Bundling Public and Private Goods[1]

Geoffrey Heal
Columbia Business School, New York

December 2000, revised July 2001.

[1]I am grateful to Karl-Goran Maler and Antonio Rangel for valuable conversations on this topic. Participants in the environmental economics seminar at Stanford also contributed greatly to refining my ideas. Author's e-mail address gmh1@columbia.edu and URL www.gsb.columbia.edu/faculty/gheal/

Abstract

I review cases in which developers have chosen to conserve local environmental amenities as part of a profit-oriented strategy. The proximity of these amenities added more to the value of the property constructed than could have been gained by removing them and building more residences. I show that this is consistent with a theoretical proposition not previously noted: a price-discriminating monopolistic supplier of a private good that may be bundled with a local public good should provide the local public good (and the private good) at a Pareto efficient level. There is no under-provision of the public good in this case. Even though there is no market for the public good, the fact that its extent affects the willingness to pay for private goods will ensure that it is provided efficiently, provided that this willingness to pay can be captured by those selling the private goods. In a competitive market for the private good this willingness to pay could not be captured by sellers, but would be dissipated by competition and would accrue to the buyers as consumer surplus. And of course a separate market for the pubic good would not reach an efficient level of provision because of the classical free rider problem.

Keywords: local public goods, bundling, price discrimination, monopoly, environment, urban development.

JEL Classification: H 41, Q 2, R 41.

1 Property Values and Local Environmental Amenities.

Local public goods affect property values. Schools are the canonical example: house prices reflect access to good public schools. This is also true for environmental public goods: econometric studies by Sieg Smith Banzhaf and Walsh [21] and Chay and Greenstone [5] both indicate that house prices are positively affected by local environmental quality. Recently property developers, aware of this, have deliberately conserved environmental assets and provided local public goods as a part of a profit-maximizing development strategy.

Two cases capture well the key issue. Spring Island off the coast of South Carolina has long been highly valued as a nature reserve. Zoned for development, it was auctioned in 1990. The State of South Carolina bid, hoping to purchase the land for conservation, but was outbid by a developer. The latter, instead of constructing the 5,500 homes permitted, built only 500 high-value properties and deeded the balance of the land to a land management trust whose objective is to conserve the natural environment. He subsequently explained that, as proximity to a nature reserve boosted his customers' willingness-to-pay for quality, limiting development in this way raised the value of the homes sufficiently to make this the most profitable strategy [10]. A similar story relates to hunters in Montana, who had long hunted over many thousands of acres of unspoiled land. Concerned that summer home development might end this, they borrowed money to buy the land and finance the construction of a small number of luxury homes. The hunters placed a conservation easement on the remainder of the land, reserving the right to hunt on it themselves, and selling the houses for more than the total cost of buying the land and building the houses [13].

What do these examples suggest? Clearly proximity to a unique and beautiful environmental site (a local public good) enhances property values, and some developers believe that this is sufficient to justify conserving such sites even when developing them is an option. In other words, the conflict between development and conservation may not be as sharp as generally thought: there may be cases in which the most profitable development requires some measure of conservation. In economic terms, bundling a local environmental public good with homes may be a profitable strategy. Developers and urban planners now refer to this as "smart growth." An early illustration of this point emerges from the history of New York's Central Park. When the designer Frederick Law Olmsted was asked how the City could pay for the park, he responded that its presence would raise property values and the extra tax revenues would easily repay the construction costs. History shows that was correct. (Lerner and Poole, The Trust for Public Lands [16])

These observations naturally prompt us to examine in more detail the incentives that a developer faces for providing a local environmental public good. It would be interesting if there were conditions under which a profit-maximizing developer would provide a local public good at the economically optimal level. Given our normal scepticism about the ability of markets to provide public goods optimally, this appears at first sight an unlikely outcome. But I shall show that there are in fact reasonable and robust conditions under which this occurs. When viewed from the appropriate perspective, this result is intuitive.

The precise result to be proven is the following. A price discriminating monopolist provides a private good that may be bundled with a public good affecting its value, and also provides the public good. Then the monopolist will provide the latter at its economically efficient level.

In the next section I prove this result. Subsequently I place it in the literature and relate it to the well-known results on Lindahl markets and to earlier results on price discrimination in markets with private goods and increasing returns. There is also a close connection with the literature on the provision of local public goods in competing jurisdictions, especially with a result due to Scotchmer [20]. It will be clear that while my research was motivated by environmental examples, the results are more general and pertain to any public goods that can be bundled with private goods.

2 Monopoly, Price Discrimination and Bundling Public and Private Goods.

The model examines a property developer who owns the exclusive right to develop a site that is an environmental asset valued by the local population. Maximum development of the site will destroy this asset totally, but is nevertheless permitted by zoning regulations. The developer has to choose the optimal balance between development and conservation. More development means more houses but less of the environmental public good, which may reduce the population's willingness to pay for the houses. The population of house buyers has preferences that are described by the utility functions $u_i(y_i, h_i, e)$ where i is a typical buyer $(i \in N)$, y_i is $i's$ income or wealth, h_i is the level of housing consumed by i in the area to be developed and e, a local public good not specific to i, is the quantity of a local environmental asset preserved by the developer. We should think of income y_i as a proxy for the consumption of all goods other than housing and the local public good. Both h_i and e may in principle be finite-dimensional vectors, so that there may be many dimensions to the quality and quantity of housing and of the environmental public good. However for simplicity I shall treat them as real numbers. The utility function u_i is assumed to be differentiable and strictly concave.

