

**AUCTIONS FOR CONSERVATION CONTRACTS: A REVIEW  
OF THE THEORETICAL AND EMPIRICAL LITERATURE**

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Report to the

**Scottish Executive Environment and Rural Affairs Department**

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## EXECUTIVE SUMMARY

### Background and objectives

Since the launch of the Agri-Environmental Regulation in 1992, environmental contracting has become a key instrument of rural environmental policy across the EU. In Scotland, more than 1.2 million hectares of land are enrolled in agri-environmental schemes. The area of land under conservation management is set to increase further: Scotland is introducing a system of whole-farm support, called Land Management Contracts, designed to reward the full mix of economic, social and environmental benefits provided by farmers and crofters. The increased importance of agri-environmental policy in Scotland and elsewhere has, to date, not been reflected in innovative policy design. It remains the norm in European agri-environmental policy to offer a single, fixed payment for compliance with a pre-determined set of management prescriptions. Innovative policies based on contract and auction theory have been proposed to improve policy performance.

This report aims to provide SEERAD with a comprehensive review of the literature on conservation contract design and the use of auctions in agri-environmental policy and natural resource management. The theory and practice of auction and contract design is a burgeoning field of economic research which, because of technicalities, is not easily accessible to the layman. This report is intended to bridge the knowledge gap between researchers in the field and officials who consider using auction and contract theory to inform practical policy design. In particular, it aims to address key questions of auction and contract design and to provide SEERAD with conclusions as to whether or not, under current knowledge, an auction system could now be used in Scotland.

### An economic critique of agri-environmental contracting

While environmental contracting represents a significant innovation in policy terms, there are a variety of fundamental limits to this approach. The source of most of these problems lies in the fact that landholders know more about on-site costs and local impacts than the conservation agency, a situation referred to as ‘information asymmetry’. This can give rise to incentive problems limiting the effectiveness of environmental contracts as follows:

*Adverse selection* means that farmers who have already managed their land in an environmentally friendly way have a greater incentive to join a conservation scheme than farmers with less environmentally friendly farming practices: the former will have to make fewer and less severe changes to current farming practices, resulting in lower compliance costs. This will result in comparatively small additional environmental benefits and an overcompensation of compliance costs. The basis of adverse selection is information asymmetry: farmers differ in their compliance costs, and if these differences could be observed by the agency then farmers could be paid a rate equal to their individual compliance costs. In the absence of such information, the agency can only offer a flat rate, which cannot be cost-effective.

*Moral hazard* occurs if the conservation authority does not perfectly monitor compliance with the terms of the contract. Imperfect compliance monitoring can provide farmers with an incentive to renege on their contracts: if they are successful in avoiding detection by the conservation agency, they receive the compensation payment without incurring the costs implied by their contractual obligations. Evidence reported

in the literature suggests that adverse selection and moral hazard are widespread phenomena of agri-environmental management.

The typical agri-environmental contract does not provide producers with adequate *incentives for entrepreneurship*: to seek out new methods of reducing costs, to introduce new ideas, or to be willing to take risks for the provision of countryside goods. This is because environmental goods and services are normally not directly contractable, implying that rewards cannot be based upon environmental *outcomes* and must instead be linked to *activities*, i.e. changes to the management of the land.

There are *uncertainties over the property rights* in the environmental capital generated through contracting. When contracts expire, there can be no guarantee that the conservation assets will continue to be maintained because farmers are free to revert to intensive farming practices. Government may respond by introducing restrictive designations or covenants to protect long-term environmental gains. The prospect of this happening may deter farmers from considering participation in the first place.

The need to deal with information asymmetry and producer heterogeneity can give rise to *high administrative costs*. An empirical study reports average annual administration costs between €9 and €75 per hectare and between €140 and €2,446 per participant.

### **Agri-environmental contract design with limited information**

Policy mechanisms designed to address adverse selection can be broadly classified into two categories: self-selection mechanisms (through contract menus) and auction mechanisms. *Self-selection mechanisms* are set up as principal-agent models whereby the principal (the conservation agency) devises different contracts for different resource settings of agents (the farmers), depending, for instance, on whether they are high-cost or low-cost compliers. The principal tailors farmers' choices in such a way as to induce farmers with a particular resource setting to choose the contract meant for them. This tailoring is done through contractual provisions which require that farmers with a particular resource setting, say highly productive land, prefer the contract intended for highly productive land to all other options offered in the menu. By choosing the appropriate contract, landholders reveal their resource setting to the conservation agency, thereby reducing the information asymmetry. Despite this advantage, no use seems to have been made of incentive-compatible contracts in the practice of agri-environmental management. This is not surprising given the theoretical nature of contract mechanism design and the restrictive assumptions underlying the models.

