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Designing Markets for Biodiversity Offsets:

Lessons from Tradable Pollution Permits

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Keywords: Biodiversity, offsets, tradeable pollution permits, transactions costs,

conservation planning

JEL codes: Q28, Q57, Q58

Designing markets for biodiversity offsets: lessons from tradable pollution permits

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Abstract

Biodiversity offset markets are one option for managing the trade-offs that exist between conservation targets and the increasing demand on land for urban development and agricultural expansion at local, regional and international scales. Drawing on lessons from the tradable pollution permit market literature, we review the key design parameters for biodiversity offset markets and consider how these have been applied in practice in the U.S., Australia, and the UK. We argue that offset markets should only be applied where the conservation target is a well-defined measure of biodiversity. Efficient offset markets require goods to be simple, measurable units that are fully exchangeable. This allows the market to operate under simple trading rules and engage with the widest number of participants, allowing gains from trade to be realised. We argue that a well-designed and managed offset scheme can be a more cost-effective way of meeting conservation targets than regulation.

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Urban development and agricultural expansion to meet the demands of an increasing global population have placed significant pressures on habitats and associated species (Foley *et al*. 2005; Pereira *et al.* 2010). There is a trade-off between these development needs and the long-term sustainability of biodiversity and associated habitats (Rands *et al*. 2010). Economists argue that incentive or market-based environmental policy mechanisms can help manage these trade-offs cost-effectively, making environmental protection possible at lower costs than regulatory alternatives. Identifying if, and how, these market-like mechanisms can be created is a major task for those interested in protecting the environment (Hanley *et al.* 2013). One of the best-known and researched environmental markets is the market for tradable pollution permits(TPP). An obvious question is thus whether market-based policies can be as cost-effective in securing biodiversity conservation as they are claimed to be for pollution control.

In this paper, we argue that much can be learnt from theory and practice in the design of TPP markets, which can be applied to the design of biodiversity offset markets. We first define biodiversity offsetting and offset markets, followed by a systematic review of the key concepts of permit trading in the context of pollution markets. Building on this, we then discuss what we consider the main parameters for successful biodiversity offset markets from an economics perspective and assess how these parameters have been applied in practice in the U.S., Australia, and the UK. We focus on markets for biodiversity offsets rather than bilateral deals between a developer and an offset investor. Markets where multiple suppliers and demanders of offset credits interact to establish an offset price are needed to realise the full cost-saving potential of the concept, since competition between offset suppliers is essential to enable cost-minimising conservation actions to be identified.

Defining Biodiversity Offsets

Biodiversity offsets provide measurable conservation gains to compensate for adverse impacts on biodiversity from project development (such as dam or road construction, or new housing) and are intended to result in no net loss of biodiversity (IUCN 2014). Offsets are considered to be the final option under the “mitigation hierarchy” after all reasonable measures have been taken to first avoid or minimize development impacts and then restore biodiversity on-site (ten Kate *et al.* 2004). Proponents of biodiversity offsetting argue that coordinated, large scale restoration efforts can provide quicker, more certain and cheaper mitigation than site by site mitigation undertaken by the developer (Defra 2013). By using a standard framework for evaluating impacts on biodiversity this can speed up the assessment process and give developers more certainty on what the planning system will require. Furthermore, the market element allows developers to purchase "off the shelf" offsets which removes the need for negotiations between regulator and developer over what would be provided as mitigation (Bonds 2003). Additionally, there is an expectation that habitat restoration would be undertaken by qualified ecologists rather than developers, resulting in higher quality habitats and sites that could be managed proactively for wildlife (Conway *et al.* 2013). Set against this, critics of biodiversity offsets point to a failure of offset projects to actually deliver the promised environmental benefits, and to inadequate monitoring and enforcement procedures (Maron *et al.* 2015).

The first country to adopt a market-based approach to offsetting was the U.S. under Section 404 of the Clean Water Act (1977) and required "no net loss of wetland acreage and function". Wetland mitigation banks were developed during the 1980s, although it was not until 1995 that Federal Guidance on banking was issued (Environmental Defence 1999). The application of offset banking expanded in the U.S. to encompass habitat banking for endangered species (now commonly termed "conservation banks") when the State of California allowed offset trading under the NCCP Act of 1991. As of January 2017, there were 1664 (Section 404) mitigation banks and 162 conservation banks listed on the U.S Bank Tracking System (U.S. Army Corps, 2017).