Initially I am assuming that only members of the group N are affected by the public good e, and that all members of this group derive utility from both the private good h_i and the public good e. Prior to any development occurring, buyers have initial endowments of the various arguments of their utility functions given by (y_{i0}, h_{i0}, e_0).

We have to be careful how these initial endowments are measured. Clearly they must represent the pre-development position. For housing this is easy: if there is no housing in the area at issue, then agents' initial endowments h_i are zero. As an illustration of the issues that arise with respect to endowments of the environment, consider the case of Spring Island before it was sold: zoned for development, it was still providing a habitat for wildlife, to the benefit of many regional residents. They were enjoying a local public good although they had no legal right to it because of the owner's right to develop. In this situation I say that their initial endowment of the public good is zero, that is, their endowment is the amount to which they are legally entitled. This differs from the amount that they are actually enjoying. The important point here is that residents will have to pay to ensure a continuation of the public good.

Suppose that as a result of development the amounts of housing and of the public good change to $(h_{i0} + \Delta h_i, e_0 + \Delta e)$. The we define agent *i's willingness to pay* for this change as the value w_i that solves the equation

$$u_i (y_{i0}, h_{,0}, e_0) = u_i (y_{i0} - w_i, h_{i0} + \Delta h_i, e_0 + \Delta e) \tag{1}$$

It is the reduction in income that leaves the agent just as well off after the change as before, a standard definition (Varian [23]). We can think of the vector $(-w_i, \Delta h_i, \Delta e)$ as agent *i's* net trade vector. Definition (1) tells us that this net trade vector leaves the agent on the same indifference curve as the initial endowment.

The developer faces a cost function $c(\Delta h_1, ..., \Delta h_N, \Delta e)$ which is denominated in units of income y. The function c is differentiable and strictly convex, showing increasing marginal costs of providing housing and environmental quality. I assume that the developer is profit-maximizing and is able to price discriminate fully, extracting from each buyer his or her willingness to pay for any combination of housing and environment. For a developer of exclusive homes who has the sole right to develop a specific area, this seems a reasonable assumption. There are usually no list prices for such homes, though perhaps an indicative price range. The problem facing the developer is therefore to choose the levels of housing development Δh_i and the conservation of the environment Δe so as to maximize profits, given by

$$\max \sum_i w_i - c(\Delta h_1, ..., \Delta h_N, \Delta e)$$

subject the constraints given by the definition of willingness to pay in (1). Profits here are the difference between total willingness to pay and total costs. Writing out the obvious Lagrangean

$$L = \sum_i w_i - c(\Delta h_1, ., \Delta h_N, \Delta e) +$$
$$\sum_i \lambda_i (u_i (y_{i0}, h_{i0}, e_0) - u_i (y_{i0} - w_i, h_{i,0} + \Delta h_i, e_0 + \Delta e))$$

leads to the following first order conditions (here λ_i is the shadow price on the $i-th$ constraint in (1)):

$$\begin{aligned} \frac{\partial c}{\partial h_i} &= \lambda_i \frac{\partial u_i}{\partial h_i} \\ \frac{\partial c}{\partial e} &= \sum_i \lambda_i \frac{\partial u_i}{\partial e} \end{aligned} \tag{2}$$

Eliminating the shadow prices gives

$$\frac{\partial c}{\partial e} = \sum_i \frac{\partial c / \partial h_i}{\partial u_i / \partial h_i} \frac{\partial u_i}{\partial e}$$

If we simplify and assume that $\partial c/\partial h_i = \partial c/\partial h \ \forall i$, so that the cost of housing does not depend on the identity of the buyer, then this reduces to

$$\frac{\partial c/\partial e}{\partial c/\partial h} = \sum_i \frac{\partial u_i/\partial e}{\partial u_i/\partial h_i} \tag{3}$$

which looks like the familiar characterization of the efficient provision of a public good, namely that the marginal rate of transformation should equal the sum of the marginal rates of substitution. We can confirm this by formally posing and solving the problem of maximizing social welfare, namely

$$\begin{gathered} \max \sum_i \mu_i u_i \left(y_{i0} - w_i, h_{i0} + \Delta h_i, e_0 + \Delta e\right) \\ \text{subject to } c\left(\Delta h_1, ..., \Delta h_N, \Delta e\right) \leq \sum_i w_i \end{gathered} \tag{4}$$

