**Auctions for conservation contracts: an empirical
Examination of Victoria's Bush Tender Trial**

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Abstract

In this paper we provide an analysis of Victoria's BushTender Trial. BushTender is an auction-based approach to allocating conservation contracts that is currently being trialed in two Victorian regions. We analyse the bids provided by landholders. We compare the discriminative price auction to a hypothetical fixed-price scheme. We also comment on anecdotal evidence about the likely *indirect* benefits of BushTender.

Disclaimer: The opinion herein is that of the authors, and not the Department of Natural Resources and Environment, nor the Government of Victoria.

1. Introduction

Governments allocate significant resources to natural resource and environmental management. In Australia, programs such as the Natural Heritage Trust ($1.5 billion over six years), and the National Action Plan for Salinity and Water Quality ($1.4 billion over seven years) demonstrate the magnitude of these commitments by both State and Federal Governments. These and other environmental and natural resource management programs employ a combination of intervention mechanisms including community and catchment-based planning, voluntary programs, fixed-price subsidies and grants, education programs and capital works programs.

Although there is general acknowledgment that these programs have altered community awareness about environmental issues, there is not a widespread belief that these programs have cost-effectively achieved on-ground outcomes. For example, the Australian National Audit Office (2001) commented on the National Heritage Trust by saying that the program has been successful in "raising awareness and empowering communities, fostering integrated planning…but few projects have the potential to lead to broad scale long term landscape outcomes…and is…poor in monitoring, administration and cost shifting".

In terms of achieving landscape outcomes, and 'cost shifting', Latacz Lohmann and Van der Hoomsvoort (1997) argue that there are good reasons to consider auctions, which can be used to create markets for public goods. The Victorian Department of Natural Resources and Environment (NRE) is currently trialing an auction-based approach to allocating conservation contracts to private landholders. The trial is called BushTender.

In this paper we report on the performance and implications of BushTender. While the focus of this auction has been on biodiversity conservation, there are implications of this approach for other land-related environmental management problems such as dryland salinity and water quality.

1.1 Conservation of biodiversity on private land

There is over one million hectares of native vegetation remaining on private land in Victoria. Much of it is of high conservation significance providing habitat for native

plants and animals as well as generating other environmental services. Approximately 15 per cent of Victoria's threatened vegetation types rely solely on private land for their survival. An additional 35 per cent of threatened vegetation types occur largely on private land, making private land conservation an imperative if these species are to be conserved.

Conserving biodiversity on private land has been an important, but elusive, objective for government agencies. Generally, it has not been feasible to include remnant vegetation on private land in the national reserve system. This approach would probably be costly to administer for two reasons: remnants are often small scale, and disparate; and incorporating them into the reserve system would not take advantage of local knowledge, expertise and resources.

Governments have employed a range of mechanisms for biodiversity conservation on private land. Land for Wildlife and Trust for Nature are examples of voluntary schemes that facilitate landholder commitments to biodiversity conservation. Grants, offered on a fixed-price basis, have been available under the Bushcare program of the National Heritage Trust for fencing and management of remnant vegetation, and some state governments in Australia have introduced legislation intended to prevent clearing of remnant vegetation.

Despite these measures, many important biodiversity assets on private land remain subject to degradation due to land-use practices such as grazing by stock, firewood collection and weed and pest invasion. NRE (2000) concluded that the existing programs employed to achieve biodiversity conservation objectives have "failed to engage landholders, particularly commercially oriented farms". Hamilton, Dettman and Curtis (1997) found that in Victoria's Box-Ironbark region, up to 80 per cent of the remnant vegetation occurred on larger, potentially commercially orientated, properties. However, these landholders tended not to be engaged in existing voluntary programs.

2. Markets for biodiversity conservation

It is generally acknowledged that existing markets and institutions misallocate resources to environmental goods and services. Markets are generally efficient in allocating resources to 'exploitation activities' but may be ineffective with respect to environmental conservation. Commodity markets, for example, provide clear signals to individual landholders about the value of clearing land for agricultural production, yet markets for conservation actions are missing or inefficient.

Ideas about why markets are missing or inefficient have changed over time. Coase (1960) argued that when property rights are clearly defined, market players will bargain to achieve an efficient solution (create a market), assuming that transaction costs are zero. However, when transaction costs are not zero (ie, positive), the institutional arrangement that minimises transaction costs should be preferred.