Global awareness of offset markets is increasing through initiatives such as the Business and Biodiversity Offsets Programme (BBOP) and interest from global conservation organisations such as the IUCN. Offsetting generates about between $2 and $4 billion per annum (US Dollars) in funds for conservation globally and brings 187,000 hectares of land under conservation or legal protection annually (Madsen *et al.* 2011).

From Tradable Pollution Permits to Biodiversity Offset Markets

Tradable pollution permits were first proposed by Crocker (1966). Many of the principals involved in creating TPP markets have important analogues when considering markets for biodiversity offsets. When establishing a permit trading scheme, the first fundamental issue to be decided by the government or regulatory agency is to set a cap (or limit) on overall emissions Once a cap is set, the allowed emissions, represented by permits, are allocated (freely or through auctioning) to firms (Hanley *et al.* 2013). Given their initial allocation of permits, firms are then able to buy and sell permits in the market. Since the reduction in allowed emissions, as reflected by the cap, creates emissions scarcity, this stimulates a market for emissions trading: firms that produce more emissions than their allocated quota need to purchase permits from firms who reduce emissions below their quota. There is usually significant heterogeneity in the marginal costs of emissions reductions between firms, and it is this cost heterogeneity that generates the cost-savings to be reaped through the trade of permits in the pollution market. Firms who can reduce emissions cheapest will supply permits and those firms whose marginal costs of emissions reduction are highest will look to purchase permits instead. If the permit market is competitive and all possible gains from trade are realised, the market minimizes the cost of achieving the emissions reduction target (de Vries and Hanley 2016).

One of the most successful TPP markets has been the U.S. sulphur dioxide (SO_2) cap-and-trade scheme, introduced in 1995 as part of the 1990 U.S. Clean Air Act Amendments. The objective of this program was to reduce total annual emissions by 10 million tons relative to 1980 levels. Many trades occurred, and emissions decreased by 36% between 1990 and 2004, with considerable cost-savings estimated relative to a command-and-control alternative (Schmalensee and Stavins 2013). The scheme highlighted the importance of monitoring and enforcement, as continuous monitoring helped to build market confidence (Stavins 1998). High levels of compliance were achieved by the large penalties that would be imposed on firms in case of non-compliance. The program also demonstrated the beneficial role of private sector brokers to provide information on prices and match trading partners, which significantly reduced transaction costs. These are costs associated with finding a trading partner (search and information), negotiating and concluding the deal and having the deal approved by the regulator (bargaining and decision), and costs associated with monitoring and enforcement. Transaction costs are indeed a key aspect of tradable pollution markets: high transaction costs are a barrier to trading and can prevent possible cost savings from being realised. A concrete example of this is the Fox River water pollutant trading programme in the U.S. where high administrative requirements eliminated gains from trade (O'Neil *et al.* 1983).

An important insight for the design of biodiversity offset markets from this experience is that the government needs to set a clear regulatory cap aimed at conserving a well-defined measure of biodiversity or habitat. The cap could require, for example, no net loss of a particular habitat type or of a particular protected species, as applied to the trading schemes operating under the U.S. Clean Water Act (1972) and U.S. Endangered Species Act (1973). Firms wishing to develop in areas which contain these habitats or species would need to hold permits showing that they are conserving a similar amount of habitat or abundance of the species elsewhere. These permits would be provided by landowners who invest in restoration or protection actions, which earn them a financial return from the sale of offset credits. The expected outcome of this market is that development would take place in the most expensive places to conserve, and conservation would take place in the areas where the costs of biodiversity enhancement are lowest, but crucially whilst still meeting the conservation targets set by the government. Indeed, a biodiversity offset market could minimize the costs of meeting the conservation target and the costs associated with meeting planning regulations imposed on developers (Fernandez and Karp 1998; Shogren 1998). The magnitude of the potential cost savings offered by a market of this type depends on how much variation there is in the costs of conserving the focal habitat or species across the landscape. Studies of conservation costs to date have revealed a high degree of heterogeneity in the costs of conservation (reviewed in Armsworth 2014), suggesting large efficiency savings may be possible from biodiversity offset trading schemes.