Here the $\mu_i \in [0,1]$ are welfare weights that sum to one. Under the assumption that $\partial c/\partial h_i = \partial c/\partial h \ \forall i$ this problem once again yields as first order conditions (3). Indeed it yields the same first order conditions under all assumptions, as analysis of the Lagrangean shows:

$$L = \sum_i \mu_i u_i \left(y_{i0} - w_i, h_{i0} + \Delta h_i, e_0 + \Delta e\right) + \nu \left(c\left(\Delta h_1, ..., \Delta h_N, \Delta e\right) - \sum_i w_i \right)$$

From this the first order conditions are

$$\begin{aligned} \mu_i \frac{\partial u_i}{\partial h_i} + \nu \frac{\partial c}{\partial h_i} &= 0 \\ \sum_i \mu_i \frac{\partial u_i}{\partial e} + \nu \frac{\partial c}{\partial e} &= 0 \end{aligned}$$

and it is easy to verify that they are identical to (2). We thus have the following proposition:

Proposition 1 *If utility functions are strictly concave and the cost function strictly convex, then a profit-maximizing developer who has sole development rights and can practice first order price discrimination will provide an economically efficient combination of the private goods involved in housing and the public goods involved in environmental conservation.*

Even though there is no market for the public good, the fact that its extent affects the willingness to pay for private goods will ensure that it is provided efficiently, as long as this willingness to pay can be captured by those selling the private goods. In a competitive market for the private good this willingness to pay could not be captured by sellers, but would be dissipated by competition and would accrue to the buyers as consumer surplus. Some buyers might therefore be better off under competition but the allocation of resources to the public good would no longer be efficient. And of course a separate market for the pubic good would not reach an efficient level of provision because of the classical free rider problem.

In a loose and intuitive sense the environmental public good is being "bundled" with the private good housing. This leads one to ask whether the result just proven relies in some way on complementarity between the environmental good and housing. In fact it does not, as indicated by the absence of any cross derivatives of the utility function in the key first order conditions (3). Bundling is perhaps not a good metaphor for what is happening here. The central feature is that there is a non-marketed good that affects consumers' utility levels and that all consume at the same level by virtue of its being a public good. Because the developer provides each consumer with an individual level of housing h_i and charges each a different price w_i, he is able to tailor the proportions in which people consume housing and the environmental good to their preferences and reach an efficient allocation in a way that would not be possible if everyone faced a uniform price for housing. Figure 1 illustrates this idea.

It shows the preferences of a typical consumer between the public good and housing, a private good. (Recall that utility depends also on a third good, income or wealth.) Also shown is the frontier giving the trade-off between the two goods faced by the developer. Because there is no market in the environmental good, and because this will as a public good typically be underprovided, we might expect that the competitive market solution would be at a point like A. The producer could choose a combination such as B at which the consumer would be better off. Alternatively, he could choose a point such as D where the consumer is no worse off but the producer's total use of the resources available to him is less, as he is operating well inside his production possibility frontier. Points such as C in between are also possible. The intuitive point here is that as there are efficiency gains from shifting the output mix towards the environment, the consumer can be made better off at no real resource cost to the producer and in exchange for this the producer can extract wealth — a compensating variation — from the consumer. Through price discrimination the producer makes the consumer pay for a better output mix.

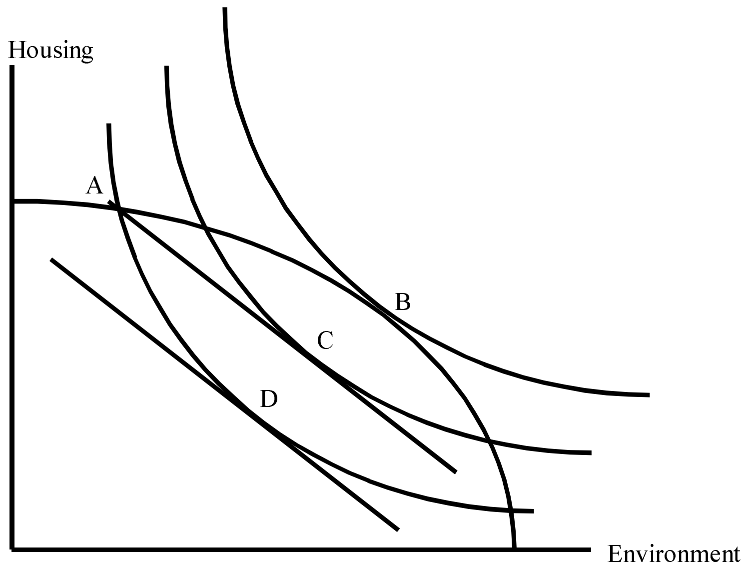

Figure 1: Figure 1

2.1 A Generalization

The explanation above makes it clear that the phenomenon formalized in proposition 1 is in fact more general that the context in which it is presented. It does not depend on complementarities between the public and private goods, but only on the fact that there is a good for which there is no market. In the absence of this market the producer has the power to improve the consumer's welfare via adjustments to the output mix as well as via the total amount of the private good placed on the market, and can charge for this. Similar results will therefore hold whenever there are unmarketed goods provided by a supplier of private goods who can price discriminate. We can formulate a more general result as follows.

