Using Environmental Offsets in Wetlands Management

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Abstract

Environmental offsets have been proposed as a technique for managing the environmental impacts of new developments in regions that are not in compliance with environmental standards. By requiring developers to "offset" any impacts by purchasing "environmental credits", environmental quality can be maintained or even improved. Environmental offsets have a lot of intuitive appeal, and are being used widely in the USA, Australia and other countries. However there is at present no robust theoretical framework for analyzing the use of offsets, which has led to some of the weaknesses of existing programs and criticisms against the use of offsets. We present an economic model for designing offset programs that is based on identifying and valuing environmental service flows. We also discuss a number of factors that influence the effectiveness efficiency of offset programs including fungibility, effects on incentives of landholders and uncertainty and make recommendations about how to respond to these factors based on our model. The distributional effects of offsets are also explored and it is noted that offsets are not distributionally neutral. We argue on the basis of distributional effects that it is not appropriate to use offsets alone to seek to improve environmental quality. Furthermore, we recommend the combining of offsets with other market-based instruments such as Pigouvian taxes or cap and trade systems in order to reduce the negative distributional effects of offset programs, provide greater scope for achieving environmental improvements and to increase the probability of achieving first best (socially optimal) solutions.

Keywords: offsets, market-based instruments, efficiency, distribution

1. Introduction

The primary goal of offset programs is to allow further development while maintaining existing levels of environmental quality. The central idea of an offset program is that developers "offsets" impacts at a development site by undertaking equivalent environmental improvements at a second, nearby, site. Developers either undertake the offsets themselves or purchase environmental "credits" from a business or government agency that specializes in generating these credits, which is known as an "offset bank". As a result, there is no net-environmental impact. The use of environmental offsets is therefore consistent with the notion of strong sustainability, whereby sustainability is achieved when the overall stock of natural assets is not diminished (Hanley, White and Shogren 1997). Offsets may also be designed so that they achieve net-environmental improvements. This would happen if developers were required to achieve larger environmental improvements than any impacts they have caused.

Most applications of offsets have occurred in the United States, where they have been used in several different contexts. Perhaps its best-known application in the United States is wetland mitigation banking (US Corps of Engineers et al 1995). Here, if new developments cause wetland impacts and it is not possible to mitigate these impacts on-site (using best available technology), then wetland offsets at secondary sites may be approved. Some 219 wetland mitigation banks were found to be operating in the United States in 2001 with another 95 banks pending approval (Environmental Law Institute 2002).

There has also been a lot of interest in Australia in the use of offsets. There is an offset policy for aquatic habitat in place (NSW Fisheries 1999) as well as a major vegetation offset program known as Property Vegetation Planning which was legislated in 2004 (NSW Government 2003). Various other offset trials involving biodiversity, nutrients and salinity are being conducted in other states (NSW Environment Protection Authority 2002a, 2002b, Whitten et al. 2003). Offsets are also being proposed as an alternative for controlling the emission of greenhouse gases.

Given the increasing the use of offsets in the USA, Australia and elsewhere, it is worth considering some of the theoretical and applied issues in implementing offset programs from the perspective of economics. Indeed there is reason to be cautious in the implementation of offsets programs, with existing empirical evidence suggesting that some programs have been problematic. For example, Salzman and Ruhl (2000) reported evidence from Maryland relating to Wetland Mitigation Banking that despite there being a gain of 122 acres in the Chesapeake Bay area through mitigation between 1991 and 1996, there had been a net loss of 51 acres of wetland functions. Furthermore, some commentators have suggested that theoretically offsets are more suited to certain environmental problems such as pollution control rather than biodiversity management (Vernon and Godden 2002).

Surprisingly, theoretical issues have not received a lot of attention in the debate about offsets. Arguably, a proper theory for offsets has not yet been developed, with only limited treatment in Baumol and Oates (1988) and Vernon and Godden (2002). Therefore in Section 2 we develop an economic model of the use of offsets in wetland management. We show that some of the present confusions in the literature arise out of the lack of a strong modeling framework. Then in Section 3 we use the model developed in Section 2 to analyze some of the more applied issues in designing offsets policy, including fungibility, risk and uncertainty, the effect on incentives, distributional issues, and combining offsets with other market based instruments. Some final thoughts about the prospects for the use of offsets are offered in Section 4.

