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Designing Markets for Biodiversity Offsets: Lessons from Tradable Pollution Permits

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Abstract

1. Globally, governments and regulators face an ongoing trade-off between meeting economic development needs and conserving biodiversity. Markets for biodiversity offsets are one tool which could secure biodiversity protection at lower costs to society whilst allowing some economic development to still take place.
2. We provide a new perspective on biodiversity offset markets by focussing on what can be learnt from one of the best-researched environmental markets: the market for tradable pollution permits. We argue there are four key design parameters in terms of *how* and *what* to trade. These design parameters likely determine the ecological effectiveness and economic efficiency of any market in biodiversity offsets.
3. *Policy Implications.* Applying lessons from tradable pollution permit markets will be important if the benefits of biodiversity offset markets are to be realised more fully in future. A well-functioning market for biodiversity offsets dually minimises the economic costs of preventing future losses in biodiversity due to development and provides an economic incentive for landowners to invest in biodiversity conservation. The most crucial aspect of the market is what to trade (the currency in the offset market), and this has significant implications on the other key aspects of market design; the trading ratio which governs the rate of exchange between offsets at different points in space and time; the scale of the market; and how the market is regulated. We argue that markets function best where the conservation priority is a well-defined unit of biodiversity which can be readily measured and monitored. In situations where there are already strong regulations safeguarding biodiversity, the benefit of biodiversity offset markets is in reducing the aggregate costs of conservation. We believe biodiversity offset markets will offer the highest potential in developing countries with weaker environmental protection and a greater need to reconcile economic development needs with conservation under limited funding.

Keywords

biodiversity offsetting, conservation planning, conservation policy, environmental economics, offset policy, habitat banking

1. Introduction

Some parts of the world already have strong regulations protecting biodiversity, however, in developing countries especially, there are ongoing trade-offs between meeting economic development desires and securing biodiversity conservation (Rands *et al.* 2010). Lowering the perceived cost of conservation is crucial in helping to reduce these development-conservation conflicts (Buschke *et al.* 2017). *Markets* for biodiversity offsets are one such tool to lower costs but identifying how this market-like mechanism can be best implemented is a challenging task (Hanley *et al.* 2013).

Biodiversity offsets compensate for unavoidable damage from development by providing measurable conservation gains and are considered the final option under the mitigation hierarchy, once measures to avoid, minimize and restore have been undertaken (ten Kate *et al.* 2004). Within the mitigation hierarchy, developers can offset directly or purchase offset credits from a third party provider who manages a parcel of land for its conservation value (ten Kate *et al.* 2014). Proponents of biodiversity offsetting argue that this allows for coordinated, large-scale restoration efforts which can provide quicker, more certain and cheaper conservation gains than site-by-site mitigation undertaken by developers (Levrel *et al.* 2017). Furthermore, the market aspect of biodiversity offsets provides an on-going financial incentive for land owners to invest in conservation (Squires & Garcia 2018).

There have been numerous reviews of biodiversity offsetting, predominantly from the ecological perspective concerning the effectiveness of restoration, the functionality of restored systems compared to natural systems, how to assess ecological equivalency, and additionality (Bull *et al.* 2013; Bull *et al.* 2015; Bull *et al.* 2017; Maron *et al.* 2012; Quétier *et al.* 2014; Maron *et al.* 2015; Maron *et al.* 2016). Perspectives have also been offered from environmental law and policy (Salzman & Ruhl 2000; Salzman & Ruhl 2006). However, there have been few contributions from the economics literature on the subject. This article extends the current literature by focussing on what can be learnt from one of the best known and researched environmental markets: the market for tradable pollution permits. We argue that valuable insights from theory and practice in the design of pollution permit markets can be applied to the design of biodiversity offset markets, particularly in terms of *how* and *what* to trade.