Following on from Coase, Williamson (1985) has used the term 'information-impactedness' to describe any situation where there is incomplete, or asymmetric, information. Williamson argues that information impactedness affects the feasible modes of organisation (or contract). Generally, information impactedness increases the cost of a transaction, hence, parties to a transaction will attempt to minimise these costs via contract design, or governance arrangements.

The basic idea that that information asymmetry affects the way markets operate was was introduced by Akerlof (1970). Subsequently, many economists have refined our understanding of how the distribution of information affects market players, and how these players may or may not respond to the problem (for some of the general developments, see, for example, Laffont 1990).

Latacz-Lohmann and Van der Hamsvoort (1997) explain how information asymmetry affects the market for environmental goods and services associated with land. They note that there is a "clear presence of information asymmetry in that farmers know better than the program administrator about how participation (in conservation actions) would affect their production plans and profit". Likewise, environmental experts, not landholders, hold information about the importance of environmental assets that exist on farm land. However, landholders may not have all the relevant

information about government priorities and are unlikely to understand how this information might influence subsequent contracts.

These information problems impede the emergence of conventional markets for land related environmental services. Latacz Lohmann and Van der Hamsvoort (1998) conclude "that some institution other than a conventional market is needed to stimulate the provision of public goods from agriculture". They argue that auctions are "the main quasi-market institution used in other sectors of the economy to arrange the provision of public-type goods by private enterprises".

2.1 Auctions for biodiversity conservation contracts

The use of auctions to achieve government aims has been successful where their designs reflect both the nature of the object in question (eg. heterogeneous parcels of land, multiple units) and the objectives of the auction (eg. environmental goals, fostering competition)[1]. Klemperer (2000) notes that "auction design is a matter of horses for courses, not one size fits all".

Formal analysis of auctions in the economic literature is relatively new. Early work on auctions stems from the seminal papers of Friedman (1956) for the case of a single strategic bidder, and Vickrey (1961) for the equilibrium game theoretic approach. The development of appropriate game theoretic tools has made auction theory an increasingly researched topic. The three broad models studied are: the independent private value model of Vickrey (1961), the symmetric common value model of Rothkopf (1969) and Wilson (1969, 1977) and the asymmetric common value model of Wilson (1967). Several survey articles offer insights into the results, and approach, of the theoretical literature on auctions, for example, Wolfstetter (1996).

With regards to BushTender, there were three important auction design issues: auction format; contract design; and specification of NRE's biodiversity preferences. In the next few sections we examine these aspects of the BushTender trial.

2.1.1 Auction format

In this section we analyse BushTender's auction format, which included:

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[1] We apply this theory to the design of the BushTender Trial below.

- First price, sealed bid, single round;

- Price minimisation and price discrimination;

- Individual management agreements with progress payments; and

- No reserve price.

First-price, sealed bid, single round

Collusion between landholders bidding in an auction was an important consideration in the choice of auction format. Repeated open, ascending and uniform-price auctions are generally more susceptible to collusion than a sealed-bid approach (see Klemperer 2000). Where bidders are risk-averse, a first-price sealed bid auction will facilitate lower bids because landholders can reduce commodity and weather related income variability by adding a regular income stream from conservation payments (Riley and Samuelson 1981).

A single round, as opposed to multiple rounds of bidding, was chosen because landholders were assumed to have independent private values rather than common values. Variation from farm to farm with respect to soil quality, rainfall, production systems etc. suggest that landholders would base bids on their own information about opportunity costs and would be unlikely to alter the initial bid on the basis of information about other landholders' valuations.

Price minimisation and price discrimination − One of the important design issues associated with land-use auctions is whether to offer a fixed-price payment or to allow competitive bidding to determine payments. Latacz-Lohmann and Van der Hamsvoort (1997) show that a competitive bidding process with payments determined by each bidder offers significant advantages in terms of cost effectiveness from the buyer's (in this instance, NRE's) point of view.

Individual management agreements with progress payments - Where there are non-standard benefits (ie, benefits that vary from site to site), then individual management agreements provide NRE and landholders with relatively more flexibility. In other words, NRE can recommend actions that are valuable given the nature of the site, and landholders can undertake those actions that they prefer. For example, on some sites

regenerating understorey will be an imperative, whereas on others abstaining from firewood collection might be relatively important. Progress payments allow NRE a simple sanction in the case of non-performance: NRE can withdraw future payments. This is consistent with the approach used in the US Conservation Reserve Program.