2. A Model of Offset Banking

Offset banking has a lot of intuitive appeal. An intelligent six year old would grasp the concept and appreciate the sense of "fairness" involved. If you mess up an area and you are unable to clean up that area, you should clean up an equivalent area elsewhere. But whatever the intuitive strength of offsets, there is no agreed framework for understanding the application of offsets. We develop a model for offsets policy based on the models used for understanding pollution permits, such as Krupnick et al. (1983). This relatively simple framework can clear up many of the existing confusions in the literature on offsets.

Offset banking is a regulatory scheme where private developers must "bank" some equivalent land for each private development that is pursued in a wetland area. This banked land is purchased by the private developer and handed over to a wetlands bank that will restore the wetland function of the land and hold that land in trust. In the following we assume that the banking of land will guarantee the flow of environmental services from that land, but the development of land will cut off all environmental services from that land. The operation of wetlands banks is discussed in Section 4.

How are we to value an environmental asset such as an acre of wetlands? It is the flow of environmental services from the wetlands that are valued by society, although an existence value for the acre could also be included. Valuation methods such as contingent valuation or choice modeling surveys can place a value for society on a unit change in the environmental services.

In a wetlands area, we can identify the different environmental services that the area produces. Assume we have n types of environmental services that we identify as of interest from a wetland area. The marginal social benefit for environmental service j depends on the quantity of environmental services. Assume we can estimate the net present value of an infinite flow of service j, call that value P_j. We have a vector P of length n of the prices of the environmental services flowing from a wetland[1].

We can estimate the flow of environmental services from an acre of the wetland. We can then divide the wetlands into m zones, where all of the acres in each zone have similar environmental services flows. We can then define a vector of average environmental services flows for each acre in zone i as the vector of length n, D_i (a row vector). We stack these vectors into a matrix of dimension m times n, D. The element D_{ij} of matrix D then represents what an acre of wetland in zone i produces in terms of environmental service j. The "region" concept here is flexible in the sense that we could define region geographically or we could define region as a "type" of land, such as restored versus original wetlands, or a mix of the two.

Offset banking is then represented by a set of purchases of land in the wetland. The development of an acre will remove the environmental service flow of that acre, so we would represent that development by a negative number. The transfer of land to a land bank or the rehabilitation of land is represented by a positive number, since it will guarantee positive future flows of environmental services. We can represent an offset by a

[1] The benefit transfer technique would be well-suited to developing these prices. If the use of prices is considered inappropriate or if prices are not possible to generate in a region, then some form of weights could be used based on, for example, multicriteria analysis.

vector of numbers of length m, O, where each element O_i represents an offset or development of O_i acres in region i.

The net change in environmental service flows from a particular set of land purchases and offsets can be represented by the vector product

$$O'D$$

And the social value of the net environmental flows affected under an offset is calculated:

$$O'DP$$

An offset scheme will typically specify the ratio at which land in different regions can be swapped. Acres within the same zone will trade at one-for-one, but acres outside that region will typically transfer at a higher or lower rate. Define this transfer ratio by a vector, T. An offset scheme then can be represented by the requirement that any development on land within the wetlands be accompanied by a transfer of other lands into a land bank such that:

$$O'T \geq 0$$

Where the ratio T_B/T_A is the rate at which the developer is allowed to transfer an acre from region A into a number of acres from region B. An offset transfer ratio can be defined as one acre in region A is equivalent to two acres in region B, or as one acre of original wetland is equivalent to two acres of restored wetland.

The transfer of private land into a land bank for an offset will require the purchase of that land on the open market. Let C(O) be the market cost of acquiring the vector O of acres of private land for the development and the offset. The price in the open market is assumed to be the private development value of the land. For negative values of O, the vector C(O) represents the development value of an acre, while for positive values of O, the vector

C(O) represents the cost of acquiring land to put in a bank. The marginal cost of acquiring an acre in zone j is then $\frac{\partial C_i(O_i)}{\partial O_i}$ which is a non-decreasing function of O_i.

