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Analysis

Conservation when landowners have bargaining power: Continuous conservation investments and cost uncertainty

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ABSTRACT

Spatially heterogeneous costs of securing conservation agreements should be accounted for when prioritizing properties for conservation investment. Most researchers incorporating conservation costs into analyses have relied on estimates of landowners' opportunity costs of accepting a conservation agreement. Implicitly assumed in such studies is therefore that those who "produce" biodiversity (landowners) receive none of the surplus available from trade. Instead, landowners could use their bargaining power to gain profits from conservation investments. We employ game theory to determine the surplus landowners could obtain in negotiations over conservation agreements, and the consequent effects on conservation outcomes, when enrolment decisions are governed by continuous variables (e.g. the proportion of a property to enrol). In addition, we consider how landowner uncertainty regarding the opportunity costs of other landowners affects these outcomes. Landowners' ability to gain surplus is highly variable and reflects variation in the substitutability of different properties for achieving a specified conservation objective. The ability of landowners to obtain profits from conservation agreements results in conservation outcomes that are substantially diminished relative to when landowners accept investment at opportunity costs. Uncertainty increases landowner profits, leading to a greater diminution in conservation benefits.

1. Introduction

To make conservation measures more effective and efficient, researchers in conservation planning have attempted to incorporate spatially explicit conservation costs into their analyses (Naidoo et al., 2006). For example, Ando et al. (1998) estimated conservation costs throughout the USA using average county-level agricultural land values, while Stoms et al. (2011) equated the development potential of agricultural land in California with its cost for conservation. These studies and others (e.g. Carwardine et al., 2008; Polasky et al., 2001) use the agricultural value of land as a coarse proxy for the cost of conservation for two reasons. First, there is a lack of published data on acquisition costs of land for conservation (but see Davies et al. (2010)), meaning that there is little alternative but to use proxy data. Second, agricultural land values provide a measure of the opportunity costs of using land for conservation rather than production (Adams et al., 2010).

Most conservation agreements on private land are secured through a voluntary negotiation process (Ferraro, 2008). In such a process, the range of cost outcomes is bounded below by the landowner's willingness-to-accept (WTA) and above by the conservation group's willingness-to-pay (WTP). If a landowner is indifferent between conservation and production, the WTA is bounded below by opportunity costs because such a landowner will not accept a conservation payment of a value less than can be achieved through continued production. By using the proxy of agricultural land values, researchers implicitly assume that conservation costs equal landowners' WTA. This is the best-case outcome for conservation in which all of the surplus available from trade is obtained by those who "consume" biodiversity (conservation groups), with none of the surplus going to those who "produce" it (landowners).

For this best-case scenario for conservation to be realised, conservation groups would need to hold all of the bargaining power in negotiations. In general, the distribution of bargaining power among negotiating parties depends on the level of competition in a market. A conservation group with a broad focus, and thus many potential landowners with whom to seek agreements, may indeed have a very strong bargaining position. However, where a conservation group has a more

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narrowly focused objective, increasing the abundance of a single rare species, for example, or where there are many conservation groups in competition for a valuable conservation asset, it is the landowner who would hold most of the bargaining power. This variation in the potential distribution of bargaining power means that many, if not all, conservation agreements will be reached with a division of surplus between the landowner and conservation group, rather than the conservation group obtaining the total surplus as has previously been supposed. To ensure that conservation planning exercises accurately estimate the benefits that will follow from investments, it is therefore necessary to know the amount of profit landowners could obtain from conservation contracts.

We began to investigate these ideas in Lennox et al. (2012), where we modelled the situation in which a conservation group identifies one site to enrol in its conservation programme. We determined the maximum producer surplus that this single landowner could garner, thus calculating the conservation group's WTP. Both the theoretical and numerical analyses in our paper highlighted a large gap between the WTA and the WTP, indicating that previous conservation planning studies may have significantly underestimated the cost of providing conservation.

In this present paper, we extend these ideas beyond the simple case investigated in our initial study. First, rather than identifying a single site for protection, we model the situation in which the conservation group seeks to simultaneously secure negotiated agreements on multiple sites. We employ a negotiation structure in which the conservation group solicits payment requirements from landowners for conservation measures on their sites and then makes investment decisions in light of these demands (similar to the negotiation method used in the Conservation Reserve Programme (Hanley et al., 2012) and the Victoria BushTender trial (Stoneham et al., 2003)). To contrast with previous studies that have provided the best-case scenario for conservation in which all landowners accept conservation investment at opportunity costs, we analyse the scenario in which all landowners use their bargaining power in an attempt to secure payments that maximize their profits—for a discussion of whether or not landowners are motivated solely by profits see, for example, Chouinard et al. (2008). This negotiation framework therefore involves competitive interactions between landowners: if a landowner makes excessively high payment demands, she/he will gain limited or no profits because the conservation group can choose to invest with other willing landowners. Landowners must therefore make payment demands in light of these competitive forces.

