EcoTender: Auction for multiple environmental outcomes

National Action Plan for Salinity and Water Quality

National Market Based Instruments Pilot Program

Project final report

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The EcoTender pilot is an application of part of a broad agenda of work on environmental mechanisms that has been developed over the past five years. Although this has involved many people a key contributor is Gary Stoneham, Chief Economist, Department of Sustainability and Environment.

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Foreword

Market-based instruments (MBIs) are policy mechanisms that can be used to manage environmental problems and assets in a more cost-effective way than current prescriptive approaches, at least theoretically. The National Market-based Instruments Program has been implemented to test designs of MBIs on real environmental problems. $5 million has been allocated to the program in the first round to trial ten MBI designs across Australia. The Victorian Department of Primary Industries is leading a trial called the 'Multiple-Outcome Auction of Land-Use Change' or the ***EcoTender*** Pilot.

EcoTender is designed to use a BushTender style auction mechanism to encourage private landholders to manage their land and water resources to provide catchment wide salinity, water quality, water quantity and biodiversity benefits. The trial is designed to test the feasibility of using one mechanism to simultaneously encourage land-use change for multiple environmental purposes.

EcoTender represents a significant advance towards implementing a comprehensive market-based approach to managing environmental problems. The design of a successful pilot requires implementation of an auction mechanism that can process complex natural resource information combined with information elicited from landholders to ensure cost effective use of government funds.

1 Executive Summary

This paper reports on a pilot auction for multiple environmental outcomes. The $500,000 EcoTender pilot is an initiative of the Victorian Department of Primary Industries (DPI), funded by the National Action Plan (NAP) for Salinity and Water Quality Market Based Instruments Program (MBI). The pilot is being developed and implemented by DPI and the Department of Sustainability and Environment (DSE), in central Victoria.

The pilot demonstrates a linkage between the auction process and an innovative Catchment Modelling Framework (CMF) used to estimate *multiple* environmental outcomes including carbon, terrestrial biodiversity, aquatic function and saline land area.

Auctions have been used in the past to distribute environmental funds. BushTender, a single dimension auction (one environmental outcome) demonstrated significant cost savings could be achieved when compared to other grant based approaches (Stoneham *et al*. 2003). If correctly applied auctions can help to overcome common problems involving *asymmetric information* – where landholders have information about the cost of undertaking an action but this information is hidden from the agency that is providing the funds. The agency needs both cost information from landholders and information linking landholder actions to environmental outcomes (*missing information*), to allocate funds cost effectively. In general, these auctions aim to provide private landholders with the incentive to truthfully reveal their cost of undertaking specified actions that produce environmental outcomes.

This is the first time a market-based policy has been fully integrated from *desk to field* with a biophysical model, the CMF, for the purchase of multiple outcomes. This CMF solves the *missing information* problem of linking paddock scale landuse and management to catchment scale environmental outcomes. The framework also incorporates a number of biodiversity algorithms that estimate current and future eco-system benefits.

In EcoTender the Victorian Government is the sole purchaser and multiple landholders located within North Central Victoria are the potential sellers. After a

period of communication with landholders in the identified areas, the Department conducts site assessments of landholders that register their interest and meet the base criteria. The landholders are informed about the actions available to them and the environmental scores for each of the goods being assessed in the auction. Landholders can then submit a bid to the Department identifying the actions they agree to perform if successful in the auction and the amount that they require to perform them. All bids are then assessed according to their total environmental benefit divided by the cost of each bid, which represents the value for money of a bid. The value for money achieved by the auction is then maximised subject to the budget constraint of the auction. This process ensures the auction achieves the most cost-effective result for the Department, given the budget available to it, the bids received in the auction and the preferences of the Department between goods.

The following sections report on the overall performance of EcoTender, factors contributing to its success, additions to the knowledge base to support future implementation and potential applications.

1.1 Overall performance of EcoTender

Key performance measures for EcoTender include its ability to discover the price of supplying environmental outcomes and make use of this information to allocate resources in a cost-effective manner.

Price discovery

The auction required landholders to submit a dollar value bid to undertake a set of actions that would provide environmental outcomes, as estimated by the Department. Landholders were provided with a list of actions and the resultant environmental outcomes for terrestrial biodiversity, aquatic function and saline land. The sum of all outcomes was the total score for each farmer. Landholders were provided with a distribution of total scores to help inform them about the relative benefit of their score to other bidders.

Using the total score and the bid it was possible to determine the supply cost per unit of total environmental outcome. Combining this information for all bids a supply curve was developed which depicts the rising marginal cost of supplying environmental outcomes in the pilot areas.

From the supply curve the cumulative cost of purchasing environmental outcomes was calculated and combined with the budget to determine which bids were selected.

Resource allocation

The process of ordering the bids ensured the environmental outcomes were procured cost effectively. That is the bids were selected on a value for money basis, the lowest cost bid is selected first and so on until the budget is exhausted.

At this stage it is not possible to determine whether this is the most efficient outcome. The efficient group of bids would those selected where the demand for environmental goods is equal to the supply. However, information that describes the demand for environmental outcomes in a manner that could be combined with the supply information is currently not available.

In order to reveal the demand for environmental outcomes information is needed relating the cost of providing them to preferences for those outcomes, relative to other goods and services. Approaches previously considered for obtaining this type of information include survey/valuation techniques (contingent valuation, choice modelling), past budget allocations and using the preferences of a representative party (environmental expert, Minister). Each of these approaches was considered but none were adopted in the pilot (see Chapter 6 for detail). A science-based approach was used to determine the total environmental benefit (see Section 5.3.2). This approach implies a tradeoff between each of the environmental outcomes and can be used with pilot results to inform future applications.

If this type of pilot were to run as program, ensuring information about environmental outcomes is available to decision-makers is essential to inform the development of preferences in the future.

1.2 Factors contributing to the success/failure of EcoTender

Key to the success of the EcoTender was the multi-disciplinary approach to design and implementation. For example, economic theory needed to link with sophisticated biophysical modelling through to field officer implementation and communication.

The following sections outline how each disciplinary area contributed to the success of EcoTender.

Economic Theory: Mechanism and contract design

Two key areas of economic research included auction and contract design. Auction design is important to ensure problems of asymmetric information are overcome and environmental outcomes can be procured cost effectively. Contract design is used to ensure the successful delivery of environmental objectives.

Auction design

EcoTender is based on an auction approach to allocating conservation contracts and can be viewed as a multi-outcome analogue of BushTender (Stoneham et al 2003). The EcoTender auction has the following design features:

- First price
- Sealed Bid
- Single round
- Information about Metric Revealed

This is basically the same as the BushTender auctions except for the last feature: in BushTender the government revealed only part of the information regarding the metric (or landholder scores) for the environmental outcome (terrestrial biodiversity). However, landholders were provided with all relevant information informing them about the context and significance of their site but not a specific score. In EcoTender the government revealed full information about the environmental outcome scores.

Landholders were provided with the score for each environmental outcome and the total environmental outcome score. Further, landholders were provided with a distribution of the total environmental scores for all potential bids.

Overall the auction methodology employed in EcoTender is considered to be relatively sound and well tested in laboratory settings and in the field. However, further auction design work is warranted, particularly in the areas of repeated auctions, site synergies and participation payments.

Contract Design

In EcoTender the Department is interested in purchasing contracts for the provision of environmental outcomes. However, we assume the Department cannot purchase these outcomes directly and must influence landholders to produce actions or outputs that may result in outcomes. We assume that actions may lead to on-site outputs that may lead to catchment outcomes.

Each EcoTender contract is based on the obligations of two parties: the Department; and a landholder. The contracts require the Department to provide payments for actions undertaken or outputs provided, given there has been some proof of fulfilment.

'Proof' generally comes in the form of self-reporting. In addition to self-reporting there will be monitoring of sites by Departmental officers. Each site will be visited at least once throughout the contract period.

There are two types of EcoTender contract: one for revegetation; and another for management of remnant native vegetation. Remnant management and revegetation contracts are for five and ten years, respectively. For both contract types if the milestones have not been achieved despite attempts to reconcile, the contract may be ended without making remaining payments.

For both contract types the Department spreads payments over time according to a U shape. That is, the Department makes relatively large payments at the commencement and completion of the contract—25 percent in each instance, making up 50 percent of the overall payment. The remaining 50 percent is paid in the intermediate periods.

The economic literature on contract design delivers some broad messages about the way to design contracts. When the theory is applied, the following recommendations can be made for the EcoTender pilot:

- the agency should think hard about the relationship between actions on the ground, and overall outcomes when designing contracts;
- where cost-effective, the agency should contract landholders to produce outputs, rather than inputs;
- where the above is not cost-effective, the agency can contract landholders for inputs;
- whether contracting for inputs or outputs, the agency should link the contract services to a monitoring, compliance and enforcement regime including self-monitoring; and

- payments for services should be linked to the outcomes of the monitoring (this is the 'compliance' aspect).

Biophysical Information: Measurement of outcomes

A key innovation of EcoTender was an attempt to score multiple environmental outcomes. In order to achieve this the Catchment Modelling Framework (CMF) was developed and employed. The CMF was developed to estimate the environmental impacts of multiple environmental outcomes and to spatially represent these to potential bidders (landholders) and the purchaser (Victorian Government) of these services.

The CMF models landholder actions at the scale in which they occur – farm/paddock – explicitly accounting for the heterogenous nature of the environmental outcomes. This allows the Department to explicitly measure and account for heterogeneous nature of environmental outcomes. As heterogeneity between landholders and sites exists it is possible to get more environmental outcomes for a given environmental budget as apposed to paying a flat rate and assuming equal environmental benefit.

This approach also offers the prospect of improving the cost-effectiveness over the single dimension auction by maximising the total of environmental benefits per dollar spent. It also reduces the costs of providing information about the impact of land-use change, thereby reducing transaction costs associated with procuring environmental outcomes. For instance rather than running several programs for each environmental element (salinity, water quality, etc) a single program can be run purchasing bundles saving on contact time with landholders and information gathering to determine the relative environmental merit of each site.

The catchment modelling framework presented here focuses on providing the *missing information* linking on and off-site environmental outcomes with on-site actions on private land. The framework has been designed to explicitly model and report the joint production of environmental outcomes which links effectively with policy to efficiently allocate conservation funds.

The CMF has incorporated biophysical processes to account for soil erosion, water, carbon and saline land to estimate environmental outcomes. Further, biodiversity algorithms have been incorporated which evaluate the current location of native vegetation and biodiversity landscape preference which assesses the future spatial needs of key mobile fauna species. The CMF is the only framework (the authors are aware of) that has brought together both biophysical and eco-system information.

The CMF has significantly reduced the transaction costs associated with accurately determining environmental outcomes for any site within the landscape. The CMF can be readily calibrated to any catchment providing there is sufficient data for calibration. Further, the framework can be readily updated as new data becomes available.

The framework has demonstrated the importance of joint production in environmental outcomes and the heterogenous nature of the landscape in terms of environmental outcomes at the farm level.

The following areas warrant further research if the CMF or like approach is to be applied in the future:

- Assess diminishing marginal product when developing metrics.
- Current metrics consist of a service and significance component. More scientific information is needed to produce a reliable significance measure.
- Bids are currently assessed independently of one another. However, a combination of bids may have a greater impact than the sum of them alone. Combinatorial approaches to bid selection warrant further investigation.

Project management and communication

During the auction and score design phases there was strong emphasis on field officer participation to ensure successful implementation.

Given past experience implementing auctions the implementation process was relatively straightforward. However, the communication needed to be modified significantly to account for multiple environmental outcomes. This was informed by the metrics that would be employed with respect to preferences and the need for field staff to be able to communicate them in the meaningful manner.

A description of each of the metrics and a spatial map showing its potential score was provided to the field officers for distribution to landholders. This information was used to impart an understanding to landholders about the multiple nature of environmental outcomes and indicate to them whether their land is in a high or low impact area. Further, if landholders had a choice about the size and location of sites in which they could undertake actions they could tailor their sites in order to maximise potential environmental benefits and, in turn their total environmental score.

Economic theory was useful in designing the communications to reflect government preferences for each of the environmental outcomes. It was important for the field officers to be able to communicate how bids were to be selected and whether there was a preference for any of the outcomes. If there were a preference for any of the outcomes the field officer would have to discuss how each of the actions would influence each of the outcomes, further complicating overall communications with landholders. Farmers were told government gave equal weighting to all outcomes. In this way the main driver of outcomes was the actions undertaken, area (larger areas generally score higher) and the location of the site.

The design of the CMF was tailored so field officers could easily produce the environmental score for each site. It was also useful for managing the vast quantities of information involved in running such a program. For instance, for each site the following information is stored by the CMF for current and future reference: geo-referenced location information, current and proposed land use, terrestrial biodiversity attributes, weeding, fencing and other management options, management plans and bid sheets.

The CMF produced most of the documentation that was needed for provision of management plans, bid sheets, aerial photography of location etc that is sent to farmers for them to assess whether they would like to submit a bid. Final bid assessment is also linked to stored information and was made available to the bid selection panel.

1.3 Skill development

For a *standard* auction, the design employed by EcoTender is transferable and applicable. However, there are a number of skills required to analyse the nuances of each new application.

Expertise and skill development

Project personnel developed specialist and generalist skills in the implementation of multiple dimension auctions. These include modelling complex landscape systems for policy applications, groundwater and surface water modelling, software development for application in the field, communication and design and contract design. These skills are essential for future applications and development of the methodology and approach. The following summarise specific and general skills and expertise developed during the EcoTender pilot.

- Economic skills for auction and contract design and application.
- Economic expertise in asymmetric information and preference revelation.
- Hydrological and plant/animal modelling expertise.
- Spatial modelling/information skills and expertise
- Expertise when incorporating and communicating preferences for multiple environmental outcomes.
- Extension techniques to communicate complex natural resource management issues to landholders.
- Skills and expertise in developing scoring methodologies (scientific, economic) for multiple environmental outcomes.
- Expertise and skills in the application of the Catchment Modelling Framework, specifically to assist field officer implementation, process and score sites, store and process information, determine both the on and off site impact of landholder actions.

1.4 Results

The department called for expressions of interest from May 2005 and completed site assessments in late October 2005. 84 sites were assessed on a total of 40 farms. 50 bids were submitted from 21 farms. The total value of these bids was $835,000.

The following notes characterise the bids:

- 46% of the bids were revegetation

- the total revegetation bids resulted in an estimated 21,000 tonnes of sequestered carbon
- 72% of the bids produced two or more environmental outcomes
- All bids provided a biodiversity benefit, 72% provided an aquatic function benefit while only 8% provided any salinity benefits.

The following points characterise the accepted bids:

- 31 bids accepted (62% of total)
- successful bids covered 259 ha (revegetation 76 ha, native vegetation management 183 ha). This was 70% of the total area offered (353 ha).
- 10,078 tonnes of carbon of which 8,087 tonnes were sold by the landholders to a third party, the remaining carbon was retained by landholders.
- of the bids selected 97% of them had two or more environmental outcomes
- Only a few bids provided a salinity benefit, which can be explained somewhat by the size and location of the sites. The largest site was 45 ha which is sufficient to provide salinity benefits, however it was located in an area of the catchment that is not amendable to providing salinity benefits. Other smaller sites were located in areas of the catchment amenable to providing salinity benefits, but they were not large enough.

2 Introduction

Currently BushTender is a high profile mechanism for environmental improvement in Australia, and in some other parts of the world. Over the last five years the BushTender approach has attracted much attention from policy analysts and academics associated with the debate about mechanisms for environmental improvement, particularly in relation to terrestrial biodiversity.

Stoneham *et al.* (2003) argue that the BushTender approach—which uses an auction mechanism to procure terrestrial biodiversity management from landholders—is a cost-effective and transparent mechanism. They support these arguments by reporting results from a pilot auction in the north east and north central regions of Victoria.

Subsequent to the initial pilot Australian governments have funded several additional BushTender type auctions, and derivatives of the approach. For example, the Victorian government has funded several other applications of the BushTender approach and the Commonwealth government contributed $5 million to the funding of market-based instruments (MBI) projects. Several of the successful MBI projects are derivatives of the BushTender approach.

However, there is an on-going debate surrounding the usefulness of auctions as a mechanism for environmental improvement on private land. Advocates argue that they are a cost-effective, transparent means of allocating resources to environmental goods. Within public policy circles critics argue that auctions are difficult to understand and communicate, and costly to implement.

This paper contributes to the current policy debate in several ways. We examine another auction pilot, called EcoTender. This is a multi-outcome extension of BushTender—whereas BushTender focused on terrestrial biodiversity, EcoTender includes several other environmental goods: saline land; aquatic function, and carbon sequestration.

The basic rationale for including several goods in the auction mechanism is twofold. First, environmental goods may be ‘jointly supplied’. For example if a landholder plants trees this may simultaneously impact on carbon sequestration, saline land, and aquatic function. Second, since auctions for environmental goods involve site visits, it may be more economical to visit each landholder only once in relation to all goods, rather than visiting them separately for each good.

The EcoTender approach raises several challenges, but two are particularly important.

- Complex Measurement of Environmental Outcomes

  The BushTender pilots made an important contribution to policy improvement by providing the Victorian government with a metric to quantitatively assess the terrestrial biodiversity benefits that result from a change in land management/use. However, EcoTender requires a more complicated metric: it must provide a quantitative assessment on many additional goods. The metrics for these additional goods requires relatively more complex science than that in BushTender. For example, the assessment of aquatic function and saline land require detailed hydrological modelling. This modelling is provided via the Catchment Modelling Framework (see Chapter 5 for detail).

- Developing and expressing preferences for different Environmental Goods

  Since the EcoTender pilot will asses the impacts of landholder management on several environmental goods, the agency must explicitly discriminate across these goods when comparing landholder bids. Whilst in BushTender the agency compared all bids based on a terrestrial biodiversity metric, in EcoTender the agency must compare the value of (say) one unit of biodiversity to one unit of improved aquatic function.

In this paper we argue that EcoTender provides useful information on both these issues. On the first issue we prove that it is possible to develop the required metrics across several environmental goods and implement this in the field. On the second issue we explain our approach, highlight key issues, and advocate a way forward in terms of future research.

2.1 Description of pilot areas

The pilot was run in two sub-catchments in Victoria, namely the Avon Richardson (371,000ha) and Cornella (47,000ha), see Figure 1 below.

Figure 1. Pilot areas

Catchment selection was based on data availability, the areal extent of any proposed land use change, the type of management considered by land managers and a requirement that the focus catchment be a priority region as identified by the appropriate state and regional authorities. The landscape also needed to be topographically and climatically variable and the catchment also needed to be unregulated (not controlled by in-stream structures and no diversions for other uses such as irrigation) and monitored so as to provide continuous stream-flow and water quality data to underpin model calibration and validation.

The current landuse in the Avon Richardson comprises 52% cropping, 37% grazing, 6% trees and the remaining 5% constituting urban infrastructure and water bodies. Annual rainfall ranges from 350 to 765 mm/year. In contrast the current landuse in the Cornella catchment comprises 53% cropping, 26% grazing, 20% trees and the remaining 1% constituting urban infrastructure and water bodies. Annual rainfall ranges from 450 to 670 mm/year.

3 The Economics of Environmental Goods

In open, decentralised economies markets are the primary institution through which individuals/firms engage in transactions that create value. Within the economic system, these individuals/firms search for transactions that maximise their private or collective well-being.

Markets have not, however, evolved in all areas of the economy, even when there may be valuable transactions that could potentially take place. The usual approach in these situations has been for government to step in with command and control approaches. This has traditionally defined the scope of government activities and we observe a strong presence of government in sectors such as the environment, health, education etc.

Where markets for the environment are missing or inefficient, economists argue that the welfare of society is reduced. Generally this is observed as a fall in income but in the case of the environment, it means that total well being is diminished. If markets are missing for environmental goods and services, resources are likely to be over-allocated to exploitative activities, such as land clearing (where there are clear signals to investors), and under-allocated to conservation activities (eg. nature conservation). Understanding why markets have not evolved to deal with the environment is an important step in designing mechanisms and developing the information required to support them for an efficient allocation of resources to the conservation of environmental goods and services.

3.1 Demand and Supply of Environmental Goods

The efficient provision of a good—including an environmental good—requires the connection of two factors: supply and demand. Where there are willing buyers and willing sellers intuition suggests that a deal will be of benefit to both groups. In economics terms, we know that these exchanges are the basis of wealth creation in society, but have not been possible for many environmental goods and services.

In this section we will explain how these two factors connect to provide a notion of efficiency, and then we will discuss in more detail the problem of discovering the demand and supply side of environmental goods. We will also introduce some of the key instruments that have been advocated to circumvent the problems that arise.

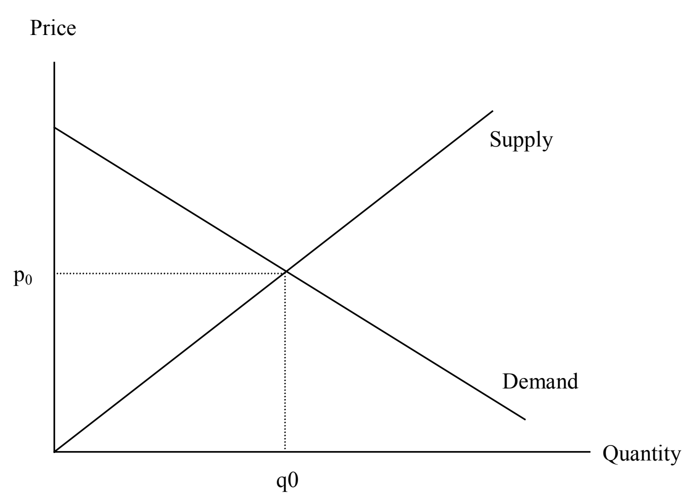
3.1.1 Efficiency

Figure 2 below is a demand and supply diagram. The quantity of an environmental good (such as biodiversity) is on the horizontal axis, and the price of the good is on the vertical axis.

The demand curve represents the different values placed on an environmental good by society. Briefly, these values are made up of the benefits that society enjoys from different quantities of the environmental good. Society enjoys benefits for a variety of reasons including the enjoyment from watching or viewing species; the benefit of knowing that species are being maintained now for future generations ('existence values'); and the option value of maintaining biodiversity for some as yet unforseen use.

The demand curve is shown to fall as the quantity of the environmental good increases. This reflects a basic assumption that when society has lots of the environmental good, it values an additional unit relatively less. Sometimes the demand curve is called a 'willingness to pay' function, because the value derived from any good represents how much people are willing to pay for another unit of that good.

Figure 2. Classic Economic Diagram of Demand and Supply



The supply curve in Figure 2 represents the cost of producing different quantities of the environmental good. The slope and position of the curve depends on the nature of the technology that is used to produce an environmental good (for example, the mechanism that is used) and prices in the economy. We discuss this more extensively in Chapter 4. However, for the moment we can assume that each point on the supply curve represents the minimum possible cost of obtaining an additional unit of the environmental good.

The supply curve is shown to slope upwards. This represents the fact that when there is already a large amount of biodiversity being supplied, it costs more to obtain an additional unit. This is because as we increase the amount of the environmental good we have to drag productive inputs away from ever more valuable alternative uses. We can get the first few units of the environmental good at low cost, but once these low-cost options are exhausted, then we start to face higher costs.

The intersection of supply and demand form price, p_0. The provision of the quantity q_0, by suppliers who can provide at a cost of less than p_0 is *efficient*.

The reason that the point (p_0,q_0) is efficient can be seen as follows. Securing an amount of the environmental good over and above q_0 would be inefficient because the cost of these units is greater than their benefit. Securing less than q_0 would mean that there are valuable transactions that have not been made—there are potential transactions that have benefits greater than costs. At (p_0,q_0) all value creating transactions have taken place.

3.1.2 Key Economic Concepts

There are several key economic concepts that help us understand what prevents society from achieving an efficient result in terms of environmental goods. We discuss two broad areas: property rights and transaction costs. In transaction costs we include a discussion about problems associated with information.

Property Rights

A well-known theorem in economics states that if property rights are well defined and transaction costs are low then individuals can bargain to achieve efficient outcomes. This idea, due to Coase (1937) has highlighted to economists the importance of property right specifications in terms of ensuring efficient outcomes.

Viewed in terms of Figure 2 this theorem says that if the rights to an environmental good (or the right to damage it) were well defined then—in the absence of transaction costs—the relevant individuals will come together to bargain towards the efficient solution.

However, transaction costs are substantial in the case of environmental goods. In the next section we will explain the types of transaction costs that are important for environmental management.

Transaction Costs

Bardsley *et al.* (2002) note that ideas about why markets are missing or inefficient have changed over time. The authors note that Coase (1937) identified 'transaction costs' as the main obstacle to the existence of markets.

Williamson (1996, pg 379) defines transaction costs as the "ex ante costs of drafting, negotiating, and safeguarding an agreement and more especially, the ex post costs of maladaptation and adjustment that arise when contract execution is misaligned as a result of gaps, errors, omissions, and unanticipated disturbances"

Gathering and exchanging information is a key aspect of the transaction costs associated with environmental management. We consider two aspects of the information problem in this section: where information is currently unknown and must be discovered by say scientific inquiry (unknown information) and where information is held by some agents, but not others (asymmetric information).

Unknown Information

Part of the transaction costs associated with environmental goods is the exact nature of the good, the manner in which it is damaged, and the actions that may improve it are unknown. Hence, prior to developing a market that helps procure more such a good (or helps enhance its quality) this information has to be discovered, generally via scientific inquiry.

For example, it may be clear that the quality of river is in decline: flora and fauna are disappearing, and this disrupts the functioning of the river. However, it may be unclear exactly which factors impact on the river, how they affect the river's characteristics and the avenue by which this impacts on the flora and fauna.

A number of studies have suggested that conservation programs using a range of mechanisms (grants, taxes) have been relatively ineffective because they have focused on on-site information rather than environmental outcomes (Ribaudo 1986, Wu and Bogess 1999, Wu and Skelton-Groth 2002). For example conservation programs have focused on on-site physical criteria, such as soil erosion and recharge, rather than the benefit to the environment of a reduction in erosion or recharge. Further, there is a growing recognition that environmental outcomes are correlated – benefits are jointly produced by the same action. For instance, revegetation may jointly produce carbon, improvements to water quality and wildlife benefits. Wu and Bogess (1999) refer to this as an ecosystem-based approach that recognises the interaction between alternative environmental benefits. They show that an efficient fund allocation must account for both physical production relationships between environmental outcomes and the value (to the environment) of those outcomes.

The costs of gathering information regarding environmental improvements could be described as transaction costs. They are all the costs that need to be incurred prior to any transaction that may be struck between those interested in improving water quality, and those that may provide the actions that actually improve water quality.

Asymmetric information

Asymmetric information and aggregation problems are important factors in explaining the non-existence of markets. Information problems can add to transaction costs and hence impede potential buyers and sellers from engaging in transactions. The basic reason that asymmetric information hampers markets is that it is hazardous to do business with someone who has relevant but hidden information.

Akerlof (1970) showed that the existence of asymmetric information (that is, where one party is informed about aspects of the economic problem and the other is not) can render some seemingly competitive markets inefficient. In the limit, this phenomenon can result in the non-existence of markets. The uninformed party, in many environmental problems, is liable to be exploited, and may be unwilling to participate. Akerlof demonstrates that the demander of the goods risks purchasing a 'lemon', because they don't have sufficient information describing the good, which the seller possesses.

3.1.3 The Demand Side

Environmental goods are a form of 'public good'. This means that they have several specific characteristics that make it difficult to ascertain the position and slope of the demand curve.

A public good is one where it can be consumed by many different people and not diminish in quantity (non rivalry) and it is difficult to exclude people from using it at reasonable cost (non excludability).

These two traits raise problems on the demand side because individuals will not voluntarily reveal their valuation of the good. Instead, because the good is non rival an individual will aim to consume it when it is available, but will attempt to *free* ride on the contribution that others make to the cost of its provision.

Solving the free rider problem presents difficulties for individuals attempting to strike bargains associated with better environmental outcomes. Often the free rider problem is solved via centralisation: a governments steps in and acts as the representative of the community in relation to the demand for environmental goods, however, to do this requires some coercion (the compulsory levying of taxes, the setting of laws, etc).