We can define a social optimum problem. Let the value of the private land to enter a land bank be the market cost of the offset, then minimizing the purchases of private land minimizes the market opportunity cost. The socially optimum distribution of private land for development versus private land for offset banking occurs at:

Max {-C(O) + O'DP}

Where C(O) is the loss and gain of private development possibilities and O'DP is the gain of environmental services in the bank.

The social optimum occurs when for an acre in region i

$$\frac{\partial C_i(O_i)}{\partial O_i} = D_i P$$

Where the development value of a marginal acre in region i ($\frac{\partial C_i(O_i)}{\partial O_i}$) is just equal to the value of the environmental flows from an acre in region i (D_iP).

First-best outcome: At the social optimum, all acres in region i with a development value greater than D_iP will be developed, while some or all of the acres with a development value less than D_iP will be banked.

Under an offset we are typically in a second-best situation where, instead of maximizing social welfare, we maximize some constrained problem. Offsets were initially designed for a case where the area was already in violation of some environmental standards, so that no scheme could proceed that involved lowering any of the environmental flows.

The restricted social optimum in this case is:

Max {-C(O)}

Subject to $O'D \geq 0$ (n constraints)

Where the private developer is achieving the high net value of land purchases subject to the requirement that there is no net loss of any of the n environmental service flows. This model is just a variant of Krupnick et al (1983). From Krupnick we know that an offset that minimizes the market value of private land withdrawn from the market is feasible.

Typically in an offset banking scheme, the problem facing a developer is:

Max {-C(O)}

Subject to $O'T \geq 0$ (one constraint)

where the private developer is minimizing the net value of land purchases subject to meeting the trading requirement under the offset banking scheme.

Using this notation, some of the previous discussion about offsets becomes clearer. We will explore some of these issues in the design and implementation of offsets in the next Section.

3. Some Challenging Issues with Environmental Offsets

While offsets are particularly intuitive, there are a number of factors that can greatly influence the efficiency, effectiveness and equity of offset programs. In this section we discuss six of these issues and make recommendations about how each ought to be managed.

Fungibility

Fungibility refers to the equivalence of different types of pollution or biodiversity. The concern is that the implementation of an offset scheme will lead to a drop in environmental services in a particular region or of a particular type.

There are two separate issues in the discussion of fungibility. The first is one of incorrect implementation. In this case the designer of the scheme (in the mind of the person raising the issue of fungibility) has either:

> (1) set the transfer rate, the Ts, at an incorrect value so that in the process of developing, too little land has been set aside in the offset bank and too few positive environmental flows guaranteed; or
>
> (2) set like against non-like, so an environmental service in one area is being balanced off against a very different environmental service in another area, when there should be two separate environmental services.

The first complaint is raised in the Chesapeake Bay case by Salzman and Ruhl (2000). As noted above, they estimated that despite there being an offset scheme in place a net loss of 51 acres of wetlands function was experienced during 1991 and 1992. This loss was due to high environmental service flow acres being developed while low environmental service flow acres were banked. The solution is to redesign the offset scheme so that the transfer rates are raised across either region or across type of acreage. In the notation of the model developed in Section 2, we would want the transfer ratios to be set equal to the ratios of the values of the environmental flows from each region/type:

$$\frac{T_j}{T_i} = \frac{D_j P}{D_i P}$$

The second complaint is raised with respect to issues such as “hot spots”, where environmental service flows are said to be at a critical level within or in part of a region. In such a case, extra service flows in a different area in the region may not balance out the loss of service flow in the area where the development occurs. A hot spot can be considered to be an area where a threshold for a particular environmental service flow has been or is close to being exceeded, so that more severe environmental impacts have or will be experienced. This presents the challenge of how to model a non-linear impact. We propose the creating of a separate vector of premium prices that are activated when threshold environmental service flow levels are met or exceeded to account for this critical flow in the area under threat.

The critical flow argument could logically be extended to the pointed where all flows and all acres are declared to be unique. This however would most likely make all offset schemes administratively impossible, without having to directly oppose them. In some cases this argument appears to be disguising a philosophical disagreement with the possibility of offset programs.