Rather than relying on self-selection, *auctions* harness market forces to induce farmers to reveal, through the bidding process, their compliance costs to the conservation agency. Competition is the driving force behind this cost revelation: farmers are asked to bid competitively for a limited number of conservation contracts. In formulating their bids, they thus face a trade-off between a higher net gain from a higher bid and a reduced chance of winning. Producers facing competition are less likely to 'overbid' relative to their true compliance costs. Competitive bidding thus reduces over-compensation and increases cost-effectiveness. Auctions have the added advantage of acting as a price discovery mechanism for environmental goods and services for which there are no well-established markets and thus no prices. In an auction, prices are determined through a decentralised process which takes account of private information held by the bidders. However, an auction is a complex incentive mechanism, involving

a higher risk of failure than a simple fixed-rate payment. The diffusion of auctions into the practice of agri-environmental management has been slow, but interest in auctions for purchasing conservation services from private landholders has recently grown.

Progress on designing efficient solutions to the moral hazard problem has been slower and confined to theoretical models with little relevance to the practice of agri-environmental management. The important policy conclusions from the literature are these: Incentives for non-compliance are shaped by the farmer's compliance costs, the payment level, the non-compliance detection probability and the level of fines for detected violations. The propensity to compromise conservation agreements is highest when compliance costs are high in relation to the payment level. This in turn suggests that (a) overcompensation can reduce the risk of non-compliance and thus the need for compliance monitoring and (b) that monitoring efforts should be concentrated on high-cost farmers, e.g. farmers with high pre-contractual land use intensities. Payments in excess of compliance costs are most likely to be cost-effective in situations where compliance monitoring is technically difficult (and thus costly).

We considered the proposition to pay farmers based on environmental outcomes rather than, as is common practice, on the landholder's activities or conservation effort. There is a dilemma here between two aspects. Payments made on the sole basis of effort without reference to output create little incentive for achieving the desired output, effectively exacerbating moral hazard and adverse selection. Payments made on the sole basis of output without reference to effort can create a very risky situation for the landholder, insofar as many factors beyond his or her control (such as droughts, floods or pest invasions) can intervene to perturb the relationship between effort and outcome. Agents who are willing to bear that risk will demand a high risk premium in return which, in turn, may make the transaction unattractive to the conservation agency. The problem is exacerbated by uncertainties with the observational and measurement techniques available. It is often difficult, if not impossible, to come up with precise and reliable estimates of environmental change. This is likely to lead to complaints and appeals from landholders, resulting in high transaction costs. In theory, and abstracting from the measurement problem, contracts could be devised whereby the total payment is split into two: an effort-based and an outcome-based instalment. The effort-based payment could be made once a farmer has signed a conservation contract and has implemented the stipulated conservation activities. The outcome-based payment would depend upon some quantitative measure of the environmental benefits after a stipulated time period. Mainly because of the problem of unobservability of environmental outcomes and the risks of litigation linked to unclear landholder responsibility, it appears preferable, for the time being, and until some general guidelines have been worked out, to stick to effort based-payments. However, improvements in knowledge (for example, new technology that allows lower-cost monitoring of specific environmental outcomes) may enable conservation agencies to base at least part of their payments on output.

### **Conservation auction design**

Auctions can be regarded as a trading mechanism and analysed from a design perspective – that is, how these markets can be designed in such a way that they achieve specific outcomes. Outcomes commonly sought in conservation auctions are allocative efficiency, i.e. selection of participants with the highest benefit-cost ratio, and budgetary cost-effectiveness – that is, buying the most conservation benefit with a



given budget of public money. Auction theory is not well developed for conservation auctions and thus offers little guidance for the design of tendering mechanisms in such contexts. Most analyses testing alternative auction designs therefore have relied on economic experiments, numerical simulations or, simply, intuition and economic reasoning.

There is the choice between **different payment formats**. In the discriminatory format (the most commonly used), each bidder is paid an amount equal to his or her actual winning bid. In a uniform-price auction, by contrast, all successful bidders earn the cut-off price – either the highest accepted or the lowest rejected bid. The main difference between discriminatory and uniform pricing is its impact on bidding behaviour. Under the *discriminatory format*, bid formation depends not only on a bidder's own cost of conservation activities but also on his or her best guess of what the highest acceptable unit bid might be. This creates room for bidders to shade their bids above their true opportunity costs and thereby to secure themselves a profit or rent. Overbidding implies that the auction does not reveal bidders' *true* opportunity costs. Theoretical modelling suggests that overbidding is highest for the lowest-cost bidders, whereas the highest-cost bidders bid closest to their true costs (though still marginally above). However, these highest-cost bidders are not those that are usually selected; rather, the lowest-cost bidders are, but they get paid well above their true costs. Note however that this overpayment is usually smaller than under a flat-rate scheme.

Under *uniform pricing*, by contrast, a bidder's bid *only* determines the chance of winning but *not* the payment received. Bidders' dominant strategy thus is to bid their true opportunity costs. Any other strategy would reduce a bidder's potential gain from the auction. Bids under uniform pricing rules can thus reveal bidders' *true* opportunity costs.

Theory provides little guidance to tell which of the alternative pricing rules can generally yield greater budgetary cost-effectiveness. On balance, the discriminatory payment format appears to be the more appropriate payment rule for conservation auctions, except when there are reasons to believe that bidders will considerably shade their bids. However, if cost revelation (rather than value for money) is the overarching priority, and perceptions of fairness are not a political issue, then the implication is to use uniform-price auctions.