However, even with a government acting as a representative for the community there are still significant information problems. A government that attempts to represent the community's preferences faces (at least) two key problems. First that such a task is inherently difficult to do due to the nature of the problem: if preferences of individuals are 'complex' then there may be no sensible way to aggregate them (this idea is due to a famous theorem by Kenneth Arrow, called the impossibility theorem). Second, government will face very large costs if consulting each and every individual on even a single topic (e.g. strength of preference for a certain environmental good), and so the transaction costs of information gathering over many topics is prohibitive. However government decisions about environmental management still require trade-offs, making such trade-offs explicit and understanding how some low-cost information gathering can improve these decisions is very important in order to attain the efficient outcome (see Chapter 6).

3.1.4 The Supply Side

Where there are valuable potential transactions that could take place, then there are opportunities to invest in activities that supply these goods and services – for example, given appropriate incentives and information, many landholders could change land-use in ways that will increase the supply of environmental goods and services.

If government is the key demander of environmental goods on behalf of society then it needs to implement mechanisms that are cost effective, given the circumstances. To do this requires that the government overcome a key problem: asymmetric information.

Latacz-Lohmann and Van der Hamsvoort (1997) explain how information asymmetry affects the functioning of markets for environmental goods and services associated with private 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" pg 407.

On the supply side of the environmental market there is a lack of information about the cost of the goods. Stoneham *et al.* (2003) address these information problems and show it is possible to create a market. They conclude, "The pilot auction (BushTender) has shown that it is possible to create at least the supply side of a market for nature conservation and in conjunction with a defined budget, prices can be discovered and resources allocated. Characterising nature conservation on private land as a problem of asymmetric information has improved our understanding of why this and related environmental markets are missing or ineffective and has introduced an alternative policy mechanism to those currently available" (pg 496). Further, the authors argue that BushTender is cost-effective relative to other schemes such as fixed-price grants—their analysis shows the latter may be nearly 7 times more expensive to achieve the same outcome.

Auctions help a government to forge deals with landholders *en masse*. As the Williamson definition of transaction costs (Section 3.1.2) points out, transaction costs involve both the costs of drafting and negotiating an agreement, and also the costs of monitoring, enforcing and adapting the contract *ex post*. In EcoTender—as in BushTender—the parameters of ongoing management are defined in a contract. The contract must clearly specify the objectives of the agreement between government and landholders. Government must structure the contract so that the incentives (rights and responsibilities) ensure the objectives of the contract are achieved. In general landholders have the responsibility to provide environmental management, and government has the responsibility to pay for these services. Government also has a responsibility, to the taxpayer, to ensure that the outcomes of the contract are achieved, hence monitoring and enforcement are an important part of the contract. (see Chapter 7).

3.1.5 Cost-effectiveness versus Efficiency

Auctions help to lower transaction costs in terms of dealing with the supply side of the market (see Chapter 4). Hence, auctions may help an agency ensure that it produces environmental goods at the lowest possible economic cost.

Efficiency requires that environmental goods are produced at lowest economic cost, *and* that they are produced up to the point where the last unit is valued at exactly its cost of production (where demand equals supply), as explained above.

Hence auctions alone do not guarantee efficiency. Rather, they have to be mixed with good information about demand—the benefit from receiving another unit—to ensure an efficient outcome.

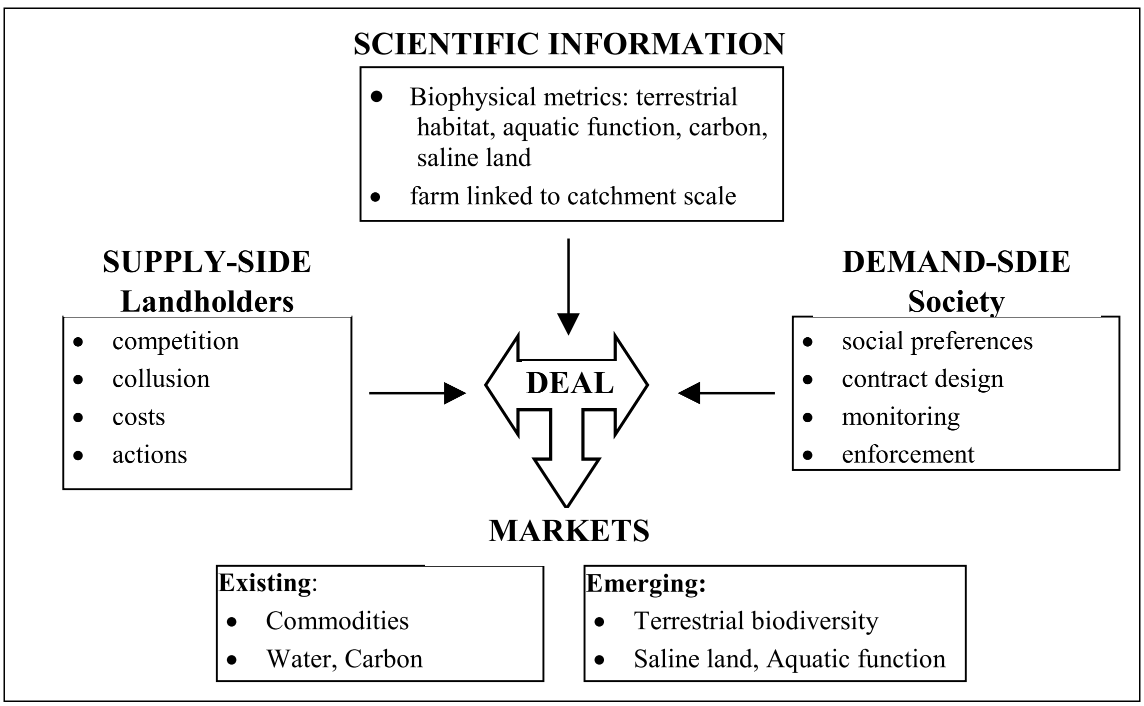
Such a task would be the focus of a program where funding were adjusted considering the demand and supply conditions. It is not possible in one pilot, with a budget constraint, to ensure that efficiency is achieved, particularly given the current state of technology regarding the revelation of demand (see Chapter 6).

3.2 Designing Markets: Pictorial Representation

Figure 3 illustrates information that is relevant to the formation of markets for environmental goods and services and the players that hold this information. As noted by Latacz-Lohmann and Van der Hamsvoort, landholders hold information about the supply cost of changing land use or management (opportunity cost). Scientists hold information about the biophysical impact of changing land use and society holds information about the value of these goods and services (willingness to pay).

In the figure an environmental policy culminates in a transaction (the "DEAL") between a government representing society (demanding more environmental goods and services) and the private landholder (supplying environmental goods and services). Striking a fair deal between society and the landholder is the objective of the mechanism design problem. Society should not be asked to pay more than the competitive supply price and landholders will only supply environmental goods and services if they are adequately rewarded for the resources diverted from other uses of land. Further, society wants to understand what it is paying for in order to express preferences for alternative environmental goods and services and allocate budget. Society needs information that measures and describes the environmental goods and services.

Figure 3. Information Framework



4 Supply Side Mechanisms in EcoTender

As stated above, EcoTender is based on an auction approach to allocating conservation contracts and can be viewed as a multi-outcome analogue of BushTender auctions (Stoneham et al 2003). In this Chapter we discuss the general advantages of auctions and then look specifically at the auction design for EcoTender. We also briefly discuss the fact that in the EcoTender pilot carbon sequestration was not treated as a good like others—biodiversity, land de-salinisation and aquatic function. Instead it was assumed in the pilot that a tradable permit market exists for carbon, and hence that landholders can sell sequestered carbon into a tradable permit market at a fixed price (per tonne).

4.1 Auctions: General

4.1.1 Auctions to Reduce Transaction Costs

Our focus in this chapter is on delivering well-defined (in terms of quality and quantity) environmental services at least cost (see Chapter 5 for how this quantity and quality is determined). As always government will have to consider a range of mechanisms and their advantages and disadvantages.

Auctions are potentially a very useful mechanism in this circumstance since they allow government to engage a large number of landholders in a systematic way and to forge agreements *en masse*. (see Stoneham et al 2000). If designed well, auctions will have advantages over other mechanisms such as one-to-one negotiations since they will expedite the negotiation process according to set of transparent rules. That is, they can lower the transaction cost of achieving a *given* outcome[1]. For instance, grant programs require negotiating with each potential recipient of funds to determine cost shares and the actions they can undertake. Whereas in an auction the actions are generally defined prior to commencement and clearly articulated to all potential participants and cost shares are determined by the participants within a prescribed time. Further in an auction participants recognise there is competition between them

[1] Williamson (1988) has argued that transaction comparisons are generally undertaken holding the quality of the outcome constant.

for access to funds, participants have an incentive to reveal their true cost rather than game play to maximise their grant.

An important aspect of the transaction cost problem: Information exchange

To illustrate the information problems associated with environmental improvement, imagine you were a purchaser of environmental services and you had a limited budget. Your job is to purchase as much biodiversity as possible and you know that landholders can provide biodiversity services by changing land-use or modifying land management practice. There are a large number of landholders willing to supply additional *units* of biodiversity services, each at a different price. If you have perfect information, that is you know the price at which each landholder is willing to supply, your job is easy: you allocate the budget to each landholder, from the lowest to highest price (per unit), until you exhaust your budget.

In contrast, imagine that you do not have perfect information; you do not know each landholder's relative cost of supplying biodiversity services. What do you do then?

An auction is a process that allows a good or service to be exchanged, by getting (say) sellers to bid for the right to provide a good or service to a buyer. An auction allows a buyer to get sellers to reveal information about their cost of supply by engendering competition between suppliers.

With respect to exchanging biodiversity outcomes, there are two key players: landholders or farmers that sell services (management actions) and an agency that buys those services. Latacz-Lohmann and Van der Hamsvoort (1997) explain that there is an 'information problem' in this exchange because

> *"farmers know better than the program administrator about how participation (in conservation actions) would affect their production plans and profit"* pg 407.

This information problem stems from the fact that landholders differ: not all landholders will have the same biodiversity assets, or face the same costs to maintain/enhance those assets. Landholders know their own costs of taking actions, but an agency would not know these costs (the agency does not have perfect information). Further a landholders costs may be influenced by their value system and their view to cost sharing for the provision of public goods.

On the flip side, an environmental agency, not landholders, would know its preferences/priorities regarding different environmental assets (see Chapter 6 for detail). Further, an agency may know better than landholders how management actions may enhance those environmental assets. However the agency does not have information about the specific assets on each landholder's site. To obtain this, agency staff may have to visit landholders and look at their site. Then, the agency needs a 'metric' to describe the good/service that would come from improved environmental management by the landholder (see Section 5.3.2).

A key aspect of the auction is that a government can blend these two pieces of information. Briefly, this is done in BushTender as follows. An agency calls for bids from landholders interested in supplying biodiversity services. Participating landholders supply information about the actions they would undertake, and the cost of these actions. The agency analyses bids and selects those that are most cost effective. Cost effectiveness is judged by comparing each bid using an index that joins information about the benefits (the biodiversity metric) and costs (the bid price).

4.2 Auction Design, and the treatment of Carbon in EcoTender

4.2.1 The treatment of carbon: Hypothetical Tradeable Permits

Whilst the focus of this chapter is on auction design, it is worth considering the way that carbon is treated in the EcoTender mechanism.

The goods in EcoTender are scored according to an index or metric. For the non-carbon goods—land de-salinisation, biodiversity and aquatic function—these indices are aggregated using weights to form a 'single' index that measures the landholder's contribution to environmental production. The agency chooses bids by considering each landholder's production (index value) over bid price—we can call this the environmental benefits index (EBI).

The environmental benefits index does not include carbon sequestration; instead it is assumed that carbon sequestration is sold into a tradable permit market (or emissions trading system, ETS).

The European Union is already operating under an ETS. There is currently no ETS in Australia. However, Australia's states are currently considering the design of a system for potential implementation as early as 2008. NSW has its own Greenhouse Gas Abatement Scheme (G-GAS).

The reason for considering carbon in this way is that it allows an examination of the way that an auction interacts with other environmental markets. This issue was considered in some detail by Strappazzon *et al.* (2003). The authors examined the implication of running an auction for conservation contracts—that produces multiple environmental goods—when a tradable permit market exists for one of the environmental goods. The authors used a model of landholder bidding (from Latacz-Lohmann and Van der Hamsvoort 1997) to examine the implications of different property right specifications. The authors found that the two environmental mechanisms interact more efficiently when landholders have the property right to sell carbon sequestration.

In the pilot, landholders are paid a fixed price of $12 per tonne of carbon sequestration. This is based on estimates of the market price from the greenhouse market operating in NSW (the so-called NSW G-GAS scheme), which was $15 per tonne. However, the EcoTender price is lower due to the fact EcoTender sequestration is not Kyoto compliant which credits traded in NSW are. The primary interest in paying for carbon is to demonstrate environmental markets (auctions) can be linked with contemporary markets.

In theory landholders will subtract some or all of this cost from their bid price if carbon sequestration is jointly produced with other products (e.g. terrestrial biodiversity). The degree to which landholders will subtract this carbon-sequestration revenue from their bid price depends on the level of competition in the auction.

4.2.2 Auctions

Even if auctions are a useful tool for conservation contracts on private land, government faces several challenges in terms of successfully designing and implementing them. In this and the next few sections we step through some of the key considerations from an EcoTender perspective.

There is an extensive literature on auction design that examines which auction is best under different circumstances. Reviewing the literature is beyond the scope of this paper. Useful—albeit technical—reviews are given by Wolfstetter (1996) and McAfee and McMillan (1987). A useful notion to keep in mind when designing auctions comes from well-respected auction theorist, Paul Klemperer (2002), who notes,

> *"anyone setting up an auction would be foolish to follow past successful designs blindly; auction design is not one size fits all"* (pg 187)

In other words, a government using an auction needs to think hard about what it is trying to achieve, and to design the auction so that it achieves its aims. The EcoTender auction has the following design features:

- First price
- Sealed Bid
- Single round
- Information about Metric Revealed

This is basically the same as the BushTender auctions (Stoneham et al 2003) except for the last feature: in BushTender auctions government revealed only part of the information regarding the metric (or landholder scores) for each environmental good. However in EcoTender the government revealed full information about the metric. In the next few sections we will discuss these design features.

4.2.3 Budget constrained

All BushTender auctions to date have been run with a budget constraint, and no reserve price. A budget constraint means that the Government awards contracts in order of cost effectiveness: contracts are ordered from most-to-least cost-effective and are then awarded until the budget is exhausted.

An alternative approach is to award contracts to all those bids that are below some reserve (or ceiling) price.

The reason for using budget constraints in BushTender, up to this point, has been mostly practical: governments tend to allocate budgetary amounts to projects. Although this implies an implicit maximum price paid for environmental goods, *ex* *post,* the agency need not determine this maximum price *ex ante.* If programs such as BushTender and EcoTender were on-going programs then it would be useful to consider the feasibility and applicability of a reserve price strategy in more detail (see Chapter 6).

4.2.4 Price discriminating

Auctions can be designed so that successful bidders are paid the price that they specify in their bids (a discriminative price auction), or so that successful bidders are paid the same price (a one price auction), for example that of the highest accepted bid. Bidders may alter their bidding strategy based on which type of auction is being run.

The choice of auction type needs to consider:

- The impact on efficiency via the ability of the approach to get sellers bidding close to their true cost (truthful revelation) and
- The way that economic rent is split between the government and landholders.

For example, in a competitive, discriminative price auction the government may capture more of the rent, especially from low-bidding suppliers. This is because in a one-price auction low bidding suppliers are paid above their costs and so they capture more of the rent than they would in a discriminative price auction. In this case, a one-price auction would be less cost effective than a discriminative auction. This result is supported in the preliminary findings of an experimental study being performed by Cason and Gangadharan 2005. Their paper reports a test bed laboratory experiment in which sellers compete in sealed offer auctions to obtain payment to subsidise pollution abatement. Two different treatments, discriminative and one-price auction rules, are applied and preliminary results indicate that sellers are more likely to bid further from their true cost in a discriminative price auction but that the discriminative price auction achieves more pollution abatement given the budget constraint.

Similarly, in a one price auction sellers may bid closer to cost than in a discriminative price auction. This may occur because in a one price auction, all successful sellers are paid a price for their good or service that is above what they offered to sell for. Therefore sellers have an incentive to bid at their true cost because bidding above their true cost lowers the probability that they will be accepted but is not likely to raise the price that they will be paid. Cason and Gangadharan's preliminary results

(2003) also support this hypothesis. In a discriminative price auction, it is hypothesised that sellers have more of an incentive to bid above their true cost—compared to a one-price auction. This is because although bidding above their true cost decreases the chance of a sellers bid being accepted, it also increases the size of the rent that they are likely to capture.

The hypotheses above are important because government may wish to capture as much rent as possible if it is aiming to be highly cost effective. However, cost effectiveness may not be the only aim of the government. For example, the government may believe a one price auction would be more attractive to landholders if they were able to make a profit, through capturing a larger share of the rent, from entering the auction. By running an auction that is more attractive to landholders the government may achieve additional benefits from increased education or create a viable market for these outcomes over time.

Which type of auction is most appropriate will depend on whether the net benefits of a one-price auction (efficiency, distribution and the effects that each of these may have on attitudes, participation etc.) outweigh the discriminative price auction.

The pilot is a small-scale one-off auction, the budget for landholder payments is restricted, and the pilot is interested in getting a useful amount of data in order to conduct post-auction analysis. Given this it was decided that the cost-effective benefits of the discriminative price auction would outweigh it's potential costs more so than for a one-price auction.

4.2.5 Sealed bid

In EcoTender (and previous BushTender auctions) bidders place their bids in sealed envelopes: these are ‘sealed bid’ auctions. If a landholder wishes, no other persons will see the bid, apart from departmental personnel that deal with the bid assessment process. An alternative is an open auction where bidders get to observe others’ bids.

Sealed bid auctions are useful in some cases where there are few competitors for a product, or if collusion is perceived to be a problem. However, neither of these is perceived to be particularly problematic for natural resource management auctions: auctions for conservation contracts generally involve over 50 bidders.

However, a large number of bidders means the alternative to sealed bid auctions—an open auction—is only feasible via computer networks. To date, this has been perceived as impractical.

4.2.6 Multiple Rounds

Within one auction bidders may be allowed or required to submit one bid only. Or, they may be allowed to submit a bid and learn whether their bid is provisionally accepted and then be required to submit another bid based on that knowledge, and so on.

An auction that allows bidders to resubmit bids is called a multiple round auction. A multiple round auction may take various forms. For example, it may accept the successful bids in the first round and only allow unsuccessful bidders to resubmit.

Multiple round auctions allow sellers and purchasers to reconsider what bids they make and choose to accept, respectively. That is, they allow some feedback to occur between supply and demand. A multiple round auction may have efficiency benefits because it allows more information to flow between the buyers and sellers. This can be particularly desirable when there are interactions between bids: that is, if one bid is accepted or not influences the desirability of another bid.

Due to increased complexity and time requirements, having more than one round in an auction will increase transaction costs. Whether the increase in transaction costs outweighs the increase in the efficiency of the auction will be an important determinant in choosing whether to include multiple rounds in an auction.

In the multiple outcome pilot the efficiency benefit from the increased flow of information from a multiple round auction was not thought to outweigh the transaction costs that would be required in order to do this. This is also due in part to the time constraints for project delivery and funding available to research this area.

The personal site visits are considered enough to achieve efficiency through the flow of information between landholders and the Department (see Chapter 8).

4.2.7 Information Revelation by Government

In a procurement auction, government may choose to reveal all or very little information to sellers regarding for example: the level of demand that it has for various outcomes; and the benefits of a particular site alone or in relation to other sites in the area.

The amount of information that is provided to land holders may affect their bidding strategy, in terms of whether they choose to participate in the auction, which types of actions or outcomes they agree to and the price that they set for their bid. Information may affect both the cost effectiveness and the efficiency of an auction. It may also have effects external to direct auction outcomes, in terms of education and reputation.

This issue may be accentuated by repeated auctions: education, participation and reputation are more likely to be factors of significance when an auction is repeated.

In BushTender auctions landholders were ranked using a biodiversity benefits index (BBI) composed of three elements:

- A measure of the value of native vegetation on a site, the biodiversity significance score (BSS);
- A measure of the improvement in the quality of a site arising from an action or group of actions, that the landholder agrees to do such as controlling weeds, or excluding stock, the habitat services score (HSS); and,
- The landholder's bid.

The BBI index (BBI = (BSS x HSS)/$) was used to rank bids according to the value for money that they were estimated to provide. BushTender regional officers revealed to landholders only the HSS score; not the BSS score, although landholders were provided with information about the various elements that contributed to their score (eg. vegetation quality and status, etc). This was based on the assumption that that if some information were kept hidden from landholders, then the auction would be relatively more cost effective than revealing all of the information.

Cason, Gangadharan and Duke (2003) used laboratory experiments to examine bidder behaviour in an auction when the value of their output was known, compared with when it was not. They concluded that when some information was hidden an auction was probably more cost-effective. In part this was due to the fact that when information was revealed some sellers colluded to raise prices.

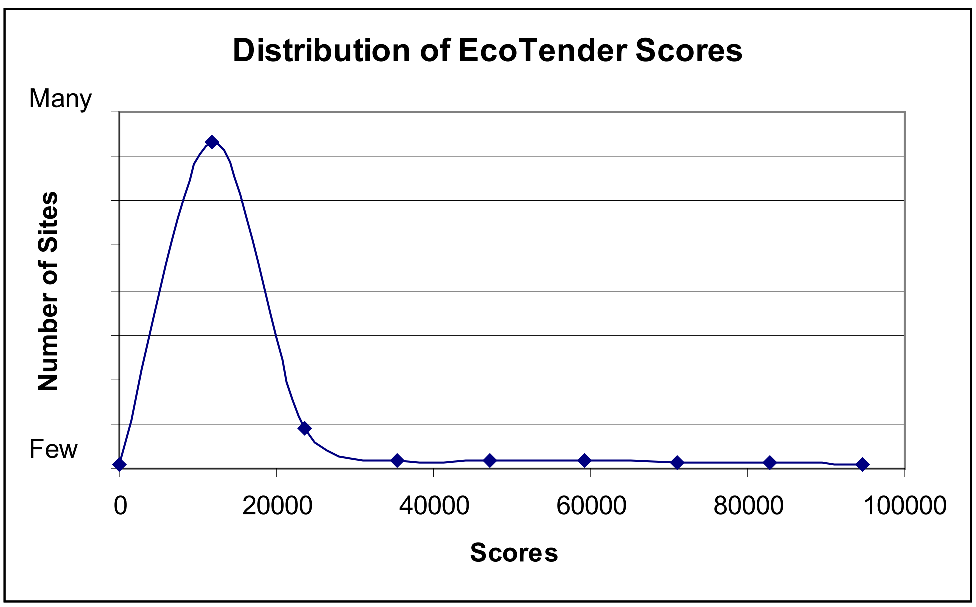
In the short-run, withholding some information limits the scope for landholders to extract information rents from the auction. Clearly, landholders that know they have the only remaining colony of some plant or animal, will be able to raise their bids, well above opportunity cost, compared with a situation where this information were not known by the landholder.

In EcoTender there were several aspects to the scoring technique that included:

- Carbon sequestration
- Terrestrial Biodiversity
- Aquatic Function
- Salinity mitigation

These are all described in more depth in section 5.3.2 below. In EcoTender landholders were informed completely about their total score across the components, and the distribution of scores across the auction participants, prior to their bid being submitted. Specifically, landholders were shown the following:

Figure 4. Distribution of total scores



There are several reasons for this. First, although Cason et al argue that the revelation of the metric may hamper cost effectiveness it is unclear whether this induces truthful revelation relatively better then when information about the metric is fully disclosed. Following completion of the pilot it may be possible to examine the bid data and determine whether providing full information influenced cost effectiveness.

Second, the risk of collusion was thought to be minor since, as explained above, the auction involves a large number of participants over disjunct areas and uses a sealed bid.

Third, complete revelation of the index and examination of the results will allow for econometric analysis to check if bid scores are correlated, *ex post*.

4.3 Auction Design Future Directions

In this section we comment on some of the outstanding issues associated with auction design that have not been regarded above. These are:

- Repeated auctions;
- Site Synergies; and
- Participation payments

The way that the agency takes account of preferences across environmental goods is considered in-depth in Chapter 6.

4.3.1 Repeated Auctions

The pilot auction of conservation contracts, by its very nature, was necessarily simplistic. It was constructed essentially as a 'one-shot game' between the government and private landholders. Before this approach could be applied more generally auctions would need to be designed within a repeated game context.

Design of a sequential auction, however, would be more complicated than EcoTender because landholders and government could be expected to learn through rounds of the auction. Under these circumstances, landholders could change their bidding strategies and possibly raise the cost of nature conservation 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. The reserve price in this case was set as a per hectare rate and when landholders learned this reserve price, they anchored their bids accordingly.

4.3.2 Site Synergies

Auctions focus on contracts with individual landholders. However, in general the aim of contracting individuals is to achieve some overall change in the landscape. In some cases the value of an individual's actions are greater if taken in conjunction with the actions of another individual. We call this situation 'site synergies'. Currently the index for biodiversity attempts to take site synergies into account by using a 'landscape context' scoring element. However, there may be alternative ways to provide incentives for landholders to act together. As a first step, the agency would have to score bids contingently: landholder *A*'s score would be greater if they were successful in conjunction with landholder *B*. Second, there would have to be some mechanism that incorporated some incentive to landholders providing synergies. In the simplest case this may simply be information to those landholders that they were providing synergy benefits.

There may also be context specific synergies for a site. For instance a site may be within a rabbit control area and all else held constant may score higher that a site not within a rabbit control area.

A more complex approach would be to provide some financial incentive that is associated with the synergy. Laboratory experiments have been carried out examining this issue (Shogren et al 1999). However, these experiments were not geared towards auction design. This would seem an important area for future research.

4.3.3 Participation Payments

Participation payments can be used to encourage more landholders to participate in an auction. If in an auction such as EcoTender the number or composition of bidders in the auction were increased the value (total rent) of the auction may potentially be increased (through increased efficiency). For example, an auction with 100 participants, where benefits are purchased from the lowest cost providers participating in the auction may not be as valuable (achieve as much rent in total) as an auction with 150 participants, where benefits are purchased from the lowest cost providers. This may be because the additional 50 participants may include a large proportion of the low cost providers and their existence may impact on the bidding of the other 100 bidders.

Participation payments could also be used in a targeting manner, to encourage particular types of landholders (who may be more likely to produce valuable outcomes) to participate in an auction. For example, if the value of the action of one landholder is considerably increased if his neighbour also participates in the auction.

However participation payments increase the cost of an auction, both directly through the cost of participation payments, and indirectly through increased transaction costs, because there is a need to process more landholders in the auction (ie, paper work, site visits, modelling requirements, etc. may increase). The additional costs of participation payments should be considered as a trade-off to the benefits that participation payments might bring.

5 Science and information – estimating environmental goods

This section reports on the next advance in the application of market-based instruments to environmental problems associated with private land-use. It reports on the information needed to conduct EcoTender where the purchaser is provided with information about the impact of land-use change for four environmental dimensions (carbon sequestration, aquatic function, dryland salinity impacts and terrestrial biodiversity). The Catchment Modelling Framework (CMF) was developed to estimate the environmental impacts of these multiple environmental outcomes and to spatially represent these to potential bidders and the purchaser (Victorian Government) of these services.

For a given on farm action environmental outcomes vary between landholders. Past modelling approaches have adopted large homogenous land areas assuming the environmental outcomes within the area are the same for all landholders. The CMF models landholder actions at the scale in which they occur – farm/paddock – explicitly accounting for the heterogenous nature of the environmental outcomes. As heterogeneity between landholders exists it is possible to get more environmental outcomes for a given environmental budget. This approach offers the prospect of improving the cost-effectiveness over the single dimension auction by maximising the total of environmental benefits per dollar. It also reduces the costs of providing information about the impact of land-use change, thereby reducing transaction costs associated with procuring environmental outcomes.