Reserve price – Reserve prices are, often, a key element of auction design. However, reserve prices are less important where there is a budget constraint (see Myerson 1981, Riley and Samuelson 1981). The pilot auction of biodiversity conservation contracts had a severe budget constraint and a reserve price was not formulated *a priori*. However, if sequential biodiversity auctions were to be considered, a reserve price strategy would become relatively more important: it would be possible to transfer funds between auctions to maximise the biodiversity outcomes presented in other regions, or in subsequent auctions.

2.1.2 Contract design

The objective of the contract between landholders and the government agency concerned with biodiversity conservation is to improve the status and resilience of habitat for native plants and animals. This outcome is, however, difficult to measure and monitor. For example, monitoring the impact of changes to land management in terms of improvement in the stock and quality of fauna and flora would be very costly and subject to dispute.

An alternative strategy would be to specify the contract on the basis of inputs such as fencing, weed control, understorey protection etc. These inputs are known to improve biodiversity status and resilience, but the transformation function that maps these actions (inputs) into outcomes is not known with certainty, even if the actions are carried out diligently. Further, the effect of unexpected events, such as drought and floods could not reasonably be predicted by either the landholder, nor NRE.

These two problems (unobservability of outcomes and imperfect knowledge about the transformation function) were considered by Ouchi (1979), and explained in the context of the public sector by Wilson (1989). Williamson (1985) has characterised this as the problem of 'measurement'. The principal-agent literature has considered one or both of these problems to varying degrees (see for example, Holmstrom and Milgrom 1991, 1994) This literature has recommended a host of ways to deal with

these difficult problems, that include: organising activities inside the firm; using fixed pay arrangements (again inside the firm); and contracting on the basis of inputs.

In BushTender, NRE based contracts with landholders on inputs (as specified in individual management agreements). This was for two main reasons. First, undertaking the work inside the Department was not a realistic possibility on account of the fragmented nature of the holdings, and hence the cost of management (see above). Second, given that contracts with external (outside of the firm) agents were needed, there was no low-cost measure of outcomes on which to base (enforce) these contracts. One of the only options left for NRE was to contract on the basis of inputs.

This has implications for risk bearing, specifically, the government agency bears most of the risk where contracts are specified in terms of inputs. This may be sufficient for the trial, where the main purpose was to test the auction mechanism and the supporting information systems. However, improvements in knowledge (for example, new technology that allows lower cost monitoring of species prevalence) may enable a government agency to base at least part of its payments—in some future scheme—on output.

2.1.3 Specification of biodiversity preferences

Notwithstanding the problem of ex-post monitoring of outcomes, NRE still needed to allocate their monies using information about the *likely* biodiversity benefits that would be generated from any management agreement. An important component of the auction of biodiversity conservation contracts has been the development of a language and metric to estimate the relative importance, in terms of biodiversity benefits, of different actions (inputs) on different sites.

To this end, each vegetation site offered into the auction was assessed on the basis of the significance of the vegetation type, and the contribution to biodiversity benefits that would accrue from various landholder actions. A Biodiversity Significance Score (BSS) was developed by ecologists to rate each site according to its conservation value. The Biodiversity Significance score reflects existing information about the scarcity of remnant vegetation types, according to Ecological Vegetation

Classifications[2]. A Habitat Services Score (HSS) was developed to measure the amount of biodiversity improvement offered by the landholder. In brief, it converts actions nominated by landholders, such as fencing remnants and weed control, into a score reflecting the estimated improvement in biodiversity status.

Landholders were only informed about some factors that affected the conservation status of their site (for example, whether it contained threatened species); they were not provided with the exact value of their Biodiversity Significance Score. The Habitat Services Score was, however, fully revealed to landholders. This strategy was empirically supported by commissioned experimental work (Cason *et. al.* yr 2002) that examined bidders behaviour in an auction when the value of their output was known, compared to when it was not. When bidders did *not* know the value of output, their bids tended to be based on the opportunity costs of land-use change. By contrast, when bidders were given information about the significance of their biodiversity assets, they tended to raise bids and appropriate some information rents. In BushTender, the exact value the Biodiversity Significance Score was withheld from landholders to improve the auction's cost-effectiveness. There are, however, other considerations that may influence this strategy which are discussed later in the paper.

Bids into the auction were ranked on a cost-effectiveness basis, by comparing a quality-adjusted measure of benefits (habitat services offered, multiplied by conservation significance of the site) to the cost (or price) of the bid. This objective was represented as a Biodiversity Benefits Index (BBI) calculated according to the following formula:

$$BBI = \frac{BSS \times HSS}{bid} \qquad (1)$$

3. Implementation of the pilot auction of biodiversity conservation contracts

The Department of Natural Resources and Environment conducted the auction of biodiversity conservation contracts in two trial regions of Victoria, namely parts of the North East and North Central Catchment Management areas (Figures 3.1 and 3.2).