A **reserve price strategy** is a key element of auction design. A reserve price is an upper limit on the amount the agency is willing to pay for a unit of the conservation good being traded. This can be pre-announced or not. There are two potential reasons why conservation agencies should consider setting a reserve price. The first is bidding competition: a reserve price adds to the risk that bidders might lose an auction by bidding too high. Second, it may act as a signal of the agency's (or society's) maximum willingness to pay for conservation services, thus representing the demand side of the 'market' in countryside benefits. A reserve price should be considered if bidding competition is expected to be weak and if there is risk of bidder collusion. This is the case when the number of potential bidders is small or when bidders learn to 'game' the auction in multiple bidding rounds. Reserve prices are less important where there is a strict budget constraint.

Conservation auctions can be conducted either with a **fixed budget** (which is the norm) or, alternatively, with a **fixed target**. In the first case, the agency accepts bidders based on their benefits to bid ratios until a predetermined fixed budget is

exhausted. The size of the conservation scheme in terms of hectares of land enrolled is determined as a residual from the budget and the bids offered. In the target-constrained auction, by contrast, the agency predetermines the size of the conservation scheme and accepts bids until the target is achieved. In this case, the necessary budget is not known before the auction is completed. There are no *a priori* reasons to believe that one auction format is better than the other except, perhaps, that the existence of a budget constraint may have the psychological effect of ‘disciplining’ bidders, encouraging them to enter more competitive bids. Experimental studies found no significant differences in the performance of the two auction formats. We thus conclude that there are no strong reasons to suggest the preferred use of one of the two auction formats. Practical considerations, however, call for the preferred use of the budget-constrained auction: it is the more ‘natural’ format in the environmental area where schemes usually have a limited budget and EU regulations limit the degree of overcompensation of farmers’ opportunity costs. A target-constrained auction may be called for in situations where the agency cannot fall short of its environmental objectives.

Auctions for conservation contracts are normally designed as **repeated auctions** where bids for the same contracts are invited over a sequence of years. Such a system provides scope for bidders to analyse the results of preceding bidding rounds and use this information to update their bids. Experience with the Conservation Reserve Program in the US has shown that after a few bidding rounds the average bid was almost exactly equal to the maximum acceptable payment level from preceding rounds, implying that farmers had learned the cut-off points. Under no circumstances should the conservation agency therefore publish information about the average or the maximum accepted bid or the distribution of bids received in preceding bidding rounds. Another potential remedy to the problem of learning is to amend the rules of the auction in each bidding round. This would make the system less predictable, thus maintaining a certain degree of uncertainty among bidders. A reserve price may also be effective in countering bidder learning.

A parcel’s conservation value may increase if adjacent parcels are also put under conservation management. The presence of such **site synergies** requires auction design refinements. The agency may wish to encourage all pertinent landholders to participate in an auction so that bids with synergetic values are accepted together. One solution is to allow neighbouring landholders to submit joint bids that cover sites belonging to different holdings. Landholders who submit a joint bid have the local knowledge to decide among themselves how best to share effort and payments among their members, thereby helping the agency with the funding decision. The efficiency and payment properties of joint bidding are barely explored in the literature and detailed auction rules are yet to be developed. These properties would need to be explored through appropriately designed economic experiments, before such schemes can be recommended for practical use. Another unresolved issue is how best to provide incentives for landholders to act together. One way is for the conservation agency to score bids contingently: landholder *A*’s score would be greater if he or she were successful in conjunction with landholder *B*. This would have to be communicated to potential bidders before bidding commences. Since landholders cannot be expected to be aware of conservation synergies, it is important to inform those landholders that they were providing synergy benefits. In the Scottish context, this may be relevant to the Rural Stewardship Scheme, particularly its Common Grazing measures.

The choice of an appropriate **bid evaluation system** is a key design issue. The main purpose of bid evaluation is to incorporate information on conservation benefits in an

auction. Conservation benefits are often site specific and depend upon the resource setting. Benefit indicators can be used to quantify site-specific effects of conservation activities. If bids contain more than one conservation benefit, a multi-criteria bid scoring system can be used to aggregate the various benefit variables into one figure representing an estimate of the overall conservation benefit of each bid. These aggregate measures of conservation value draw on environmental assessments conducted by ecologists and are limited by whatever data a conservation agency is able to collect. Aggregation methods differ mainly in the choice of relative weights for individual benefit variables. Examples include the biodiversity quality (BQ) index used in the BushTender pilots in Australia and the environmental benefit index (EBI) used to select bids under the Conservation Reserve Program in the US.

We advocate the use of Data Envelope Analysis (DEA) to construct a so-called value-for-money frontier. DEA is a benchmarking technique based on linear programming. Bids that lie on the frontier are assigned a value of one, indicating that they offer the best value for money. For all bids not on the frontier, DEA indicates by how much the bid would have to be lowered so that the proposal represents the best value for money. In order to take account of the agency's preferences for different quality attributes, one can input preference weights to come up with appropriate scores for bid selection. Bids are then ranked by these efficiency scores, and the offers with the highest scores would be selected until the budget is exhausted. The information needed to construct the value-for-money frontier comprises, for each bid, estimates of the different quality attributes and the bid amount. All quality attributes must be readily observable and not subject to manipulation or misrepresentation by the bidders. From a practical perspective, DEA offers the advantage of generating virtually incontestable bid rankings: if a bid turns out to be bad value for money, then there is a strong argument for rejecting the bid. This minimizes the scope for complaints and appeals by unsuccessful bidders. However, DEA is less transparent and more difficult to explain to bidders and stakeholders than alternative, more intuitive bid ranking systems.