Let the utility function be $u_i(y_i, g_i^m, x, x_i)$ where as before y_i is a measure of income or wealth, g_i^m is a vector of goods provided by a discriminating monopolist, x is a vector of public goods for which there are no markets and x_i is a vector of private goods consumed by agent i for which there are no markets. As an illustration, components of x_i might be person-specific externalities or endowments of goods for which there is no market. As before we define an initial position $u_i(y_{i0}, g_{i0}^c, g_{i0}^m, x_0, x_{i0})$ and a change from this

$$u_i(y_{i0} - w_i, g_{i0}^m + \Delta g_i^m, x_0 + \Delta x, x_{i0} + \Delta x_i)$$

and define willingness to pay as the value of w_i that satisfies

$$u_i(y_{i0}, g_{i0}^c, g_{i0}^m, x_0, x_{i0}) = u_i(y_{i0} - w_i, g_{i0}^m + \Delta g_i^m, x_0 + \Delta x, x_{i0} + \Delta x_i)$$

Here we are allowing possible changes in all arguments of the utility function: the change in income is of course a proxy for changes in the consumption of other goods. A monopolistic supplier of the goods g, x and x_i chooses the variations in these from the initial endowments so as to maximize his profits subject to his revenues being the total of willingness to pay and costs being given by a cost function:

$$\max \sum w_i - c\left(\Delta x, \Delta x_1..\Delta x_N, \Delta g_1^m, ..., \Delta g_N^m, \right)$$

subject to

$$u_i\left(y_{i0}, g_{i0}^c, g_{i0}^m, x_0, x_{i0}\right) = u_i\left(y_{i0} - w_i, g_{i0}^m + \Delta g_i^m, x_0 + \Delta x, x_{i0} + \Delta x_i\right)$$

By standard arguments the first order conditions for this problem are:

$$\begin{aligned} \lambda_i \frac{\partial u_i}{\partial g_i} &= \frac{\partial c}{\partial g_i}, \\ \sum \lambda_i \frac{\partial u_i}{\partial x} &= \frac{\partial c}{\partial x} \\ \lambda_i \frac{\partial u_i}{\partial x_i} &= \frac{\partial c}{\partial x_i} \end{aligned}$$

where as before the λ_i are shadow prices on the constraints on utility levels. It is routine to confirm as before that these are identical to the first order conditions for maximization of the weighted sum of utilities subject to a constraint that the total cost not exceed the total willingness to pay. Hence we can state the following:

Proposition 2 *Assume that utility functions are strictly concave and the cost function strictly convex. A profit-maximizing firm has a monopoly over the supply of a set of private goods and also determines the supplies of public goods and non-traded private goods, all of which enter agents' utility functions. If this firm price discriminates, then the resulting allocation of resources will be Pareto efficient.*

3 Discrete Choices

So far we have assumed the scale of environmental conservation, or the scale of the local public good, to be a continuous variable. In many cases, including environmental cases, this is not so: a site is either preserved or developed, a species preserved or not, etc. Both conservation and development may have to occur at a minimum viable scale if they are to occur at all, forcing a choice of one or the other. In an example to be discussed below, farmers in southern Africa can either use their land for cattle ranching or for game ranching (populating it with native flora and fauna) but cannot do both. The cattle eat the local vegetation and the local carnivores eat the cattle, so farmers have to choose one or the other. In this discrete choice case all of the above results carry over, and there is an interesting extension to second best cases in which not all willingness to pay can be extracted by the seller.

Assume now that the local environmental amenity is either preserved P or not N, and that there are no other options. Everything else is as in the model of section 2. If the developer chooses P then agent i's willingness to pay is given by

$$u_i(y_{i0}, h_{,0}, e_0) = u_i(y_{i0} - w_i, h_{i0} + \Delta h_i, P)$$

which we denote $w_i(h_i, P)$. Otherwise it is $w_i(h_i, N)$. The developer maximizes profits by finding the most profitable development strategy conditional on choosing P, then doing the same conditional on choosing N, and then choosing the overall maximum. Formally the first stage of the problem is

$$\max_{h_i} \sum_i w_i(h_i, P) - c(\Delta h_1, ..., \Delta h_N, P) \quad (5)$$

where $c(\Delta h_1, ..., \Delta h_N, P)$ is the cost of the housing vector $\Delta h_1, ..., \Delta h_N$ given the decision to preserve. Let $\Pi(P)$ be the profit that results from solving this problem and $\Delta h^*(P)$ the maximizing choice of housing development. Using the obvious extension of this notation, finding the best strategy conditional on choosing N involves solving

$$\max_{h_i} \sum_i w_i(h_i, N) - c(\Delta h_1, ..., \Delta h_N, N) \quad (6)$$

and we denote the resulting profits and strategies by $\Pi(N)$ and $\Delta h^*(N)$. Clearly the developer will choose P rather than N if and only if $\Pi(P) \geq \Pi(N)$ and in this case will implement $\Delta h^*(P)$.