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[2] Ecological Vegetation Classes indicate whether vegetation is presumed extinct, endangered,

Figure 3.1: North Central Trial Area – Replace with map of Victoria with regions identified.
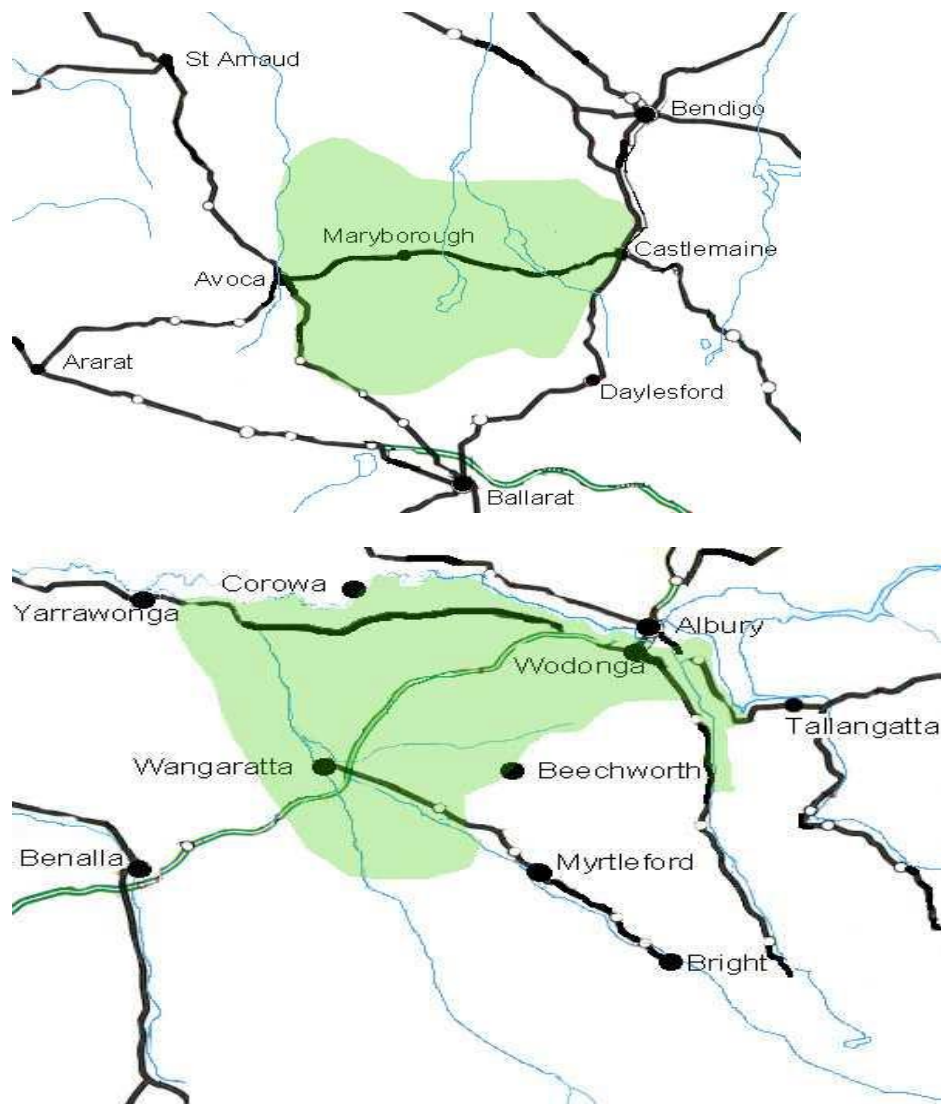

Figure 3.2: North East Trial Area

After initial publicity about the auction, interested landholders were visited by a field officer who assessed the quality and significance of the native vegetation on the site (BSS) and discussed management options with the landholder. Landholders then identified the actions they proposed to undertake on the site and, with the field officer, prepared an agreed management plan as the basis of their bid. Following the site visit, landholders received a printed draft management plan. This contained some information about the relative conservation value of their site, and their HSS.

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vunerable, depleted etc.

Landholders then submitted their management plan along with a bid for payment to carry out the actions identified.