Prior to landholders forming their bids, the government agency needs to decide **how much information** about what it values in the auction it is going to **reveal** to them. Theoretical considerations suggest that if bidders know their own quality estimates and the agency's preferences, they will strategically avoid price competition and offer the mix of service attributes that best matches the agency's preferences. They thus compete directly only with those offering the same quality mix, thereby reducing price competition. By contrast, lack of information on the agency's preferences compounds the guesswork that bidders face in formulating their bids: not knowing the agency's preferences, bidders are unable to supply favourable but costly service attributes and price competition becomes the driving force of the auction, preventing bidders from capturing large rents. These theoretical predictions have been confirmed by laboratory experiments. A reasonable compromise between full information revelation and no information revelation might be to publicise the quality criteria but not the weights attached to individual attributes. Knowledge of the package of attributes that the conservation agency intends to purchase is necessary to attract the 'right' landholders and give them some guidance to formulate proposals that match the agency's preferences. On the other hand, too detailed knowledge of the criteria and the weights for each attribute may encourage bidders who offer high-quality packages to shade their bids too much above opportunity costs.

### Case studies of conservation auctions

We reviewed case studies of conservation auctions covering the USA, Australia, continental Europe and the UK. For each auction, we reviewed the problem addressed, objectives, auction design, auction outcomes, and lessons learned. The schemes reviewed differ in their policy goals, their ways of setting reserve prices and their methods of assessing environmental benefits and ranking bids. These case studies are summarised in the table below and further explained thereafter.

Summary table of case studies reported

<b>Auction name</b>	<b>Problem</b>	<b>Key design feature(s)</b>	<b>Noteworthy results</b>	<b>Lessons learned</b>
<b>CRP (USA)</b>	Land set-aside	Multiple sign-up; multi-criteria bid ranking	Long-lasting; 10% of US farmland enrolled	Bidders learn to game the auction!
<b>BushTender (AUS)</b>	Buy bush management and conservation	Individual management plans	Large cost savings relative to fixed prices	High initial investment and learning costs
<b>ALR: Auction for Landscape Recovery (AUS)</b>	Multidimensional auction targeting biodiversity, salinity, groundwater	Setup similar to BushTender but allows for joint bidding and site synergies	Cost savings significant but less than for BushTender	3 types of bidders; auction performance depends on benchmark
<b>Challenge Funds (UK)</b>	Extension of woodland area, among other things	Individual planting plans; multi-criteria bid ranking	Very effective in achieving objectives; some cost savings	20% higher admin. costs; considered 'un-fair' by some; discontinued <sup>(1)</sup>
<b>EcoTender (AUS)</b>	Multi-dimensional auction similar to ALR	Setup similar to BushTender. EBI <sup>(2)</sup> computed through catchment modelling	N/A	N/A
<b>Grassland pilot (GER)</b>	Encourage broader participation in AgEnv schemes	Auction used to determine top-up payment	Low rate of participation; fewer bidders than expected	Payment level not the only determinant of participation
<b>Outcome-based auction (GER)</b>	1) Payment on output, not input 2) Estimate TC <sup>(3)</sup>	Simple classification of output quality	Low TC <sup>(3)</sup> reflect simple scheme	Compare output and input based payments

(1) Note the importance of (perceived) fairness as a criterion of political acceptability.

(2) EBI = Environmental Benefit Index

(3) TC = Transaction Costs

The **Conservation Reserve Program (USA)** has multiple objectives ranging from erosion control through habitat improvement to income support for farmers. Under this program, landholders bid for government funds for retiring their lands from farm production for a period of 10 to 15 years. Current CRP auctions employ an environmental benefit index to compare bids. This index accounts for land quality heterogeneity and weights various environmental objectives according to their relative importance. Currently (2005), approximately 33.5 million acres of farmland are enrolled in the CRP. Each contract covers an average of 74 acres with an average rental rate of \$45.95 per acre. From its beginning in 1986, the CRP was conceived as a multiple sign-up scheme. This has allowed landholders to learn where the (implicit) bid cap lies and to gradually adjust their bids to this cap, eroding the cost-effectiveness of the auction.

The **BushTender pilots**, carried out in 2001-2003 in Victoria, Australia, were designed to test the idea according to which auctions could efficiently purchase public environmental goods from private landholders. The good in question was biodiversity as captured through improved 'bush' (i.e. native vegetation) management. Expressions of interest were first called for, then government officers visited the farms and the land areas up for tender. Ecological data were collected on these areas and analysed by scientists to devise a Biodiversity Benefits Index (BBI). Bids were ranked according to the BBI/bid ratio, from highest value per dollar bid down, until the budget constraint was hit. Subsequent analysis of first round results claimed a benefit of 700% of that which would have been obtained through a fixed-price scheme. We question the validity of this figure because of the 'non-standard' way in which it has been computed. Transaction costs for the first round of BushTender, which included on-site research, ecological scoring and auction administration costs, amounted to roughly 50% to 60% of the amount spent in the auction. The involvement of government officers and their dedication to explain to farmers the ins and outs of this new payment system were found to be important for securing sufficient participation and thereby the level of competition necessary for the auction to play its efficiency role.