We can readily show that the socially optimal choice satisfies the same inequalities as the most profitable choice, so that we have an extension of the earlier results: the profit-maximizing private developer who price discriminates fully will choose a level of public good provision that is socially optimal.

4 Global Public Goods

We can now use the results of the last section, on provision of public goods involving discrete choices, to extend the analysis of the earlier sections to a more general class of situations, situations in which the developer cannot hope to capture all of the population's willingness to pay for the public good. This could happen for several reasons, the most obvious of which is that the good is valued by people who live far away and are not in a position to buy houses affected by its preservation or to visit it personally. These are the classic cases of existence value. In such cases the public good is global, or at least regional. Species conservation, to be discussed more below, provides a good illustration: landowners may gain from conserving rare species and charging eco-tourists for viewing them, but there will generally be many who value the existence of these species yet are not is a position to view them. Landowners will be unable to tap their willingness to pay. Another possibility is that the developer's inability to price discriminate fully prevents him from appropriating the value created by conservation.

Suppose that for either of these reasons, or for others, the developer can appropriate only a fraction $\alpha \in (0,1)$ of the population's willingness to pay for the bundle of public goods and housing. Then the profits from conservation and non-conservation, given previously by (5) and (6), now become respectively $\max \alpha \sum_i w_i (h_i, P) - c(\Delta h_1, ..., \Delta h_N, P)$ and $\max \alpha \sum_i w_i (h_i, N) - c(\Delta h_1, ..., \Delta h_N, N)$. So the decision to preserve turns on the inequality

$$\max \alpha \sum_i w_i (h_i, P) - c(\Delta h_1, ..., \Delta h_N, P) \lesseqgtr \max \alpha \sum_i w_i (h_i, N) - c(\Delta h_1, ..., \Delta h_N, N)$$

Clearly if

$$\max \sum_i w_i (h_i, P) - \max \sum_i w_i (h_i, N) > c(\Delta h_1, ..., \Delta h_N, P) - c(\Delta h_1, ..., \Delta h_N, N)$$

so that preservation is most profitable when all willingness to pay is captured, and so is socially optimal, then for some $1 > \alpha^*$ it is still true that for $\alpha > \alpha^*$

$$\alpha \left(\max \sum_i w_i (h_i, P) - \max \sum_i w_i (h_i, N) \right) > c(\Delta h_1, ..., \Delta h_N, P) - c(\Delta h_1, ..., \Delta h_N, N)$$

So in spite of the inability to appropriate the full willingness to pay, the developer's optimal strategy still coincides with the socially optimal choice, provided that a sufficiently large fraction of willingness to pay is captured.

5 Illustrations

In the examples that I cited at the start of this paper a private developer had exclusive rights to develop an area of environmental value, and was probably in a position to price discriminate between customers. These examples reflect a point that has been neglected in the rather polarized debate about conservation versus development, the point that under certain conditions private developers do have an incentive to conserve environmental assets. It seems that some recognition of this fact is now emerging in the urban planning literature.

Clearly the point is more general than the environmental context, applying in any context where public goods can be bundled with private goods to affect buyers' willingness to pay for the latter. Eco-tourism provides another important environmental context for this phenomenon. Consider southern Africa: here it has often proven most profitable for farmers to stop farming and restore their land to its natural state, with native vegetation and animals, so as to charge tour managers for bringing tourists to view the animals. The extent to which this has happened has taken many conservationists by surprise, to the extent that about 18% of the land area of the southern third of Africa (South Africa, Namibia, Botswana, Zimbabwe, Tanzania, Mozambique and Angola) is now given over to "game ranching", as this is called. In Zimbabwe the land devoted to conservation has increased eight fold in the last quarter of a century. (Heal [13], Bond [1], Cumming [6], [7], Cumming and Bond [8]) The impact of this profit-oriented development on conservation has been far-reaching and positive, with the populations of many species rebounding from threatened levels. The game ranchers are providing public goods, the conservation of species, and are "bundling" these with private goods, accommodation and tour guiding. In many cases they are local monopolists and can probably price discriminate. These cases may be an important illustration of the last version of our results, in that they involve discrete choices between conservation and development and are clearly situations where the continuation of species via habitat conservation is of value to many people who will never visit the sites as paying tourists. Only a fraction of the world's willingness to pay can be appropriated, but this appears to be sufficient to ensure conservation.

Another possible application in the environmental area involves water. The quality of the water in a watershed is a local public good, being the same for all who draw from that watershed. The water itself, however, is a private good, which is unavoidably bundled with the pubic good. In some cases water is provided by private corporations who control the watershed and therefore the quality of the water emerging from this. They are almost by necessity local monopolists, and were they able to price discriminate then we would know from the earlier results that they would provide water quality at a level that is economically optimal. In practice such corporations are heavily regulated and water prices are controlled politically in most countries, so that the results here cannot be applied. They do, however, have policy implications, to which I return later.