A second issue is with respect to the adequacy of an offset trading program. If there is only one environmental service flow, then the socially optimal transfer ratio is simply the ratio of the service flows. Thus if environmental service flow j (eg waterbird habitat) is the only service produced in wetland types A and B, however twice as much of j is produced in A than B, then a trading ratio of 2:1 would be appropriate. However if we have more than one type of environmental service flow produced, a simple trading ratio represented by a scalar will not adequately represent the trade-offs that should be appropriately made across a vector of environmental service flows. Thus while a 2:1 trading ratio may be appropriate for one service flow, other trading ratios may be appropriate for other services; hence transfer vectors will more accurately ensure that environmental service flows are properly offset compared to the use of a naïve singular trading ratio.

If the transfer vectors are calculated from the ratios of values of the environmental service flows, D_iP, we can have offset developments that result in increases in social value and also satisfy the offset requirement O'T > 0, but result in a decrease in one of the environmental flows as O'T > 0 is not sufficient for O'D ≥ 0.

We could require that the transfer ratio, T, be calculated so that it guaranteed that all offset developments into a particular region would result in no net loss of environmental flows. The trading ratios would be calculated by selecting the maximum scalar within the transfer vector (assuming region B is the region in which development will be sought):

$$\frac{T_B}{T_A} = \max[\frac{D_{Bj}}{D_{Aj}}] \text{ over all the types of services j}$$

While this is a restrictive assumption, in this case there will be possible developments that:

(1) would increase social welfare;
(2) would result in no net loss of environmental service value, O'DP ≥ 0; and
(3) would be rejected as O'T < 0.

An offset banking scheme can either guarantee improvements in social welfare or guarantee improvements in all environmental flows but cannot do both.

Thus in the special case where there is one environmental service that is critical, for example water flow, we would set the transfer ratios equal to the water flow produced by an acre in each region (where “w” denotes the critical flow):

$$\frac{T_B}{T_A} = \frac{D_{Bw}}{D_{Aw}}$$

is the environmental flow price weighted transfer ratio, where we have let the price of the critical flow be infinite.

This special version of an offset scheme resembles "strong sustainability". We reject any change that would result in a lowering of a critical environmental flow- no matter how beneficial such a change might be for social welfare. The defense of this position rests on the critical nature of the environmental flow. Yet the questions should still be asked whether a superior outcome might not be achieved by using the vector of environmental flow prices, P, to indicate the critical value of the environmental service flow at risk.

If there are no restrictions placed on trading, there is a real risk that environmental functions may be compromised by a large change in the location of development. A large increase in development could alter the flows – the D_i's – to such a degree that hotspots are created. In this case the vector of premium prices should be utilized for offsets in areas of critical environmental impact, as discussed earlier.

Another question that arises is the effect of a large change in location on the marginal benefit received by a community from a wetland. Empirical evidence indicates that Wetland Mitigation Banking in the US has cased the supply of wetlands to shift from highly populated to less populated areas. So while there has been no net loss of wetlands, it is likely that has been a loss of functional values for resident populations. The marginal value of the new wetland for the community would be expected to have a very different and probably lower value. Importantly, this difference in marginal value would be captured by the model proposed here as it focuses on the value of environmental service flows rather than the quantity of environmental assets. In this example, the change in the value of the recreational services provided would be captured through the measurement of use-values from the environmental service flows in the calculation of the offset.

Gains versus Losses

While the proposed model does value changes in environmental service flows, it is assumed that the price given to the service flows is not influenced by whether the change is an increase or a decrease in the particular flow. Yet the literature relating to prospect theory would suggest that gains and losses associated with the use of offsets may be valued differently. Kerr and Sharp (2004) used choice modeling in a case study involving stream mitigation in New Zealand to identify the value that the community had for the losses in environmental quality created by development, and the environmental gains created by offsetting. They found that there are differences in the values that the community has for the gains and losses, even though they involved the same environmental outcomes. The implication is that it may be appropriate to use different vectors of prices for both gains and losses in the proposed model.

Risk and Uncertainty

In any offset program it is likely that we will have imperfect ecological and hydrological data, so that the environmental service flows resulting from offset activities – the D_i's – are estimated imprecisely. Therefore any offset program will run the risk that the overall environmental service flows will be lower after development takes place because of incorrect estimation of changes in flows. The possibility also exists that the environmental service flows will be improved after the development, but because programs schemes are often implemented in environmentally-stressed areas, the downside risk is the risk of concern to policy-makers.