2. From Tradable Pollution Permits to Biodiversity Offset Markets

This paper argues that much can be learned about better designs for biodiversity offsets from tradeable pollution permit markets (Crocker 1966). By "better designs", we mean policies which achieve a higher degree of cost-saving whilst also meeting environmental targets. In a tradeable pollution permit market, a regulatory agency sets a cap (or limit) on overall emissions. Allowable emissions are then allocated to polluting firms freely or through auctions. Given their initial allocation, firms are then able to buy and sell permits in the market. Since the reduction in allowed total emissions creates scarcity, this stimulates emissions trading. There is usually significant heterogeneity in the marginal costs (the cost of reducing one more unit of emissions) between firms. It is this cost heterogeneity that generates the cost-savings to be reaped through permit trade. Firms that reduce emissions at the lowest marginal cost will sell permits, and firms with high marginal costs of reducing emissions will purchase permits. Through trading, well-functioning permit markets minimise the overall cost of achieving an emissions reduction target (de Vries & Hanley 2016). Fundamental to realising this cost-saving potential are *transaction costs*. For a market to function well there must be clearly defined property rights to facilitate the exchange of rights. Transaction costs are associated with defining, establishing, maintaining and exchanging such property rights (Stavins 1995). Higher transaction costs can inhibit both buyers and sellers from participating in a tradable permits market, so regulators must design trading programs with this in mind (Cason & Gangadharan 2003).

The use of pollution markets has grown substantially since the 1980s. One successful market has been the US SO2 cap-and-trade scheme, introduced as part of the 1990 U.S. Clean Air Act Amendments. Its objective was to reduce total annual SO2 emissions from power stations by 10 million tonnes relative to 1980 levels, in a manner which balanced the need to cut emissions against the desire to avoid high costs to industry. Trading resulted in cost savings between 15%–90% relative to the costs of conventional forms of regulation (Schmalensee & Stavins 2013). High levels of compliance were achieved through rigorous monitoring and enforcement (Stavins 1998). Another successful market was the US Lead Phasedown Permit Market, begun in 1982. This market provided incentives for firms to adopt more efficient technology earlier than under increased regulatory stringency alone (Kerr &

Newell 2003). In contrast to the SO2 and Lead markets, markets for water pollution have had varying levels of success with fewer programmes implemented. Where markets have been created, these experience a much lower trading volume compared to air pollutant markets (Fisher-Vanden & Olmstead 2013). Examples of water trading markets include the Fox River (Wisconsin) and the Dillon Reservoir programme (Colorado). More recently, regional, national and international permit trading of CO2 emissions has emerged in Europe and the US. We find that increased regulatory stringency (which raised the effective price of lead) encouraged greater adoption of lead-reducing technology. We also show that larger and more technically sophisticated refineries were more likely to adopt the new technology. Importantly, we further find that the tradable permit system provided incentives for more efficient technology adoption decisions.

Whilst tradeable pollution permit markets fix the total allowable level of emissions, the cap in a biodiversity offset market should relate to no net loss of a well-defined unit of biodiversity. Firms wishing to develop land would need to hold offset credits. These demonstrate the creation of additional conservation gains to compensate for damages caused by development. These credits would be provided by landowners who invest in restoration or protection actions, which earn them a financial return from the sale of credits. The price of credits should reflect the marginal cost of securing the offset, in the same way pollution permit prices reflect the marginal costs of reducing emissions. The magnitude of the potential cost savings offered by a market of this type relative to a no-trading alternative depends on how much variation there is in the costs of conserving the focal habitat or species across the landscape. Importantly, studies of conservation costs have revealed a high degree of heterogeneity (Armsworth 2014) suggesting large efficiency savings are possible from biodiversity offset trading schemes. However, the degree to which cost-savings are actually realised depends crucially on the degree and nature of offset trading.