A number of studies have suggested that conservation programs have been inefficient because they have focused on on-site information rather than environmental outcomes. For example Ribaudo (1986) argues that conservation programs have focused on on-site physical criteria, such as soil erosion, rather than the benefit to the environment – the environmental outcome. Wu and Boggess (1999) show that in the presence of environmental thresholds allocating conservation funds based on on-site physical criteria could result in little environmental benefit. In both cases there was very limited empirical scientific data to support their findings. Ribaudo relied upon qualitative empirical analysis of one environmental benefit (erosion and water quality) to demonstrate his argument. Wu and Boggess used theoretical models to demonstrate their point but highlighted the need for empirical models to inform investment decisions.

There is a growing recognition that environmental outcomes are correlated – benefits are jointly produced by the same action. For instance, revegetation may jointly produce carbon, improvements to water quality and wildlife benefits. Wu and Bogess (1999) refer to this as an ecosystem-based approach that recognises the interaction between alternative environmental benefits. They show that an efficient fund allocation must account for both physical production relationships between environmental outcomes and the value of those outcomes. Wu and Skelton-Groth (2002) developed an empirical model to demonstrate the extent of fund misallocation when jointly produced environmental benefits are ignored.

The catchment modelling framework presented here focuses on providing the missing information linking environmental outcomes with actions on private land. The framework provides empirical estimates of correlations between environmental outcomes and explicitly links on-site landuse changes with off-site environmental outcomes. The framework has been designed to explicitly model and report the joint production of environmental outcomes which links effectively with policy to efficiently allocate conservation funds.

This section discusses and illustrates a new empirical framework for the assessment of multiple environmental benefits followed by a discussion of metrics used to estimate environmental outcomes. Preliminary results and discussion are presented in the final sections followed by recommendations for further research and conclusions.

5.1 Review of past modelling frameworks

In order to address the missing information issues, a review of contemporary catchment scale models was undertaken to identify a potential framework/s capable of assessing the site specific and off-site environmental outcomes arising from alternative land management.

The framework needs to operate at the appropriate resolution to link farm scale landuse change to offsite catchment scale impacts. Further, the model needs to report transparent measures of environmental outcomes. For instance, a change in aquatic health may contain measures of erosion to stream and litres of water to stream, were both impact on aquatic health in different ways. The final aquatic outcome may, for example, be the product or addition of these measures. In order to determine preferences for environmental outcomes the framework needs to be transparent in the manner in which measures are combined.

In the past, physically based one-dimensional simulation models have been used to evaluate the production and environmental aspects of farming systems, including the amount of deep drainage lost below the plant root zone (Coram and Beverly, 2003). The amount of excess water available (defined as rainfall less soil evaporation and plant water use) includes deep drainage and surface runoff which should be partitioned into recharge to the deeper groundwater and lateral flow to stream. This partitioning is important because the vertically dominated recharge pathway results in very different environmental outcomes to the laterally dominated flow pathway.

Past studies using one-dimensional farming systems-models have assumed deep drainage contributes only to, and is analogous to, groundwater recharge. For instance, the Liverpool Plains study (Paydar et al., 1999, Ringrose-Voase and Cresswell, 2000), identified large anomalies between recharge estimates based predominantly on deep drainage predictions derived using one-dimensional models compared with those derived based on groundwater hydrograph responses. These anomalies are directly attributable to the lack of partitioning and the lack of accounting for lateral flow processes.

The SHE model (Danish Hydraulic Institute, 1991) attempted to account for partitioning by explicitly linking farming systems models with groundwater models. However this model operates on a regular grid (representing both surface and groundwater) and adopts a generalised vegetation algorithm (Kristensen and Jensen, 1975). The grid approach limits the models ability to describe spatially varying land units which may exist at a finer scale than the regular grid cell and consequently forces the user to homogenise each grid cell to only one landuse. Additionally, the same vegetation algorithm is used to describe each landuse with different parameter sets. This limits the models ability to simulate phenological plant responses, which is important when predicting grazing/livestock interactions and pasture competition. Alternatively, the USDA soil and water assessment tool (SWAT) also uses a generalised vegetation algorithm to simulate landuse. However, SWAT does not preserve spatial resolution and does not explicitly model distributed groundwater dynamics, but rather adopts a lumped parameter approach (Neitsch *et al*., 2001).

In contrast to the physically-based catchment models described above, generalised approaches based on average annual relationships between evapo-transpiration demand and rainfall have been developed (Holmes and Sinclair, 1986, Zhang *et al*., 1999). Recent studies have adopted these empirical relationships to assess the impact of landuse change on mean annual runoff for grassland and forest catchments (Vertessy and Bessard, 1999, Zhang *et al*., 2001, Zhang *et al*., 2002). These models have limited temporal and spatial resolution to assess the impact of landscape intervention at the paddock/farm scale. Further, they are not explicitly linked to a distributed groundwater model, which is essential to estimate the groundwater discharge and off-site watertable impacts.

The Catchment Modelling Framework (CMF) was developed because no other approaches provided farming systems models that operated at the catchment scale and are explicitly linked to groundwater (Beverly *et al*., 2003). Further, they do not provide transparent estimates of environmental outcomes nor the ability to combine biophysical information into environmental outcomes in a systematic manner. The CMF can estimate multiple environmental outcomes and spatially represent these to potential bidders and the purchaser (Victorian Government) of these services.

5.2 The Catchment Modelling Framework

The auction approach explicitly recognises the heterogenous nature of landholders opportunity costs and the environmental outcomes they may produce. Past modelling approaches have adopted large homogenous land areas assuming the environmental outcomes within an area are the same for all landholders. Aggregated approaches are not suitable for application to the auction and do not allow for a comparison of environmental outcomes at the farm scale (Beverly et al 2006).

The CMF incorporates a suite of one-dimensional farming systems models into a catchment scale framework with modification to account for lateral flow/recharge partitioning (see Appendix I for detailed description). The CMF consists of an interface and a simulation environment. The interface is used to assemble time-series and spatial data sets for use by simulation models, visualisation and interpretation of data, and the analysis of simulation outputs. The interface was designed to assist in both the pre- and post-processing of spatial and temporal data sets.

The interface is also used to apply rule-based methods to analyse landscape features. For instance, remnant native vegetation maps showing current coverage are used to assess the spatial significance of alternative revegetation options. Generally, this type of analysis is rule based (ie. patch size and shape, connectivity of remnant patches, distance from sources of refuge such as river corridors or sources of replenishment such as large patches of native vegetation,). In most cases the rules are developed based on current understanding of the spatial needs of relevant species and coded into the interface for application in different catchments. The interface was developed using MATLAB (commercially available software) and can be distributed as an executable to non-technical users and stakeholders.

The simulation environment is an assemblage of one-dimensional farming systems models capable of simulating pasture, crop, trees and a fully distributed 3-dimensional groundwater model. The simulation environment has been designed to produce scripts that automate the process of employing third party software, MODFLOW. The CMF simulates daily soil/water/plant interactions, overland water flow processes, soil loss, carbon sequestration and water contribution to stream flow from both lateral flow (overland flow and interflow) and groundwater discharge (base flow to stream). The agronomic models can be applied to any combination of soil type, climate, topography and land practice. Using the interface, outputs from these simulations can be compiled for visualisation, interpretation and interrogation.

The CMF develops both a surface element network and a groundwater mesh based on unique combinations of spatial data layers. Typically the spatial data necessary to derive the surface element network includes soil, topography, landuse and climate. The groundwater model requires spatial data pertaining to aquifer stratigraphy such as the elevations of the top and basement of each aquifer, spatially varying aquifer properties and river/drainage cadastral information. Additional data includes time-series records of stream flow, groundwater hydrograph, groundwater pumping, and irrigation.

Outputs from the model can be characterised based on scale as either specific to the management scale (paddock/farm) or the sub-catchment to catchment scale.

Simulations predict soil/water/plant interactions on a daily basis providing a comprehensive range of time-series outputs for each surface element. These include:

- complete water/soil balance (soil moisture, soil evaporation, transpiration, deep drainage, runoff, erosion),
- vegetation dynamics (crop/plantation yield, forest stem diameter, forest density, carbon accumulation).

At the sub-catchment to catchment scale outputs include:

- stream dynamics (water quantity and salt loads);
- groundwater dynamics (depth to watertable, aquifer interactions, groundwater discharge to land surface and stream).

The following section outlines how the CMF is used for the development and application of environmental outcomes adopted in the pilot study.

5.3 Estimating environmental outcomes

Modelled outputs from the CMF need to be presented so purchasers (in this case the State government) can express their preferences for different quantities of environmental outcomes. Such investment decisions are often further complicated by the need to compare a range of actions across broad landscapes and different ecosystem types that may produce varying amounts of different outcomes of dissimilar intrinsic value.

The CMF needs to be able to systematically provide measures of environmental outcome that:

- incorporate the inherently different functional characteristics of different ecosystems
- integrate the joint production characteristics of environmental outcomes resulting from one action, and
- account for both the physical production relationships between environmental outcomes and the relative environmental value of those outcomes.

Building on these concepts, the EcoTender pilot uses an information framework that defines each environmental "outcome" in terms of 'service' or the change in the level of function resulting from the landholder actions and the "significance" of the change.

To estimate the change in level of function, it is necessary to have a standard reference point against which change is measured. Adapting the policy approach applied in Victoria for assessing conservation status of biodiversity assets (NRE 2002), it was decided to use pre-1750 as the "natural benchmark" against which current ecosystem function and change in function arising from landholder management actions in the catchment can be assessed. Under such an approach, the pre-1750 landscape is modelled using the assumed pre-European settlement vegetation types to provide an understanding of native vegetation cover both current and prior to clearing. The current and pre-1750 modelled landscapes can then be used to measure changes in landscape function resulting from landholder interventions based on a progression towards 1750. In this context, the pre-1750 "function" is not a target but simply a reference point for measuring change. The pre-1750 benchmark approach is also used to estimate the change in native vegetation quality or extent resulting from landholder actions (see below).

5.3.1 Actions

For simplicity and ease of testing landholder actions in the pilot are limited to indigenous revegetation and improved remnant native vegetation management. In the future other on-farm management actions could be evaluated but further research is required to determine appropriate monitoring and enforcement strategies.

Revegetation requires the establishment of indigenous species in formerly cleared areas to achieve a required target based on the modelled pre-1750 vegetation types for the site. Remnant native vegetation management involves landholder commitments that improve the vegetation quality of the site as assessed in comparison to a 'benchmark' that represents the average characteristics of a mature and apparently long-undisturbed state for the *same* vegetation type (Parkes *et al*. 2003, DSE 2004).

Indigenous Revegetation

Revegetation is limited to Ecological Vegetation Classes (EVC) (Table 1 below shows examples from the total 38 used) based on the pre-1750 vegetation maps of the region (Woodgate *et al*. 1996, Parkes *et al*. 2003, DSE 2004). EVCs are the level at which native vegetation has been mapped across Victoria. In general, EVCs are defined by a combination of floristics, life form, position in the landscape and an inferred fidelity to particular environmental attributes. Revegetation activities in EcoTender require landholders to agree to minimum standards including type, species and target densities (based on an EVC benchmark), site preparation and follow-up management.

Table 1: Examples of EVCs and revegetation targets applied by the model.

Bioregion	Description	Trees (p/ha)	Large Shrub (p/ha)	Medium Shrub (p/ha)	Small Shrub (p/ha)	Large Tufted Graminoid (p/ha)	Total (p/ha)
Goldfields	Heathy Dry Forest	100	50	1000	1500	500	2650
Goldfields	Heathy Woodland	50	0	1200	2000	0	3250
Goldfields	Floodplain Riparian Woodland	50	50	200	100	500	400
Goldfields	Box Ironbark Forest	100	0	1000	500	0	1600
Goldfields	Grassy Woodland	50	0	600	500	500	1150
Wimmera	Ridged Plains mallee	50	0	200	1000	500	1250
Wimmera	Semi-arid Woodland	50	0	600	2000	0	2650
Wimmera	Lignum Wetland	0	0	800	0	0	800

Where:

p/ha – target plants per hectare after 5 years

Trees = overstorey species (usually > 10m tall)

Large shrubs = sub-canopy species > 5m tall

Medium shrubs = shrubs 1-5m tall

Small shrubs = shrubs 0.2-1m tall

Large tufted Graminoid = non-woody grass-like plants > 1m tall

To evaluate the change in each outcome the catchment model was calibrated to pre-1750 EVC vegetation cover and extent and simulations were undertaken for 44 years based on 1957-2000 historical climate data. Each of the EVC types (Table 1) was characterised on the basis of varying root depth, root densities and over and understorey canopy dynamics.

Remnant Native Vegetation Management

Remnant native vegetation is defined as established vegetation of a type (EVC) relevant to that which existed in 1750, prior to settlement and clearing. The aim of remnant native vegetation management is to improve the anticipated future condition of the vegetation through landholder commitments that maintain and/or improve the quality of indigenous vegetation on the site. This may include foregoing entitled uses such as firewood collection and grazing (by fencing of the area) or active management beyond current obligations under legislation such as weed control, pest animal control and supplementary planting of understorey species.

5.3.2 Outcomes

An output is the direct result of an action as estimated using the CMF. For instance, the action of replacing pasture with indigenous trees results in a measurable output such as a reduction in recharge at the site. In the context of this project we are interested in the environmental outcomes that would result from a reduction in recharge. For example we are interested in whether a fall in recharge will contribute to reducing the amount of saturated land in the catchment (thus the importance of connectivity within the landscape) or whether it will reduce the amount of saline water entering a stream as base-flow, improving aquatic health.

The outcome used to assess the bids is limited by available scientific information. For instance, a reduction in recharge can be described in the following steps.

1) Fall in recharge
2) Fall in saline discharge to stream from groundwater
3) Reduced impact on riverine flora and fauna
4) Followed by an assessment of the significance of the flora and fauna within the context of local and regional stream networks. The final outcome could be an aggregate of the service provided to riverine flora and fauna, adjusted for river significance.

Currently there is very limited data available to complete steps 3 and 4. In order to score an outcome it is usually assumed that there is a positive relationship between steps 2 and 3 and the measure used at step 2 is an accurate proxy for 3.

Estimating the outcome is a more appropriate measure of the impacts of land use/management intervention. Essentially this is because the outputs (1 above) may be homogenous and are not a good proxy for the outcome – which is the objective we wish to influence. For instance there may be two sites located within a catchment and recharge is estimated to fall by 40mm due to revegetation for both. However, the outcome we are interested in is a fall in saline discharge to stream, to improve aquatic flora and fauna. When the outcome is calculated as the change in saline discharge to stream, the recharge results in a fall of 10mm and 25mm. Even though the change measured at the sites was the same (40mm) they are now different at the stream. There may be a number of reasons for this including, location in the catchment with respect to the stream, soil type, groundwater characteristic and slope. By measuring the outcome rather than using proxies, this pilot is focused on improving the quality/quantity of landscape elements thereby meeting environmental objectives.

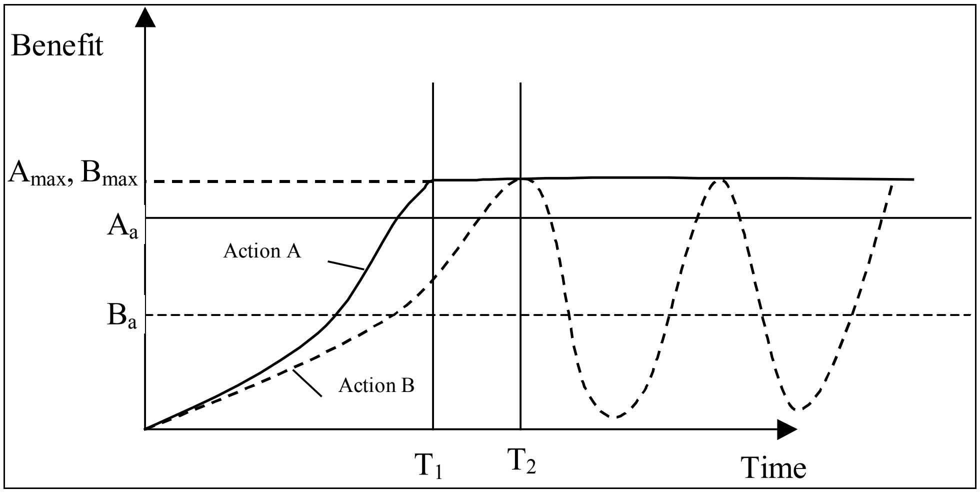
Stock and flows

The outcomes that result from land use change or management actions need to be assessed as either a change in stock or a change in flow. For instance, a reduction in recharge may result in less saturated land affected by rising groundwater when the water table has reached a new equilibrium. The reduction in saturated land at equilibrium is the benefit of intervention. Alternatively the change in saturated land could be viewed as a flow of benefits through time. As the water table approaches equilibrium there is less and less saturated land until equilibrium is reached. On reaching equilibrium there is a constant flow of benefits – the change in saturated land equivalent to the change in stock measure of saturated land.

If all actions resulted in a permanent and instantaneous change, it is possible to compare benefits based on changes in stock. However, if the form of intervention results in a time dependant outcome they may be more accurately compared based on the flows.

Figure 5 below shows the outcome resulting from two actions with respect to time. Action A is revegetation with native species and action B is revegetation with commercial forestry with harvesting at regular intervals. Action A provides increasing benefits up to T_1 reaching a maximum of A_{max}, and remaining at A_{max}. Action B provides increasing benefits up to B_{max} at T_2(where $A_{max} = B_{max}$) but then declines following harvest and rises back up to B_{max}. The decline in benefits from action B arises when the trees are harvested. Typically this type of benefit flow is observed for groundwater discharge and carbon accumulation.

Figure 5. Benefit flows and time



For action A equilibrium was reached at T_1 and for action B a temporary equilibrium was reached at T_2. If the actions were compared as stocks at T_2 they would be evaluated as having equal benefit, A_{max}. However, this approach does not account for the variability of the benefits provided through time by action B after time period T_2.

Instead, if the actions are compared as the average benefit at a point in time greater than T_2 the benefits measures would be A_a and B_a resulting in A_a ranked as providing greater benefits than B_a. Instead of using an average, the flow benefits could be discounted to reflect present value. Further research is required to determine the appropriate approach and time periods.

It is assumed that actions in the pilot are permanent in so far that both revegetation and remnant management will be ongoing. Further, the nature of the actions results in a continuous flow of benefits up to a maximum similar to example A – revegetation. Therefore when applying the CMF to determine the change in outcome a steady state solution was adopted to estimate the long term equilibrium condition under the altered vegetation/management regime.

Steady state approach to estimating outcomes

The predominant driver of groundwater flows and levels, is rainfall and in turn the recharge it creates. After long periods of high rainfall the soil reaches a point were it is saturated and there is a subsequent increase in recharge. Soil type, slope and vegetation determine the level of recharge. Groundwater levels determine the amount of saline land (land within 2 metres of the groundwater, see below of detail) which is considered and important environmental outcome. If the groundwater level is fluctuating through time then the area of saline land will also be changing. In order to measure a change in saline land area a steady state is defined where the groundwater is no longer fluctuating and saline land area is constant.

The steady state solution derived using the CMF model represents the long-term equilibrium condition within the pilot region arising from locally modified vegetation/management regimes. This condition exists when the water table is no longer fluctuating and saline land area is constant.

The CMF can be used to derive a steady state in two ways. Firstly the CMF can be run over a long time horizon whilst observing the variation in groundwater flows and level. When the variation between successive periods reaches a user-defined threshold (based on a minimum variance between current and last period or past average), then both the inflows/outflows and groundwater levels can be reported as representing steady state conditions. In turn the amount of land within 2 metres can be reported to estimate the environmental outcome. The level of variance a user is willing to accept determines the steady state solution.

Issues with this approach include computational time, climatic variations between years and the lag time between water entering and leaving the groundwater system. Further, if there is a prolonged period of either high or low rainfall the system may be exhibiting steady state properties (low variance) however it is a product of the rainfall/recharge. This is particularly noticeable for extended low rainfall periods when groundwater inflows (recharge) are very low or next to zero and outflows are constant for long periods. This would exhibit itself as a local (short-term) solution rather than a global (long-term) solution.

The second approach adopted for in pilot involves calculating the long run (approximately 40 years) average recharge and applying this to the groundwater system. This removes the rainfall/recharge variation and allows for the calculation of the steady state groundwater flows and level. The long run average recharge and surface flows are used as the input to the groundwater model and the steady state solution is then run until the groundwater has reached equilibrium. This approach overcomes the local solution issue and requires much less computational time.

Saline land

Saline or saturated land is commonly defined as the area of land where the depth-to-watertable is less than 2 meters. The groundwater height was estimated using the CMF model and the area of land classified as saturated or impacted by waterlogging was defined as those regions where surface elevation (based on a digital elevation model) less groundwater height was within 2 metres. The service score is the change in saturated land area (ha). The metric for change in saline land is the sum of the change in land area within 0.1, 0.5, 0.8, 1.0, 1.5, 2.0 m of the groundwater. The steady state approach is used to estimate the area of land.

The significance can be determined by the importance of that land within the catchment context. For example under current conditions there may be 525 ha classified as saturated. Following the implementation of the action, the amount of saturated land is reduced to 515 ha – the service score is 10ha. The significance of the 10ha is determined based on current use. For instance the 10ha may include cropping, roads, buildings and wetlands. However, in order to determine the overall significance preferences need to be explicitly expressed for each land type. Preference information was not available in a form that could be applied systematically in the pilot. Rather preferences for the pilot have been expressed as an equal weighting for each land type, reducing the outcome score for saline land to change in area alone. That is, the final metric for saline land is the fall in hectares of land within 2 metres of the water table.

Aquatic Function

Aquatic function is particularly challenging because it needs to take into account groundwater (GW) flows to stream, surface water (SW) flows to stream and the quality of both. SW and GW steady-state contributions to stream were calculated for both pre-1750 EVC coverage and current land use. The SW volumes were based on both the surface and sub-surface lateral flow contributions to stream. The GW contribution to stream includes groundwater loss to stream and groundwater discharge volumes to surface, and in turn to stream.

To assess the impact on in-stream biodiversity it was necessary to consider the relative volume and quality of SW and GW streamflow contributions. However currently there is very little science available to provide repeatable and transparent interpretations of the impacts on flora and fauna due to various flow regimes and varying ratios of SW and GW streamflow contributions. Therefore the following approach was adopted and is an adaptation or extension of the steady state principle used for the saturated land area assessment. It is recognised that this approach has been developed in the absence of clear scientific relationships between surface water flows to stream and pollutants and their relative impact on riverine flora and fauna.

Within the pilot catchment the groundwater is saline and it was assumed that a fall in saline emissions to stream may provide a benefit to the flora and fauna. Similarly, a fall in surface water arriving at stream was assumed to reduce the amount of nitrogen, phosphorous and sediment, which benefits riverine for flora and fauna. Further a change in flow timing and magnitude towards pre-1750 conditions was assumed beneficial to riverine health.

The modelled pre-1750 landscape assumes that in-stream biodiversity in the pilot catchments were adapted to the prevailing conditions at that time as determined by the contributions from ground water and surface water. That the greatest change in these elements under current practice is due to surface water contribution indicates that a reduction in SW contribution to stream is considered of greater importance than that of GW. Further to this, SW contributions to stream have altered the timing of peak and low flow periods and the temperature of the water – both of which contribute to the viability of in-stream biodiversity.

Currently within the CMF it is possible to examine the temporal aspects for changes in water volume with and between years however nutrients are not reported. As a proxy for nutrients changes in erosion arriving at stream are reported and combined with the changes in water. As such, the final metric used in the pilot for aquatic function is the product of water quantity (sum of both SW and GW mm/annum) by erosion (t/ha).

Terrestrial biodiversity

Remnant native vegetation management

Habitat service - There are a number of actions that landholders can take to maintain or improve the condition or extent of habitat on private land. These include foregoing entitled uses such as firewood collection and grazing; active management of threats beyond current obligations such as control of weeds and pest animals or supplementary planting of species-deficient areas. The value of these actions can be expressed as a Habitat Services Score (HSS) where HSS_i represents the change in quality and quantity of habitat at a Site "i". The Habitat Services Score (HSS) measures the amount of terrestrial biodiversity improvement offered by the various landholder management commitments.

Biodiversity significance - Landscapes that have been modified for agricultural purposes will not necessarily retain a representative mix of habitat types and will generally contain biodiversity assets at varying levels of depletion and naturalness. One way of expressing the conservation value of different sites is with a Biodiversity Significance Score (BSS) where BSS_i represents the biodiversity value of '*Site i*'.

The BSS rates each site according to its conservation value. The BSS depends on the type and quality of native vegetation on the site and its relative conservation status (using EVCs that have been assigned a bio-regional conservation status such as endangered, vulnerable, depleted or rare based largely on development since 1750), the plants and animals that may use the site as habitat, and the position of the site in the broader landscape and its contribution to maintaining or improving the regional native vegetation context for a range of important mobile fauna species.

Conservation status is determined using concepts of rarity and degree of threat (NRE 2002). Vegetation quality uses the 'habitat hectares' approach of Parkes et al. 2003, which assesses the vegetation according to a number of site-based attributes (e.g. tree cover, understorey diversity and cover, weediness, amount of regeneration, amount of organic material, etc.) and a number of local landscape attributes (size of patch and amount and configuration of surrounding native vegetation).

Each of the site-based attributes is assessed and scored against a benchmark that represents the average characteristics of a mature and apparently long-undisturbed state for the same vegetation type (Parkes *et al*. 2003). The landscape context (LC) score for each site is determined using a mathematical algorithm that provides a measure of the current amount and relative distribution of native vegetation within the vicinity of the site (Ferwerda 2003). The landscape context algorithm is based on the general principles that large, round patches (high area : perimeter ratios) provide the best opportunity for ecological processes to be maintained; and remnants that are surrounded by other remnants or connected to larger remnants by ‘links’ or ‘stepping stones’ provide better habitat opportunities than isolated remnants.

The landscape context (LC) layer is combined with some additional spatial rules to derive the Biodiversity Landscape Preference (BLP) layer. The LC layer is weighted to reflect those parts of the landscape where both the requirement for restoration and “function” of native vegetation restoration activities are optimised. These are typically areas located between the most intact landscapes where the functionality of restoration is greatest but where the requirement for restoration is least, and the most fragmented landscapes where the requirement for restoration is greatest but the functionality of restoration is least. The weighted LC layer is combined with rules relating to patch size and shape, connectivity of remnant patches, distance from sources of refuge such as river corridors or sources of replenishment such as large patches of native vegetation to derive the BLP. These rules have been derived based on current understanding of the future spatial needs of key mobile fauna species.

The BLP layer is effectively an assessment of the future spatial considerations of restoration. It provides a relative preference for different parts of the landscape as a measure of their potential role in restoring broader landscape function.

The BSS uses information held in corporate (government) databases, LC and BLP maps and site-based information to verify what is on the site. The metric used in the pilot is the product of HSS and BSS.

Revegetation

The scoring of revegetation is similar to remnant native vegetation management. The service score is determined by a combination of size of the site and its impact on the amount and configuration of native vegetation in the local landscape and the estimated change in vegetation condition of the site. The former is a measure of the change in landscape context (LC) resulting from the revegetation while the latter applies a fixed score to revegetation that meets a minimum required standard based on the EVC benchmark.

The significance score uses the same approach as remnant native vegetation management except that the role of the site as habitat for plants and animals is not assessed, based on the assumption that currently non-vegetated areas provide little or no habitat for native species. The metric used in the pilot is the product of HSS and BSS.

Carbon

The carbon outcome is calculated for each site by estimating the change in accumulated carbon (t/ha) between the current condition and the established EVC at maturity. Accumulated carbon is calculated using biomass production specific to each vegetation class. Both the benchmark and current condition account for different spatial vegetative cover, canopy, soil type and root development for each vegetative class.

There is no significance measure for carbon because it is a diffuse pollutant. However, the location significance of the revegetation is captured in the significance scoring of terrestrial biodiversity. The metric used in the pilot is the tonnes of carbon sequestered at each site.