Current offset programs adjust for this uncertainty by requiring that development be offset at a far higher than a one for one ratio. Or alternatively they combine this increment to the trading ratio with a staggered release of offsets to provide further information about their effectiveness. While these requirements lessen the downside risk from development, they place a large burden on new development. New development effectively pays a much higher than socially optimal price for the use of land, reducing community welfare.

If the social goal is to avoid downside risk in areas that are environmentally stressed while still allowing development to occur, a better alternative would be to require new developers to pay the expected social cost of environmental service flows affected – through the DP calculations – but then to acquire insurance against downside risk. The insurance company would then pay the difference in the value of service flows or could buy new offsets, if the value of flows fell significantly after the development occurs. By requiring insurance, the downside risk under offset program is transferred from the local community to insurance providers and thus to the developers. With the use only of trading ratios the risk of ineffective offsets is effectively transferred to the community.

Insurance payments would still be a premium over the true social cost of development being paid by new developers. New developers, through their premiums, would be paying the difference between estimated and actual environmental service flows when the difference turned out to be negative, but new developers would not be rewarded with a refund on their offset costs when the difference turns out to be positive – if the new development turned out to be more than offset under the program.

The insurance premium being paid by developers under an offset program would also depend on the size of the market for offsets and the quality of our knowledge. As the market for offset insurance gets larger, premiums would be expected to fall as the risk of any individual offset becomes a small part of the pool. As the quality of our knowledge improves, the uncertainty in any individual offset also falls. Insurance payments would evolve over time reflecting our changing knowledge and practices in way that a crude two-for-one or four-for-one requirement for offsets would not.

Effects on incentives

The creation of environmental offsets often involves offset banks undertaking projects to improve environmental quality on private property. The managers of the offset banks negotiate with landholders to undertake work such as restoration of wetlands or to agree to covenants limiting land clearing or to preserve existing wetlands in the current state. Depending on the nature of the offset program and what actions it seeks to fund, it is possible that the actions of offset banks will change the incentives faced by landholders and thereby reduce the environmental gains achieved through the offset program.

The likely effect of offset programs on incentives will firstly depend on the size of the market and the offset program. In a large market with a relatively small offset program it might be expected that an offset program will have little effect on incentives. However, where the offset program is substantial in size and well promoted, even in a large market, it would be expected that incentives would be changed. Similarly in a smaller rural or semi-rural catchment, where there is regular communication in the community, or where there is a dominant ethnic group, a relatively small offset program could create sizeable effects on incentives.

How could these incentives change behaviour? First, landholders who are planning to improve environmental quality and who in the absence of an offset program would undertake the project regardless may wait until they receive an "offer" from an offset bank. In both tenders and stewardship programs where farmers have been paid to improve environmental quality surveys have indicated that a large proportion of farmers would have undertaken the works even if they works even if they were not paid to do so. For these farmers, the main contribution of the program is temporal, bringing forward in time environmental improvements that would have eventually occurred. Second, landholders may allow environmental quality to decline in the hope of receiving a future "offer". If these two behavioral changes occur, they may reduce the environmental gains that would otherwise be achieved by an environmental offset program, effectively creating a "slippage".

Offsets may also have a negative effect on social capital within the local community. Depending on the design, offsets may communicate a negative message to environmentally responsible farmers. A naïve offset program runs the risk of rewarding farmers with poor records of environmental management, potentially creating a moral hazard where those who have been less environmentally responsible benefit. This suggests a need to include duty of care provisions within offset programs, such that offsets can only proceed if the offset site is above some minimum level of environmental quality. Or alternatively, a percentage of co-funding could be required from landholders where quality is below a minimum level of quality. This question of designing offset programs with duty of care provisions is a needy area for future research.

While changes to incentives might be expected for some landholder activities such as on-farm works or where changes in farm management are required, they might not occur in all cases. Offsets involving indefinite preservation or changes to how land is used, such as stock exclusion, may have a smaller effect on incentives. Offsets occurring on public rather than private land would also not influence private incentives. Or alternatively, in the case of pollution offsets, measures that do not require landholder participation could be undertaken. Thus there are alternatives available that are more neutral in terms of their effect on incentives.