4. Results

Table 3.2 provides some summary statistics about participation in BushTender. In total there were 126 expressions of interest from within the trial regions. Field officers assessed 116 properties containing 223 different sites. Landholders with more than one site on their property were given the option of submitting individual bids for each site or a single bid for all their sites in combination.

Table 4.1: Participation in the Trial

	North Central	North East	Total
Expressions of interest (in trial area):	63	63	126
Properties assessed:	62	54	116
Number of sites assessed	104	119	223
Average sites per property:	1.7	2.2	NA[a]
Total hectares offered:	1,834 ha.	2,011 ha	3,845
Number of vegetation types identified/assessed:	20 (out of a possible 25)	18 (out of a possible 25)	38
Largest site:	294 hectares	218 hectares	512
Number of remnant vegetation management proposals:	100	108	208
Number of revegetation proposals:	4	11	15

Notes to Table 4.1: NA=not applicable.

Table 4.2 shows a summary of results from the BushTender auction. In total 98 landholders submitted bids, 73 of which were awarded contracts. These contracts were written against the inputs and actions specified in the management agreements over a three year period. An initial payment was made to successful bidders to cover capital costs, where specified (eg. for constructing fences) with annual progress payments made on the basis of performance.

Table 4.2: Auction Results

|	North Central	North East	Total
Number of bidders	50	48	98
Number of bids	73	75	148
Number of sites	85	101	186
Number of successful bidders	37	36	73
Number of successful bids	47	50	97
Number of successful sites	61	70	131
Area under Agreement (ha)	1644	1516	3160

The budget constraint for the auction ($400,000) enabled NRE to secure a total of nearly 3,200 hectares of remnant vegetation. A mix of actions was included in the individual management agreements developed with landholders. The Biodiversity Benefits Index used in the trial—given in (1)—favoured actions that improve management of existing remnant vegetation rather than recreating new areas of vegetation.

Figure 4.1 shows the bids entered into BushTender in ascending order, from left to right[3]. The horizontal axis depicts the total quantity of biodiversity supplied, in terms of what we have labelled biodiversity quality adjusted (BQ) units. These are the numerator of the BBI as given in (1): the biodiversity significance score times the habitat services score.

The bids shown in Figure 4.1 are *inclusive* of any 'information rents' that bidders may have included in their bid price. However, we will henceforth refer to this curve as a marginal cost or supply curve for biodiversity from BushTender. This is different to the characterisation of Latacz-Lohmann and Van der Hamsvoort (1998), who differentiate the supply curve on account of it being *exclusive* of rents.

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[3] For reasons of confidentiality, we have altered all graphs in this section by doing two things: removing all outliers; and re-scaling the axes.

Figure 4.1: Marginal Cost Curve
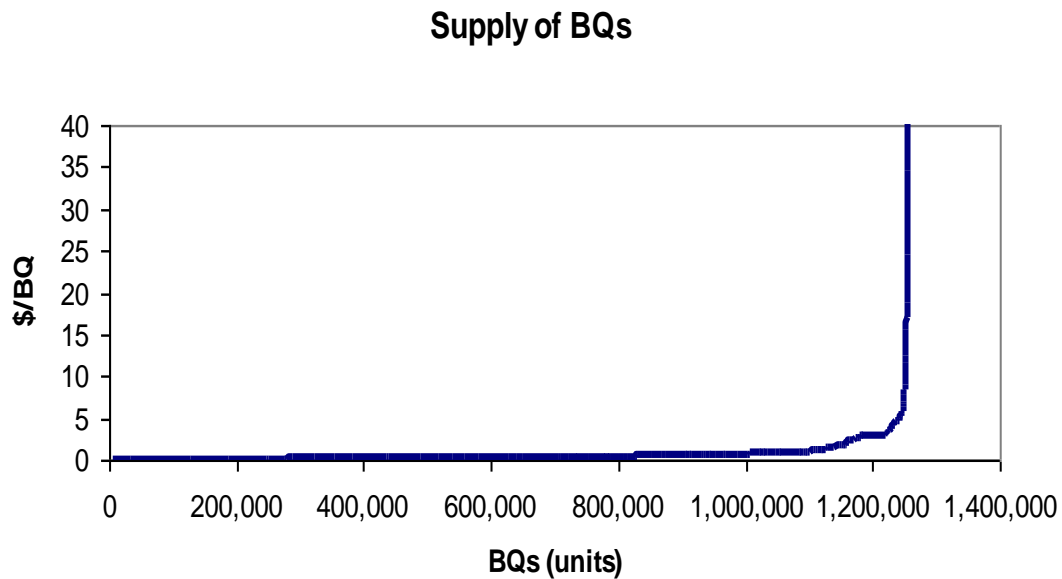
Supply of BQs

The supply curve for biodiversity is elastic over much of the quantity range but then transforms to inelastic as the quantity of BQs exceeds 1.2 million units.