The **Auction for Landscape Recovery (ALR)** aimed at securing multiple benefits from land management improvements in Western Australia, namely biodiversity enhancement, salinity control, and groundwater recharge abatement. Landholders who had expressed interest were encouraged to submit a tender describing their proposed management activities, anticipated environmental outcomes and a bid. The tender process was communicated as rewarding those who deliver the greatest environmental benefit per dollar. Tenders were evaluated using a regional metric of 'biodiversity complementarity' within a systematic conservation planning framework. This metric, unlike the BBI, accounts for synergistic aspects due to number, size and distance of several areas; the BBI focuses on the individual value of each land area. Some interesting outcomes emerge from this experience:

- Cost-effectiveness of the ALR compared to that of a uniform price scheme varies between 315% and 207% in round 1 and 165% and 186% in round 2, depending on whether the fixed price scheme is input-based or output-based.
- There was no evidence to show that the auction imposed higher administrative costs than equivalent schemes using the same amount of information to underpin the selection process. This was because most of these costs were not linked to the specifics of running an auction.

- The building by natural scientists of a comprehensive scoring index for ranking multidimensional auctions is an exercise fraught with pitfalls. Subjectivity cannot be avoided, even if it is buried in the appearance of an objective measure (the scoring index).

**EcoTender**, carried out in the state of Victoria, Australia, is an offshoot of BushTender and similar in intent to the Western Australian Auction for Landscape Recovery (ALR), in that it aims to secure multiple environmental benefits, including improvements in salinity control, biodiversity enhancement and water quality. A specific feature of EcoTender is that it uses information from catchment-based modelling to estimate both local and catchment-wide impacts on environmental outcomes as a result of changed land use and management. Bids can be lumped or separate; that is, a landholder can submit a bid for a number of areas or separate bids for each. Pooled bids across several farmers are also allowed. Payments are not only input-based (management actions), but also include an output-based element. This is an ongoing programme for which no results are yet available (2005).

**Challenge Funding** was introduced into Scottish forestry policy in 1997 – with the launch of the Grampian Challenge Fund and the Central Scotland Challenge Fund. These funds operated under the umbrella of the Woodland Grant Scheme (WGS) and offered additional grants to the standard WGS grants for extending the woodland area in specific geographical areas. They were competitive in that applicants were required to submit bids to the Forestry Commission (FC) for this additional money. Both funds were closed for applicants in 2002. Currently only one challenge fund is in operation. This is the Woodlands In and Around Towns (WIAT) Challenge. A judging panel awarded grants to those applicants whose plans best met the aims of the Challenge and offered the best value for money. The panel selected high-scoring, low-cost bids first. Beyond that they traded off score against cost in a subjective way. The funds were very successful in rapidly expanding the land area under forestry. Subsequent analysis of the data showed that, to secure all the bids with a fixed-rate premium would have required a budget 33% to 36% above that spent under Challenge Funding. Forestry Commission staff reckon that operating the challenge funds took 20 per cent more staff time per application than fixed-rate incentives. A subsequent survey revealed some dissatisfaction with a grant scheme based on tendering. The main comment was that it was ‘unfair’ in some way. There was a consensus from stakeholders that challenge funds were too uncertain for the applicant and that they should be replaced by locational premia (i.e. fixed rates per ha).

The focus of the **Grassland Conservation Pilot Tender** (Germany) was on maintaining low-intensity grazing systems. The conservation agency had initially offered fixed-rate payments. After only very few farmers had signed up, an auction was run to determine the excess payment required to induce broader participation. A bid cap of 53 per cent of the fixed-rate payment was imposed for the first round. All bids below that reserve price were accepted. The reserve price was not known to the bidders before auction. Fewer farmers than expected (15 in each of the three bidding rounds) submitted a bid, implying that the scheme was not effective in encouraging broader participation in agri-environmental management. Subsequent analysis revealed that uncertainty over yield losses and the impacts of the latest CAP reform were key deterrents to participation.

