely possible. In a particularly successful dryland afforestation program in Israel's Yatir Forest, soil carbon content on highly eroded drylands *doubled* within thirty-five years of planting (Safriel et al., 2010), even if land fertility today is still but a fraction of the original levels prior to overgrazing. The restoration process has just begun. Accordingly, in ZNLD offsets, while ecological "losses" will be immediate, it will typically take a long time to find out whether the offset is producing the anticipated benefits (Bashkin and Binkley, 1998). The underlying dynamic is asymmetrical.

It is difficult, therefore, and frequently impossible to design a system that can guarantee such longwinded oversight. Hence the Sierra Club critique focuses on the inability to maintain a fifty-year monitoring and enforcement presence for offsetting. The organization argues that if it takes fifty years to create a healthy wetland or forest, then the capacity to monitor by an objective third party must be part of any trade, with a bank holding in escrow monies sufficient to compensate in the event that the promised ecological functions are not attained (Sierra Club, 2005).

The most common means of addressing the problem of delays in existing programs is a requirement that offsetting activities not only become operational but also be proven effective before allowing damaging projects to begin. Hence, in the U.S., conservation banking requires that lands set aside be "permanently protected through fee titles or conservation easements … in perpetuity" before the first environmental credit is granted. For wetland offsets, up-front demands include a secured site, an approved mitigation plan and even performance-based milestones (e.g., planting or establishing certain plant communities). The significance of *a priori* empirical evidence of benefit before approving a land trade is even more important in a ZNLD program because the science of the ecological restoration of drylands remains so undeveloped. Only recently did research find that carbon uptake in arid and semi-arid rangelands is typically controlled by abiotic factors and is not given to enhancement by changes in the management of grazing or vegetation (Booker et al., 2013). Assuming that the carbon content of soils is one of the key aspects of a ZNLD trade, additionality would not consistently be achieved by a trade on lands near the xeric end of a rangeland climatic gradient that was primarily based on the improved management of rangelands.

Such meticulous, "prerequisite" conditions and requiring a "burden of proof" prior to approving activities that will lead to land degradation are likely to constitute a significant disincentive for investors and are bound to be unpopular with developers. Beyond the considerable delay, a substantial monetary outlay must be made before the actual expenses associated with a project are incurred. And still, implementation of *a priori* measures for land rehabilitation will not entirely assuage the concerns of environmental advocates: a temporal lag will still exist, especially when soil restoration processes are involved. Despite the investment, there is no guarantee that the anticipated land restoration will be attained.

Moreover, because the environmental loss is considered to be largely irreversible, environmental benefits should be expected to be established "in perpetuity." In practice, this offers a more compelling compliance strategy. To this end, existing offset programs include such long-term elements as: management plans, performance standards, land tenure requirements, restrictions on damaging activities, monitoring, legal and financial assurances, and contingency and remedial actions in the event of offset failure (McKenney and Kiesecker, 2010).

In soil restoration interventions, a range of physical measures can increase the likelihood of an offsetting initiative's success. These include returning natural water flow patterns, removal of disturbances (e.g., fencing to guarantee seedlings against grazing damage) and zoning restrictions or stipulations. But ultimately, even if rehabilitating lands are declared to be closed reserves, there is little that can be done to guarantee the sustainability and success of these interventions in the long run.

3. Conclusions – learning from offset programs

Ultimately, soil productivity is a renewable ecosystem service, making soil restoration a very real and practical option on many degraded lands (Adeel et al., 2005). This means that ZNLD programs have a plausible scientific basis. To ensure the effectiveness of implementation, a global ZNLD initiative should integrate the lessons learned from existing offset programs designed for other environmental objectives.

For instance, after the International Union for Conservation of Nature reviewed offset programs around the world designed to ensure "no net loss of biodiversity," it recommended a six-step process for compensation actions:

- Biodiversity offsets should only be used as part of a hierarchy of actions that first seeks to avoid impacts and then minimizes the impacts that do occur;
- A guarantee needs to be provided that the offset proposed will occur;
- Offsets are inappropriate for certain ecosystem (or habitat) types because of their rarity or the presence of threatened species within them;
- Biodiversity offsets most often involve the creation of a new habitat, but can include protection of an existing habitat where there is currently no protection;
- A clear currency is required that allows transparent quantification of values to be lost and gained in order to ensure ecological equivalency between cleared and offset areas;
- Biodiversity offsets must take into account both the uncertainty involved in obtaining the desired outcome for the offset area and the time-lag that is involved in reaching that point (ten Kate et al., 2004).

Such recommendations are also highly germane in the context of land degradation offsets and address many of the aforementioned concerns about potential obstacles. Accordingly, the following six measures should be part of future ZNLD programs to ensure their effectiveness:

1. Financial mechanisms should be established to ensure the implementation of land restoration measures and the long-term monitoring of progress;
2. Clear parameters for assessing land degradation should be set prior to the approval of offsets. These should not only be a reliable indicator of healthy soils but also be measurable by and given to simple and inexpensive monitoring;
3. Prior to approval, detailed plans with quantified objectives need to be submitted to the relevant authorities. These need to include site-specific data about soil characteristics of the lost and rehabilitated site, specifying the measures taken to ensure the attainment of restoration objectives;
4. Once the plans are approved, soil rehabilitation efforts should begin in order to establish the feasibility of the offset program, even if the restoration process is still at a nascent stage;
5. Geographic flexibility can be built into offsetting programs and trades as long as it is also clear that in cases of especially valuable soils that are essentially irreplaceable, ZNLD offsets should not be allowed;
6. Scientific uncertainty about the final outcome of a land restoration intervention should lead to an increased mitigation ratio, where a greater area of land is rehabilitated than that which is lost.

Adoption of these conditions in ZNLD programs will increase the likelihood that net losses in land fertility will not occur as part of future land degradation offsets. This in no way means that present knowledge regarding land rehabilitation is sufficient. Based on the experience in wetland offset programs, experts recommend that research focus on documenting the methods behind successful restoration efforts. This means ongoing monitoring of several performance indicators to allow for "adaptive management," allowing for the integration of any lessons learned into future trades (Larson, 2013). A similar approach should be adopted for land degradation. There should be a learning curve that is linked to program specifications and expectations.

A global ZNLD strategy may offer hope for a frustrated international community that has not yet begun to meet the challenge of desertification. But it must be launched with foresight and humility based on the flaws of comparable offset programs.

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