Although NRE did not use a reserve price for the pilot (see above), a reserve price could important if sequential auctions were run. The slope of the supply curve for biodiversity would be important in formulating a reserve price strategy. With experience, the government agency could withhold some funds from one auction in anticipation of more cost-effective bids in the next round.

A scatter of bids, with the threshold-BBI curve (the solid curve), is given in Figure 4.2. The threshold BBI is the value of the marginal bidder's BBI. In other words, the curve shows combinations of HSS/bid and BSS which—when multiplied by each other—equal the threshold-BBI. Bids at the top-right of the diagram represent high biodiversity value and low offer price; they are preferred bids. All those bid points to the right of the threshold-BBI curve are 'successful' bids. Changing the budget constraint would change the location of the threshold-BBI curve, specifically, it would be to the right with a lower budget constraint (and vice versa).

Figure 4.2: Threshold-BBI and Bid Data

Threshold BBI (for $400,000)

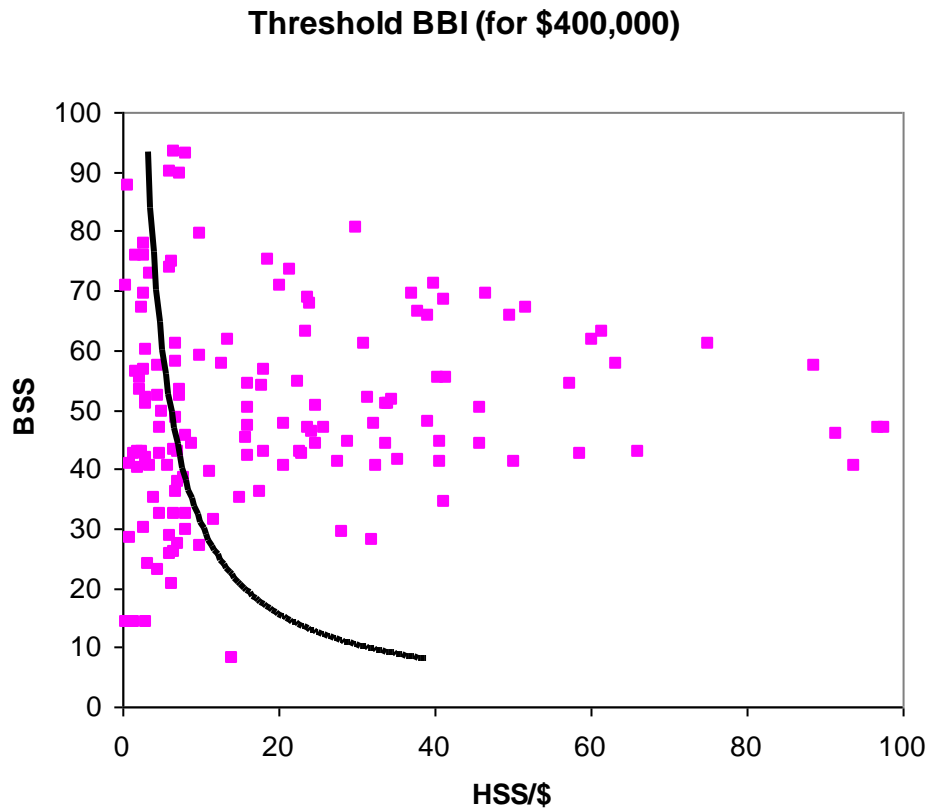Figure 4.2 shows that bids were scattered, that is, landholders exhibited diversity in both HSS/$, and BSS. Essentially, the auction enables an agency to exploit this diversity: an agency can reward those bidders offering very good value for money bids, at the price they nominate. The horizontal distance between the threshold BBI and any successful bid point could be seen as a surplus or rent to the government agency running the auction; holding all else constant, this is the gain to NRE from this contract.

The diversity of bids, particularly the fact that some landholders offered very low bids per-hectare, implies that some landholders were probably prepared to share costs with the government to conserve biodiversity. Other landholders, it seems, charged NRE the full opportunity cost of land-based activities[4]. NRE commissioned a survey of

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[4] We cannot reveal the costs per hectare for confidentiality reasons.

bidders, non-bidders and those unaware of BushTender, to analyse whether bidders in BushTender were 'representative' of landholders in the trial region (Sweeney 2002). Sweeney's analysis shows that participants in the auction were representative of the population in the trial regions with respect to farm size, income source and age. This is an important observation if the auction-based approach were ever considered for a more pervasive scheme in the future.