We argue below that much can be learnt from theory and practice in the design of TPP markets about the key design parameters of biodiversity offset markets (Figure 1). Summarizing, these lessons are that: (i) offset markets can be a more cost-effective way of achieving an environmental target than regulation; (ii) the more complex the design of the offset scheme, the higher the transactions costs of participating in the market, and thus the lower the fraction of potential gains from trade that can be realised; (iii) effective monitoring of actions and outcomes is required; (iv) the potential gains from introducing a biodiversity offset market are reduced by interactions with existing policies; (v) legally-binding targets bring greater participation than voluntary actions; (vi) how successful an offset scheme is judged depends on whether one prioritises its cost-effectiveness or its environmental effectiveness (Goulder 2013). We now review each of these factors in more detail.

1. Offset Currencies

TPP markets arose from specific regulatory targets for emission reductions, with the unit of permit trading represented by emissions (for example one tonne of SO_2). Efficient markets require goods to be grouped into simple, measurable, standardised units in order so that they are fully exchangeable, i.e., tradable. For biodiversity offsetting, a vague cap dictating “no net loss of biodiversity” leaves room for ambiguity and is difficult to measure and quantify. This undermines effective monitoring and enforcement, with the prospect of poor market functioning in terms of lack of both cost-effectiveness as well as environmental effectiveness. In contrast, if the cap were no net loss of habitat, then measurement using the habitat hectares approach to measurement could provide a suitable currency. This approach takes into account the area of habitat lost due to a specific development action, and uses this to calculate the area of new habitat needed. The habitat hectares approach has been applied to mitigation banking in the U.S., to BioBanking in Australia and more recently trialled in the UK as part of six biodiversity offset pilot projects (Parkes *et al.* 2003, Defra 2012) (see Panel 1). Alternatively, a regulatory cap based on endangered species populations allows the use of either habitat or species-based currencies. Species-based approaches take into account the spatial extent and suitability of a habitat for a particular target species and have been applied to several species as part of conservation banking in California (McKenney and Kiesecker 2010). One can also envisage a biodiversity offset market defined in terms of tonnes of carbon storage, for example in the context of saltmarsh and seagrass conservation. Broader policy goals, such as no net loss of wetlands function or delivery of some ecosystem services, would require a much more complex currency to capture the range of values and to also ensure equivalency in trading (Salzman and Ruhl 2005).

Many of the criticisms of biodiversity offset markets stem from the difficulties in measuring different aspects of biodiversity and how these translate into a mechanism of exchange (Bull *et al.* 2013). By placing a clear and quantifiable regulatory cap at the forefront of market design, the currency can be more readily established, and many of the concerns regarding trading different types of habitats, species and functions become less problematic. We recommend that offset markets should employ a simple currency that focuses on a single aspect of biodiversity, such as a single species or habitat type.

2. Trading ratios

Once the currency for exchange has been established (as determined by the regulatory cap), trading ratios are then required to determine the rate of exchange between sellers and buyers at different points in space (Drechsler and Wätzold 2009). For example, if one unit of offset credit is created by a restoration project in Location A, how many units of species conservation, habitat or other metric does this offset for a biodiversity-depleting project some miles away at Location B? Ideally, such trading ratios need to reflect the many potential sources of heterogeneity implicit in the definition of the credit. These include spatial variation linked to differences in habitats or species across space, and differences in the timing of delivery of gains versus losses (Bonnie 1999, McKenney and Kiesecker 2010; Maron *et al.* 2012).

The issue of trading ratios has been considered extensively in the TPP literature, as spatial variation in the damage costs of air and water pollutants gave rise to a considerable literature on how to consider such variation using trading ratios (Fowlie and Muller 2013). Trading ratios were originally developed for point-source air and water pollutants, where the effects of one unit of emissions on a measure of ambient air or water quality vary across space. Fluctuations in pollution damage costs over time (e.g., due to seasonal rainfall patterns) can also be included in trading rules (Hanley *et al.* 1998). Trading ratios are key to the design of point and nonpoint source pollution trading in the U.S. and Australia (Horan and Shortle 2011). However, complex trading rules, designed to be more consistent with environmental complexity in terms of the spatial variation in damage costs, have been shown to increase transactions costs, hence reducing market participation

The optimal trading ratio for biodiversity offsets has been explored theoretically from an economic perspective (see Bonds and Pompe 2003; Doyle and Yates 2010). The ecological literature has provided a series of ecological models and case studies. Methods have included Location Impact Factors to adjust for location differences between wetlands (Bonds and Pompe 2003); developing the widely used Habitat Equivalency Analysis into a landscape orientated method to account for spatial structures and connectivity in the landscape (Bruggeman *et al.* 2005); and accounting for uncertainty and time discounting on the offset ratio (Moilanen *et al.* 2009; Laitila *et al.* 2014). However, there is still no agreed method for calculating trading ratios (Bull *et al.* 2014), and it is not clear that all of these confounders are most usefully dealt with by adjusting trading ratios. For instance, including uncertainty over whether a specific offset project (or portfolio of projects) will deliver a specific biodiversity benefit in a trading ratio seems problematic. Such uncertainty over delivery is better handled by making use of banked credits whose environmental outcomes have already been certified, or by requiring traders to post an environmental bond which can only be redeemed when such certification is possible.