### **Conservation auction performance**

Conservation auctions are still in their infancy and data from the field are scarce. Anecdotal evidence on auction performance is often spurious and intuition unreliable. There are claims that the amount of biodiversity benefits acquired through the first round of BushTender auctions would have cost about seven times as much if a fixed-price scheme had been used instead. A study is in the process of evaluating the Scottish 2001 fishing vessel decommissioning exercise, and preliminary results suggest that the gains from the auction relative to a budget-equivalent fixed price scheme are not nearly as high. These results are more in line with findings reported in Latacz-Lohmann and van der Hamsvoort (1997) who simulated farmers' bidding behaviour in a hypothetical conservation programme. They found efficiency gains ranging from 16 to 29%, depending on how the auction was implemented and how winners were selected. These figures compare to Challenge Fund's 33 to 36%. However, White and Burton (2005) find efficiency gains between 200 and 315% for the Auction of Landscape Recovery (ALR) pilot in Western Australia. Some care has to be taken in interpreting all these figures: because they are based on different counterfactual fixed-payment rates, they cannot be compared to each other. These variations suggest that it is probably too early to make a robust assessment of the cost-effectiveness of auctions in agri-environmental management. However, there is unanimity in the empirical literature that bidder learning poses a substantial threat to the efficiency of multiple-round conservation auctions. Both experimental studies and agent-based simulation studies have confirmed the experience with the US Conservation Reserve Program: when bidders have the opportunity to learn from preceding bidding rounds, they will use that information to update their bids and reap higher rents – at the detriment of auction performance.

### **Conclusions for agri-environmental management in Scotland**

Given the lack of theoretical backdrop and practical experience, we advise a cautious approach to the use of auctions in conservation contracting. We do not consider competitive bidding to be ideal for allocating Land Management Contracts as a routine policy mechanism – for a number of reasons:

First, there is unlikely to be much variation among landholders in the costs of carrying out the management options. For bidding to be effective, farms must be heterogeneous in their compliance costs. Second, most of the measures are reasonably straightforward to cost. There is thus no need to use an auction as a price discovery mechanism. Third, Land Management Contracts are heterogeneous. Different landholders will include different combinations of management options in their bids. SEERAD would face the challenge of devising a multi-criteria bid scoring system to aggregate the various dimensions of a bid into one figure representing an estimate of the overall (economic, social and environmental) benefit of each bid. While this is not an infeasible task, in practice it is likely to involve high transaction costs and the risk of complaints and appeals from unsuccessful applicants.

Whether competitive bidding is the appropriate mechanism for allocating contracts for the extended Land Management Contracts Scheme (to be launched in 2007) is a matter of debate. This scheme is designed to deliver *tailored* (rather than widespread) economic, social and environmental benefits. Tailored benefits usually require very specific measures targeted to specific resource settings. To the extent that tailoring involves spatial targeting or the use of strict eligibility criteria, the number of potential

applicants may fall below the level required to secure sufficient bidding competition. In such circumstances, an auction is not the appropriate incentive mechanism and fixed-rate payments or individually negotiated grants should be considered instead.

Auctions work best when the number of bidders is high, contracts are homogenous and landholders are heterogeneous in their compliance costs. Of all agri-environmental schemes offered in Scotland, the Organic Farming Scheme is probably the one which best meets these requirements.

To the extent that theory provides insufficient guidance for most conservation applications and empirical evidence on auction performance is inconclusive, we conclude with a recommendation not to implement any full scale auction schemes without first carrying out some experimental investigations, first in the controlled conditions of the laboratory, then as reduced-scale field pilots. This ‘test-bedding’ of policies allows policy makers and administrators to make at low cost all the serious and potentially expensive mistakes both in the financial and in the political sense. Controlled laboratory experiments thus represent a central stage in the learning process towards successful auction design and implementation.



## 1. INTRODUCTION

### 1.1 Background to the study

Agri-environmental policy originated in response to the perceived limitations of conventional agricultural policy and has initially served the dual purpose of supply control and environmental protection. However, as the policy has matured it is increasingly justified in terms of multifunctionality: agri-environment policies promote non-commodity outputs jointly produced with agricultural commodity outputs. Because the non-commodity outputs have public-good characteristics there is market failure and hence the state has a role in promoting agri-environmental outputs. Agri-environmental policy may thus be seen to create ‘quasi-markets’ in these goods in that government undertakes to purchase these goods from private landholders on behalf of society. The EU Rural Development Regulation grants Member States a large measure of subsidiarity for designing their own schemes, matching them to local conditions and advancing regional priorities. This discretion has resulted in a wide variety of measures with a range of objectives and management prescriptions, implemented at different geographical scales – from local to national.

The Forward Strategy for Scottish Agriculture stresses the multifunctional role of Scottish agriculture. The Strategy states that “future support to farming must be designed in a way which rewards the mix of benefits required by the Scottish public and does not mask market signals” (<http://www.scotland.gov.uk/library3/agri/fssa-02.asp>). The Custodian of Change Report reinforces this view, stating that “Agriculture and the environment are inextricably linked: the agricultural industry has the potential, responsibility and opportunity to bring increased environmental and agricultural benefits to the countryside” (<http://www.scotland.gov.uk/library5/agri/awwg-00.asp>).

The importance of agriculture to the environment is recognised by the introduction of agri-environmental schemes. Spatially targeted schemes in Scotland include the SSSIs and ESAs. Other environmental schemes such as the Rural Stewardship Scheme, the Farm Woodland Premium Scheme and the Organic Aid Scheme operate throughout Scotland. Overall more than 1.2 million hectares of land in Scotland are enrolled in agri-environmental schemes. Expenditure on agri-environmental programmes was about £33 million in 2003 whilst the expenditure of Scottish Natural Heritage on land management agreements promoting biodiversity and access to private land amounted to £14 million. The budget for agri-environmental and rural development measures is set to increase through ‘modulation’: Scotland is introducing a system of whole farm support, called Land Management Contracts, designed to reward the full mix of economic, social and environmental benefits provided by farmers and crofters.