6 Related Literature.

We have known for a long time that a price discriminating monopolist picks the socially optimal level of output for private goods in a conventional market situation with no external effects, pubic goods or non-convexities (Varian [23]). This basic result has subsequently been extended to situations involving increasing returns in production, where the central proposition is that in a general equilibrium model with some firms having non-convex production possibility sets, a monopolistic manager of the non-convex firm who price discriminates may under certain conditions support a Pareto efficient allocation. The most general result of this type is in Edlin Epelbaum and Heller [9]. A more limited precursor is Brown and Heal [4], and there is a general review of results of this type in Heal [14]. The present proposition can be seen as a further contribution to this tradition. We show that the efficiency of a discriminating monopolist extends to another category of economic environment, that involving public goods. There is however one critical difference: in the papers cited on price discrimination and increasing returns it is always assumed that the increasing returns good is traded in a market. Here, as we are dealing with non-excludable public goods, we cannot suppose a market for the public good but have instead to consider an "indirect market" created through bundling with a private good.

We have known since the work of Lindahl, formalized and developed by Foley [11], that there are conditions under which we might be able to use a market to allocate public goods. The key idea in this literature is that there are many prices for the public good, one for each buyer. Prices then reflect the willingness-to-pay of different consumers. The proposition is that there exists a set of prices for a public good such that if the seller and all buyers take these as given and maximize profits or utility respectively, then the outcome is Pareto efficient. As many commentators have noted, the problem with this result is that each of the markets here is a bilateral monopoly so that it is not obvious why the participants should take prices as given. The present framework avoids this shortcoming. But it is more than a restatement of the Lindahl result: the current result relies on the bundling of public goods with a private good and on the monopolistic position of the seller of the private good with which the public good is linked.

There is an additional literature on the market provision of public goods, which focuses on the case of market provision of what are termed "excludable public goods" or "collective goods". These are goods with two properties: if produced for one consumer then they are produced for all, and at the same time it is possible for the producer to exclude from consumption those who have not paid for the product. This literature addresses questions such as whether the competitive or monopolistic provision levels will be too high or too low (see Brennan and Walsh [2], Britto and Oakland [3] and Thompson [22]). The precise conclusions are not important here as the model does not capture the problem of concern: environmental public goods are not excludable in the sense of these papers. We therefore cannot have a market in environmental goods — hence the need to consider bundling them with private goods.

The current results are also connected with issues discussed in the literature on competition between jurisdictions, growing out of the work of Tiebout and others. An interesting result is that of Scotchmer [20], who considers competition between numerous jurisdictions, each of which is characterized by a certain level of provision of local public goods. Individuals are free to move between jurisdictions. She defined a competitive equilibrium between jurisdictions in this framework, and then established two striking results. One is that at an equilibrium, property prices fully capitalize the level of provision of public goods. The second is that a competitive equilibrium between competing jurisdictions is Pareto efficient, and so in particular provides public goods at the efficient level in each locality. The fact that property prices fully reflect the value of public goods to residents shows that the analysis works through effects that are similar to those considered here. The similarities go further: in Scotchmer's work, as here, there is no market for the public good. It is bundled into the characteristics of a jurisdiction.

The relevance of Scotchmer's results in the environmental context is probably limited: many environmental assets are unique so that it is of limited interest to consider competition between indefinitely replicated jurisdictions containing them. This type of result seems more applicable to reproducible public goods such as schools and other public infrastructure. In the environmental field it might perhaps apply to air quality standards, although in many cases these would spill over to neighboring jurisdictions. However, it is intellectually interesting to know that we can achieve efficiency in the provision of local public goods via the reflection of their contributions to welfare in property prices, and that we can do this by two methods that are polar opposites: jurisdictional competition or price discriminating monopoly.

A recent paper by Holm-Müller [12] contains ideas similar to those developed above. Entitled "Financing Nature Conservation through Complementary Private Goods",[1] it also has as its main theme that bundling nature conservation with private goods may provide incentives for conservation. As the title suggests, the author assumes that the result depends on complementarity between the two types of goods, and so fails to see the generality of this mechanism and to state the conclusion that is implicit in her analysis, namely that bundling can lead to a first-best outcome. However, this paper certainly contained the basic intuition of the present paper.

7 Policy Implications.

The apparent incompatibility of development and environmental conservation lies at the heart of many policy dilemmas. It is almost institutionalized by the U.S.'s Endangered Species Act (ESA), which provides for a complete prohibition of any form of economic activity on land supporting an endangered species. The apparent dilemma is heightened by the fact that areas that are rich in biodiversity are often also attractive to humans as areas to reside or to spend vacations - a recent article in Science noted the strong correlation between real estate property values and measures of biodiversity ([24]).

In a limited number of cases the endangered species act has been modified in its implementation to introduce market-based incentives: the most striking case involves the red cockaded woodpecker, which is endangered and nests in forests owned by International Paper in Florida. The US Fish and Wildlife Service (which implements the ESA) and International Paper reached the following arrangement. A target number of breeding woodpecker pairs has been set, and provided that this number is attained or exceeded then International Paper will be regarded as complying with the

[1] I am grateful to Oliver Deke for this reference. The article is in German and the original title is "Finanzierung von Naturschutz über Komplementärgüter."