3.1 Policy Targets and Exchange Currencies

Efficient markets require goods to be grouped into simple, measurable, standardised units so that they are fully exchangeable. The more diverse the units of exchange, the less efficient the market. Pollution markets arose in response to regulatory targets for emission reductions. The unit of emissions formed the credit (e.g., one tonne of SO_2 or CO_2), which has proved to be a fungible currency. However, it is significantly more difficult to translate biodiversity into a simple exchange mechanism (Bull *et al*. 2013).

A regulatory target of "no net loss of biodiversity" is broad and may encompass many elements of the environment. It is hard to reduce these elements to one single, unique unit of exchange (Bull *et al.* 2015). This results in an ambiguity in the choice of the offset currency. Historically, many offset schemes have favoured aggregated currencies which bundle elements of biodiversity, allowing for the substitution of elements which supports market flexibility (Gardner *et al.* 2013; van Teeffelen *et al.* 2014). However, these currencies run the risk of "out of kind trading" and are often critiqued for failing to secure no net loss (Bull *et al.* 2017). Habitat-based approaches were first used in US Wetland Mitigation Banking where credits were calculated using habitat acreage. More recently these have developed to take account of wetland functioning (Hough & Robertson 2009). A more complex habitat-based approach has been applied to BioBanking in Australia where credit value is based on several site attributes and the profile of an offset credit must match the credit profile of the land area being developed. This results in a large number of credit profile combinations, making it difficult for developers and landowners to match their credits (OEHNSW 2014).

Complexities in the definition of the unit of credit can have substantial impacts on the transaction costs. Increasingly complex offset currencies will have high requirements for data collection, reporting and monitoring. This increase in complexity will reduce gains from trade likely to be delivered (Woodward 2003). The success of the US Lead pollution market has been partly attributed to the ease of the monitoring and reporting requirements: refineries were responsible for self-monitoring and reporting but none of the requirements required more information than that which was already available (Hahn & Hester 1989).

The frame of reference used to define No Net Loss or Net Gain should be clearly identified in the policy goal. Frames of reference include the baseline from which biodiversity loss is measured and counterfactual scenarios for the level of biodiversity if development had not taken place (Gibbons *et al.*

2016). This allows the policy to be evaluated in terms of whether its outcome is better for biodiversity than in the absence of offsets (ten Kate *et al.* 2014). We argue that offset markets should only be employed where there is a regulatory cap on some specified element of biodiversity which is readily quantifiable. This will allow the establishment of a relatively fungible currency for the market, and for less costly assessment, reporting and monitoring. For more complex policy goals encompassing many elements of biodiversity, offset markets may not be the best approach.

3.2 Trading Ratios

The trading ratio refers to the relative quantity/quality of biodiversity gained and lost at offset and impact sites (Bull *et al.* 2017). Ratios are needed to reflect the many potential sources of heterogeneity implicit in the definition of the offset currency. These include spatial variation linked to differences in habitats or species across space and differences in the timing of delivery of gains versus losses (McKenney & Kiesecker 2010; Maron *et al.* 2012). Methods to calculate trading ratios have included Habitat Equivalency Analysis to account for spatial structures and connectivity in the landscape (Desvousges *et al.* 2018) and accounting for uncertainty and time discounting (Laitila *et al.* 2014). The more complex the definition of the offset credit, the more likely that trading ratios will be required.

The issue of trading ratios has been considered extensively in the pollution literature, due to spatial variation in the damage costs of air and water pollutants (Fowlie 2013). Trading ratios were originally developed for point-source air and water pollutants, where the effects of one unit of emissions on some measure of ambient air or water quality vary across space (Hanley *et al.* 1998). Trading ratios are key to the design of point-nonpoint source pollution trading in the U.S. and Australia (Horan & Shortle 2011). However, complex trading rules, designed to be consistent with the spatial variation in damage costs, have been shown to increase transactions costs, hence reducing market participation. This was particularly evident in both the Fox River and Dillon Reservoir water pollution markets. The Dillon Reservoir programme imposed a 2:1 trading ratio, which raised the price of trades and diminished the demand and number of trades that took place in the first 15 years of the scheme (Woodward, 2003). For the Fox River, just one trade took place during the whole lifetime of the scheme, due to the complexity of the design of the scheme which required significant regulatory approval and created high transaction costs for firms (Atkinson & Tietenberg 1991). Strict regulatory requirements have also been a feature of offset markets in New South Wales Australia. Reviews of BioBanking have shown that many developers feel the strict offset requirements are a barrier to offsetting and instead choose alternative mitigation options. The current market has a low offset supply which is limiting transactions and failing to produce the cost-savings initially anticipated (OEHNSW 2014).