Distributional consequences of offsets

The distributional consequences of offsets have been little considered in the economics literature which is surprising given the importance that the literature places on equity as well as efficiency. It is evident though that offsets are not distributionally neutral. In assessing the distributional consequences of offsets we can delineate between three main groups. The first are those who have already developed or purchased land that has been developed. A development that occurred prior to the introduction of the offset program will avoid the banking requirements imposed on an identical development built after the introduction. One would therefore expect that this additional development cost would be partly or fully capitalized into the market price of existing developments. Thus this group of people would be gainers under an offset program.

The second group is those who own land or in the future will own land that they wish to develop. It is this group of people who will now have to purchase offsets to mitigate the negative environmental impacts from their development. Hence this group will be losers from a program. Furthermore, if the program is designed to achieve net environmental improvements such that developers have to more than offset their environmental impacts, the losses faced by this group will increase.

The strategy of seeking to achieve environmental gains solely through an offset program inappropriately places the responsibility for maintaining and improving environmental quality on new developers. It is not consistent with the polluter pays principle which implies that all polluters – both old and new – should pay for the pollution they create. Furthermore, given the capital transfer made to those who have already developed their properties through the implementation of an offset program, it is not clear why only new developments should be solely tasked with the achievement of environmental improvements.

The final group is those who own land which can potentially be used for offsets. For this group there will potentially be gainers and losers. An offset scheme will have the effect of increasing the value of land with high environmental service flows, while decreasing the value of land with low environmental service flows.

Thus there is a case for considering the equity effects of offsets, and what impact there might be on the more disadvantaged in society. There is also a rationale to consider how offsets might be combined with other instruments to make it more equitable, which is a question we turn to next.

Combining Market-Based Instruments

While offset programs can be solely implemented to mitigate the environmental effects of new developments, they can also be combined with other MBIs as part of a wider strategy to improve environmental quality. The combining of offset programs with other instruments has the advantage of reducing some of the undesirable distributional consequences of solely using offsets, as well increasing the likelihood of achieving first best solutions. One alternative for combining instruments is to use an offset program with a Pigouvian tax on pre-existing developed land, where the Pigouvian tax for an acre of land in zone i would be the annualized value of:

$$D_i P$$

where D_iP here represents the value of the environmental services that would have flown from the land if it had not been developed.

Use of a Pigouvian tax would penalize existing polluters making the combined offset and Pigouvian tax more consistent with the polluter pays principle. In addition, because the Pigouvian tax is faced by those owning existing developments, the gain in market prices of the properties owned by this group would be reduced. In the case where the capitalized value of the reduced environmental service flows from the development of their property (the net present value of the Pigouvian tax) is equal to the cost of an offset for a new and equivalent development, the gain in market prices would be removed. For an individual property, whether a capital gain or a loss is achieved will depend on whether the net present value of the Pigouvian tax is less than or exceeds the cost of purchasing offsets. In the latter case, exiting developments could be given the opportunity to purchase offsets to mitigate their environmental impacts.

A further advantage of combining offsets with a Pigouvian tax is that one is more likely to achieve optimal allocation of land for both development and environmental uses. Consider the case of existing developments where the value of the developed land is less than the value of the environmental service flows after rehabilitation, for example a farm in a sensitive wetland area. These lands are exactly those lands that should be in the offset bank – the acres that should be restored to wetlands.

Implementing a Pigouvian tax alone would mean that the private value of this land is negative, and the farm would be abandoned, but this provides no incentive for rehabilitation. For cases such as this it is apparent that a Pigouvian tax alone would not be sufficient to maximize social welfare. Similarly, an offset alone would not necessarily maximize social welfare as this area would only be rehabilitated if the area was purchased for offsets for a new development elsewhere. If the market for offsets was thin, there might not be enough offset activity to warrant rehabilitating this farmland. Combining a Pigouvian tax with an offset program that purchased low economic value land and restored that land to wetlands would achieve the first-best outcome and avoid the problem of thin markets that offsets might suffer.

An alternative to combining offsets with Pigouvian tax is to combine them with a cap and trade system. This is more relevant to the case of pollution offsets rather than for biodiversity offsets. Here a cap and trade system could be used for existing developments and an offset program used for new developments. Even where the existing developments are non-point sources cap and trade systems may be possible provided that the non-point sources can be combined into districts that form point sources (Austin 2001).