The following table summarises the outcomes used in the pilot.

Table 2. Summary of outcomes, service and significance

Attribute	Change in level of service	Desirable change	Significance
Terrestrial Biodiversity	Δ habitat score (habitat maintained or improved per ha)	Increase	Biodiversity conservation significance , threatened species conservation status, habitat quality, landscape preference
Aquatic function	Δ water "quality" (tonnes of soil / ha to stream) Δ water quantity (mm of water / ha to stream)	Decrease	(not applied in pilot)
Saline land area	Δ saline land (ha with groundwater < 2m)	Decrease	can discriminate - but given equal weighting in pilot
Carbon sequestration	Δ carbon sequestered (tonnes / ha)	Increase	n/a

Total environmental outcome

The pre-1750 benchmark was also used to calculate the final aggregate score. For each of the environmental outcomes the pre-1750 and current stock of each outcome was calculated under steady state conditions for the catchment (see Table 3 below).

Table 3. Pre-1750 and current environment outcome stocks

Environmental outcome	Pre-1750 stock (A)	Current stock (B)	Difference (A-B)
Habitat hectare[1]	418,140	19,081	- 399,059
Saline land area (<2m)	83,702	127,153	+ 43,451
Aquatic function	27,070	94,320	+ 67,250

1) Applied to both remnant management and revegetation

For each site assessed in the auction equation (1) was applied to determine the aggregate score.

$$Total\ Score = \left(\frac{A_i}{D_A} + \frac{S_i}{D_S} + \frac{B_i}{D_B} \right) * 100 \qquad \text{(i)}$$

where:

A_i, S_i and B_i are the aquatic, saline and biodiversity outcomes respectively for site i

D_A, D_S and D_B are the respective aquatic, saline and biodiversity differences from Table 3 above

In effect the above equation calculates the total percentage movement towards pre-1750 conditions for each of the environmental outcomes.

Carbon is dealt with as a market good and landholders are paid separately for each unit produced. The selection of bids is based only on the Total Score and the cost of the bid, farmers adjust their bid given the knowledge they will receive carbon payments if their bid is accepted.

Pilot Areas

Catchment selection was based on data availability, the areal extent of any proposed land use change, the type of management considered by land managers and a requirement that the focus catchment be a priority region as identified by the appropriate state and regional authorities. The landscape also needed to be topographically and climatically variable and the catchment also needed to be unregulated (not controlled by in-stream structures and no diversions for other uses such as irrigation) and monitored so as to provide continuous stream-flow and water quality data to underpin model calibration and validation. Additionally, catchment selection was based on the presence and quality of time-series groundwater observation data, which is used to conceptualise and validate the groundwater dynamics.

For each spatial vegetation coverage, discrete land units across the catchment were defined based on soil, slope, climate, landuse, land management and elevation. Each land unit varied in size ranging between several hectares to tens of hectares and was connected to an underlying groundwater model. Assigned to each land unit was a biophysical farming system model simulating daily soil/water/plant interactions.

The calibration procedure adopted a split sample test with non-overlapping calibration and verification periods. The calibration strategy was applied to pre-scenario conditions between 1957 and 1995 whereas model verification was assessed on data measured between 1996 and 2000 inclusive.

Calibration of the framework was based on matching measured salt export, stream dynamics, selected groundwater hydrograph responses, depth-to-watertable information and mapped groundwater discharge areas. Stream flow analysis techniques were applied to measured stream gauge data to derive quickflow (overland, sub-surface and groundwater surface discharge) and groundwater baseflow (groundwater flows into streams) estimates. The calibration criterion compared these quickflow and baseflow time-series data sets with predicted volumes to calculate goodness of fit based on 44 years of historical climate data.

In the case of the Avon-Richardson catchment, the simulated area of groundwater discharge was 16,200 ha which was in agreement with the mapped 15,500 ha. Groundwater mean annual baseflow was simulated to be in the order 250-300 ML/year, which was also in agreement with gauged stream flow data. The validation process of the CMF has produced results consistent with measured stream flow and recharge estimates (Beverly *et al*., 2003, Paydar and Gallant, 2003, Tuteja *et al*., 2003, 2004).

Field validation

In order to undertake field validation the CMF was used to assess outcomes in terms of saline land area, aquatic function, soil loss (erosion) and terrestrial biodiversity under both current and pre-1750 landuse. The pre-1750 condition was based on Ecological Vegetation Class (EVC) description of vegetation cover (Parkes EcoTender et al 2003, see Table 1 above).

The CMF systematically simulated the impact of changing landuse to pre-1750 on 25ha parcels of land across the entire catchment whilst assigning current landuse to all other land units[2]. The resultant predictions were assembled as spatial maps and were used to identify "*hot spots*" within the catchment where a 25ha change in landuse/management had the greatest impact on (a) groundwater discharge volume to stream, (b) groundwater discharge volume to surface, (c) change in depth to watertable and (d) surface flow volumes to stream.

Based on the predicted changes field validation was undertaken aimed at assessing the robustness, resolution and appropriateness of the simulation predictions derived using the CMF modelling approach. For instance three *hot spots* were identified as high impact locations. In these cases they were situated in the low lying area of the catchment and showed a high impact on off-site saline land. The sites were visited to determine if they were high groundwater areas and if revegetation with indigenous species would result in a significant fall in saline land. The first site was under cropping and tile drainage systems had been installed indicating that the area was subject to water logging. Water logging is synonymous with high discharge (either through infiltration excess or groundwater) thus indicating the site would be a good place to revegetate and reduce saline land, supporting the modelled results. The other two sites were currently used for grazing but there was remnant vegetation remaining. The remnant vegetation was typical for a seasonally inundated areas (swamp species) also indicating the area was subject to water collection and water logging, again supporting the modelled results.

A number of other sites were visited to compare modelled (based on aerial/satellite imagery) landuse with observed landuse. As expected there were a number of

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[2] There are approximately 14975, 25ha parcels in the Avon-Rchardson.

anomalies between the broad-scale spatial data sets and field observations of landuse. In order to ensure the modelled results of landuse change are representative, field officers were provided with the ability to validate and modify modelled landuse whilst undertaking a site visit.

5.4 Preliminary simulation results

The following results are limited to pre-implementation, as field application commenced in early June 2005 and final assessments are not currently available. In order to present preliminary results the CMF was used to assess outcomes in terms of saline land area, aquatic function, soil loss (erosion) and terrestrial biodiversity under both current and pre-1750 landuse. The pre-1750 condition was based on Ecological Vegetation Class (EVC) description of vegetation cover (Parkes *et al* 2003, see Table 1 above). The CMF systematically simulated the impact of changing landuse to pre-1750 on 25ha parcels (there are approximately 14,975 parcels in the Avon-Richardson.) of land across the entire catchment whilst assigning current landuse to all other land units.

A parcel of any size could have been simulated but it was thought that 25ha was reasonable for communication to farmers about the idea that area matters when trying to maximise the environmental outcomes for their actions. The resultant spatial information is also used to provide a context for impact to farmers. Figure 6 below is as example of the type of spatial information used for communication with farmers.

It should be noted that the magnitude of the changes are not linear in so far that, the sum of the impacts arising from landuse change on any two parcels may result in a greater change than the addition of the impacts derived from each parcel. That is to say outcomes are area and spatially dependent. The distribution and magnitude of results reported here would be different if smaller or larger parcels of land were simulated. Given the non-linear nature of the results with respect to area and location it is important to calculate the outcomes for each site once it is mapped by field staff. During pilot implementation each site is evaluated taking into account its unique size and location within the catchment. Basing bid selections on *a priori* modelling information may over or under estimate the benefits of any given site and reduce the cost effectiveness of the auction as a whole. The results for the each environmental outcome are presented below.

Aquatic function

For aquatic function the predicted SW and GW contributions to stream were calculated under steady state for both pre-1750 coverage and current land use across the entire catchment. The SW is based on both the surface and sub-surface lateral flow contributions to stream. The GW contribution to stream includes groundwater loss to stream and groundwater discharge volumes to surface, and in turn to stream.

Modelled results indicate that changing landuse to pre-1750 condition across the entire catchment would result in a 19,800 ML/year reduction in lateral flow to stream relative to current condition (see Table 4 below).

Table 4. SW and GW contribution to stream, EVC pre-1750 and current landuse

Catchment coverage	Surface water contribution to stream (GL/year)	Ground water contribution to stream (GL/year)	Mean annual total stream flow (GL/year)
EVC pre-1750	7.3	12.5	19.8
Current landuse	26.4	54.6	81
Percent change (pre-1750)	+72%	+77%	75%

Table 4 shows the predicted SW and GW contributions to stream under current and pre-1750 conditions. Notably there has been a significant increase in both flow regimes relative to pre-1750 conditions. Surface water flows increased by 72% due to tree clearing and the introduction of pasture and annual cropping enterprises. There has been a correspondingly very large increase in groundwater flows to stream (77% increase). Therefore any reduction in surface water and groundwater contributions to stream, a movement towards pre-1750, is considered desirable (based on the benchmark approach discussed above).

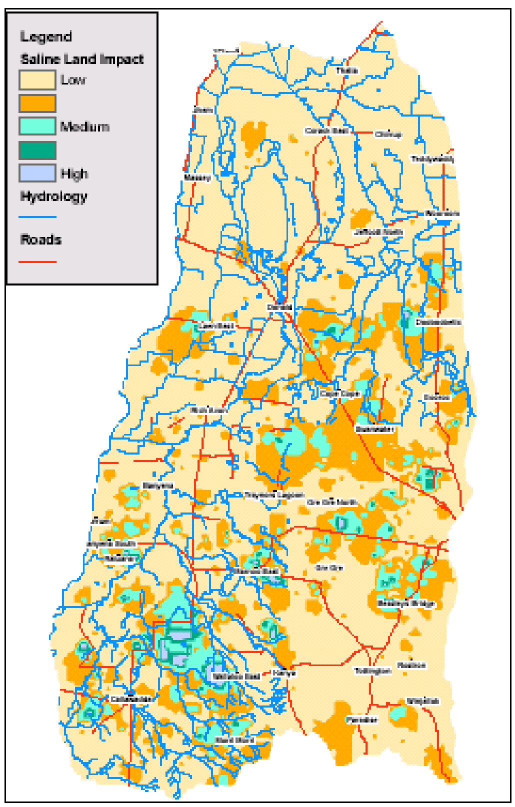
If scientific evidence were available to describe the relative impact of each type of water it may be desirable to attach weights to them based on their contribution to aquatic health. However, for the pilot no weighting's were attached due to limited scientific information about their relative impacts. For each of the 25ha parcels modelled the sum of the change in GW and SW ranged between 0 and 30 ML with an average response of 4.1ML assuming steady state conditions.

In order to reflect changes in water quality estimates of erosion were also obtained. Changes in erosion to stream varied between 0 and 0.36 tonnes per ha/annum. The final aquatic function score is a combination of the change in stream flow (surface water and groundwater) and erosion.

Saline land area

Changing landuse to pre-1750 condition on discrete 25 ha units was predicted to reduce the area of saline land by 8.5ha on average with the maximum impact being approximately 125 ha depending upon landscape position and groundwater characteristics. Figure 6 below shows a map of the variation in impact. This type of map is also used by field officers for communication with farmers to indicate the relative importance of their site (farm) within the landscape.

Figure 6. Change in saline land impact



The predicted groundwater impacts were then compared to the predicted changes in recharge for each site to see whether recharge is an accurate proxy to make decisions about investment in the landscape. Of the 14,975 cells modelled, the correlation was 27% between a change in recharge and a change in saline land area.

The impacts of a change in recharge vary across the catchment as a function of the underlying groundwater characteristics and groundwater flow directions and gradients. That is, a unit change in recharge (arising from reafforestation) in the north-westerly zones of the catchment have very different impacts relative to a unit change in recharge in the south-westerly regions of the catchment. As a general rule a unit change in recharge will have a different impact on saline land depending on where it occurs in the catchment. This result suggests recharge is not a suitable proxy for investment when considering the off-site impacts (saline land area) of landuse change.

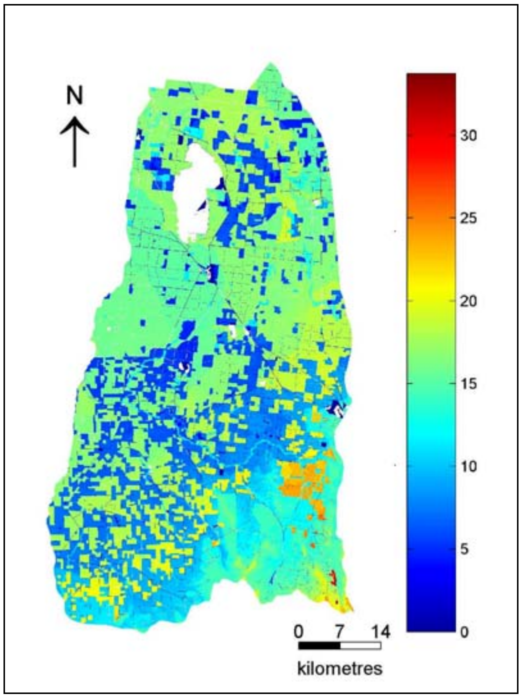
Terrestrial biodiversity

A priori, it is not possible to report the biodiversity outcomes because the habitat service score requires a site visit to determine the current condition of the site and to assess particular biodiversity assets (e.g. habitat for rare or threatened species). However, components of the biodiversity significance score, biodiversity landscape preference (BLP) and landscape context (LC) can be examined because they are modelled using existing information on native vegetation extent and configuration. BLP ranged between 0 and 90 and LC ranged between 0 and 23.

Carbon

Predicted carbon sequestration ranged from 0 to 34 kg/m^2 averaging 13 kg/m^2. The total amount of carbon sequestered is driven primarily by the EVC replacing current practice. Figure 7 below is a map of the change in sequestered carbon (t/ha) arising from replacement of current landuse with pre-1750 vegetation for the Avon Richardson sub-catchment.

Figure 7. Sequestered Carbon



Joint production and heterogenous outcomes

One of the key motivations for developing the CMF was the hypothesis that environmental outcomes are jointly produced and this feature might improve the cost effectiveness of funds allocated to the environment. In order to determine if outcomes are jointly produced a random sample of sites were assessed for saline land, carbon, terrestrial biodiversity and aquatic function. These sites were then sorted to determine whether they were producing more than one outcome – for the single action revegetation. Analysis of the simulation results derived for all sites with the pilot suggest that 73% generate two or more environmental goods supporting the hypothesis that environmental outcomes are jointly produced from a single landuse change.

Given outcomes are jointly produced there may be scope to reduce total costs if outcomes are correlated. For instance the use of one outcome as a proxy for others may reduce the level of model reporting and complexity. This may save time and reduce the transaction costs associated with estimating outcomes. In order to test if outcomes can be used as proxies for one another the outcomes are tested for spatial correlation.

The table below shows the correlation matrix between the metrics for aquatic function, saline land, carbon and the significance indices for terrestrial biodiversity, for the whole catchment.

Table 5. Whole of catchment spatial correlation matrix

	Aquatic Function	Carbon	Saline Land	BLP	LC
Aquatic Function	1.00				
Carbon	0.17	1.00			
Saline Land	0.16	0.06	1.00		
BLP	0.03	-0.07	-0.09	1.00	
LC	0.09	-0.06	-0.17	0.64	1.00

BLB - biodiversity land preference, LC – landscape context

Results presented in Table 5 suggest that there is a very low correlation at the catchment scale between outcomes, and as such we would expect a lot of variability in the *total score* (sum of outcomes) reflecting landscape variability. These results support the need to estimate the outcomes for each site during the auction because no assumptions can be made about the level or ratio of outcomes.

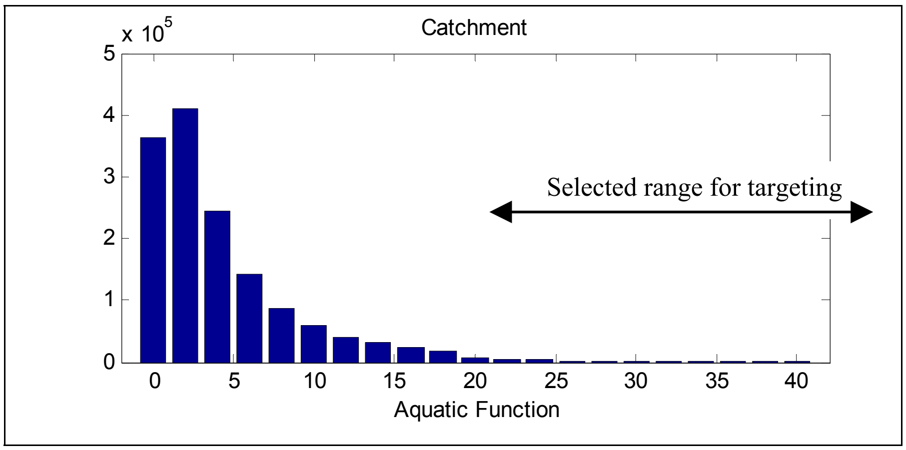
From Table 5 it can be observed that there is a positive correlation (0.17) between carbon and aquatic function. This is due to a number of biophysical factors. Firstly, revegetation generally sequests greater amounts of carbon than current practice and revegetation has a strong influence on surface water dynamics. For instance revegetation reduces surface water runoff, erosion and recharge, all of which are used to calculate the aquatic function outcome. In this pilot results indicate that revegetation produces both carbon and aquatic benefits 17 percent of the time.

BLP and LC are correlated because they are based on the same base data set (spatial location of current native vegetation) but are not identically correlated because they represent different landscape function and attributes. LC is focusing on the current existence whilst BLP focuses on the future impact of terrestrial biodiversity management or revegetation. They are examining different aspects of *eco-system* function, current function and future function given landuse intervention.

The CMF is shown to provide *ex ante* data on expected outcomes. There is a temptation to use this data to target areas with the aim of reducing the number of site/farm visits thereby saving time (reducing costs) or achieving greater outcomes (areas with *ex ante* high outcome scores).

The following is an example of targeting areas of the catchment based on high outcome scores. Figure 8 below shows the histogram for aquatic function outcomes for each site within the catchment (approximately 1.4 million units each 50m^2 resolution). Using tools built into the CMF specific areas of the histogram can be remapped by selecting a range.

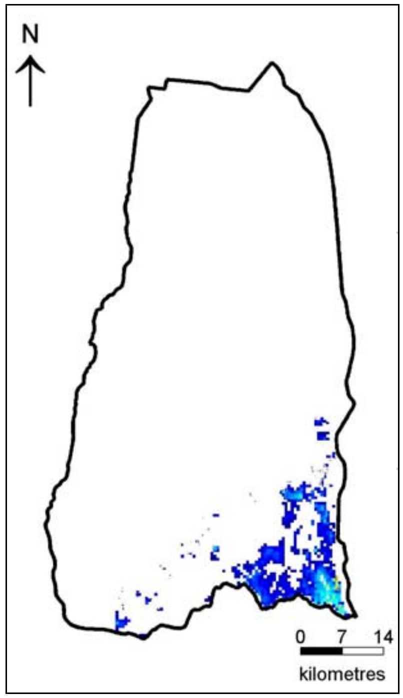
Figure 8. Catchment - Aquatic Function Histogram



For this example land areas that scored aquatic function greater than 15 were mapped to show their location within the catchment (see Figure 9 below). This shows there is a concentration of land in the south east of the catchment scoring high for aquatic function. It may be possible to target these areas for land use change reducing the costs by not visiting other areas of the catchment, were aquatic function the primary outcome of interest. However, it was shown above that there is a very low correlation between outcomes, so targeting this area may reduce the overall quantum of outcomes.

While it may be tempting to target high impact areas the cost of undertaking actions in these areas may be high. It may be possible to target areas with lower aquatic impact at a lower cost, thus reducing the cost per unit outcome. Therefore the overall cost for a given level of aquatic function would be lower. Also, areas with a lower aquatic function score may increase the scores of one or more of the other outcomes, generating greater outcomes in aggregate, assuming the purchaser is indifferent between outcomes. Further, it is not know how much needs to be paid to a landholder to secure their participation. The auction approach adopted in the pilot exploits the heterogenous nature of both the outcomes and costs.

Figure 9. Targeting high scoring aquatic outcomes



Implementation and training

A possible barrier to adoption of the CMF is its scientific complexity. The framework needed to be used by field officers either on site or locally. An interface was developed with the field officers that enabled them to down-load site information into the CMF for processing. The interface provided the officers with the ability to validate landuse (both current and proposed), run the biodiversity algorithms and finally report the outcomes.

One field officer was assigned to each sub-catchment and they undertook 8 hours training in the use of the interface. One of the officers had previously conducted single outcome assessments (biodiversity) using a paper based system, which they found to be time consuming with significant potential for error. Further it was very difficult for them to trace the process if bids needed to be altered or for audit purposes. They reported the interface to be non-threatening and there is no longer the need for reams of paper to complete the biodiversity assessment because the CMF had been programmed to complete the process with their input. On average site visits are taking one day to complete. This includes travel, site assessment, post processing data and administration.

5.5 Discussion

The CMF produces previously unknown information thereby allowing for a more efficient and valuable exchange of environmental outcomes between government and landholders. Previously the government was purchasing inputs with little knowledge of future environmental outcomes. The CMF has the potential to significantly improve the benefits of government spending on the environment by explicitly linking payments for actions to outcomes.

The CMF has significantly reduced the transaction costs (on and off-site) associated with accurately determining environmental outcomes for any site within the landscape. The CMF can be readily calibrated to any catchment providing there is sufficient data for calibration. Further, the framework can be readily updated as new data becomes available.

Generally, fixed-price grants based programs have focused on one environmental outcome and required information to support spatial allocation decisions, or worse still, allocate funds based on lowest cost without any consideration of outcomes. The CMF has reduced transaction costs and accounts for multiple environmental outcomes.

The CMF has incorporated biophysical processes to account for erosion, water, carbon, saline land to estimate environmental outcomes. Further the landscape context (LC) considers the current location of native vegetation and the biodiversity landscape preference (BLP) considers the future spatial needs of key mobile fauna species. The CMF is the only framework (the authors are aware of) that has brought together both types of information.

The framework has demonstrated the importance of joint production in environmental outcomes and the heterogenous nature of the landscape in terms of environmental outcomes. This information has been incorporated into an auction-based approach (EcoTender) offering the possibility for significant cost savings.

Results presented in this paper demonstrate that a unit change in recharge (arising from reafforestation) has very different impacts on saline land depending on where it occurs in the catchment As such recharge is not a proxy for saline land area when considering the off-site impacts of landuse change. The use of recharge as a proxy would reduce the cost effectiveness of available environmental funds, if a change saline land area were an objective.

The correlation results presented in Table 5 and those specific to aquatic function (Figure 8 and Figure 9) indicate that the CMF is capable of exploring the trade-offs between environmental outcomes. However, targeting areas based on outcomes alone, ignores the cost side of the problem. It may be the case that all high cost land use changes are located in south east of the catchment. If cost effectiveness is the objective (minimising the total cost per unit outcome) then it may be beneficial to go elsewhere in the landscape.

It is not until the cost information is available that a decision can be made about the most cost-effective distribution of funds across the catchment. Using outcome information alone may result in much higher total costs.

Interpreting the biophysical information into economic costs – for instance converting yields to opportunity cost – is tempting but potentially very costly, as it ignores the heterogenous nature of landholders costs. In many instances biophysical information has been used to estimate costs for targeting purposes.

Data from previous auctions for conservation contracts show that when landholders were engaged in a competitive bidding process for conservation contracts, their bids displayed much larger variation than can be explained by variation in land capability (Stoneham *et al*., 2003). The average bid per hectare in BushTender was $274/ha but the standard deviation of bids was $349/ha. Whilst there was some variation in the quality of land between bidders, the auction was confined to a relatively homogeneous (with respect to agricultural production) Box Iron Bark vegetation classification. This result is significant because it means that the cost of land-use change is different on each farm and this information needs to be truthfully revealed rather than estimated using bio-economic models that treat landholders as homogeneous agents.

If outcomes are appropriately developed to reflect the importance of location now and in the future and account for all on-site and off-site impacts, the remaining exercise is to employ a mechanism that reveals the true cost of making the changes, hence the use of auctions.

The CMF was developed to support EcoTender and as such, there are a number of areas that would benefit from further research and effort. From an economic point of view there has been no account for diminishing returns or preferences between outcomes. The framework has shown the dependency between spatial locations for individual sites but has not included empirical approaches (for instance synergies between sites) to exploit the opportunity for further cost savings.

In the pilot areas water is not used for productive purposes. A reduction in stream flows could have deleterious economic impacts if the water is collected and used for productive purposes. There are a number of policy issues associated with the need to address the trade-off between water for environmental purposes and water for productive or consumptive purposes if this approach were to be adopted in an area used for water collection. However, the CMF provides the information needed to implement of test policy options.

The methodology developed in this study links landuse and management with biophysical crop growth and environmental processes on a site-specific basis with the capacity to assess the off-site impacts at both the farm and sub-catchment scales. This approach accounts for spatial variability and connectivity within the landscape.

Results presented in this section demonstrate the value of adopting a holistic catchment modelling framework to inform a market-based auction process. The project is applying the CMF to estimate multiple environmental outcomes, both on-site (biodiversity, erosion and carbon sequestration) and off-site (catchment yield and water quality), arising from landuse change at the farm scale.

The framework has shown that recharge alone is not a suitable metric for the allocation of environmental funds for the prevention of saline land. Further the CMF has shown that targeting a single outcome is not sufficient to capture the heterogeneity of landscape change at the farm scale. Combining this information with auctions for landuse change provides the opportunity to purchase environmental outcomes more cost effectively than current grant based approaches.

The Catchment Modelling Framework provides policy makers with a new tool to analyse landscape intervention and make informed decisions about the outcomes resulting from investment at the paddock scale. The framework is practical and feasible for application in the field and provides a cost effective, replicable and transparent method for the assessment of environmental outcomes to support programs for the allocation of environmental funds.

6 Preferences – Demand side

Using the Catchment Management Framework (CMF) to estimate environmental outcomes and an auction to create competition between landholders provides the implementing agency with the necessary information to derive the cost effective supply of environmental goods. However, this does not in itself create a market for the environmental goods. To do this, the demand side must also be addressed.

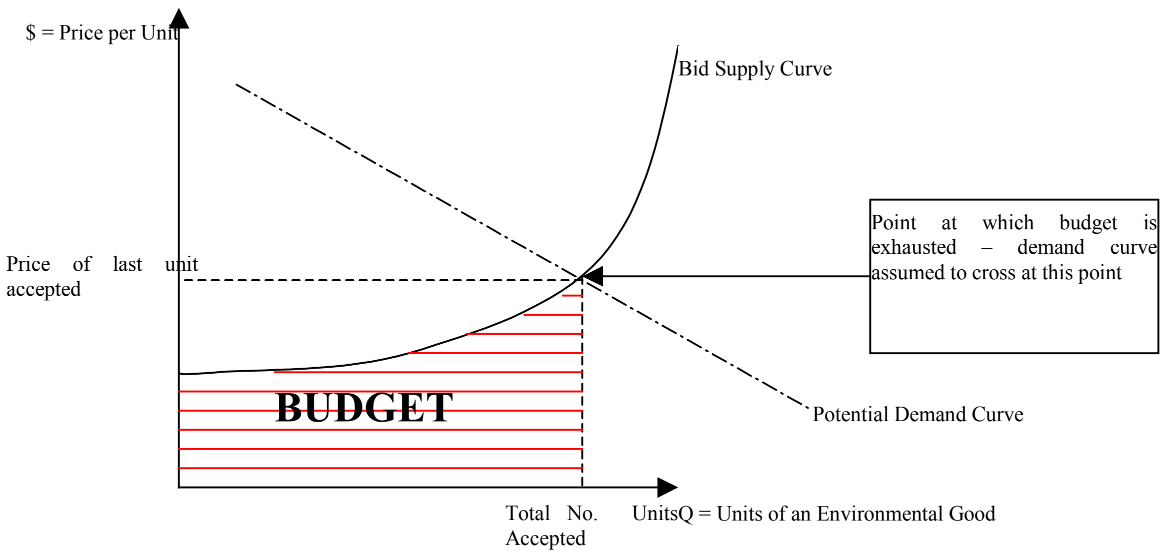
Markets involve buyers and sellers participating in transactions that make both parties better off. A buyer is made better off as the price they pay for a unit of a good is below the maximum amount that they would be willing to pay for a good. A buyer's 'willingness to pay' function for a good is referred to by economists as their demand function for a good. Information about demand is therefore necessary to ensure that a buyer will be made better off by participating in the auction.