Offset markets work best when the currency is a readily measurable habitat or species. In turn, this reduces the needs for overly complex trading ratios. Moreover, we recommend that offset credits are only exchanged when the environmental outcomes (gains) have been certified (Bekessy *et al.* 2010). This eliminates uncertainty over whether an offset project (or portfolio of projects) will deliver biodiversity benefits and limit the predictive modelling required to calculate losses and gains. This already happens under US Wetland Mitigation Banking where a credit release schedule is defined at the outset of the project. The schedule should reserve a significant share of credits to be released only after the achievement of ecological performance criteria, although some advanced credit release is permitted to foster investment (McKenney & Kiesecker 2010).

3.3 Market Scale and Trading Volume

Successful pollution markets are those featuring a significant number of potential participants. In thin markets, comprising only a few buyers and sellers, trading may be inhibited and the performance of the market can suffer. In the US, SO_2 markets have been more successful in reducing compliance costs and meeting emission reduction targets than water pollution markets, due to the absence of geographic limits imposed on the SO_2 market and thus a large number of potential traders participating. Water pollution trades are restricted to the watershed only so that firms have more limited trading options. Moreover, thin markets are more vulnerable to the exercise of market power by individual traders (Fisher-Vanden & Olmstead 2013).

Many existing biodiversity offset markets have similar geographic restrictions to water pollutant markets. From an ecological perspective, larger geographical markets run the risk of offsetting being too far removed from the development site, leading to concerns over changes in the functional quality and scale of the traded habitats (BenDor & Brozović 2007). This can be overcome in principle by using a trading ratio accounting for locational differences. Smaller geographic areas, however, limit the scope for trading. For example, the UK biodiversity offset pilot primarily restricted trades to within the local authority area and failed to create a single exchange, given the limited number of buyers and sellers (Baker *et al.* 2013; Carlos 2017). In contrast, The US Wetland Mitigation Banking Market operates over much larger service areas.

The second concern regarding large offset markets is how these change access to biodiversity for people living closest to the planned development (BenDor & Stewart 2011). This is even more challenging in developing countries, where people are often more dependent on natural resources and poorly executed offsets could exacerbate poverty (Griffiths *et al* 2018). Griffiths *et al* (2018) argue that a no-worse-off principle should be applied: social gains from new offsets must be at least equal to any social losses arising from development. This additional principle will add a further layer of complexity to the offset system, potentially requiring reduced geographic markets and/or further trading ratios to account for locational differences between affected persons.

Despite these concerns, we would advocate creating at the minimum a regional offset market embedded in a broader landscape plan. This offers the opportunity for thicker markets to develop with more traders and allows for less volatile price signals, reducing uncertainty for investors in conservation (Wissel & Wätzold 2010). From an ecological perspective, isolated offset projects are more likely to fail when compared to a project that is incorporated into a larger, ecosystem-based conservation bank or regional conservation plan. In contrast, a habitat or species which is found in a limited or niche area offers fewer opportunities for creating offset sites, increasing the costs of degrading these habitat types to the point where development may no longer be viable.