The second important difference between this and our earlier study relates to the investment decision of the conservation group. In Lennox et al. (2012), the conservation group was constrained to the simple binary choice of enrolling the site or not in the conservation programme. However, it is often the case that conservation decisions can be varied over a range of possible values. For example, decisions over how much investment to devote to a region, how much time to spend on a conservation activity or how much land on a site to procure for conservation span a continuum from zero to the available maximum. A central difference between the binary- and continuous-type investments relates to the substitutability of sites. When the decision variable is enrol/do not enrol the site, only differences between sites are important. When the decision is represented by a continuous variable, in response to landowner demands the conservation group can additionally give consideration to the substitutability of differing levels of conservation on individual sites. Negotiations with multiple rather than a single landowner and the altered nature of site substitutability between the binary and continuous decision variables could affect the ability of landowners to make profits from conservation investments and are therefore the focus of this paper.

When making payment demands to maximize profits, landowners' strategies will be guided by the information they possess about factors such as the conservation value and opportunity costs of their and other landowners' sites. The quality of this information, and its utility when making payment demands, is likely to be highly variable, depending on the nature of the conservation programme and the farming system in which the landowner is embedded. For instance, in many rural communities landowners depend on each other for services, such as the sharing of equipment and labour, land renting, joint irrigation and drainage projects, and assistance in times of need (Rashford et al., 2003). Landowners are also part of a local social network through which they are cognisant of the land use decisions of others (McGuire et al., 2013). As a consequence of these interactions, where conservation groups or particular conservation programmes operate in limited geographical areas, landowners are liable to have substantial information about one another. This information, which may not be available to conservation groups, can be used by landowners when setting payment levels to maximize profits. For conservation programmes that are more diffuse, the information available to landowners will be much less certain and this uncertainty could impact their strategies. To consider how this impact will be manifest, in this paper we also investigate how landowner uncertainty regarding the opportunity costs of other landowners influences payment demands, landowner profits and conservation outcomes.

Game theory is the mathematical study of competitive and strategic interactions. Many game theoretic models have been developed to analyse how those seeking to maximize profits should set prices in competitive contexts. The first such analysis was undertaken by Bertrand (1883) in which a duopoly with homogeneous goods and equal production costs was modelled as a game of complete information—both firms knew all salient facts about their competitor. Here, we model Bertrand competition in the context of conservation planning. Our models have more realistic assumptions than the classic Bertrand model: rather than being homogeneous, we assume that conservation benefits are differentiated substitutes; we account for asymmetric costs with variation in landowner opportunity costs; and we model games of both complete and incomplete information – landowners do not know the exact opportunity costs of other landowners – to investigate how landowner uncertainty affects outcomes. In the next section, we lay out the mathematical models. Following on from this, we analyse the case of a hypothetical duopoly (two landowner system) to exemplify the mathematical formulation and show how solutions are found. Finally, we apply our results to a case study of a farming system in the Peak District of the UK to investigate the profits landowners can make from conservation investments.

2. Mathematical Models and Solution Methods

2.1. Problem Formulation

We assume that the conservation group identifies a set of landowners/sites, $I = \{i | i = 1, \ldots, n\}$, of conservation interest. Function V_i describes the conservation benefit of investing in site i. We assume that V_i is concave, twice differentiable and monotonically increasing. For simplicity, we also assume that conservation benefits accrue additively over sites. The level of conservation effort that the conservation group devotes to site i is represented by x_i, and the vector $\mathbf{x} = (x_1, \ldots, x_n)$ represents the effort level on all sites. (Conservation effort is a generic measure that encompasses all examples of continuous investments. Where applicable, we will specify what conservation effort represents.) The opportunity costs to landowner i of accepting a unit increase in conservation effort is c_i. Landowners can make payment demands in excess of opportunity costs to gain surplus from the conservation investment. Let Δc_i represent the payment above opportunity costs that landowner i demands. Given the unobservable nature of landowners' true opportunity costs, the conservation group is unable to partition the payment demand of landowner i, represented by p_i, into the opportunity costs (c_i) and surplus (Δc_i) components. Finally, the total conservation investment over all sites is limited by