ESA, whatever modifications it might make in the habitat under its control. Further, the agreement also provided that any surplus of breeding pairs over this target number could be "banked." This means that it could be used by the company to offset ESA requirements with respect to red cockaded woodpeckers elsewhere, or title to the surplus could be sold to other landowners and used by them to gain some measure of exemption from ESA provisions (Jorling [15], and for a general discussion of the ESA see Noss O'Connell and Murphy [18]). The important point here is that the costs of compliance with the ESA have been reduced by this agreement, without reducing its effectiveness. Indeed, the benefits go beyond this: as the production of nesting pairs over a target level is saleable, International Paper now actually has an economic incentive to encourage the endangered species, something they never had with a strict interpretation of the ESA. (Mathematically, this is analogous to a tradable permit market, which generates incentives for pollution reduction even after a firm's target has been met.) Recent reports suggest that International Paper may be able to sell banked breeding pairs for as much as $100,000 per pair (personal communication, W. Coleman, EPRI).

There are two points to this example. One is that the Endangered Species Act makes little or no reliance on market incentives, but that on the few occasions when it has been modified to incorporate these the result appears to have been a success. The second is that the mechanisms discussed in this paper provide a natural route for incorporating additional market-based incentives in measures such as the ESA. They indicate that the presumed conflict between development and conservation may be resolved under certain conditions, and that developers might actually benefit from a carefully-structured conservation program. This seems likely to be of particular significance in the context of Habitat Conservation Plans (HCPs), the mechanisms through which the ESA is often implemented in cases where the endangered species are threatened by destruction of their habitat as a result of development (for more background, see [18]). HCPs are local development plans that are supposed to ensure that adequate habitat for the endangered species is maintained while allowing some level of development to go ahead. There appear to be no cases of such plans attempting to capitalize on the possible willingness of home buyers to pay for proximity to conserved areas and areas that are the habitat of rare species. The results of this paper, and the cases cited in the introduction, suggest that there is significant potential here. The critical issue is to ensure that the consumer surplus generated by the local environmental amenities accrues to the developers who are affected by limitations on their ability to build.

There are many other environmental amenities whose provision seems to come within the scope of the results discussed here. Several were mentioned as illustrations. Conservation prompted by the potential income from eco-tourism is a good example: the public good, conservation, is being bundled with and is enhancing the value of private goods such as travel, accommodation and guide services. This bundling has proven to provide strikingly powerful incentives for conservation in southern Africa and perhaps elsewhere. If conservation has value to people who do not visit the sites, there are benefits that are not captured by those who conserve and so conservation may be underprovided relative to a first best solution, although as explained in section 4 the discrete choice nature of conservation decisions may provide a margin within which incomplete capture of willingness to pay will not matter. Donations to conservation-oriented organizations might also fill some of this gap and internalize a part of the remaining externalities.

Water supply seems to be another example of a case where public goods are bundled with a private good to enhance its value to consumers. In this case the water itself is a private good whereas its quality is a public good, being the same for all consumers of the water in a given watershed. And the quality of the water in a watershed depends directly on the state of the environment in that area. New York City's experience with the Catskill watershed illustrates these points well (see [13] and National Research Council [17]). So a monopolistic supplier of water from a watershed, free to charge according to willingness-to-pay, would have a strong incentive to control environmental quality in the watershed region to the point where it meets requirements for economic efficiency. As noted in [13], there are even cases of water supply companies that do not have the ability to price discriminate making investments in the quality of their watersheds.

Clearly there is nothing in the analysis that limits its applicability to the environmental area. However, it is hard to think of compelling examples in other fields.[2] Consider public school systems, which are certainly local public goods that affect property prices. It is rarely if ever the case that a property developer has the possibility of influencing the quality of the school system that serves the houses he is building. The house buyer certainly buys a bundle of housing and school services (and other local public goods), but the developer only supplies a part of the bundle.[3] In a sense there is a missing market here: the school system influences the homebuilder's profitability but he is not able to register his preference for better schools. The same argument applies to many other non-environmental public goods, such as law and order, roads, and public amenities such as parks. In contrast the developer of homes is sometimes in a position to impact the scale of local environmental amenities as his development plan in effect determines these amenities.

[2] Richard Schuler has suggested to me that Microsoft is practicing this bundling by combining control of the PC operating system with a monopoly of the production of application software. Sale of the application software allows it to appropriate some of the gains from provision of the operating system, which has some of the characteristics of a public good.

[3] In the literature on jurisdictional competition (see Scotchmer [20]) it is nevertheless assumed that the developers of the competing jurisdictions do indeed provide all of the local public goods for the jurisdictions that they are developing.