The increased importance of agri-environmental policy in Scotland and elsewhere has, to date, not been reflected in innovative policy design. It remains the norm in European agri-environmental policy to offer a single, fixed payment for compliance with a pre-determined set of management prescriptions. The main obstacle to designing and implementing more targeted policies is limited information on the side of policy makers and regulators. Information asymmetries between landholders and environmental agencies can give rise to a range of incentive problems limiting the effectiveness of the schemes and making them expensive to run. This information asymmetry implies that first-best programmes are often not possible. For example, farmers cannot be offered an incentive payment equal to their individual compliance

costs because the conservation agency lacks the relevant information. Second-best programmes can be obtained by applying mechanism design theory under asymmetric information. Competitive bidding has been proposed as one such mechanism. In a conservation auction, farmers are asked to bid competitively for a limited number of conservation contracts. In formulating their bids, they thus face a trade-off between a higher net gain from a higher bid and a reduced chance of winning. Producers facing competition are less likely to ‘overbid’ relative to their true compliance costs. The expectation thus is that competitive bidding will increase the cost-effectiveness of agri-environmental spending.

The diffusion of auctions into the practice of agri-environmental management has been slow, but interest in auctions for purchasing conservation services from private landholders has recently grown. Governments in Australia and elsewhere increasingly recognise the potential of auctions as a policy tool for allocating public resources. Designing auctions that work well in the field, however, can pose significant challenges. The literature on auction design is littered with examples of failure and highlights the need for auctions to be tailored to the specific characteristics of different situations.<sup>1</sup> Noteworthy examples include the New Zealand and the Dutch auctions for broadband spectrums (McMillan, 1994). Klemperer (2002; 2004) and Rothkopf and Harstad (1994) review the practical implementation problems of auctions and highlight the gap between theory and practice. Success of conservation auctions depends on having a thorough understanding of bidding behaviour and paying close attention to design details. Auction theory provides a framework for developing practical design guidelines.

While auctions can address the problem of overcompensation, they do not overcome the problem of moral hazard. The basis of the moral hazard problem is imperfect information about farmers' actual compliance. Imperfect compliance monitoring provides farmers with an incentive to renege on their contracts. The problem is exacerbated by lack of information about environmental outcomes and the relationship between farmers' actions and such outcomes. A number of approaches to combating moral hazard have been proposed in the contract design literature, but hardly any of these are well enough adapted to the complex regulatory process of agri-environmental contracting as to be of practical use for policy administrators.

## **1.2 Objectives**

The overarching objective of this study is to provide SEERAD with a comprehensive review of the literature on conservation contract design and the use of auctions in agri-environmental policy and natural resource management. The theory and practice of auction and contract design is a burgeoning field of economic research. However, it is not easily accessible. Much of the literature is presented in a technical way. As a result, many results remain obscure to outsiders. This report is intended as a primer on auction and contract design in the field of environmental policy, aiming to fill the knowledge gap between researchers in the field and officials who consider using auction and contract theory to enhance the performance of agri-environmental policy.

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<sup>1</sup> See Klemperer (2002) for an overview of auction failures.

The specific objectives of this research are to:

- ❑ consider the rationale and relevance of auctions to agri-environmental and nature conservation policy, including a discussion of the pros and cons of conservation auctions in different contexts and circumstances;
- ❑ review the main types of auction that could be used to allocate conservation contracts and discuss the key features to be considered in the design of conservation auctions and of agri-environmental contracts in general;
- ❑ assess the information requirements relating to the specification and measurement of nature conservation/biodiversity outputs, including a review of different bid ranking mechanisms;
- ❑ examine monitoring and measurement problems, including a discussion of contract enforcement issues and whether contracts should be based on actions (inputs) or results (outputs);
- ❑ review case studies of auctions in the practice of conservation contracting covering UK, EU and Australian examples.

The report aims to provide SEERAD with conclusions as to whether or not, under current knowledge, an auction system could be used in Scotland and, if not, what further research would be useful.

### **1.3. Methodology**

The methodology for the study comprises the following elements:

- (a) A comprehensive review of the literature on conservation contract design in the presence of information asymmetry and of the use of auctions in agri-environmental policy and natural resource management. This review covers both theoretical and empirical/practical aspects of contract and auction design. At a more general level, we demonstrate how asymmetric information can give rise to different types of incentive problems in agri-environmental contracting. We then review approaches designed to alleviate these problems. We finally home in on conservation auctions and provide an in-depth discussion of the design and running of auctions, including ways of ranking bids. We also review results from empirical and experimental studies into the performance of conservation auctions to provide SEERAD with some indication of the potential cost savings from using auctions.
- (b) A combined postal/telephone survey of conservation agencies that use auctions to allocate conservation contracts. The purpose of the survey is to gauge experiences gained and lessons learned, to identify solutions to limitations and practical difficulties experienced in the running of conservation auctions, and to gauge opinions on ways of increasing the performance of auctions.

### **1.4. Outline of the report**

The report is organised into six further sections.