Although it is difficult to compare the results from the auction with other mechanisms, we have tried to examine how a fixed-price scheme would compare with the discriminative price auction used in the pilot. To make this comparison, we must assume that the agency could, with a repeat experiment that offered a fixed price, get bidders to bid in the same fashion as they did in the BushTender pilot.

Figure 4.4 illustrates that in a fixed-price scheme, an agency would pay each successful landholder the same price: the price of the marginal offer[5]. For the last unit of biodiversity purchased in BushTender, this marginal price is approximately $2.30 (see Figure 4.4). This is the fixed-price that an agency would need to offer landholders to generate the same supply of biodiversity made available from the price discriminating auction (approximately 1.16 million units of biodiversity). A fixed-price scheme would require a budget of approximately $2.7 million (almost seven times more than the actual budget) to get the same quantity of BQ units as the discriminative price auction. Looked at another way, Figure 4.4 shows that—for the same budget of around $400,000—a fixed price scheme would give an agency approximately 25 per cent less biodiversity. The supply of biodiversity falls from 1.65 million to 0.87 million units of biodiversity, with a fixed-price scheme compared with the discriminative price approach.

If both BushTender and a fixed price scheme resulted in the same bidding behaviour from participants (as assumed above), then there would be no difference in the efficiency of the two schemes; they would both allocate contracts to the same bidders. There would, however, be a difference in the distribution of the schemes, and hence the cost-effectiveness from government's point of view.

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[5] 'Price' here is dollars per BQ.

Figure 4.4: Comparison on One-Price versus Discriminative Price Auction
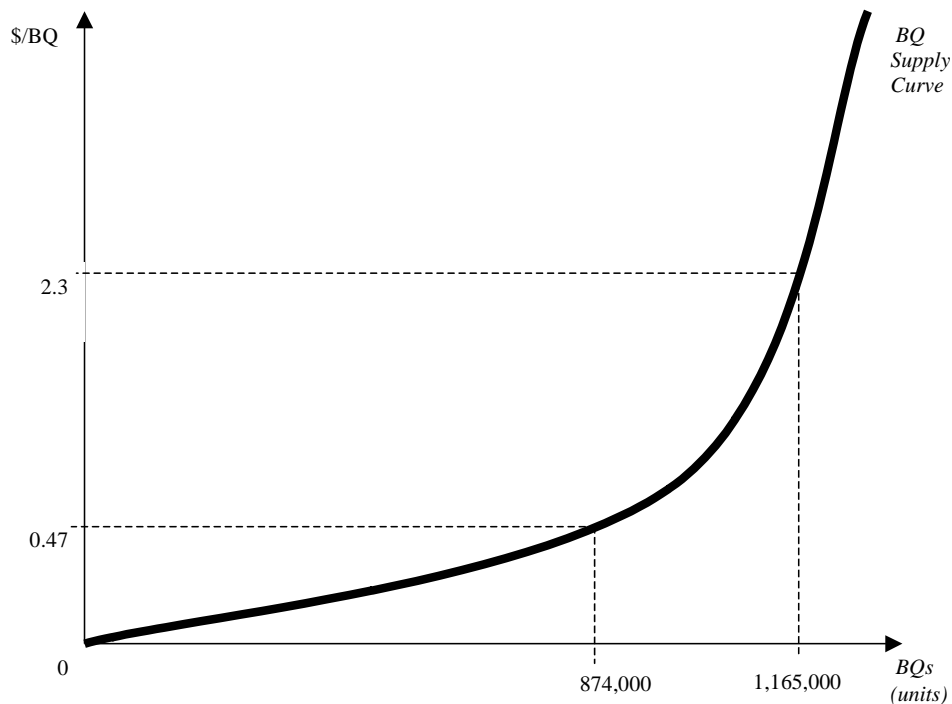
5. Discussion and Summary

This paper has shown that it is possible to design and operationalise a market-based approach for one environmental management problem involving land management. Characterising biodiversity conservation on private land as a problem of asymmetric information has improved our understanding of why related environmental markets are missing or ineffective and introduced alternative policy mechanisms to those in current use. Auctioning biodiversity conservation contracts offers many advantages over planning, command and control, voluntary approaches and fixed price policy mechanisms. This is not to suggest that auctions are a viable replacement for these other mechanisms – it does, however, add an important new mechanism to the environmental policy tool kit.