This chapter discusses the method that dealt with the demand side in BushTender style auctions and when government is procuring single public goods on behalf of society (Section 6.1). It explains in Section 6.2 that this method is not sufficient to deal with the demand side when an agency is procuring outcomes that are jointly supplied. The difficulties in determining willingness to pay or formulating preferences on behalf of society for public goods where markets are new or do not currently exist are discussed (Section 6.3 and 6.4) and some options that were considered for choosing bids in EcoTender are presented in Section 6.5. Finally the method used to choose bids in EcoTender is described and the rationale for choosing this method explained in Section 6.6.

6.1 The Demand Side in BushTender Style Auctions

In BushTender style auctions for single environmental goods the demand side is addressed by using a budget to purchase the most cost-effective bids until the budget is exhausted. This ensures that, given the budget constraint and the bids received in the auction, the maximum amount of the single environmental outcome is procured. If the budget method is assumed to be efficient, the point at which the budget is exhausted is assumed to reflect the agency's demand for the environmental good (terrestrial biodiversity). That is, if it is assumed BushTender is efficient in the amount of terrestrial biodiversity it procures, it is implicitly assumed that the benefit of the last bid accepted is at least equal to the cost of accepting this bid. This accords with standard economic theory that the price and quantity of the good will be determined by the point at which marginal cost is equal to marginal revenue. For BushTender to deal efficiently with demand, it is effectively necessary for the budget to be set with perfect information about the supply price and to reflect society's demand for terrestrial biodiversity, this concept is illustrated in Figure 10.

Figure 10. Addressing Demand in BushTender Style Auctions for Single Goods



While using a pre-determined budget (a budget set before bids have been received) may not always result in the agency's demand actually being accurately reflected, the explicit revelation of the supply price of additional units of environmental goods, as BushTender does, allows an agency to communicate and compare prices. This enables the agency to adjust and update budget allocations so that over time it moves towards the point at which the marginal supply curve meets the agency's willingness to pay for the next unit of the environmental outcome. The implications of a budget allocation in one auction may be analysed and used to update budget amounts to be used in subsequent auctions. This enables changes to be made so that in subsequent auctions the budget more accurately reflects the agency's (and the community's) demand. Budgets, altered over time, are used to deal with the demand for many publicly funded goods including education, health, defence, etc.

6.2 The Joint Supply Problem

While addressing the demand side in an auction using a budget constraint updated over time may be suitable for a single dimension auction, this method does not lead to a cost effective result where there are multiple jointly supplied environmental outcomes.

Inter-linkages in the landscape mean that an action that affects one environmental good also has other environmental outcomes which may be positive (in the sense that another environmental good is also produced) or negative (another environmental good may be depleted). In this case environmental goods are said to be 'jointly supplied' such that one action, which has one lump sum cost, produces multiple outcomes.

Where environmental goods are not interlinked in the landscape and can be provided separately, an auction for multiple outcomes may still be beneficial to reduce the transaction costs of running a number of auctions. Where goods are not jointly supplied we could make separate or isolated decisions about how much of each good to procure. In this case we may be able to contemplate using the same BushTender type method to deal with the demand side, with the assumptions that this would entail. We may allocate an amount that we are willing to spend on procuring each type of outcome (separate budgets for each good) and then spend each budget on the actions that provide the good for which that particular budget is allocated most cost effectively. This process could be continued for each budget in turn until all budgets are exhausted. With no jointness in supply each budget would be spent on procuring actions that provide only the good for which the budget was allocated.

The growing recognition that one action produces multiple outcomes (see Chapter 5) and contributes to the difficulty in addressing the demand side problems of multiple outcome auctions as it can not be dealt with by assigning a separate budget for each type of public good. Where jointness in supply exists, an auction to procure an environmental outcome must take account of all jointly supplied environmental outcomes in order to maximise the benefits of the bids accepted in the auction, and to avoid unnecessarily creating negative environmental benefits.

It now becomes important for the agency to explicitly determine its relative preference for each good. In order to choose bids the agency will have to make decisions such as deciding whether it is better to accept a bid that delivers more terrestrial biodiversity and less aquatic function or a bid that offers less terrestrial biodiversity and more aquatic function. In making this decision the agency must, either explicitly or implicitly, express a relative preference or 'weighting' between the two goods.

For example, consider three bids received in a procurement auction for two environmental outcomes, terrestrial biodiversity and aquatic function, bids A, B and C as described in Table 6. The procuring agency has a positive willingness to pay for both these environmental outcomes. Bid A is for $15 and has a score of 15 for terrestrial biodiversity and a score of 30 for aquatic function. Bid B is for $12 and has a score of 20 for terrestrial biodiversity and 20 for aquatic function, and bid C is for $15 and has a score of 16 for terrestrial biodiversity and 32 for aquatic function.

Table 6. Three Hypothetical Bids Received in An Auction for Two Goods

	Bid A	Bid B	Bid C
Units of Terrestrial Biodiversity (Hha x BSS)	15	20	16
Units of Aquatic Function (T/ha x mm/ha)	30	20	32
Bid Cost ($)	15	12	15

Comparing the three bids, it is possible to conclude that an agency, whatever it's preferences between the goods and given the budget constraint allows, would choose to accept bid C over bid A. Doing so enables it to, for the same cost, obtain the same amount of terrestrial biodiversity but more aquatic function. However, when deciding whether it will accept bid A or bid B, the problem is not as clear because it is not possible to incur no additional cost and get more of one good without getting less of another by accepting one bid or another. Bid A has a score of 10 more than bid B for aquatic function, but has a score of 5 less for terrestrial biodiversity for the same price. To determine which bid an agency is better off accepting it must decide whether it is willing to trade 5 units of terrestrial biodiversity for 10 units of aquatic function. If an agency chooses to accept bid A over bid B, it is willing to trade 1 unit of biodiversity in exchange for 2 units of aquatic function. To choose which bid it would prefer to accept an agency must determine how much of one good it is willing to trade for another.

One way an agency may choose to express its preference between the goods to simplify the process of ranking bids in order of preference or value for money is to apply weights to the scores for each different outcome. For example, I may decide that I prefer an apple to an orange, and if someone offered me 3 oranges in exchange for an apple I would accept the offer but I would not swap my apple for any less than three oranges. In choosing between bags of the mixed apples and oranges I might therefore apply a weight of 3 to each apple and 1 to each orange to derive a total score for each bag of apples and oranges. The total score of each bag obtained using the weights divided by the price determines the value for money provided by each bag.

Consider for example, an agency could determine that it was willing to trade 1 unit of biodiversity for a minimum of 2.5 units of aquatic function. The agency could simplify the process of choosing between the three bids in line with this preference by putting the scores for both goods in terms of one of the goods. Given a unit of biodiversity is worth 2.5 units of aquatic function to the agency, the agency could multiply biodiversity scores by 2.5, this product would be the biodiversity score in terms of equivalent aquatic function units given the agency's preference, thus comparable to the raw aquatic function scores. The relative sizes of the sums of the product of biodiversity score by 2.5 and the aquatic function scores can be used to rank the bids in order of value for money to the agency, as shown in Table 7.

Table 7. Applying Weights Representing Willingness to Trade One Good for Another

	Bid A	Bid B	Bid C
	Weighted Scores	Weighted Scores	Weighted Scores
Terrestrial Biodiversity	15 x 2.5 =37.5	20 x 2.5 = 50	16 x 2.5 = 37.5
Aquatic Function	30	20	32
Total Weighted Benefits in equivalent terms*	67.5	70	69.5
Cost	15	12	15
Value for Money (total benefits* per dollar)	4.50	4.67	4.63
Bid Ranking	3	1	2

If an agency has preferences that lead to a weight of 2.5 being applied to biodiversity and a weight of 1 to aquatic function, bid B provides the most value for money, followed by bid C, and then bid A.

Until now we have discussed applying weights to outcome scores with the unstated assumption that these same weights are applied to all bids assessed regardless of other bids chosen in the auction. Economists often assume that the demand for goods exhibits 'diminishing returns', that is as more of a good is obtained a buyer is willing to pay less for the next unit of the good. Where multiple goods are being purchased, this form of preference function would result in the weight applied to an outcome being reduced as more of that good is bought compared to other goods. Weights may therefore change depending on the bids already chosen, for example, biodiversity might be weighted more highly if the successful bids provide less of it and this weight may decrease as bids provide more biodiversity.

Holding weights constant to choose bids in an auction does not necessary signal a rejection of the idea that there may be diminishing returns for the goods. It may be that the quantities of environmental outcomes procured in the auction is small or marginal relative to the total amount of the good in the landscape, or the amount to be procured via alternative avenues. If the process of adjusting weights as bids are selected in an auction is thought to add little benefit but involves some transaction cost due to added complexity, it may be better for an agency to hold weights constant during an auction. The agency could deal with diminishing returns if necessary by adjusting weights in between auctions.

In EcoTender this problem is made more complex as there are three public goods and each bid may have a different cost.

6.3 The Exchange of Goods: Private and Public

However, articulating a willingness to pay for environmental outcomes, or even a preference between environmental outcomes is problematic for an agency that is attempting to procure these goods in line with society's demand for them. This is largely because the environmental outcomes are what economists refer to as 'public goods', and markets for these goods either do not exist or are very new. The following two sections explain the problems that these factors raise.

Private goods are goods whose owners can choose to ensure that only they get the benefits of the good. This is a result of clearly defined rights associated with the ownership and use of the good. One persons use of a private good diminishes the quantum of benefits of that good available to be enjoyed by others. For example, if I own a pen, I can prevent someone else from using that pen so that only I benefit from it. My use of the pen diminishes the value of that pen to another person.

Generally where the net benefits provided by a private good outweigh the transaction costs of exchange, markets naturally emerge to facilitate the exchange of these goods between sellers and buyers.

Over time different types of markets have evolved, based on the characteristics of different goods, providing buyers with information that assists them in formulating their willingness to pay. For example, labels, inspections and trial periods all provide buyers with information that may be useful to determine their willingness to pay. Different market characteristics have developed for different goods depending on the information requirements of buyers, for example, some goods are purchased without inspection as labels provide buyers with adequate information, while buyers of goods such as second-hand houses or cars, require building or mechanic inspections before purchasing.

In these markets often a 'market price' arises for private goods that are commonly bought and sold. The market price tends to strongly influence the highest price that a buyer is willing to pay for a good. A buyer who knows that the good can be bought elsewhere or on a normal day for this price will be reluctant to pay more than this amount for the good.

In EcoTender carbon sequestration is treated as if it is a private good, in part to demonstrate that a multiple outcomes auction could connect with a cap and trade system, such as a tradeable emissions permit market for carbon. It is assumed that property rights and a tradeable emissions permit (TEP) market are established for carbon, and a market price exists for tonnes of carbon sequestered. It is assumed that landholders who produced carbon could sell it to a third party, for example a broker or a buyer in the TEP market.

To proxy a potential way that the TEP market could interact with a multiple outcomes auction a third party is participating in EcoTender as the purchaser of carbon. Landholders understand that, if their bid is successful in the auction process, for every tonne of carbon provided in their bid they will receive a payment. This is the amount estimated as the market price for carbon produced by bio-sequestration less transaction costs.

There are two characteristics of public goods that mean that markets do not naturally emerge to result in their optimal provision. Firstly, public goods are *non-*

appropriable such that individuals cannot own, for example, environmental amenities such as clean air or water. Secondly, public goods and services are *non-rival* so that enjoyment of them (for example, the environment) by one individual does not preclude enjoyment by others. An individual will be reluctant to pay for the entire cost of a public good as they are unable to prevent others from enjoying its benefits and they may be able to get the same benefits if they choose not to pay for it and someone else does. The enjoyment of the benefits provided by public goods by many people leads to the problem of free-riding and as a result government usually steps in to purchase or provide public goods on behalf of those who benefit from them.

As the number of individuals who benefit from a public good increases, estimating how much of a public good should be provided, and at what cost, becomes increasingly difficult.

In addition to the private good carbon, the other outcomes included in the auction are:

- terrestrial biodiversity (measured as the change in habitat per hectare multiplied by the biodiversity significance score);
- aquatic function (measured as the change in water quality – tonnes of soil per hectare arriving at stream, multiplied by the change in water quantity – mm of water per hectare arriving at stream); and,
- decrease in saline land area (measured as the decrease in hectares of land with groundwater less than 2 metres deep).

These three goods are assumed to be public goods that the Department, on behalf of the community, wishes to pay landholders to provide.

Estimating the community's willingness to pay for public goods for which markets are not yet established is more difficult. As markets facilitating the buying and selling of public goods have generally not emerged, there is no market price that can be used to reflect the threshold price above which a buyer will not be willing to pay for these goods. In addition this means that people are not familiar with purchasing clearly defined units of public goods for an explicit sale price. Individuals often do not have the information they would require to estimate their willingness to pay for public goods.

In addition there are thousands of individuals in the community. Even if individuals did have an estimate of their demand for a public good, it would be difficult and involve prohibitively high costs for the government to obtain an accurate revelation of this information from all individuals in order to determine the community as a whole's demand (willingness to pay).

6.4 Purchasing in new markets

The problem of dealing appropriately with the demand side is exacerbated by our unfamiliarity with making informed purchases of units of the environmental goods (defined by metrics) provided by bids in EcoTender. While the agency may have implemented programs to provide environmental outcomes previously, the use of metrics and supply prices revealed by the auction is very new. The agency does not have knowledge about the 'market price' of the environmental outcomes upon which to base an estimate of its willingness to pay for additional units of the environmental goods.

Consider goods that you regularly purchase and the information you use to determine how much of each good you purchase, for example, when shopping in the supermarket. You might have information about the usual price of the different goods and how those prices fluctuate, for example with season. You might know that fruit is not always of good quality in the supermarket, but that there is a green grocer next door which sells better quality fruit but at a higher price. Based on many past experiences using different goods and your current situation (for example, you may have no fresh food in the house) you generally have a good idea about which goods you prefer today over other goods.

Most people will have little understanding of what a one unit score of the environmental outcomes in EcoTender represent. For example, consider terrestrial biodiversity, not more than a handful of people would have a clear understanding of the impact of an increase of one unit in a particular landscape on their, or society's in general, utility.

Making decisions about how much of different goods to purchase when unfamiliar with the measurement and supply characteristics of the goods is problematic. Combined with joint supply and the public good characteristics, identifying and articulating preferences for goods becomes even more difficult.

However, while choosing bids to achieve the theoretically efficient allocation at the point where demand equals supply may not be possible, at least initially, addressing the demand side so that we

- become familiar with purchasing these goods,
- learn more about our relative preference for them,
- learn more about the cost of attaining them through alternative means, and,
- investigate further the impact that they have on the landscape and our lives,

will enable us to be more confident of the trade-offs we are prepared to make to reflect our demand for the different goods in the future.

6.5 Some Options for Choosing Bids and Associated Issues

In this Section we discuss some methods that have been suggested to deal with the demand side and choose which bids to accept in the auction.

With joint supply and the absence of market prices we do not consider the option of allocating separate budgets for each good as this will not be cost-effective, as discussed previously.

All options allow for the fact that in the pilot we are constrained by the budget available to pay to successful bidders, that is, they involve the assumption that in the EcoTender pilot we intend to spend approximately $X on bid payments. This was the case in EcoTender.

All options contain the assumption that goods are jointly supplied and to achieve the best results for the environment and our money it is necessary to consider all environmental outcomes in choosing which bids to accept.

The options presented here fit into two broad approaches. These approaches have different implications for engagement with stakeholders, particularly in terms of telling landholders what the decision about whether to accept their bids will be based on. This will impact on the auction design and communication with landholders in terms of what landholders are told about the relative importance of their scores for different goods. The design described in Section 4.1 is based on the option chosen to assess bids in the pilot.

The two broad approaches also contain different assumptions about the level of information we need in order to determine the types of trade-offs we are prepared to make between environmental goods.

Approach 1. Determining the relative weights, or the formula by which they will be determined, prior to bid analysis

The first broad approach discussed involves making a decision about our preference for one good in terms of the others before we analyse the potential total outcomes of different combinations of bids in the auction.

By making a choice about the trade-off we are willing to make between goods, we are able to apply weights (or an equation if we build diminishing returns into the bid selection process) to the scores for each good. We are then able to choose the bids that provide the maximum total benefit subject to our budget constraint. Doing this means we can be confident that, given our budget constraint, it is not possible to get more of any environmental good without giving up some of another, because if it were, there would be another bid combination that would provide us with greater total benefit.

In order to communicate the bid selection process to landholders, so that they may best tailor the relative amounts of goods provided in their bids with our articulated preferences, we must determine the relative weights to apply prior to site visits and receiving bids (and the information that they provide). This means we must make our decision about the trade-offs that we're prepared to make between different goods before we have the information that bids provide, for example we will not know how much of one good we can gain by giving up some of another.

Options within this broad type involve using different methods to determine the appropriate 'weights' or relative preference for units of the different environmental goods.

This approach involves determining weights or being explicit about preferences before the bids have been submitted and analysed. Landholders can be informed of the method to be used for assessing bids prior to fashioning their bids. Landholders can therefore tailor their bids to best suit the preferences expressed to them by the Department.

Note that all options for choosing and using relative weights to reflect preferences must reflect the fact that a unit of an outcome represents an actual good, in the context of environmental outcomes a unit represents a quantum of physical change in the landscape (Table 2, p 57). This quantum of change, or physical impact, is what we must base preferences on because this is what we are ultimately concerned with. If scientists change the scoring unit for an outcome (for example, if for aquatic function, water quantity is measured in centimetres of water to stream rather than millimetres) the weights applied must change to reflect the fact that the agency's preferences have not changed, only the magnitude of scores. Table 2 illustrates how changing the measurement of aquatic function from millimetres of water per hectare to stream to centimetres per hectare arriving to stream, may reduce the magnitude of aquatic function scores by ten. If the weights previously applied to biodiversity scores are not changed to reflect the change in scoring magnitude for aquatic function, the preferences for the goods implied by the weights will change, which means they do not accurately reflect preferences for physical amounts of the environmental outcomes in the landscape. Altering the magnitude of aquatic scores by a magnitude of ten would mean that where an agency was indifferent between a unit of biodiversity and 2.5 units of aquatic function, it is now indifferent between a unit of biodiversity and 0.25 units of aquatic function. 0.25 units of aquatic function where aquatic function is measured in cm of water to stream represents the same physical outcome as 2.5 units of aquatic function would if water were measured in mm to stream.

Table 7 illustrates the application of weights that reflect the agency's indifference between 2.5 BBI units and 1tonne soil/ha by 1mm water/ha to stream. Table 8 demonstrates that if the weights are not adjusted to reflect the change in magnitude of scoring for aquatic function, the preferences employed implicitly change, for no reason, to reflect an indifference between 2.5 BBI units and 1 tonne soil/ha by 1mm water/ha to stream.

Table 8. Weights reflecting preferences for physical amounts of outcomes

	Bid A		Bid B		Bid C	
	Old Weighted Scores	Adjusted Weighted Scores	Old Weighted Scores	Adjusted Weighted Scores	Old Weighted Scores	Adjusted Weighted Scores
Terrestrial Biodiversity	15 x 2.5 = 37.5	15 x 0.25 = 3.75	20 x 2.5 = 50	20 x 0.25 = 5.00	16 x 2.5 = 40	16 x 0.25 = 4.00
Aquatic Function	3	3	2	2	3.2	3.2
Total Benefits*	40.5	6.75	52	7.00	43.2	7.20
Ranking	3	3	1	2	2	1
Implication of weights	Indifferent between 2.5 BBI units and 1 tonne soil/ha by 1 cm water/ha to stream	Indifferent between 2.5 BBI units and 1 tonne soil/ha by 1 mm water/ha to stream	Indifferent between 2.5 BBI units and 1 tonne soil/ha by 1 cm water/ha to stream	Indifferent between 2.5 BBI units and 1 tonne soil/ha by 1 mm water/ha to stream	Indifferent between 2.5 BBI units and 1 tonne soil/ha by 1 cm water/ha to stream	Indifferent between 2.5 BBI units and 1 tonne soil/ha by 1 mm water/ha to stream

Weights may be determined based on:

- past budget allocations for each good.
- the maximum possible score for each good by any bid received in the auction.
- movement towards a target level.
- results of a preference survey of the community.
- results of a single survey of the preference of the Minister, a senior bureaucrat or a departmental officer, on behalf of the community.

Choosing bids based on the **past budget allocations** for each good requires determining, physically, the amount of each good that the separate budgets produced. For similar reasons described above in relation to ensuring preferences are for physical amounts of environmental goods, or physical changes in the landscape, past budgets can only be used to formulate weights if the physical quantum of the good that they purchased is known. If last year $2 million was allocated to aquatic function and $1 million to terrestrial biodiversity, it is meaningless to assume that the weights that should be applied are 2 to 1. Determining the physical amount of the environmental goods provided by the budgets is likely to be difficult, generally metrics have not been used and a comparison is not possible.

Using the relative sizes of the **maximum possible score** for each good produced by a bid in the auction to determine weights implies that we are indifferent between gaining the maximum possible amount of one good, say terrestrial biodiversity, and the maximum possible amount of another good, say aquatic function. As long as the maximum possible scores are measured in the same units that bids are compared on, this will be consistent no matter what magnitude of scoring is used for the different goods. However, calculating the maximum possible scores for each good is problematic, particularly for salinity mitigation as the relationship of hectares that action is taken on to hectares of saline land impacted on is non-linear. Different bids contain action taken on different areas of land, therefore the non-linear relationship means the maximum possible salinity mitigation score can not be established *a priori.*

Using **movement towards a target** level to determine our preference for different combinations of bids would entail establishing what our target for each good is in terms of the metrics or units of each good as measured in the auction. The agency is then indifferent between a proportional movement towards the biodiversity target, and a movement of the same proportion towards the aquatic function target. For example, if one combination had a total result of biodiversity moving 10% of the way to its target, salinity mitigation moving 5% and water quality moving 15%, its total score would be 30. The combination of bids with the maximum score would then be chosen. Using this method would mean that we were saying we are indifferent between a one percentage movement of one good towards its target and a one percentage movement of another good towards its target. Using this method defers the problem of determining and expressing preferences, with all the difficulties that this entails, to the process of setting and quantifying targets, it does not eliminate it. Addressing the problem of defining preferences in the target setting phase is likely to be less transparent and therefore to have less learning and dynamic adjustment benefits over time.

Conducting a **stated preference survey of the community** to determine relative weights to apply to amounts of each good that will reflect the community's preferences for those goods would be likely to be costly. Much of this cost would be due to the fact that to participate in such a survey with any meaning and relevance participants must understand exactly what a unit of each of the goods represents. They would need to understand the current condition of the landscape in terms of amounts of each of the goods and what impact different amounts of each of the goods is likely to have on the landscape, etc. Informing all members of the community who participate in the survey so that they were confident they understood this would mean that transaction costs associated with this method are likely to be high. In addition, information that we are able to provide to participants prior to the auction results may not be sufficient for participants to feel confident that they are making informed decisions.

The **stated preference of the Minister** or a bureaucrat would entail ensuring they understood what a unit of each environmental good represents as described above. However, the cost of providing this information to one person would be less than providing it to many members of the community. Again information that we are able to provide prior to bid analysis may not be sufficient for them to feel confident they are making an informed decision.

Approach 2. Presenting information to assist in determining preferences

The second broad approach involves collecting all the bids from landholders before presenting ***information to assist in determining preferences*** between different goods. This data is then analysed and presented to the decision maker in a manner that provides information about the possible combinations of bids and the environmental goods that they provide, and the trade offs that are inherent in choosing one combination of bids over others. The decision maker can then use this information about all the possible choices of different combinations of bids (for which we can't get more of one good without getting less of another) to decide which combination of bids is most preferable, given all of this information. Options within this broad approach involve determining who the decision maker/s should be, what information can be gathered that will best enable them to make their decision, and how that information can best be presented to them.

As with the options in the previous approach discussed, within this approach it is also important that the decision-maker or makers understand what a unit, as scored in the auction, of each good represents.

The types of information provided to the decision-maker may include information about:

- The different combinations of bids for which more of one good can not be obtained without sacrificing some of another, that is possible given the budget constraint, and the trade-offs between the goods inherent in choosing one combination of bids as opposed to another.
- The extent of the environmental goods involved in the landscape prior to the auction.
- The estimated price at which the environmental goods could be obtained through alternative mechanisms.
- etc.

Research into this area of economics has been limited in the past. It is likely that with the development and increased application of these types of mechanisms that deliver joint multiple public good outcomes further research into this area of economics is necessary and valuable. In particular it appears that research that provides greater insight into the types of information and the way that it can best be presented may allow those purchasing environmental goods on behalf of the community to make the best decision they can at any particular time, given the information available.

6.6 Choosing Bids in EcoTender and the Way Forward

The research on the demand side that would have been necessary to properly implement many of the options discussed above could not be conducted within the timeframe and budget of the pilot.

The option chosen reflected the uncertainty surrounding the impact that the environmental goods will have on the landscape, bidding by landholders, the implications and tradeoffs that would occur from weighting preferences towards one good over another, etc. As we know so little about implementing an auction for multiple, jointly suppled environmental outcomes the pilot was considered a learning exercise. Therefore it was thought to be important to handle the demand side simply, to ensure it was easy to communicate to landholders and other stakeholders, and to make it transparent so that results produced can be analysed and learnt from before subsequent applications.

To choose successful bids, the following method was used. For each environmental outcome, the difference between the estimated pre-1750 level and the estimated current stock was calculated. The raw outcome score for an outcome in a bid was then divided by the difference between pre-1750 and current stock levels to produce a percentage movement towards pre-1750 conditions for each outcome. The percentage movement or adjusted score's for each outcome produced by a bid were then added to produce a total score, which when divided by the cost of the bid produced the 'total value for money' produced by that bid. Choosing those bids that provide the best value for money, or the greatest total adjusted score per dollar, until the budget is exhausted ensures that it is not possible to get more of one good without giving up some of another.

By using this method the department is effectively indicating that it is indifferent between a score that reflects a 1% movement towards pre-1750 levels for biodiversity and a score that reflects a 1% movement towards pre-1750 levels of aquatic function. This option is similar to the stated preference of the pilot manager (a departmental officer) and belongs to "Approach 1. Determining the relative weights prior to bid analysis" where a percentage movement towards pre-1750 levels are used to identify the appropriate weights for each outcome.

As previously discussed, when bidding landholders understood that if their bid was accepted using the above scoring method, for each tonne of carbon sequestered they would receive a payment of $12.

The simplicity and transparency of this option allows reflection on the result, facilitates feedback from stakeholders on the goods chosen and the trade-offs made and other learnings that will help inform and refine the method of dealing with demand to more accurately capture society's preferences.

Using the earlier example bids described in Table 6, Table 9 illustrates the method used to choose bids assuming a budget of $30. After accepting the bid providing the highest EBI per dollar (bid C) for a payment of $15, the bid providing the next highest EBI per dollar (bid A) is accepted for a payment of $15. At this point the $30 budget is exhausted, and bid B must be rejected.

Table 9. The method used to choose (hypothetical) bids with a $30 budget

	Bid A	Bid B	Bid C
Terrestrial Biodiversity	15 / 399059*	20 / 399059*	16 / 399059*
Aquatic Function	30 / 67,250*	20 / 67,250*	32 / 67,250*
Environmental Benefits Index	0.000484	0.000348	0.000516
Cost	15	12	15
Value for Money (EBI/$)	0.000032	0.000029	0.000034
Priority Ranking	2	3	1

While this option for selecting bids to procure multiple outcomes was considered suitable for the pilot as it was primarily a learning and demonstration exercise, further research to identify the most appropriate method of determining preferences may be necessary to maximise the benefits of these mechanisms providing multiple outcomes. Analysis of the results of the pilot will assist in this work, as will developing a more thorough understanding of how preferences are formed and the least cost method by which the communities preferences can be translated through to a system for choosing bids with multiple outcomes in an auction.