3.4 Regulating the market

An ongoing concern with biodiversity offsetting is that it provides an incentive for quick and cheap mitigation: whilst both offset providers and buyers are price conscious, neither need be quality conscious (Wainger *et al.* 2010). To resolve this, adequate governance, monitoring and enforcing of offsets needs to be developed through a range of legal and financial tools. However, this means that the regulatory capacity needed to administer biodiversity offset markets is high and may not exist in all countries (ten Kate *et al.* 2014). Moreover, higher regulatory and reporting requirements typically result in higher transactions costs, reducing the gains from participating in an offset market (Stavins 1995).

In the pollution permit market, brokers provide information on potential trading partners in order to reduce search costs for firms. A clearinghouse buys pollution reduction credits and then sells these to polluters needing to purchase credits (Stavins 1995). The equivalent could be devised for a biodiversity offset market where the regulator provides or facilitates a clearinghouse which buys the certified offset credits from landowners 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 oversight of this clearinghouse. This not only reduces transaction costs but also ensures that credits are only being sold when they provide the required biodiversity value (Woodward & Kaiser 2002).

A further difference between the pollution permit markets and current biodiversity offset markets is the often-voluntary nature of biodiversity offset markets. One of the reasons behind the success of the SO_2 market was that firms were mandated to acquire credits, or else to cut their emissions (Stavins 1998). In contrast, developers can *choose* to purchase compensatory offsets as the final stage under the mitigation hierarchy but can also choose to undertake their own mitigation. As such, there is a limited business case to motivate landowners, communities and NGOs to invest in long-term activities to provide offset banks (ten Kate *et al.* 2014). One perspective is to re-consider the traditional application of the mitigation hierarchy by allowing developers to choose a “best package” of conservation outcomes from avoid, minimize, restore and offset. Relaxing the hierarchy to allow developers to choose whether they avoid, minimize, restore or purchase offsets may offer a potential net gain for conservation activities as developers can choose to send funds to the least cost conservation activity (Squires & Garcia 2014).

3. Conclusions

This paper analyses key parameters for biodiversity offset markets based on insights from theory and practice in tradeable pollution markets. We have shown that the most effective pollution permit markets engage with a wide number of participants and operate under simple trading rules to reduce transaction costs. Biodiversity offset market regulators need to design schemes which encourage participation and foster the development of a market. The key design parameters we identify are i) policy targets and exchange currencies: the unit of exchange should be determined by the regulatory cap for a specified aspect of biodiversity where data can be readily collected and monitoring take place with relative ease. ii) the trading ratio: we recommend using as simple a scheme of trading ratios as consistent with the environmental objective, to avoid increasing transactions costs. iii) Market scale and trading volume: we would advocate creating a regional offset market embedded in a broader landscape plan to maintain an adequate scale of offset market whilst minimising uncompensated local impacts. iv) Regulating the market: the regulator should provide or enable a clearinghouse or bank(s) for offset trades, similar to a tradable pollution market.

Can biodiversity offset markets prove to be a cost-effective conservation mechanism? In situations where there are already strong regulations safeguarding biodiversity, the benefit of biodiversity offset markets is in reducing the aggregate costs of conservation. If an appropriate geographic scale is chosen for biodiversity offset markets, there may also be benefits in terms of more coordinated conservation. However, these potential benefits must be weighed against the risk of slippage in poorly-designed or regulated markets. Potentially bigger biodiversity gains through offsetting can be reaped in places where strong biodiversity protection measures do not yet exist and where finding a means to reduce perceived “biodiversity versus development” conflicts will be key to convincing reluctant regulators to implement stricter protection measures. For these gains to be realised, markets must be designed in a way which enhances the chances of cost-saving trades. This paper shows that we can learn from tradeable pollution markets how to enhance biodiversity offset markets in a way that does not undermine conservation goals.

Authors' Contributions

K.N, F.dV and NH conceived the original idea for the paper. K.N undertook the literature review and wrote the manuscript. P.R.A participated in drafting the article and revising it critically for the intellectual content. All authors contributed to and gave approval for the final manuscript.

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Data accessibility

We do not use data in this article

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