3. Market Definition

Market size refers to the number of potential buyers and sellers in a market. In the context of tradeable biodiversity offsets, this is affected by a number of factors, including the policy goal and geographic scale. Lessons from TPP markets have taught us that the greatest number of potential participants (largest market size) should be allowed to trade to maximise cost savings. Thin markets, comprising only a few number of offset buyers and sellers, result in reduced cost-savings and erratic price signals (Liski 2001). For biodiversity offset markets, erratic price signals will increase the uncertainty on investor returns from development and, in turn, increase development costs (Wissel and Wätzold 2010).

However, creating a large market geographically implies a greater heterogeneity in the biodiversity value of conservation actions at different sites. This places more emphasis on appropriately defined trading ratios to take into account locational differences. In practice, there is concern that large geographic markets run the risk of offset schemes being too far removed from the development site, leading to changes in the local functional quality and scale of habitats (BenDor and Brozović 2007).

Isolated mitigation projects are more likely to fail compared to a project that is incorporated into a larger, ecosystem-based conservation bank or regional conservation plan (Crooks and Ledoux 2000).

The majority of current biodiversity offset markets are compliance markets where developers can *choose* to purchase offset credits under the final stage of the mitigation hierarchy. If unable to avoid impacting a protected habitat or species and having already minimised the impact on it, a developer faces a choice of either undertaking an offset project themselves or finding a partner to do it for them whether inside the market or not. To foster the establishment of thicker markets, thus allowing the potential cost savings from trading to be realised, there may be an argument for *requiring* that developers purchase any offset credits they require through the marketplace (see Panel 2), rather than undertaking an offsetting project themselves.

4. Duration

Another important design question concerns how long a biodiversity offset should be valid for. Compliance periods in TPP markets are usually on an annual cycle with firms having to surrender or declare permit holdings equal to their emissions, whilst permits may have a legal validity extending over a longer period (e.g., 5 years). Over time, societies' demand for environmental policy may change, implying a need to adjust the regulatory cap on emissions. This argument can also hold for biodiversity conservation: biodiversity offset markets are designed to reach specific conservation goals, but societies' preferences for conservation may change. Moreover, the willingness of both buyers and suppliers to participate in the biodiversity offset market may be affected by how long credits are valid for (Broch and Vedel, 2012).

The majority of offset frameworks call for offset sites to be protected for as long as development impacts persist (Pilgrim and Bennun 2014). In cases where development is considered irreversible, the site should be protected in perpetuity. As discussed by Alvarado-Quesada *et al.* (2014), there is concern as to whether this is practical. Since funds are needed for long-term monitoring of mechanisms, legal assurance is needed to restrict activities which may harm the offset site, and a clear management plan is required detailing who will maintain the offset site and for how long. Evidence from existing offset schemes suggests that landowners and regulatory bodies view offset designation on much shorter timescales. In the UK, many stakeholders argued that restricting the definition of offsets to land set-aside "in perpetuity" was unattractive for landowners with many unwilling to permanently give up agricultural and development rights on their land (Defra 2013; Sullivan and Hannis 2015).

5. Administration

Administration in TPP markets includes enforcement, monitoring and reporting of trades and emissions reductions, as well as approvals for the buying and selling of permits. For biodiversity offset markets a central authority is also needed to administer the scheme to undertake ecological impact assessments, monitor actions and ensure compliance. It has been argued that both offset providers and buyers are price conscious rather than quality conscious, implying a preference for quick and cheap mitigation (Wainger *et al* 2010). Early experience of the U.S. wetland banking market showed that schemes suffered from low compliance rates and resulted in a net loss of habitats (Brown and Lant 1999). One option to resolve this is for the regulator to provide a clearing house or bank, similar to a TPP market. A clearing house buys the offset credits and then sells these on to developers needing to purchase credits. The regulator ensures adequate monitoring and reporting at the level of individual offset projects through the oversite of this clearing house; the regulator thus only needs to oversee the clearing house rather than multiple biodiversity offset providers. This eliminates the need for contracts and regulatory links between the permit providers and sellers, which not only reduces transaction costs but also ensures that credits are only being sold when they provide the required biodiversity value (Woodward and Kaiser 2002).