7 Contract design

Contracts are used in everyday economic life, such as when we buy car insurance or make a verbal promise. People use contracts to formalise and enforce promises in delivering goods or services. Enforceable contracts underpin economic progress. Contracts can be written to provide incentives to deliver goods and services in efficient ways but it is equally possible that contracts may be written to provide incentives to be inefficient. For example, if a government wants services to be provided over a period of time like say five years and the contract specifies that it will pay for those services in full up-front then this provides a perverse incentive: if the provider reneges after receiving payment it will be costly for the Department to then enforce the contract.

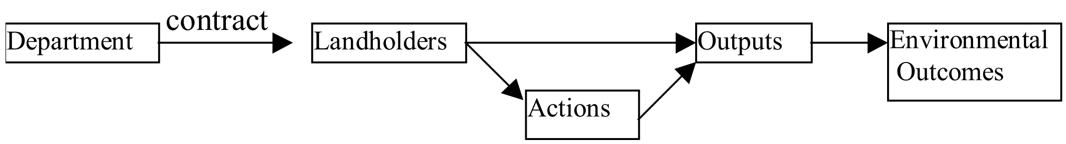
Hence the incentives contained in a contract are crucial in determining whether or not contract compliance is achieved and whether or not parties decide to participate in the first place. If contract design is not well thought out, the objectives of the buyer and seller may not be achieved.

This section looks at how the economic literature contributes to the design of contracts. First, we describe EcoTender contracts. Then we discuss the key concepts in economic theory that can be used to analyse the problem of contract design for EcoTender: asymmetric information; moral hazard; risk; commitment; and renegotiation. During this discussion we will examine how each concept was used in the design of the EcoTender contracts.

7.1 EcoTender Contracts

In EcoTender contracts the Department is interested in environmental outcomes. However, we assume the Department cannot purchase these outcomes directly, and must influence landholders to produce actions or outputs that may result in outcomes. We assume that actions may lead to outputs that may lead to outcomes. For example, an action may involve the spraying of weeds. The output from this is the removal of weeds from a certain area. The outcome is the increased quality and quantity of native vegetation. This is shown in Figure 11 below.

Figure 11. Actions, Outputs and Outcomes



Each EcoTender contract is based on the obligations of two parties: the Department; and a landholder. In general landholders are required to undertake actions or produce outputs that will lead to outcomes associated with environmental services. The Department is required to provide payments for these actions or outputs given that there has been some proof of fulfilment.

'Proof' generally comes in the form of self-reporting. Landholders must report whether they have undertaken actions or produced outputs over a specified time period. The Department then follows up on landholders that do submit a report or if a report has gaps or errors in it. In addition to self-reporting there will be monitoring of sites by Departmental officers. Each site will be visited at least once throughout the contract period.

There are two types of EcoTender contract: one for revegetation; and another for management of remnant native vegetation. Contracts for revegetation are relatively more 'flexible' in terms of timing since landholders are required to revegetate with certain species at a certain density and landholders report back to the Department after they have completed each milestone. Flexibility is available due to climatic uncertainty, it is in neither the Departments interest nor the landholders to attempt planting when there is a high likelihood of plant death/failure. With remnant management contracts landholders are generally required to undertake certain actions and report on them annually.

Remnant management and revegetation contracts are for five and ten years, respectively. For both contract types if the milestones have not been achieved the contract may be ended without making remaining payments.

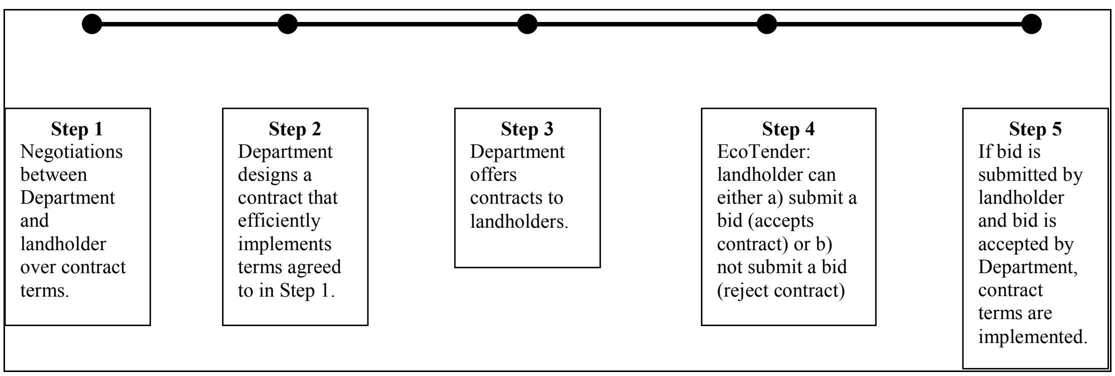
For both contract types the Department spreads payments over time according to a U shape. That is, the Department makes relatively large payments at the commencement and completion of the contract—25 percent in each instance, making up 50 percent of the overall payment. The remaining 50 percent is paid in the intermediate periods.

7.2 Economics of Contracts: The Contracting Process

In economics, contracts are written by a *principal* and offered on a take-it-or-leave it basis to *agents*. In our case, the Department is the principal and the landholder is the agent. The realities of contract design are different than economic theory assumes, but there are some lessons we can draw on for contract design. In this paper, we assume the Department's aim is to design a contract that *efficiently* implements the mutually agreed outcomes between it and the landholder. By an 'efficient contract' we mean one that maximises the value of the contractual relationship.

We assume the contracting process is as described in Figure 12:

Figure 12. Contracting Process



In the following sections we examine several economic concepts: asymmetric information; moral hazard; risk distribution; commitment; and renegotiation. Throughout we refer back to the design of EcoTender contracts so as to illustrate how the theory has been applied in practice.

Asymmetric information

How the Department designs a contract for environmental management on private land is an important question because the problem is characterised by *asymmetric information* (see Chapter 4). If individuals are not self-interested and rational as economic theory assumes but instead had preferences that were identical to the Department's then asymmetric information is not a problem. Let us call such individuals whose preferences are identical to society 'model citizens'. These model citizens would not hide any private information they possess even if it is valuable to the Department. This is because model citizens know the Department will value such information in order to design a socially optimal policy. These model citizens also value the design of a socially optimal policy and so would voluntarily reveal their private information. But this assumption that individuals behave like model citizens is untenable because there is no evidence that individuals generally behave in this way. Instead, we assume that individuals are rational and self-interested**.** This is not entirely satisfactory explanation of individual behaviour in general, but it is the most appropriate assumption of individual behaviour in an *economic* situation. We will assume that landholders are rational and self-interested.

Given the rationality assumption, asymmetric information is a problem when the Department is designing contracts for environmental management. To see why, recall that landholders' private information is valuable to the Department (in auction design chapter). Implicitly, we have assumed that landholders know the Department values landholders' private information. Asymmetric information allows rational landholders to take advantage of their private information in two ways: 1) the landholder can misrepresent what type of landholder (e.g. low or high cost) they are (*adverse selection*) and 2) misrepresent what management actions they have undertaken (*moral hazard*)[3]. Adverse selection is dealt with by using an auction: a competitive auction allows the agency to discriminate between low and high cost suppliers (see Chapter 4). Hence our focus in this Chapter is on the reduction of moral hazard.

Moral Hazard

In insurance, the moral hazard problem is where an individual purchases insurance but changes their behaviour to become less careful. Insurance reduces the cost of risky actions. This could mean insurance distorts the individual's risk profile from being an *actuarially fair* risk (risk burden is shared between the parties optimally) to becoming actuarially unfair (the insurer bears more risk than it is willing to). Take the example of car insurance: a motorist who purchases car insurance may become a

[3] The terms 'adverse selection' and 'moral hazard' have their origins in the insurance literature when insurers saw risk in moral terms. In economics, these terms do not have the moral overtones that insurers attached.

riskier driver by speeding more or taking less precautions when driving than would be the case if the motorist had to bear all the risk of driving. From this discussion, moral hazard is the problem where insurance has the perverse effect of encouraging insured agents to take more risks.

Moral hazard stems from asymmetric information because if the insurer were able to monitor insured individuals' actions in reducing risk than the insurer could penalise individuals who do not undertake preventative measures. However, asymmetric information is a reality insurers (and the Department) face. Undertaking preventative measures (management actions) is costly for insured individuals so there is an incentive for them to avoid these costs.

Moral hazard in the case of EcoTender is the risk of breach of contract by not undertaking the contracted management actions. Using a livestock exclusion example, moral hazard would be where a landholder violates this term of the contract by letting livestock into the remnant vegetation area. Moral hazard arises in the case of environmental management because contracted actions are costly to the landholder. Preventing moral hazard is an important determinant of the overall success of EcoTender because if landholders do not undertake the contracted management activities then it is unlikely any of the objectives of the program will be achieved. Designing contracts that provide incentives for individuals to undertake the contracted management actions is vital to the success of the EcoTender.

Dealing with Moral Hazard

In this section we analyse ways of dealing with moral hazard. We focus on the role of monitoring and enforcement. With regards to the latter, we discuss the role of the payment schedule.

Monitoring

Moral hazard can be partially dealt with through monitoring and enforcement of contracts. This assumes that the Department is able to monitor landholders' actions and enforce the contract at relatively low cost.

Monitoring can be based on explicit measures specified in the contract such as actions or output. In EcoTender contracts landholders self-report according to contract requirements. In remnant vegetation contracts landholders self-report on actions. But in revegetation self-reporting is largely with respect to outputs.

However, a landholder self-reporting that she has undertaken an action is not a guarantee that such an action has been undertaken. In order to provide further incentive to truthfully report the Department also undertakes monitoring by having regional departmental officers visit EcoTender sites. During the EcoTender contract period the Department will monitor some portion of the participants each year and will monitor all landholders at least once. The Department's approach to monitoring is informed by the level and quality of self-reporting by landholders. In particular the Department makes inquiries if a landholder fails to report on progress, or if a report has gaps or errors in it.

Monitoring may not prove unequivocally whether or not an action has been undertaken. Monitoring may be infeasible because there is no *verifiable* measure of landholders' actions at reasonable cost. Consider the case where the Department contracts for actions to establish understorey. Assume this requires planting of different species' seed in certain proportions at a certain time of the year. Unless a Departmental officer were to arrive at a landholder's property at the exact time that planting occurred there would be little chance of proving that the required action were undertaken at the correct time. If successful planting were technically complex then structuring the contract around the output—understorey generation—may not be feasible since landholders may not be willing to take on all the technical risk (see below).

In such cases the Department may have to take the chance initially that such actions are undertaken. If many such contracts lead to improved understorey over time then clearly there is some compliance with the agreement. However if understorey does not improve at all on the relevant contracts then the Department may have to try a different approach, or await technical advance that lowers risk or allows monitoring at lower cost.

Enforcement

Assuming the Department has some way of monitoring landholders, let us now consider the enforcement problem. Assume that the Department has a legally enforceable contract with a landholder. When the Department finds verifiable evidence that the landholder is in breach of contract, the Department can choose to enforce penalties against the landholder or not. Enforcement needs to be possible at low cost to be a *credible threat* to punish non-compliance.

However at times enforcement may not be possible at low cost. For example, the cost of enforcing contracts through the law courts may outweigh the expected benefits of contract compliance. This may mean enforcement is not *credible*; if a landholder believes that the Department will not enforce a contract even if she is caught in breach of contract, then there is no expected cost of engaging in moral hazard behaviour: the incentive to violate the terms of the contract becomes even stronger.

One way to circumvent this problem is to base contracts on actions or outputs that are easily verifiable (e.g. establishment of revegetation). In this case then at least the threat of non-payment is enforceable. If the contract is large in terms of Departmental resources committed, then there is also the possibility that enforcement via courts is a worthwhile option.

The manner in which the Department structures the payment schedule can have an important impact on landholders' incentives to comply with the contract, and hence the Department's ability to enforce the contract. If there is a large payment due on completion of the contract then this provides some incentive for the landholder to ensure she complies and hence receives payment. In EcoTender, the final payment makes up 25 per cent of the total contracted price. The Department can withhold payments as a credible threat against non-compliance.

Uncertainty and Risk

Risk is an integral part of agriculture and environmental management. Although there is risk surrounding many variables in EcoTender contracts, in this section we will concentrate on *technical risk*: the risk that certain actions, even if carried out diligently, do not lead to the desired outputs. This is due to the fact that there is uncertainty about the 'production function' due to a lack of knowledge. For example, the best way to produce and manage understorey—which is made up of many different species in certain proportions—may not be well understood.

When a contract is executed for environmental goods and there is technical risk, then the risk of non-production is borne by the parties in some agreed way, at an agreed price. Hence, in designing contracts for environmental goods the Department may decide to (a) assume much of the risk for non-production; or (b) delegate that risk to landholders. In the latter case, risk-averse landholders will demand a risk premium, following the standard theory concerning a risk-return trade-off (see below). Generally in EcoTender the Department delegates risk by contracting landholders for output, and it assumes risk by contracting for actions[4].

For example, in the case of water quality, the Department can design a contract that delegates to a landholder all the responsibility for water quality of a nearby stream which means the landholder bears all the risk for improved (or reduced) water quality. In this case a *risk premium will be* needed to pay risk-averse landholders to undertake costly management actions. Management actions are risky because of the scientific uncertainty of the causality between management actions and environmental outcomes. If the landholder bore most or all of the risk, a substantial risk premium would need to be paid to the landholder to accept the contract.

The Department may choose to bear some portion of the risk for water quality by choosing an intermediate (albeit imperfect) measure of water quality such as making contract payments contingent on reduced fertiliser intensity; by doing this, the Department assumes a greater share of the risk of water quality improvement.

Alternatively, the Department could make contract payments contingent on an easily achievable measure that may (or may not) be correlated with the desired environmental outcome; in this case, the Department bears *all* the risk. This could be called *perfect insurance*. In the water quality case, an example of perfect insurance is where the landholder agrees to not using fertiliser in paddocks near a stream. Perfect insurance is socially optimal if there is no possibility of moral hazard; in other words, if there is no asymmetric information. The Department avoids providing perfect insurance to landholders by deferring a significant proportion of payments until the conclusion of the contract. This shares risk between the landholder and the Department by requiring the former to finish the contract to the Department's satisfaction before receiving final payment.

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[4] We have already discussed the other reason that the Department may contract for actions: when the cost of monitoring or enforcing around outputs is considered too high.

If the Department were risk neutral, then it would compare all options in terms of maximum expected value without reference to risk. In other words the Department would calculate expected payoff using probability-adjusted values, and use these values without reference to their certainty or variability. If the Department were risk averse it would correct these expected values such that it valued relatively certain (less variable) propositions more. Currently in the EcoTender contracts the metric does not make an assessment of outcomes based on differential risk. More research into the risk structure of EcoTender contracts and the Department's assessment of risk is warranted.

Commitment and Renegotiation

Another aspect of the economists' view of contracts is how *commitment to the contract* by the principal is maintained. If the Department is not committed to completing the terms of the contract, landholders are less likely to comply with the contracted terms. How to design contracts to ensure commitment is maintained is one focus of this section. Another focus is when commitment can no longer be maintained, can contracts be *renegotiated* to ensure landholder compliance? We will also examine whether it is better for the Department to remain inflexibly committed to the contract or is it better for the Department to be flexible and renegotiate?

Commitment

Commitment is a term describing the ability of the principal to restrict future actions to those allowable within the terms of the contract (Salanie 1997). Economists distinguish between two types of commitment: *credible* and *non-credible*. Credible commitment is where the principal is able to commit to a contract because it has an incentive to do so. Non-credible commitment on the other hand is where the principal undertakes a commitment but it is non-credible because there is no incentive for that party to maintain commitment. Note commitment describes how willing a principal is likely to comply with a contract. The analogous concept for the agent is moral hazard.

Credible commitment by the Department is necessary to ensure contract compliance. If the Department cannot credibly commit to uphold the terms of the contract, two things can happen depending on how the Department breaches the contract.

If the Department is likely to behave in a ‘predatory’ fashion, ie, exploit its position by imposing unfair terms on contracted landholders, then landholders are unlikely to participate in an auction. However, if landholders did participate, they may bid higher amounts because of the risk of the Department exploiting its superior bargaining position; this is called the *expropriation* or *sovereign* risk. This leads to the Department being non-credible and landholders taking this into account when deciding to enter a contract or when considering contract terms and prices.

On the other hand, if the Department is unable to credibly commit to enforce the contracts when landholders are found to be in breach of contract, then landholders are likely to engage in moral hazard behaviour (see Moral Hazard above, especially enforcement). This is because if the Department is unlikely to enforce contracts, landholders can make themselves better off by engaging in moral hazard. The Department may have no incentive to enforce contracts because of high enforcement costs.

Renegotiation

Renegotiation relates to a situation where both the Department and the landholder agree to change the terms of an existing contract. Renegotiation differs from breach of contract because the former is a mutual decision whereas the latter is unilateral (Salanie 1997). Breach of contract occurs when either party abandons the contract because it no longer serves their interest. Renegotiation may occur when both parties agree to renegotiate the contract because they both believe they would be better off under new contract terms. This may be a cost-effective response by both parties because both sides will be better off under a new contract. Renegotiation may be one way of reducing the cost of non-credible commitment and moral hazard because a new contract may be more incentive compatible for both parties.

When contracts are *incomplete*, renegotiation may be necessary to ensure the objective of the contract is achieved. Incomplete contracts do not take into account all possible contingencies; it would be very costly to draft a contract that could take into account all contingencies. With incomplete contracts, a contingency may occur that may cause both the Department and the landholder to be worse off if the contract was to be inflexibly maintained. Renegotiation may then be an efficient response to unforseen contingencies if the costs of renegotiation are relatively low. Throughout this document, we have implicitly assumed contracts are incomplete.

The Department has to be careful when it chooses to renegotiate. There is a great temptation to use information collected during the initial operation of the contract. It is quite possible that when the contract was being implemented that the landholder revealed information about its management costs. If the Department chooses to use this information to impose a less favourable contract on the landholder (but one that still makes the landholder better off), this may further distort landholders' behaviour. If landholders believe the Department will use renegotiation to remove any information rents or risk premium, this may distort bids upward because landholders will know the Department will try to expropriate their rents. The threat of expropriation may also deter landholders from participating if they believe the Department will exploit its bargaining position to expropriate rents.

Implications of Commitment and Renegotiation

Commitment and renegotiation have implications on contract duration. With short contract duration, commitment is easier to maintain; this is because there is a lower probability of unforseen contingencies occurring and the cost of commitment is lower with shorter contracts. Conversely, if contract duration is relatively long, commitment is more difficult to maintain because the likelihood of unforseen contingencies occurring is relatively higher and the cost of commitment is higher. Given this, it appears there is a trade off between contract duration and commitment.

The trade off between contract length and commitment may not be so stark if renegotiation is allowed. Renegotiation allows both parties to mutually agree to new contract terms without cancelling the contract outright. However, this depends on whether or not the Department negotiates in a non-predatory fashion and commits to not expropriating rents as part of the renegotiation. This may be difficult since there is a strong (short-term) economic incentive to expropriate rents during renegotiation.

Given the possibility of expropriation, it may be more efficient for the Department to issue only short-term contracts. To enable the Department to encourage long-term management, a renewal clause can be written into these contracts that allows the Department to renew the contract if the landholder is willing to continue the contract with the existing terms. If the Department does not want to renew the contracts but wants to continue some kind of contractual relationship, it can ask the landholder to submit a bid in another auction, which allows the landholder to submit the same contract without the threat of expropriation.

In EcoTender, contracts are of relatively short time frame. Particularly remnant management contracts which are of five years duration. However, there is no ability to renew at the end of the period. In part this is because EcoTender is still a pilot with a small budget, and there are already several important issues being examined. However, it would seem that considering renegotiation and renewal are useful areas to examine in future research.

Short-term contracts have a disadvantage if the Department is seeking long-term investments in capital from landholders. For instance, the duration of the contract may be shorter than the capital life; the Department will have to fully fund the capital but gets only part of the benefit therefrom. This may not be cost-effective from the Department's perspective.

If capital is expensive and required at the commencement of the contract then there is also an issue with financing. Landholders may be reluctant to enter the EcoTender process if they have to finance expensive capital at the start of the contract. If this limits entry to the scheme then it may also diminish the competitiveness of the auction. Hence in EcoTender the payment schedule provides for a large payment upon commencement of the project. This may help signal the Department’s commitment to the contract, in addition to funding capital expenses. It does, however, place the Department at risk: if landholders renege on the contract after receiving the first payment then the Department may not be able/willing to recover the spent resources.

Another risk for the Department occurs if the capital lasts longer than the contract life and the landholder makes decisions about how the capital may be used. If the capital is transferable the landholder may benefit by transferring it, or alter its use in some way. For example, a groundwater extraction pump may be used in several ways: extracted groundwater may be placed in evaporation basins, or used to water crops, etc. If the landholder changes the manner that the capital is used (perhaps towards uses that are more profitable), then it could completely alter the effects on the environment. The negative effects of post-contract use of the capital may eliminate, or worse overtake, the positive effects sought via the contract.

Similarly, short-term contracts may not correspond with the length of time it takes for a management action to have any environmental outcome. If an outcome requires consistent management actions over a long period, a short-term contract will fail to ensure the outcome is achieved.

7.3 Summary of Issues and Approach

In terms of EcoTender, three concepts are important for contract design: moral hazard, commitment and renegotiation. Moral hazard is the possibility of the landholder not complying with the contract. Commitment is the degree the Department will comply with the agreed contract. Renegotiation is where both the landholder and the Department agreed to amend the contract in response to changing conditions to ensure both parties still have an incentive to honour the contract. Table 10 summarises which concept deals with the landholder or the Department.

Table 10. Summary of contract incentives

	Landholder	Department
Moral Hazard	√	
Commitment		√
Renegotiation	√	√

The implication of this table is that when designing a contract, the Department needs to provide incentives to discourage moral hazard. It also needs to signal commitment such as ensuring it has low-cost ways of enforcing compliance (ie, deferred final payment). Finally, the contract needs to specify when renegotiation can be commenced and specified that the decision to implement an amended contract is a mutual decision. Figure 13 summarises EcoTender contracts in more detail.

Figure 13. Summary of Contract Issues and Approach

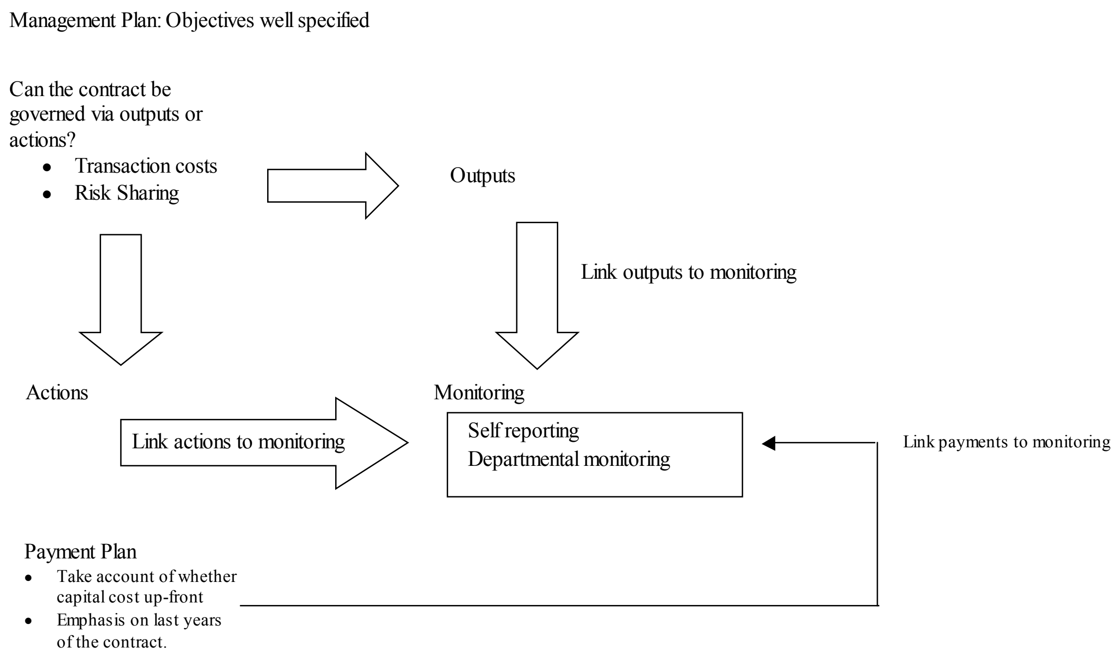


Figure 13 shows that the Department can choose to manage contracts via actions or outputs. This decision is dependent upon the cost associated with monitoring and enforcing against the different options, and on the risk implications of the different approaches.

Whether a contract is governed via actions or outputs, these should be monitored—using a combination of self-reporting and Departmental monitoring. Payments can then be linked to the outcome of this monitoring.

The payment schedule should be such that there is an incentive to complete the contract. One manner of ensuring this is to place some emphasis on the final payment. In EcoTender contracts the final payment is 25 percent of the total contract price: a reasonable incentive to complete the contract.

8 Communications and Implementation

8.1 Communications

A communications strategy was developed for the implementation of the pilot. The primary objective of the strategy was to encourage participation from landholders from the pilot areas in the *EcoTender Pilot*.

The secondary objectives of the communication strategy were to:

1. ensure landholders within the pilot areas are aware of the expression of interest process;
2. positively introduce the multiple outcomes concept and develop understanding and interest in the project among landholders and broader community not located in the project areas;
3. ensure appropriate DSE/DPI and CMA staff and stakeholders understand the pilot and are kept informed about its progress;
4. provide accurate information about the pilot on a timely basis to relevant staff in DSE/DPI/central agency, the CMAs and other government agencies.
5. ensure that appropriate Commonwealth stakeholders are kept informed of the progress of the pilot.

The communications approach to encourage appropriate levels of participation from landholders in the pilot areas involved two key stages. The first was a broad communications campaign involving media releases and advertising through regional media calling for expressions of interest. The second, if required, involved direct targeting of landholders in the pilot areas. The planned approach enabled the tracking of landholder expressions of interest and provided for contingency actions in the event of over or under-subscription.

The communication process adopted is summarised below:

Pre-launch - Educate key internal and external stakeholders about the pilot to ensure they are ready to respond to community interest

- Briefings

Stage 1 - Launch of the pilot

- Media release/Information pack
- Information sheets
- Regional advertising
- Local promotion by project officers
- DSE & links from CMA websites

Stage 2 - Encourage participation of landholders in the pilot (if required)

- Further media releases
- Further regional advertising
- Presentations at local Landcare meetings

For the pilot, implementation of Stage 2 was not required as sufficient Expressions of Interest were registered during Stage 1 of the communications campaign. As such the implementation discussion below relates only to Stage 1.

8.2 Implementation

The following table outlines the steps taken to implement pilot. Each step required a different level and type of communication ranging from very simple to intensive and complex.

Table 11 . Pilot Implementation Steps

1. Expressions of interest – landholders located in project areas register an expression of interest through their EcoTender field officer.
2. Site Assessments – the EcoTender field officer arranges a site visit with each registered landholder. The field officer assesses the site and advises the landholder on the significance of the site from a range of environmental perspectives, and identifies potential native vegetation management and revegetation options for consideration by the landholder.

3. Development of draft management plans – landholders identify the actions they are prepared to undertake and the field officer prepares a management plan as the basis for a bid.
4. Submission of bids –landholders submit a sealed bid that nominates the amount of payment being sought by them to undertake the agreed management plan.
5. Bid Assessment – all bids are assessed objectively on the basis of:

- the estimated change in the on and off-site environmental outcomes (the amount of change in environmental outcome);
- the value of the assets affected by these changes (significance);
- dollar cost (price determined by the landholder).