Many important design issues have been addressed in the process of implementing the auction. Besides choices about auction format, contract design and the specification of biodiversity preferences, many practical but important choices arise concerning communication with landholders, skills required to successfully run an auction and timing of activities. These factors all influence the performance of the auction.

Perhaps the most important finding from the pilot auction of biodiversity conservation contracts is that this approach offers significant cost-savings over a fixed-price approach. For the budget available and the bids received, it has been shown that a price discriminating auction would reduce by seven times, the cost of achieving the same biodiversity improvement using a fixed-price approach. This result is consistent with the broad predictions of Latacz-Lohmann and Van der Hamsvoort (1997).

The success of the auction can be principally ascribed to its ability to reveal the information needed to make good biodiversity conservation decisions. The auction for biodiversity conservation was designed to reveal specific information from the agency responsible for increasing biodiversity conservation and from landholders. As part of the auction, the agency was required reveal information about the relative conservation status of different areas of vegetation under consideration (the Biodiversity Significance Score) and the about the improvement in biodiversity associated with changes in land management (the Habitat Services Score). This information would significantly improve priority setting for biodiversity conservation whatever the mechanism employed.

Another factor contributing to the cost-effectiveness of the auction-based approach is that it enables an agency to take advantage of heterogeneity in landholders' opportunity costs. Many landholders participating in the auction were clearly prepared to cost-share with the Government to conserve biodiversity. Some were willing to bear nearly all of the costs of managing biodiversity while others offered bids that reflected financial opportunity costs. Hence, landholders' bids exhibited substantial variation if they are compared purely on a cost-basis. However, the differences in the bids became even more exaggerated when they were ranked according to the biodiversity benefits index, which combines cost information with benefit information.

The observation that the auction-based approach offers significant improvements in terms of cost-effectiveness compared with a fixed-price systems stems largely from the different information revelation processes in each approach. Some fixed-price approaches reveal the wrong information from the parties involved. A fixed price approach like a subsidy on some inputs, requires the landholder to reveal the actions that they believe will improve the environment (when this information is perhaps held

by environmental agencies); and agencies reveal the price that will be paid for these actions (when this information is often held by landholders).

Attention to other aspects of auction design also has make an important contribution to the cost-effectiveness of BushTender. Harnessing competition between landholders and avoiding collusion were key goals of the auction. In a one-off auction, such as the pilot, heterogeneity in landholders' opportunity costs provides scope for the government agency to select low-cost bids.

Design of a sequential auction, however, would be more complicated. In a sequential auction landholders can 'learn' through auction rounds. This could change their bidding strategies, and raise the cost to the agency. For example, Riechelderfer and Boggess (1998) found that bidders in the Conservation Reserve Program—which is a sequential auction—revised bids from previous rounds by offering bids at the reserve price. This reserve price was a per hectare rate. When landholders learnt this reserve price, they anchored their bids around it.

We would expect that a more pervasive auction-style scheme for biodiversity would base its reserve price on the BBI, as given in (1), rather than a rate per hectare. This would be harder for landholders to learn, or unravel. However, this is not to say that an agency considering a sequential auction approach should not be cautious in terms of the scheme's design.

In fact, one of the most interesting design issues with BushTender concerned the extent to which information were made known to landholders prior to formulation of their bids. For the pilot auction, information about the Biodiversity Significance Score was withheld from landholders but the Habitat Services Score was fully revealed to bidders. As noted earlier, this strategy was empirically supported by the findings of (Cason *et. al.* 2002). Although the strategy to withhold information was adopted for cost-effectiveness reasons, other considerations suggest that full disclosure of information about biodiversity significance may be appropriate. In the short-run, withholding some information limits the scope for landholders to extract rents to information from the auction. Clearly, landholders who know that they have the only remaining colony of some plant or animal, will be able to raise their bids, well above opportunity cost, compared with a situation where this information was

not know by the landholder. The alternative strategy also has merit in that the information rents that accrue to landholders would influence land markets encouraging investment in nature conservation.

Other indirect benefits could arise from the application of auctions and other market approaches to environmental management. For example, information about the marginal cost of biodiversity conservation would assist public sector decision-makers in allocating resources between conservation investments on public (eg. national parks) and private land. Similarly the emergence of more formalised and quantitative methods of expressing relative preferences for alternative environmental actions may facilitate development of more robust offset and trading schemes.

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