Conclusions

We have reviewed what we consider to be the key design parameters crucial to the success of a biodiversity offset market. When the preconditions for an offset market to offer an attractive policy option exist (for example, a clear regulatory cap on some aspect of biodiversity), then the choice of the offset metric and the determination of ecological equivalence – and thus of trading ratios – appear to be the most important factors in the performance of biodiversity offsetting as a policy tool.

Theory and practical experience in the design of tradable pollution permit (TPP) markets provides an insight into the resolution of the trade-offs between design parameters; for example, between recognising ecological complexity in the setting of exchange rates, and in reducing the transactions costs to potential participants. TPP markets have shown us that the most successful markets engage with a wide number of potential participants and operate under simple trading rules. Evidence from the U.S., New South Wales and the UK have shown that many of these lessons have not yet been applied in practice in biodiversity offsetting, implying that significant potential exists for improvement. Whilst bilateral offsets between a single developer and an offset supplier can ease tensions between development and conservation, only a fully-functioning offset market can realise the full potential of the concept in terms of minimising the economic costs of preventing future losses in biodiversity due to development, and providing an economic incentive for landowners to invest in biodiversity conservation. Learning the lessons from TPP markets will be important if the benefits of biodiversity offset markets are to be realised more fully in future.

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Figures and Panels

Figure 1: Design parameters for biodiversity offset markets. In designing offset markets there are five main parameters: the offset currency, trading ratio, offset duration, market definition and administration. Lessons for the design of each parameter can be drawn from economics, ecology and practice, with ecology teaching us the most about the choice of the offset metric and trading ratio, and economics teaching us how to design efficient markets. The choices made over any one parameter affects the other four either directly and/or indirectly.

Panel 1: Offset Currencies and Trading Ratios in Practice

New South Wales, Australia, launched BioBanking in 2010 following the Environment Protection and Biodiversity Conservation Act (1999). The main aim of the scheme is to integrate biodiversity into land use planning in areas with high development pressure, particularly within the coastal zone (Hillman and Instone 2010). BioBanking uses the habitat hectares approach with adjustments to take into account state and national priorities, regional value, landscape value and the threatened species response to proposed management actions. Post-evaluation reviews have highlighted that many ecologists feel the metric is a “rigorous, replicable and reliable scientific method for determining offset requirements”(State of NSW, 2014). At the same time, criticism has arisen over the baseline over which no net loss is measured, whilst others have argued that the policy exacerbates biodiversity decline rather than halting it (Maron *et al.* 2015).

In the UK, pilot biodiversity offset schemes were established for six local authorities from 2012-2014. The offset metric was based on the habitat hectares approach, with trading ratios used to adjust for the risks associated with restoring or expanding certain habitats and to take into account locational differences between the offset site and original site (Defra 2012). The metric received mixed reviews: some stakeholders stated that it was a relatively simple process to follow and that it delivered compensation above what would have happened in normal planning policy (Baker *et al.* 2016). In contrast, some ecologists felt that the metric was difficult to use and open to interpretation and did not account adequately for ecological connectivity (Lockhart 2015).

Panel 2: Developers Choice to Offset – A Barrier to Trading?

In Australia, 53 BioBanking agreements have been secured (as of May 2016), although many believe the scheme has not been as successful as expected. The current market has limited offset supply, which in turn has limited transactions and failed to produce the cost-savings initially anticipated. Many developers feel the strict offset requirements are a barrier to offsetting and instead choose alternative mitigation options. In response there are calls to make the scheme mandatory rather than being optional for developers, which would increase market participation and over time allow the efficiencies of trading to be realised (State of New South Wales, 2014).

Within the UK pilot areas, developers were required to provide compensation for biodiversity loss, and could *choose* to do so through offsetting. The UK scheme failed to create a single offset during the two-year programme. Follow up reviews highlighted that the potential benefits of offsetting would only be realised if driven through mandatory offsetting (Baker *et al*. 2016, Defra 2016). Despite the struggles with these pilot schemes, bilateral offsetting agreements are common in the UK as developers strive to meet conservation requirements under, for example, Section 106 of the Town and Country Planning Act. Moving these "off-market" trades into a more formal market-based setting would increase the potential cost savings that would be possible.