Funds are then be allocated on the basis of 'best-value for money'.

6. Management agreements – successful bidders are able to sign final agreements based on the previously agreed draft management plan (from 3 above).
7. Reporting and Payments – periodic payments and reporting occur as specified in the agreement.

8.2.1 Expressions of Interest

The pilot launch and call for Expressions of Interest was a critical step in the implementation process. To assist in communicating the pilot and to the target landholder audience required development of a number of information sheets. Six information sheets were produced and made available on the web for landholders to access and field officers to use for reference material and distribution. Information sheets included:

1) **General information**: this covered the background of the pilot, the process in which it was to be implemented, the geographic areas being targeted and available funds.
2) **The site visit**: the process by which landholders could organise a site visit, what was being assessed and some detail about how the significance of a site was to be determined and a description of how environmental outcomes arising from landholder actions would be scored.
3) **Bidding process**: advice to landholders on how to put in a bid, factors to consider when bidding and when to submit a bid, how bids would be assessed, how carbon would be dealt with in the bidding process and how much would be paid for

carbon, and information covering how management actions will be negotiated and recorded.

4) **Specifications of landholder actions**: detailed the types of actions a landholder could undertake including fencing, grazing, weed control, timber management, supplementary planting and fire prevention. Included information on minimum standards for landholder actions.

5) **Assessment of bids**: advice to landholders on costing their bid and an explanation of how successful bids would be determined including a description of the Environmental Benefits Index and the ranking of bids of the basis of 'best value for money'.

6) **Frequently asked questions**

8.2.2 Site assessments

The site assessment step was critical in communicating the 'whole of catchment' view to each participating landholder and providing a relative view of where their property was placed with respect to the various environmental outcomes being sought. This was new information that had not been previously communicated to any landholders in the pilot areas and required the field officers to fully understand the outputs generated from the CMF and to be able communicate this in a simple way.

As such, field officers needed training to understand the principles of the CMF and how to use the purpose-built interface designed to access the CMF for scoring. It was important the field officers had a sound appreciation of the CMF in order to address questions posed by landholders about the scoring methodology. The officers needed to feel comfortable with the concept of modelling landscape processes so that during the site visit landholders were left feeling confident in the scoring process and felt the agency was using a reliable methodology.

Given the spatial nature of the pilot, a system was devised whereby field officers entered GPS data into a hand held device (IPAQ, similar to a personal organiser with a GPS locater attached), which was later down-loaded for use in the CMF.

For each site, field officers used the IPAQ to collect and store GPS coordinates, record current landuse or EVC, and record detailed information about the current condition of the EVC (tree density, logs present, weeds, pests, etc). This was followed by a discussion with the landholders about actions (for inclusion in the management plans) that could be undertaken to provide environmental outcomes. Field officers would indicate to each landholder the type of actions best suited for the site and the minimum standards required.

The field officer then used the interface to down-load the information from the IPAQ to the CMF. They used the interface to validate data already within the model (e.g. ground truth land use data) and then calculate the environmental outcomes for the site. Additional utilities made available to the field officer in the interface included: recording system for weed and pest control; selection of observed threatened flora and fauna; copy/paste sites and zones; modify site way points; recording fencing location and length; edit habitat scoring and print management plans and bids sheets for each site. All information entered by the officers was recorded in a single file that could be readily e-mailed (via dial in, the files average 4KB) to others for validation etc.

In addition to the above information sheets, the field officers also had access to colour "maps" that spatially represented the catchment view for each of the four environmental outcomes being sought on a scale from low to high (see Appendix II for example of aquatic function). These catchment views were produced to assist landholders in understanding the idea that environmental outcomes arising from landuse change are spatially variable. They were also designed to provide landholders with a simple relative view of where their property was placed in a catchment environmental outcome context. (see Chapter 6 for preference details).

8.2.3 Development of draft management plans

The development of the draft management plan involved the field officer recording the agreed landholder actions arising from the site assessment discussion and forwarding this back to the landholder in the form of a draft management plan as the basis of their bid. There were two types of management agreements and bid sheets proposed namely, remnant native vegetation management and revegetation (see Appendix III for examples). The key difference in the agreements was that the native vegetation management agreements were largely based on inputs (e.g. retain fallen logs, erect fencing, control weeds etc.) while the revegetation plans were largely based on outputs (e.g. achieving target densities of desirable species).

Bid sheets for both remnant native vegetation management and revegetation included scores for each outcome and the total score. For the revegetation bid sheet additional information was also provided about the tonnes of carbon accumulated and provided landholders with an option to either sell the accumulated carbon to DSE at an agreed price or retain ownership of the carbon (see Appendix IV for examples). An information sheet was provided with the bids providing landholders with instructions on how to complete the bid sheet and a distribution curve of all participating total scores so each landholder could determine the relative value of their score with respect to others in the auction (see Appendix V).

8.2.4 Submission of bids

All participating landholders had 14 days from the date that they received their draft management plan to submit their bid. Landholders had an opportunity to amend their draft management plan by contacting the field officer to request a change. In such cases, an amended draft management plan was forwarded to back the landholder along with the updated score. In such circumstances, the bid submission clock was stopped at the date the landholder contacted the field officer started again when the landholder received their updated draft management plan. The landholder then had the remainder of the 14-day submission period to submit their bid.

8.2.5 Bid Assessment

The EcoTender Probity Plan called for the preparation of a Tender Evaluation Plan to provide a framework for the:

- evaluation of all bids; and
- identification of the preferred tenderers based on an assessment of the Environmental Benefit Index for each site (including the different costs and environmental outcomes associated with each site).

The aim of the Evaluation Plan was to provide:

- a clear, coherent and even-handed basis for the evaluation process;
- for the application of a ‘best value for money’ criterion for the tender process; and

- an evaluation process that is visible, defensible and auditable.

In keeping with the Tender Evaluation Plan, bids were opened and evaluated by an appointed Bid Evaluation Panel following expiry of the bid submission date for the final draft management plan.

The role of the evaluation panel was to:

- receive the unopened bid envelopes from the EcoTender Project Manager;
- open the bid envelopes and for each bid, enter the draft management plan receipt date (adjusted for any clock stoppages as a result of requested changes to draft management plans – refer to supplied table) and the postmark date received by the Department in the database;
- record in the spreadsheet compliance or non-compliance with the 14 day bid submission period;
- enter information on the landholder's assignment of carbon, for revegetation sites;
- enter the Landholder's Price in the spread sheet against the corresponding site number for the site offered on each bid sheet;
- rank the offered sites in order of decreasing EBI (using a computer algorithm);
- calculate the cumulative $ allocation and identify the cut-off site closest to but not exceeding the base allocation total of $500,000. In general, the cut-off site and other sites above the cut-off are successful subject to any recommendations by the panel on the application of a reserve price, based on an analysis of the marginal cost curve;
- prepare a table of the successful sites, prices and corresponding landholders for advice to the Project Manager.
- record and file a report of each evaluation meeting.

9 Auction Results and Preliminary Analysis

The department called for expressions of interest from May 2005 and completed site assessments in late October 2005. 84 sites were assessed on a total of 40 farms. 50 bids were submitted from 21 farms. The total value of these bids was $835,000.

The following notes characterise the bids:

- 46% of the bids were revegetation
- the total revegetation bids resulted in an estimated 21,000 tonnes of sequestered carbon
- 72% of the bids produced two or more environmental outcomes
- All bids provided a biodiversity benefit, 72% provided an aquatic function benefit while only 8% provided any salinity benefits.

A tender evaluation panel was appointed to open the bids and enter them into an electronic database. The panel consisted of a chair and two panel members. A probity adviser was also present to oversee the process and assess the bid evaluation against the requirements of the project probity plan and tender evaluation plan.

Once all the bids were opened, the cost per environmental benefit was calculated for each bid and the bids were ranked on the basis of 'best value for money', lowest cost per unit benefit to highest. Bids were then selected from lowest cost up until the $500,000 budget was exhausted. Figure 14 below shows the supply curve for the all submitted bids.

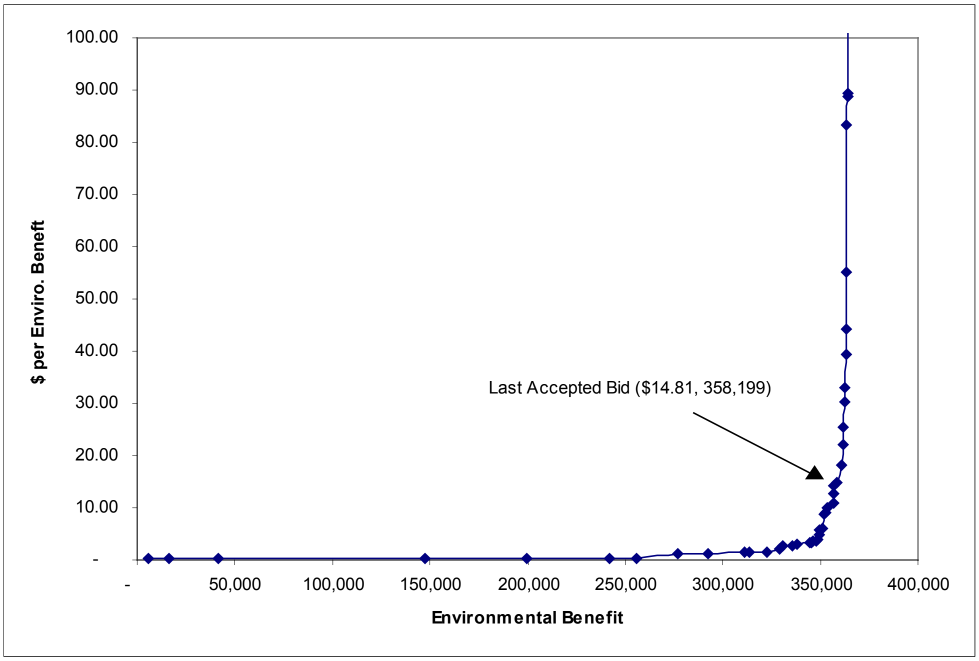


Figure 14. EcoTender Supply Curve

The supply curve shows the rising price of environmental benefits from landholders that bid. The supply curve in Figure 14 does not show the full price range on the y-axis, the price went up to $1,500 per unit environmental benefit. The last bid accepted within the budget ($500,000) cost $14.81 per unit environmental benefit.

The following points characterise the accepted bids:

- 31 bids accepted (62% of total)
- successful bids covered 259 ha (revegetation 76 ha, native vegetation management 183 ha). This was 70% of the total area offered (353 ha).
- 10,078 tonnes of carbon of which 8,087 tonnes were sold by the landholders to a third party, the remaining carbon was retained by landholders.
- of the bids selected 97% of them had two or more environmental outcomes
- Only a few bids provided a salinity benefit, which can be explained somewhat by the size and location of the sites. The largest site was 45 ha which is sufficient to provide salinity benefits, however it was located in an area of the catchment that is not amendable to providing salinity benefits. Other smaller sites were located in areas of the catchment amenable to providing salinity benefits, but they were not large enough.

9.1 Preliminary statistical analysis on bids

We undertook a statistical analysis to see if we could explain what determines the bid per site. The explanatory variables are: total environmental score, area, revegetation or remnant bid, bid contained carbon and the catchment the bid came from. The following table shows the results for all bids and those accepted (winning bids) to compare what variables may predict the magnitude of the bid.

Dependent variable: Total bid ($)		**50 obs**	**31 obs**
Explanatory Variable		**All**	**Winners**
Intercept		5445*	1592
Score		0.1	0.2*
Area		832*	689*
Rev_Dum		2940	3890
Carbon_Dum		8420*	1252
Catchment_Dum		-5342*	-706
*) Significant at 95%	R squared =	58%	78%

Where - Score is the aggregate score (saline land, aquatic function, biodiversity)

- Area (ha)
- Rev_Dum, dummy variable for 1 = revegetation, 0 = remnant
- Carbon_Dum, dummy variable for those electing to sell their carbon (1 if true)
- Catchment_Dum, dummy variable for the catchment (1 = Avon, 0 = Cornella)

Example: The average score for all bids is approximately 7,000 units, with a maximum observed at approx 100,000. For a 1,000 unit increase in score we would expect to see a winning bid increase by 1000*0.2 = $200. For each ha increase in a site we expect a winning bid to increase by $689.

The dummy variables are interpreted in a different manner. For instance the Carbon_Dum value can only equal zero (do not sell carbon) or one (sell carbon), therefore we would expect that for any given bid, if the landholder has elected to sell their carbon they would bid $8420 higher.

- The equation above suggests that the size of the bid is strongly determined by the area of the bid.
- The distribution of the scores was provided to landholders prior to bidding, however it appears that the score has very little influence on the bid.
- When all bids are accessed it appears that when a bidder has elected to sell the carbon they have increased their bid, even though they are being paid separately for the carbon. However, the influence of carbon in the winning bids is much less and not significant. This may suggest that the winning bidders were more aware of the trade-off that needed to be made between receiving money for the carbon and providing environmental goods competitively.
- In all the bids it appears that the *"catchment"* influences the size of the bid.

10 Appendix I – Biophysical model design and technical data

The CMF configurations and attributes are described below.

Surface element network: biophysical models

The modelling framework estimates the impact of various forms of intervention using a combination of paddock/farm scale models and a lateral flow model that are integrated into a regional catchment scale framework. This is achieved through the development of a surface element network that disaggregates the catchment into a series of connected units, each unit representing the paddock/farm scale. Each surface element (or "landscape unit") accounts for position in the landscape, land management and landscape attributes such as soil type, climate and topography. As such, this approach reduces a complex three-dimensional process into a number of connected units which can subsequently be evaluated using a one-dimensional farming systems model to simulate water balance, nutrient transport and production for a given combination of soil type, climate, topography and land practice. Connection to adjacent up-slope and down-slope elements enables the lateral redistribution of surface runoff and interflow (eg. perched watertables) and facilitates the transport of water and nutrients from the top of the catchment to streams and end-of-valley.

Within each surface element a unique water and nutrient balance is derived using the biophysical models to simulate soil/water/plant interactions on a daily basis. The biophysical models used within each surface element network are based on the assigned landuse. For instance, where a landscape unit is mapped as a grazing system, the simulated biophysical response would be derived using a pasture/grazing simulation model. In all instances, simulations are derived based on historical climate data, which are often extrapolated to assess future impacts of landscape intervention strategies.

The key biophysical metrics used in the pilot include runoff (surface water flow to stream), deep drainage (recharge to a deeper groundwater system), carbon accumulation and erosion. The following sections describe the farming systems models and how they are integrated into the CMF to estimate the biophysical metrics.

This is followed by a description of how they are interpreted and applied as environmental outcomes in the pilot.

Farming systems models

The surface element network contains a suite of farming systems models ranging in complexity from a simple crop factor approach to phenologically based crop and pasture modules. Some of the models are briefly described below.

Crop models: Several crop models of varying complexity are integrated into the framework and are selected by the user on the basis of data availability and appropriateness. The models range in complexity from a simple heat unit approach based on CRES-Maize (Williams *et al*. ,1982), SWAT (Neitsch *et al*. ,2001) and CRES-Wheat (Ritchie, 1985) to the more phenologically based model of Ritchie (1985), Hammer *et al*. (1982) and Jones and Kiniry (1986). The modelling framework also contains all those crop modules from PERFECT (Littleboy *et al*. ,1992).

The crop growth models predict crop phenology, leaf area and dry matter using functions of transpiration, transpiration efficiency, potential evaporation, intercepted radiation, radiation use efficiency, daily temperature and photo-period. Growth is reduced due to water, temperature, salt or nutrient stress. Crop yield is related to total dry matter and plant water use around flowering.

A daily balance of crop residue weight on the surface is maintained. At harvest, above-ground crop dry matter is added to crop residue. During fallow, residue is decayed or incorporated by tillage. Decay and residue incorporation by tillage is related to residue type and tillage implement. Percent cover is estimated from residue weight on a daily basis. Tillage affects both the weight of crop residue and surface roughness.

Pasture models: Several pasture models of varying complexity are integrated into the framework and are selected by the user on the basis of data availability, appropriateness and simulation time. The models range in complexity from a simple phase model based on Thornley (1972), GRASP (Day *et al*. ,1997) and Jones *et al*. (2002) to the complex multi-pool phenological models based on the GRAZPLAN (Moore *et al*. 1997, Freer *et al*. 1997) and SGS (Johnson *et al*. ,2003) models. In general the pasture growth modules distinguish between annual species, perennial species, legumes, grasses and forbes. In order to simulate livestock dynamics and feed intake, shoot tissue is classified into live, senescing, standing dead and litter pools. Each tissue pool is further stratified into dry matter digestibility classes, which are necessary when considering differing grazing enterprises, stocking rates, diet selection and supplementary feed regimes.

Livestock model: Livestock and vegetative cover interactions are based on energy requirements in contrast to explicitly modelling livestock growth and metabolic dynamics. Energy requirements for each class of animal were calculated on a monthly basis, following CSIRO (1990). The number of animals in each class depends on the structure of the flock. The flock structure on a monthly basis depends on the management calendar and biological variables. The management calendar includes mating times, lambing, weaning, culling, replacing and selling. Biological variables include conception rates, twinning rates and mortality rates. Additionally, the maximum amount of dry matter that an animal can eat is considered. The intake capacity of an animal depends on live weight and whether the animal is lactating. These dry matter intake capacities were estimated following Kingwell and Pannell (1987). The estimated monthly energy requirements and intake capacities of all animals in the flock were then summed and divided by the total number of "breeding units" (or adult equivalents) at the time of calving or lambing. Breeding units are ewes, or any fattening animals such as wethers in non-breeding enterprises. The final time-varying energy requirements are used by the model as the total requirement for all animals of all classes including ewes, lambs, hoggets and rams on a per breeding unit basis.

Forest model: The forest model is based on the 3PG forest growth model (Landsberg and Waring, 1997) capable of simulating growth dynamics and management impacts. The original model has been widely used in several countries and has benefited from testing and development for a range of tree species and environmental conditions. The 3PG model is based on the absorption of photosynthetically active radiation by a forest canopy, and includes functions to modify carbon fixation which is influenced by temperature, nutrition, vapour pressure deficit, stand age and soil water availability. Incorporation of this model into the spatially explicit catchment framework has required the replacement of the original monthly single-layer soil profile with a daily multi-layer hydrological model. This addition accounts for multi-layered soil profiles and root zones and better simulates soil/water/root interactions. Additional enhancements to this model include incorporation of understorey and carbon accounting.

Soil-water balance

The basic soil water balance equation simulated on a daily basis is defined by:

$$\Delta S = Rain + Irrig - Sevap - Transp - Drain + R_{on} - R_{off} \qquad (1)$$

where: ΔS is the change is soil profile water storage (mm/day)

Rain - daily rainfall (mm/day)

Irrig - daily applied irrigation (mm/day)

Sevap - daily soil evaporation (mm/day)

Transp - daily actual plant transpiration (mm/day)

Drain - daily deep drainage (mm/day)

R_{on} - daily lateral flow contribution from up-slope (mm/day)

R_{off} - daily lateral flow to down-slope cells (mm/day)

Lateral flow comprises both surface flows (runoff and infiltration excess) and sub-surface flows (interflow or flows that occur at the interface of the topsoil and less conductive subsoils such as exists in duplex soil profiles).

Soil water content is updated on a daily basis by any rainfall exceeding the daily runoff volume. For a dry soil profile, infiltration can optionally enter lower soil layers using a soil cracking algorithm. Infiltration is partitioned into the soil profile from the surface, filling subsequent layers to total saturation (field capacity).

Soil water redistribution is calculated using a linear cascading technique based on the procedure developed for CREAMS (Knisel 1980). This procedure assumes that drainage from a layer only occurs when soil moisture status is above field capacity. The drainage factor determines the proportion of soil water above field capacity draining to a lower profile layer (Knisel 1980). This factor is based on saturated hydraulic conductivity and assumes that the drainage factor equals unity when available water content above field capacity is less than half the daily maximum saturated hydraulic conductivity. It is assumed that redistribution from the bottom layer is lost as deep drainage.

Water can be lost from the soil profile as transpiration and soil evaporation. Transpiration is represented as a function of potential evaporation (based on either pan, Priestly-Taylor or Penman-Monteith), leaf area and soil moisture. It is removed from the soil profile according to the current depth and distribution of roots. Soil evaporation is based on a two stage evaporation algorithm. After infiltration has occurred, it is assumed that drying occurs up to a user-defined limit. After this limit is reached, the second and slower stage of soil evaporation commences. Evaporation will remove soil water from the two upper profile layers and drying continues below wilting point to the user specified air dry limit. The sum of transpiration and soil evaporation can never exceed potential evaporation on any day.

Runoff is calculated as a function of daily rainfall, soil water deficit, surface residue, crop cover and surface roughness. Soil water status is updated daily after accounting for runoff. Runoff depth is predicted using a modified form of the CREAMS curve number technique (Knisel 1980).

Soil water retention is the maximum potential infiltration in 24 hours or the soil water deficit. Therefore, a larger volume of runoff occurs at a low soil water deficit and little runoff occurs at a high soil water deficit. Predicted runoff will equal the daily rainfall when the soil water deficit is zero (ie. the soil is saturated).

Soil water retention is based on the rainfall versus runoff response for average antecedent moisture conditions and for bare and untilled soil. It is modified to account for crop cover, surface residue cover and surface roughness. The retention parameter is related to available soil water using a modified form of the equation from Knisel (1980).

Soil erosion is estimated on a daily basis using functions reported by Freebairn and Wockner (1986) that relate soil erosion to runoff volume, surface and crop cover, rainfall erosivity, soil erodibility, management practice and topography. This sub-model predicts soil erosion for each runoff event. Predictions of daily rates of erosion from these types of models may be in error (Littleboy *et al*., 1992a) because of the exclusion of rainfall intensity. However, this type of model is relatively accurate in predicting long-term average annual erosion (Littleboy *et al*., 1992a).

The Freebairn and Wockner (1986) cover-concentration function was determined from field data to predict soil movement from the inter-contour bank area for clays soils for situations where peak discharge cannot be adequately predicted. It accounts for variation in soil loss with cover and runoff volume, the main factors that can be managed, and uses the MUSLE slope-length, erodibility and practice factors to estimate soil loss.

The surface water and recharge estimates are calculated by partitioning water excess derived using equation (1) to account for position in the landscape, soil type and slope. The redistribution of lateral flows, both sub-surface and overland, was accounted for using the methodology developed by Rassam and Littleboy (2003). The developed generalised relationship was based on hillslope modelling results derived using HYDRUS2D (Simunek *et al*. 1999) and describes the amount of lateral flow generated as a function of hillslope angle and variations in soil conductivity through the soil profile.

Groundwater network

Underlying the surface element network is a three-dimensional groundwater model representing the aquifer systems based on MODFLOW (McDonald and Harbaugh, 1988) which is a multi-layered quasi three-dimensional groundwater flow model developed by the US Geological Survey. Groundwater aquifers are the source of underground water and are responsible for the mobilisation of salt from the deeper regolith. Groundwater dynamics influence (a) discharge to stream and (b) saturated or waterlogged land. Discharge to stream (groundwater flows to stream) occurs when the groundwater intercepts the stream and the height of the stream is lower than the height of the watertable adjacent to that stream. The groundwater discharge to stream is assumed to include contribution from groundwater baseflow and groundwater surface discharge. The groundwater baseflow is the volume of groundwater that is exchanged with a stream.

Saturated land and waterlogging are also influenced by the proximity of the underlying groundwater to the land surface. Saturation occurs when the water table rises up until it is very close to the soil surface. The soil profile is then saturated with groundwater, and if it contains salt severely impairs the productive capacity of the soil. Waterlogging is often attributed to the presence of a shallow watertable. A shallow water table impairs the ability of the soil to drain rapidly, often resulting in waterlogging, particularly during high rainfall periods.

The three-dimensional groundwater model representing the aquifer systems is linked to the surface element by landscape location. Deep drainage from each surface element is partitioned into lateral and vertical flow components, of which the vertical flow is spatially assigned to the underlying aquifer as recharge. Using the time-varying recharge estimates derived from the farming system models, the groundwater model simulates the movement of water, both laterally across the catchment and vertically to deeper aquifers, and the rate of groundwater discharge to stream and land surface. The rate of water redistribution is dependent on the structure of the regolith and the depth of each aquifer. The regolith structure influences both the conductivity (rate of water movement) and the storativity (propensity to fill) of the aquifer. In general, the higher the conductivity the less responsive the aquifer to changing recharge, whereas the lower the storativity the more responsive the aquifer to changes in recharge. The spatial assignment of these aquifer characteristics is explicitly mapped into the groundwater model as well as key features such as drainage lines, extraction bores and lakes. The groundwater model estimates the height of water at each point in the landscape for a given recharge at a given time assuming time-varying losses such as groundwater pumping and interception schemes. The saturated area is defined as the sum of those areas where depth to watertable is less than or equal to 2 metres. As such the modelling framework is also able to assess the effectiveness of engineering options such as interception drains and groundwater pumps.

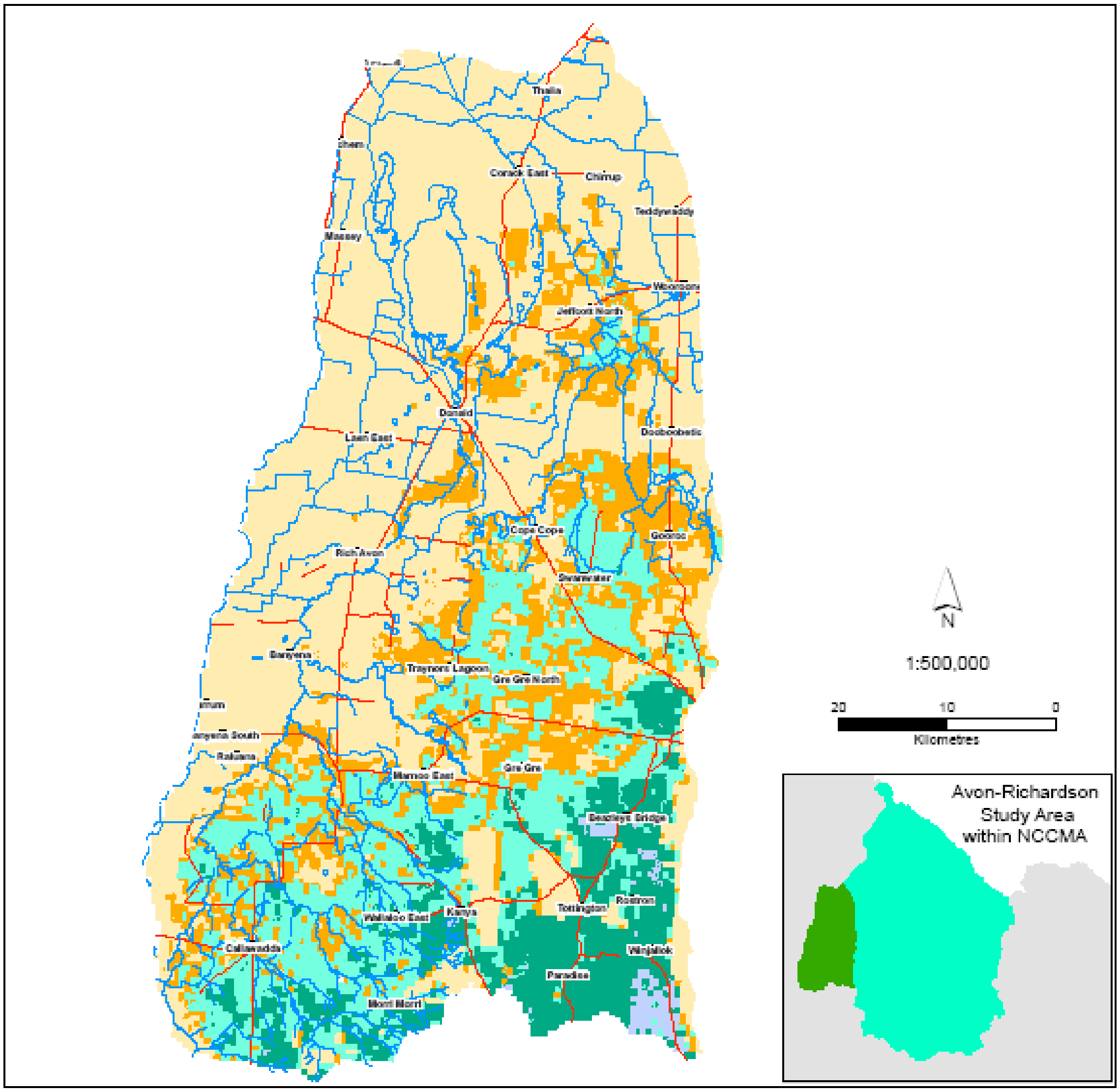
11 Appendix II: Aquatic Outcome information sheet

Victoria Department of Primary Industries

Avon-Richardson EcoTender Pilot

Aquatic Function

Victoria Department of Sustainability and Environment



Legend

Aquatic Function

- Low
- Medium
- High

Hydrology

Roads

Vegetation cover influences catchment groundwater systems, surface water runoff to streams and the erodibility of soils and this in turn impacts on the aquatic health of streams. Generally the reduction in cover of perennial vegetation associated with the introduction of European farming to Australia has resulted in increased additions to groundwater, increases in the speed of over-land flows, and higher levels of erosion, with these factors combining such that streams have lower water quality and more flow characteristics. The above map shows how both native vegetation management and revegetation activities will help to reduce erosion and to shift ground and surface water flows more towards the balance that would have existed in largely undisturbed circumstances.