The combining of offsets with a cap and trade would also have the advantage of placing the responsibility for controlling pollution with both new and existing polluters. Whether the capital gains still accrue to existing developments will depend on how permits are distributed. If they are grandfathered, existing developments will still achieve a capital gain, having been given an asset in the form of permits to pollute. However, if they are fully or partially auctioned the capital gains will be reduced or removed depending on the extent to which they are freely allocated. A second advantage of combining offsets with a cap and trade system is that the possible use of offsets would help to reduce one of the main risks of quantity based instruments- that quantity based instruments can lead to excessive costs for polluters where the remediation cost function is steep. In cases where firms find it costly to reduce their own pollution and cannot purchase permits within the cap and trade system, they can be given the opportunity to purchase offsets at a potentially lower cost.

5. Conclusions

Offsets have the potential to mitigate the negative environmental effects of new developments and thereby maintain existing levels of environmental quality. However, existing offset programs have primarily been designed with the goal of allowing further development in the context of environmental constraints mandated by law, such as the meeting of Total Maximum Daily Loads under the US Clean Water Act. The goal has implicitly been the maintenance of strong sustainability rather than the maximization of community welfare.

Despite the potential of offset programs as a tool of economic management, their theoretical underpinning has been relatively poorly developed. This has arguably lead to many of the criticisms leveled at offset programs. We propose a new theoretical model for offsets that arguably allows many of these issues to be solved more efficiently.

Existing biodiversity offset programs seek to maintain environmental assets, with the more carefully developed of these programs seeking to maintain function values rather than areas. Our proposed model can be differentiated from these existing programs by focusing not just on environmental service flows but importantly on the value of these flows. We also advocate the use of a transfer vector rather than a singular trading ratio to compare what is lost through a new development and what is gained through an offset. The use of a transfer vector that focuses on the value of service flows is a much more informative instrument to ensure that what is gained through offsetting is equivalent to what is lost via development. With the use of this offsetting model the sorts of decreases in community values through the previous use of offsets implied by the work of Salzman and Ruhl (2000) would not occur.

One of the major challenges with the use of offsets is the possible creation of unintended incentives for landholders not to undertake planned environmental improvements in the hope of being paid to do by an offset bank. The empirical evidence indicates that this is a real phenomenon that can reduce the effectiveness of offset programs. There are however several alternatives that can be pursued to reduce their effect, such as choosing offsets that have a lesser effect on incentives, the use of duty of care provisions, and requiring co-contributions. The extent to which these practices may reduce the negative effects on incentives is however unknown. Where these negative effects on incentives continue, a premium on offsets may be required to ensure that the negative effects from development are fully mitigated from a dynamic perspective.

Another thorny issue in the design of offset programs is how uncertainty about the effectiveness of offset programs should be dealt with the. Generally most previous offset programs have responded to uncertainty by increasing the trading ratio, though this has the negative effect of thinning the market and increasing the cost of offsets. Use of the trading ratio to manage uncertainty greatly reduces the social benefits from the use of offsets. We advocate instead for use of insurance to deal with cases where there are severe failures in offsets. Over time when knowledge about the effectiveness of offsetting activities improves, and in larger markets where the risk of any individual offset is a small part of the total pool, it is likely that the price of premiums will decline. Overall it would be expected that the use of insurance markets to manage uncertainty will be a much less restrictive way of dealing with uncertainty that simply doubling or trebling the trading ratio, as well more sensitive to changes in knowledge and market context.

As well as focusing on efficiency issues, we have highlighted the distributional consequences of using offsets programs. Offsets are not distributionally neutral: there are potentially large equity effects from the use of offsets. Moreover, using offsets to achieve environmental improvements exacerbates the negative distributional consequences. We contend that environmental offset should not be designed to improve environmental quality but rather only to mitigate the environmental effects of new development. We argue instead for the combining of offsets with other market based instruments such as Pigouvian taxes or cap and trade systems in order to achieve environmental improvements. As well as having much better distributional properties, as well as a much greater capacity to achieve environmental improvements, the combining of multiple instruments increases the likelihood of achieving a first-best solution, that is a social optimum.

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