8 Concluding Remarks.

The results here leave several questions open. They are avowedly partial equilibrium in nature, and do not focus on issues such are interactions between competing developments. Doing this would take the analysis into the kinds of questions that arise in consideration of competing jurisdictions in the local public goods literature. The analysis is also very static in nature, in that decisions about conservation are made once and then hold forever. The developer sets the trade-off between environment and housing and then the community lives with this choice. In a sense the developer is dictatorial. In practice it is possible for developers to act like this: in two of the cases mentioned in the introduction, the developers imposed conservation easements that enforced their selected trade-offs in perpetuity. It might nevertheless be interesting to ask whether the community at some subsequent date would like to change this trade-off if it had the opportunity. The answer is probably positive. It is certainly likely that, by standard free rider arguments, each family would like to expand its private plot at the expense of a communal conservation region. In other words, if the community established by the developer had an opportunity to review the choices made by the developer, then it would probably change them in a way inimical to the attainment of efficiency in the provision of local public goods. It would be interesting to investigate dynamically stable mechanisms in the context of this problem, as analyzed by Rangel [19] in the context of local public goods.

References

[1] Ian Bond. *The Economics of Wildlife and Land Use in Zimbabwe: An Examination of the Current Knowledge and Issues,* 1993. (WWF Program Office, Harare, P.O. Box CY, 1409 Causeway, Zimbabwe.)

[2] Geoffrey Brennan and Cliff Walsh. "A Monopoly Model of Public Good Provision: The Uniform Price Case." *American Economic Review* Vol 71 Issue 1 (March 1981) 196-206

[3] Dagobert Britto and William Oakland. "On the Monopolistic Provision of Excludable Public Goods." *American Economic Review.* Volume 70 Issue 4 (September 1980) 691-704.

[4] Donald Brown and Geoffrey Heal. "Two Part Tariffs, Marginal cost Pricing and Increasing Returns in a General Equilibrium Model." *Journal of Public Economics* 13 1980 35-49.

[5] Chay, Kenneth and Michael GReenstone. "Does Air Quality Matter? Evidence from the Housing Market," Revised December 2000. http://elsa.berkeley.edu/~kenchay/

[6] David Cumming. *Are Multispecies systems a Viable Land Use Option for Southern African Savannas?* 1990. (WWF Program Office, Harare, P.O. Box CY, 1409 Causeway, Zimbabwe.)

[7] David Cumming, *Wildlife Products and the Marketplace: A View from Southern Africa*, 1990. (WWF Program Office, Harare, P.O. Box CY, 1409 Causeway, Zimbabwe.)

[8] David Cumming and Ian Bond, *Animal Production in Southern Africa: Present Practices and Opportunities for Peasant Farmers in Arid Lands*. 1991. (WWF Program Office, Harare, P.O. Box CY, 1409 Causeway, Zimbabwe.)

[9] Aaron Edlin Mario Eppelbaum and Walter Heller. "Is Perfect Price discrimination Really Efficient? Welfare and Existence in General Equilibrium." *Econometrica* 66 4 (July 1998) 897-922

[10] Paul Thacker. "Spring Island Developers Go Green." Environmental News Network. www.enn.com/features/2000/06/06012000/island_11964.asp

[11] Duncan Foley. "Lindahl's Solution and the Core of an Economy with Public Goods." *Econometrica* 38 1 (1970) 66-72.

[12] Holm-Müller, Karin. "Finanzierung von Naturschutz über Komplementärgüter." *Konjunkturpolitik, Zeitschrift für angewandte Wirtschaftsforschung*, 45, 1999, Heft1, 24-39.

[13] Geoffrey Heal. *Nature and the Marketplace*. Island Press, Washington DC, 2000.

[14] Geoffrey Heal. *The Economics of Increasing Returns*. Edward Elgar, Cheltenham U.K., 1999.

[15] Thomas Jorling. "Incentive Based Management Strategies: a 'Common Sense' Approach to the Conservation of Biological Diversity." *The Science of the Total Environment* (1999) 240.

[16] Steve Lerner and William Poole. *The Economic Benefits of Parks and Open Spaces.* The Trust for Public Lands, 1999. (See www.tpl.org)

[17] National Research Council. *Watershed Management for Potable Water Supply: Assessing the New York City Strategy*. National Academy Press, Washington D.C., 2000.

[18] Reed Noss, Michael O'connel and Dennis Murphy. *The Science of Conservation Planning.* Island Press, Washington D.C., 1997.

[19] Antonio Rangel. "Backward and Forward Intergenerational Goods."

[20] Suzanne Scotchmer. "Public Gods and the Invisible Hand" in John Quigley and Eugene Smolensky (eds) *Modern Public Finance,* Harvard University Press 1994.

[21] Holger Sieg, V. Kerry Smith, H. Spencer Banzhaf, Randy Walsh. "Estimating the General Equilibrium Benefits of Large Policy Changes: The Clean Air Act Revisited" http://papers.nber.org/papers/W7744

[22] Earl Thompson. "The Perfectly Competitive Production of Public Goods." *Review of Economics and Statistics* Volume 50 Issue 1 (February 1968) 1-12.

[23] Hal Varian. "Price Discrimination." Chapter 10 of *Handbook of Industrial Organization Volume 1* pages 597-654. North Holland, Amsterdam, 1989.

[24] Vogel, Gretchen. "No Easy Answers for Biodiversity in Africa." *Science* vol. 291 30 March 2001 pages 2529-2530.