Map produced by Geographic Services, DSE, Wodonga, for Economic & Policy Research Branch, DPI

Data sourced from DSE/DPI Corporate Library, and DPI Economic & Policy Research.

12 Appendix III: EcoTender Contract and Management Plans

DEPARTMENT OF SUSTAINABILITY AND ENVIRONMENT

-and-

John Farmer

EcoTender

AGREEMENT FOR ENVIRONMENTAL SERVICES

(SINGLE PURCHASE)

Contract Number: ar-001

EcoTender

Agreement for Environmental Services

This Agreement is made on the..……day of………….200…. between the Landholder specified in the Second Schedule and the Secretary of the Department of Sustainability and Environment of the State of Victoria in respect of the land described in the Second Schedule.

It is agreed:

Terms and Conditions

1. The parties to this Agreement agree that they will comply with the terms and conditions set out in this clause and the First Schedule.
2. The parties to this Agreement acknowledge and agree as follows:
   - 2.1. This Agreement will commence and terminate on the dates referred to in the Second Schedule unless otherwise specified.
   - 2.2. The Secretary may terminate this Agreement at any time by notice in writing to the Landholder if the Landholder breaches any of the 'Obligations of the Landholder' or as otherwise permitted in this Agreement, and is entitled to withhold from the Landholder any outstanding payments under this Agreement.
   - 2.3. The Parties may vary this Agreement but any variations only have effect if they are in writing and have been executed by the Parties.
   - 2.4. This Agreement cannot be assigned by either party.

Signed by the Landholder

Landholder signature…………………………..	Landholder signature……………………………..
Print name……………………………………...	Print name……………………………………..
Before me: Witness signature…………………………………	Before me: Witness signature…………………………………
Print name………………………………………	Print name………………………………………

Signed by the Secretary

Signature…………………………………………. Affix Seal

Print name……………………………………...

Before me:
Witness signature…………………………………

Print name……………………………………...

FIRST SCHEDULE

1. Obligations of the Landholder

The Landholder:

1.1. Will carry out all aspects of the execution and completion of the Landholder's Commitments set out in the Third Schedule.

1.2. Is responsible for ensuring that the Landholder's Commitments comply with the lawful requirements of any Authority, and with all Acts, regulations and other laws which may be applicable to the Landholder's Commitments.

1.3. Indemnifies the Secretary for any liabilities, loss, claim or proceeding arising out of the Landholder's Commitments or in the course of the execution of the Landholder's Commitments.

1.4. From Commencement until termination of this Agreement, agrees not to clear native vegetation from the land or to apply for a permit under the *Planning and Environment Act 1987* to clear native vegetation from the land.

1.5. Will prevent the spread of, and as far as possible eliminate established pest animals on the Site in accordance with Section 20 of the *Catchment and Land Protection Act 1994*.

1.6. Will eradicate regionally prohibited weeds on the Site and prevent the growth and spread of regionally controlled weeds on and from the site, both as required by Section 20 of the *Catchment and Land Protection Act 1994*.

1.7. Will notify the Secretary before selling the land or any part of it. If the land is sold before termination of this Agreement, this Agreement will come to an end and the Secretary will not be liable to make any further payments, except a payment relating to a completed year of the Agreement for which the Landholder submits a Report.

1.8. Will provide to the Secretary written notice from the registered owner of approval of the Agreement prior to Commencement if the Landholder is not the registered owner of the land. If the Landholder ceases to occupy the land, the Secretary may terminate the Agreement.

1.9. Will allow the Secretary and the Secretary's officers, employees, agents, contractors, invitees and licensees access to, and entry onto, the land on reasonable notice being given to the Landholder.

2. Obligations of the Secretary

The Secretary:

2.1. Will pay the sums specified in the schedule of payments in the Third Schedule. The initial payment will be made as soon as practicable after Commencement. Subsequent annual payments will be made by the Secretary in accordance with the schedule of payments in the Third Schedule. Each annual payment will be subject to receipt of a Report from the Landholder.

3. Interpretation

3.1. This Agreement is governed by the laws of Victoria.

3.2. Where there is more than one Landholder the terms and conditions of this agreement bind the landholders jointly and severally.

3.3. The singular includes the plural and the plural includes the singular.

3.4. ‘Commencement’ means the date of commencement of this Agreement specified in Schedule 2.

3.5. 'Land' means all that piece of land or pieces of land identified in the Second Schedule and shown on the plan attached.

3.6. 'Landholder' means the person or persons named and described in the Second Schedule and, where the context requires, includes the Landholder's employees, agents, contractors and invitees.

3.7. ‘Parties’ means the Landholder and the Secretary.

3.8. ‘Report’ means a written report in a form provided by the Secretary demonstrating completion of all the Landholder's Commitments specified for the preceding year in the management program to the satisfaction of the Secretary.

3.9. 'Secretary' means the Body Corporate called The Secretary to the Department of Sustainability and Environment and, where the context requires, includes the Secretary's officers, employees, agents, contractors, invitees and licensees.

SECOND SCHEDULE

Management Agreement No. ar-001

Date of Commencement of Agreement: ……………………

Date of Termination of Agreement: …………………… (or the date on which the Secretary terminates this Agreement)

The Landholder

Name of Landholders	John Farmer
Mailing Address	RMB 100
	Blackwood 3456
Telephone	
Fax	
Contact name of person who should receive correspondence	John Farmer

The Landowner (if not the Landholder)

Name of Landowner	
Mailing Address	
Telephone	
Fax	

Details of property within which the Agreement applies

Property name	
Property address	Hills Road
	Blackwood

Description of land to which the Agreement applies

<u>Site one</u> (NE-028/1)

Part of the land in Certificates of Title set out below being the land delineated in red on the attached plan.

Volume:	Folio:	Parish:	Area 23 ha
Allotment:	Section:	County:	

THIRD SCHEDULE

MANAGEMENT PLAN - # ar-001/1

Landholder **John Farmer**
Site Identifier ar-001/1
(A) Targets
The targets for the management plan are:
1. Protect current site quality
2. Increase the tree canopy cover
3. Increase the cover and diversity of understorey life forms
4. Reduce the cover and extent of identified 'serious' weed species
5. Increase the recruitment of woody plant species
6. Increase the cover of organic leaf litter

(B) Landholder's Commitments

1. Use of the land
For a period of five years from Commencement, the Landholder agrees to:
- Retain all standing large trees (dead or alive)
- Retain all other standing trees
- Exclude stock from the site at all times
- Retain all fallen timber

2. Management of the land
The Landholder will complete the management actions on the land for the time periods specified in the table below:

MANAGEMENT ZONES ar-001/1a – Grassy Dry Forest, **ar-001/1b** – Heathy Dry Forest, **ar-001/1c** – Heathy Dry Forest (as per site plan)

Year from Commencement	Management actions to be completed	Timing
First	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Wild Tobacco (Woolly Mullein) as per minimum standards • Cut and paint/spot-spray Briar Rose as per minimum standards	Autumn Spring Spring/Summer
Second	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Wild Tobacco (Woolly Mullein) as per minimum standards • Cut and paint/spot-spray Briar Rose as per minimum standards	Autumn Spring Spring/Summer
Third	• Fumigate and collapse rabbit burrows as per minimum standards	Autumn

	• Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Wild Tobacco (Woolly Mullein) as per minimum standards • Cut and paint/spot-spray Briar Rose as per minimum standards	Spring Spring/Summer
Four	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Wild Tobacco (Woolly Mullein) as per minimum standards • Cut and paint/spot-spray Briar Rose as per minimum standards	Autumn Spring Spring/Summer
Five	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Wild Tobacco (Woolly Mullein) as per minimum standards • Cut and paint/spot-spray Briar Rose as per minimum standards	Autumn Spring Spring/Summer

MANAGEMENT ZONES ar-001/1d – Valley Grassy Forest, **ar-001/1e** – Grassy Dry Forest (as per site plan)

Year from Commencement	Management actions to be completed	Timing
First	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Phalaris as per minimum standards • Cut and paint/spot-spray Briar Rose, Blackberry as per minimum standards	Autumn Spring Spring/Summer
Second	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Phalaris as per minimum standards • Cut and paint/spot-spray Briar Rose, Blackberry as per minimum standards	Autumn Spring Spring/Summer
Third	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Phalaris as per minimum standards • Cut and paint/spot-spray Briar Rose, Blackberry as per minimum standards	Autumn Spring Spring/Summer
Four	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Phalaris as per minimum standards	Autumn Spring

	• Cut and paint/spot-spray Briar Rose, Blackberry as per minimum standards	Spring/Summer
Five	• Fumigate and collapse rabbit burrows as per minimum standards • Spot-spray/chip St John's Wort, Paterson's Curse, Spear Thistle, Phalaris as per minimum standards • Cut and paint/spot-spray Briar Rose, Blackberry as per minimum standards	Autumn Spring Spring/Summer

3. Fire prevention
   The Landholder will take all reasonable steps to prevent fire on the land, provided these steps are not inconsistent with the Landholder's Commitments.

4. Reporting
   As soon as practicable after the end of each year of the Agreement the Landholder will submit a Report.

SECRETARY'S COMMITMENT

1. Schedule of payments
   To pay a total of $X,000.00 over the term of the Agreement, subject to Clause 2.1 and in accordance with the following schedule:

On commencement of the Agreement	25% of the total
At the end of the first year	15% of the total
At the end of the second year	10% of the total
At the end of the third year	10% of the total
At the end of the fourth year	15% of the total
At the end of the fifth year	25% of the total

DEPARTMENT OF SUSTAINABILITY AND ENVIRONMENT

-and-

Landholder name

EcoTender

AGREEMENT FOR ENVIRONMENTAL SERVICES

(SINGLE PURCHASE)

Revegetation

Contract Number: XX

CONTENTS

EcoTender

Agreement for Environmental Services

This Agreement is made on the..……day of…………200…. between the Landholder specified in the Second Schedule and the Secretary of the Department of Sustainability and Environment of the State of Victoria in respect of the land described in the Second Schedule.

It is agreed:

1. Terms and Conditions

1.1 The parties to this Agreement agree that they will comply with the terms and conditions set out in this clause and the First Schedule.

1.2 The parties to this Agreement acknowledge and agree as follows:

1.2.1 This Agreement will commence and terminate on the dates referred to in the Second Schedule unless otherwise specified.

1.2.2 The Secretary may terminate this Agreement at any time by notice in writing to the Landholder if the Landholder breaches any of the 'Obligations of the Landholder' or as otherwise permitted in this Agreement, and is entitled to withhold from the Landholder any outstanding payments under this Agreement.

1.2.3 The Parties may vary this Agreement but any variations only have effect if they are in writing and have been executed by the Parties.

1.2.4 This Agreement cannot be assigned by either party.

2 Interpretation

2.1 This Agreement is governed by the laws of Victoria.

2.2 Where there is more than one Landholder the terms and conditions of this agreement bind the landholders jointly and severally.

2.3 The singular includes the plural and the plural includes the singular.

2.4 'Commencement' means the date of commencement of this Agreement specified in the Second Schedule.

2.5 'Land' means all that piece of land or pieces of land identified in the Second Schedule and shown on the plan attached.

2.6 'Site' means the site designated in the attached site plan upon which vegetation is actually established under this agreement.

2.7 'Landholder' means the person or persons named and described in the Second Schedule and, where the context requires, includes the Landholder's employees, agents, contractors and invitees.

2.8 'Parties' means the Landholder and the Secretary.

2.9 'Report' means a written report in a form provided to the Secretary demonstrating completion of all the Landholder's Commitments specified for the preceding year in the management program to the satisfaction of the Secretary.

2.10 'Secretary' means the Body Corporate called The Secretary to the Department of Sustainability and Environment and, where the context requires, includes the Secretary's officers, employees, agents, contractors, invitees and licensees.

2.11 'Establishment Period' means the later of:

a) the expiration of 5 years after the commencement of this agreement; or
b) the day on which the Secretary makes the payment referable to Milestone Stewardship.

2.12 'Milestone' means a milestone specified in the Third Schedule.

2.13 'Survival Target' means the target specified in the Third Schedule.

2.14 'Vegetation' means any vegetation established at the Site under this Agreement and specified in the Fourth Schedule.

2.15 'Ecological Vegetation Class' means a type of native vegetation classification that is described through a combination of its floristic, life form and ecological characteristics, and though an inferred fidelity to particular environmental attributes.

2.16 'Bioregion' means a biogeogragphic area that capture the patterns of ecological characteristics in the landscape or seascape, providing a natural framework for recognising and responding to biodiversity values.

3. Operation of this agreement

This agreement contains the entire agreement between the parties about its subject matter. Any previous understanding, agreement, representation or warranty relating to that subject matter is replaced by this agreement and has no further effect.

Signed by the Landholder

Landholder signature………………………...	Landholder signature……………………………..
Print name…………………………………………...	Print name…………………………………………..
Before me:	Before me:

Witness signature…………………………………	Witness signature…………………………………
Print name…………………………………… …	Print name…………………………………… …

Signed by the Secretary

Signature…………………………………
……….

Affix Seal

Print
name……………………………………
…...

Before me:
Witness
signature…………………………………

Print
name……………………………………
…...

FIRST SCHEDULE

Obligations of the Landholder

The Landholder:

1.10. Will carry out all aspects of the execution and completion of the Landholder's Commitments set out in the Third Schedule.

1.11. Is responsible for ensuring that the Landholder's Commitments comply with the lawful requirements of any Authority, and with all Acts, regulations and other laws which may be applicable to the Landholder's Commitments.

1.12. Indemnifies the Secretary for any liabilities, loss, claim or proceeding arising out of the Landholder's Commitments or in the course of the execution of the Landholder's Commitments.

1.13. From Commencement until termination of this Agreement, agrees not to clear native vegetation from the land or to apply for a permit under the Planning and Environment Act 1987 to clear native vegetation from the land.

1.14. Will prevent the spread of, and as far as possible eliminate established pest animals on the Site in accordance with Section 20 of the Catchment and Land Protection Act 1994.

1.15. Will eradicate regionally prohibited weeds on the Site and prevent the growth and spread of regionally controlled weeds on and from the site, both as required by Section 20 of the Catchment and Land Protection Act 1994.

1.16. Will notify the Secretary before selling the land or any part of it. If the land is sold before termination of this Agreement, this Agreement will come to an end and the Secretary will not be liable to make any further payments, except a payment relating to a completed year of the Agreement for which the Landholder submits a Report.

1.17. Will provide to the Secretary written notice from the registered owner of approval of the Agreement prior to Commencement if the Landholder is not the registered owner of the land. If the Landholder ceases to occupy the land, the Secretary may terminate the Agreement.

1.18. Will allow the Secretary and the Secretary's officers, employees, agents, contractors, invitees and licensees access to, and entry onto, the land on reasonable notice being given to the Landholder.

1.19. As soon as practicable after the completion of each milestone under the Third Schedule, the Landholder will submit a Report which will then qualify the Landholder for the appropriate milestone payment under the Secretary's Commitments.

1.20. Is required to re-establish any vegetation if it has been either:
   a) wilfully removed or damaged by the Landholder or any person acting with the Landholder's consent: or

b) removed or damaged through the Landholder's negligence.

1.12 Subject to sub-clause 1.11, is not required to re-establish vegetation if it is lost or destroyed by an event which:

a) is beyond the control of the Landholder; and
b) is approved by the Secretary for the purpose of this sub-clause, either generally or in a particular case.

Obligations of the Secretary

The Secretary:

3.1. Will pay the sums specified in the schedule of payments in the Third Schedule. The initial payment will be made as soon as practicable after Commencement. Subsequent payments will be made by the Secretary in accordance with the schedule of payments in the Third Schedule. Each payment will be subject to receipt of a Report from the Landholder.

3.2. May, from time to time, give reasonable advice to the Landholder about:

a) the management, use, development, preservation or conservation of the Site;
b) the establishment and maintenance, of the vegetation; and
c) the establishment of supplementary vegetation which the Secretary considers may be necessary from time to time during the Establishment Period, to meet the Survival Target.

SECOND SCHEDULE

Management Agreement No. site identification code

Commencement and termination

Date of Commencement of Agreement: ……………………

Date of Termination of Agreement: ……………………
(or the date on which the Secretary terminates this Agreement)

Landholder and land details

The Landholder

Name of Landholders	
Mailing Address	
Telephone	
Fax	
Contact name of person who should receive correspondence	

The Landowner (if not the Landholder)

Name of Landowner	
Mailing Address	
Telephone	
Fax	

Details of property within which the Agreement applies

Property name	
Property address	

Description of land to which the Agreement applies
Site one (site id code)
Part of the land in Certificates of Title set out below being the land delineated in red on the attached plan.

Volume:	Folio:	Parish:	Area XX ha
Allotment:	Section:	County:	

THIRD SCHEDULE

Management plan

MANAGEMENT PLAN - # ar-001/1

Landholder **John Farmer**

Site Identifier ar-001/1

Commitments, reporting and payment schedule

Milestone	***Deliverables***	***Reporting***	***Payment (% of the Total Payment)***
Commencement	Agreement is executed by both parties	Date of commencement	25%
Establishment	**1. Establishment of vegetation** 1.1 The Landholder must: (a) prepare the Site appropriately to ensure optimal establishment of the vegetation; (b) for each category specified in Column 1 of the relevant Table in the Fourth Schedule, sow seeds or plant seedlings and established either: (i) a reasonable random selection of vegetation from the corresponding suitable species specified in Column 3 of the relevant Table in the Fourth Schedule; or (ii) such other suitable species as approved by the Secretary's Representative in writing. **2. Provenance of vegetation** 2.1 Subject to item 2.2, the Landholder must endeavour to ensure that all vegetation is established by indigenous seed or seedlings sourced from at least ten parent plants from within viable populations matched to the Site in terms of soil type, altitude, topography, aspect and climate and located within 25 kilometres of the Site and within the same bioregion.	No later than 2 years following *Commencement*	15%

Milestone	*Deliverables*	*Reporting*	*Payment (% of the Total Payment)*
	2.2 If it is not reasonably practicable for the Landholder to comply with item 2.2 in the case of any suitable species specified in Column 3 of the relevant Table in the Fourth Schedule, the Landholder must ensure that vegetation of that species is established from available indigenous seed and seedlings sourced from more than one parent plant from a viable population as close as possible to the Site. 2.3 The Landholder must: (a) record the exact provenance of any vegetation established under items 2.2 and 2.3; and (b) give a copy of that record to the Secretary as part of the Report for this Milestone. **3. Site protection – fencing and fire prevention** 3.1 The Landholder must erect and/or maintain adequate fencing around the Site in accordance with defined minimum standards, to ensure that domestic stock are excluded from the Site at all times. 3.2 The Landholder will take all reasonable steps to prevent fire on at the Land, provided that these steps are not inconsistent with this Agreement.		
Stewardship	The Landholder must: (a) ensure that non-native animals are excluded from browsing or grazing the Site at all times, except as approved in writing by the Secretary; and (b) only cultivate the Site or prune or thin the vegetation to the extent necessary to achieve the Survival Target; and (c) maintain in good condition: (i) any fencing around the Site; and (ii) any set-back or fire break shown in the attached Site plan.	Minimum of three years following *Establishment*	15%
Survival 1	The Landholder must: (a) achieve the Stewardship Milestone; and (b) agree to undertake remedial actions proposed by the Secretary's	Minimum of one year following *Establishmen*	10%

Milestone	***Deliverables***	***Reporting***	***Payment (% of the Total Payment)***
	Representative in relation to: (i) the planting of additional vegetation at the Site; or (ii) pruning or thinning vegetation at the Site; or (iii) any other action to be taken by the Landholder to meet the required Survival 2 Milestone.	*t*	
Survival 2	The Landholder must: (a) achieve the Survival 1 Milestone; and (b) ensure that the number of living plants on the Site for each Category in Column 1 of the relevant Table in the Fourth Schedule complies with the requirements in Columns 4 and 5 for that Category.	Minimum of two years following *Establishment*	10%
Completion	The Landholder must: (a) achieve the Survival 2 Milestone; and (b) ensure that the number of living plants on the Site for each Category in Column 1 of the relevant Table in the Fourth Schedule complies with the requirements in Columns 4 and 5 for that Category.	Minimum of one year following *Survival 2*	25%

FOURTH SCHEDULE

The landholder will complete the following fencing in the "first" year

MANAGEMENT ZONE: ar-dun-b 001a
Erect XX m of stock proof fencing along the XX boundaries as per minimum standards

Revegetation species list and target numbers

TABLE 1 – MANAGEMENT ZONE ar-dun-b 001a – EVC (Plains Woodland)

Column 1: Category	***Column 2: Common name***	***Column 3 Scientific name***	***Column 4: Maximum density***	***Column 5: Minimum density***
Overstorey	Yellow Gum Buloke	*Eucalyptus leucoxylon* *Allocasuarina luehmannii*	63/ha	38/ha Total 38/ha
Medium Shrubs (1 – 5 m tall)	Golden Wattle Gold-dust wattle Sweet Bursaria Weeping Pittosporum Berrigan	*Acacia pycnantha* *Acacia acinacea* *Bursaria spinosa* *Pittosporum angustifolium* *Eremophila longifolia*	n/a	41/ha 41/ha 15/ha 21/ha 38/ha Total 156/ha
Small Shrubs (0.2 – 1 m tall)	Ruby Salt-bush Black Blue-bush	*Enchyleana tomentosa* *Maireana decalvens*	n/a	188/ha 188/ha Total 376/ha
Total live woody plants/hectare			n/a	570/ha

Notes:

1. The plant numbers specified in Column 5 for each category in the table above are the minimum numbers required to fulfil the *Survival 2* and *Completion* Milestones (see Third Schedule)
2. The minimum density of plants for each species specified in Column 5 is presented as a guide only. The total minimum density of plants within each life form category (Column 1) can be achieved by any combination of the recommended plant species.

13 Appendix IV: EcoTender Example Bid Sheets

EcoTender
Native Vegetation Bid Sheet

Use this sheet to make your **EcoTender** bid for the **native vegetation management** site listed below in the green box and as shown on your site plan.

Please use a black pen. Don't forget to sign your bid.

These are your outcomes for this site:

Outcome	Score[1]
Biodiversity	
Saline land impact	
In-stream water quality	
Total	

Please refer to the enclosed bidding information sheet for an assessment of the Environmental Benefit outcome of this site in comparison to all other sites assessed in the EcoTender Pilot.

NATIVE VEGETATION MANAGEMENT SITE BID

Site Identifier Insert site number

Site plan description The area shown in *insert colour* on the site plan

I offer the services as identified in Management Plan *Insert Plan ID*

My price for these services is $………………..

Landholder *Insert landholder's name*

Landholder signature………………………….. Date……………..

____

EcoTender Pilot
Revegetation Bid Sheet

Use this sheet to make your **EcoTender** bid and assign sequestered carbon ownership for the **revegetation** site listed below in the yellow box and shown on your site plan.

Please use a black pen. Don't forget to sign your bid.

These are your outcomes for this site:

Outcome	Outcome
Biodiversity	
Saline land impact	
In-stream water quality	
Total	

Please refer to the enclosed bidding information sheet for an assessment of the Environmental Benefit outcome of this site in comparison to all other sites assessed in the EcoTender Pilot.

REVEGETATION SITE BID

Site Identifier Insert site number

Site plan description The area shown in insert color in the site plan

I offer the services as identified in the Management Plan Insert plan ID

Carbon ownership (tick the appropraite box)

I agree to assign amount tonnes of sequestered carbon to the Department of Sustainability and Environment at $12/tonne ☐

I wish to retain the ownership of the sequestered carbon ☐

My price for these services is $……………….

Landholder *Insert landholder's name*

Landholder signature…………………………. Date…………….

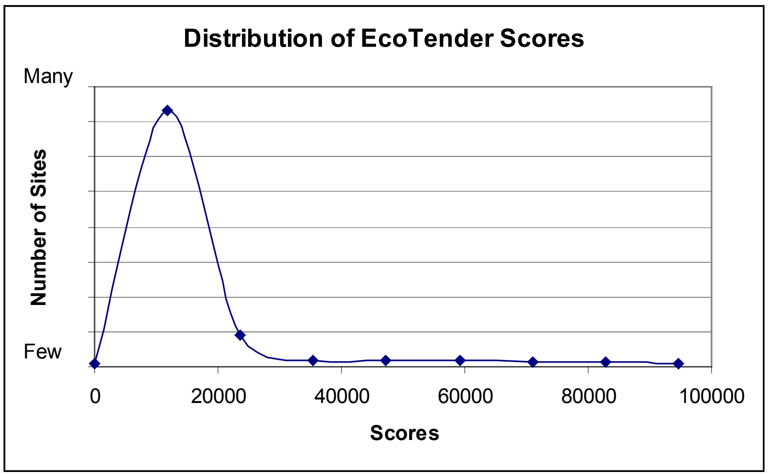
1) Where the landhodler chooses to retain ownership of the sequestered carbon, the Department of Sustainablity and Environment makes no warranty regarding the future tradeability of this carbon or state of future carbon markets.

14 Appendix V: EcoTender Example Bid Information Sheet

EcoTender Pilot: Bidding Instructions

1. Bids can only be made on the EcoTender bid sheets. Please note that a separate bid sheet is provided for each separate site and if you have more than one site then you should bid on your sites individually using the appropriate bid sheet.

2. For landholders proposing revegetation sites, bids should be entered on the appropriate "yellow" bid sheet. Bids for native vegetation management sites should be entered on the appropriate "green" bid sheet. For clarification, please check the site identification details on the bid sheet against your draft management plan and attached site plan.
3. Each bid sheet contains the total environmental benefits score resulting from your proposed commitments at the site. To provide you with an understanding of the environmental benefits of your site in comparison to all offered sites in the EcoTender pilot areas, the figure below shows the range of Total Scores for all assessed sites.



For instance, if your total score is 10,000 the figure shows there are many scores at or near this score, whereas if your score is 30,000 there are only a few at this level. It should be noted that it is the combination of the Total Score and the cost of each bid that is used to rank bids on the basis of "value for money" according to an Environmental Benefits Index.

Refer to Information Sheet 5 – *Assessment of bids* (enclosed) for how this information is combined with your bid (cost) to determine the Environmental Benefits Index.

4. Landholders with revegetation sites must also decide on whether they wish to sell the sequestered carbon to the Department of Sustainability and Environment at a fixed rate of $12/tonne C or retain ownership for use in the future. Note that the carbon outcome is not included in the Environmental Benefits Score. Successful bidders who have chosen to sell their carbon to DSE and sign revegetation management agreements will receive a total management payment that includes their bid price in addition to the carbon price.

5. Don't forget to sign and date your bid and return it in the pre-paid envelope within the 14-day bid submission period.

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