**Section 2** provides an economic critique of conservation contracting. We demonstrate how different types of information asymmetry can give rise to different types of incentive problems, and how this incentive incompatibility can undermine the effectiveness of agri-environmental contracts.

**Section 3** is a review of the literature on agri-environmental contract design under asymmetric information. We review policy approaches designed to alleviate both moral hazard (i.e. the problem of farmers compromising their contractual obligations) and adverse selection (i.e. the problem of overcompensation and targeting the ‘wrong’ farmers). We assess the rationale for using auctions to allocate conservation contracts and demonstrate that auctions are but one approach to dealing with adverse selection. **Section 4** looks at conservation auction design – that is, how this trading mechanism can be designed in such a way that it achieves specific outcomes. **Section 5** reviews case studies of conservation auctions covering the USA, Australia, continental Europe and the UK. For each auction, we review the problem addressed, auction design, auction outcomes and lessons learned. **Section 6** summarises the results of empirical studies into the performance of conservation auctions vis-à-vis alternative contract allocation mechanisms. **Section 7** summarises the main findings of the report with a view of providing an overall assessment of auctions as a contract allocation mechanism. The report concludes with a critical discussion as to whether or not, under current knowledge, conservation auctions should be used to select landholders for conservation schemes in Scotland.

## **2. LIMITS OF AGRI-ENVIRONMENTAL CONTRACTING**

While environmental contracting represents a significant innovation in policy terms, there are a variety of fundamental limits to this approach. As indicated in the Introduction, the source of most of these problems is asymmetric distribution of information between landholders and the conservation agency.

### **2.1 Adverse selection – targeting the ‘wrong’ farmers**

Adverse selection refers to situations where a farmer with a low potential for producing high-quality environmental outputs has a greater incentive to enter a conservation agreement than a farmer with a high environmental potential. For example, a farmer who has already been using a low-input farming method has a greater incentive to sign up for a conservation scheme stipulating reduced usage of pesticides and fertiliser than a farmer with a high-input technology: the former will have to make fewer and less severe changes to current farming practices. This will result in comparatively small additional environmental benefits and an overcompensation of the farmer’s compliance costs. In fact, the low-intensity farmer may have an incentive to conceal information about his pre-contractual farming practices from the agency or, even worse, may disguise himself as a high-intensity farmer in order to qualify for higher payments (Fraser, 1995; Wu and Babcock, 1996). Clearly, this reduces the scheme’s effectiveness. Thus, the basis of the adverse selection problem is asymmetric information about individual farmers’ compliance costs and pre-contractual farming practices: farmers differ in their compliance costs, and if these differences could be observed by the agency then farmers could be paid a rate equal to their compliance costs, thus saving money compared to the use of a pre-determined fixed payment level.

A study by Osterburg and Nieberg (1999) provides evidence of adverse selection. The authors analyse the spatial distribution of environmental scheme uptake in Germany. They find that participation rates are highest in regions with poorer soils, lower yields and a lower share of intensive crops, and a generally lower intensity of land use. Likewise, high participation rates are mainly found in schemes with less demanding management prescriptions, whilst uptake of highly targeted schemes addressing specific environmental problems is limited. It has been argued that adverse selection also occurred in the early rounds of ESA contracts in the UK (Whitby et al., 1990; Hodge, 1991; Colman et al., 1992; Whitby, 1994).

### **2.2 Moral hazard – incentives to evade contract requirements**

The basis of the moral hazard problem is imperfect information about farmers’ actual compliance. Imperfect compliance monitoring (i.e. a detection probability of less than 100 per cent) provides farmers with an incentive to renege on their contracts: if they are successful in avoiding detection by the conservation agency, they receive the compensation payment without incurring the costs implied by their contractual obligations. Obviously, the propensity to renege on agreements depends on a number of factors including the farmer’s attitude towards risk and morality. A formal analysis of the moral hazard problem is presented in Appendix 1. The modelling exercise shows that the conservation agency can manipulate four contract variables in order to prevent farmers from cheating. These are: (1) the probability of detection, i.e. the intensity of compliance monitoring; (2) the level of fine for detected contract

violations; (3) the stringency of the management prescriptions; and (4) the payment rate. Since detected violations involve the full grant being repaid, a high payment rate acts as a deterrent to cheating.

The moral hazard problem appears to be significant in practice, with active monitoring of farmer compliance and significant (although varying) rates of cheating reported. Giannakas and Kaplan (2002) quote US statistics showing that out of 750,000 farmers receiving conservation payments in 1997, 50,000 were audited of whom 2,000 were found to be not actively applying the approved conservation plan. Land Use Consultants (1995) found that, on 24 percent of sites visited, farmers participating in the Countryside Stewardship Scheme in England were compromising their contracts in some way. Hanf (1993) reports that one third of farmers participating in a regional nature conservation scheme in Northern Germany were not fulfilling their contractual obligations. In other instances, compliance records appear to be satisfactory (see for example Anjou, quoted in Hart and Latacz-Lohmann, 2005). Especially if contracts have standard conditions and if these conditions are familiar to all landholders within a region, the propensity to cheat is likely to be low because there will be an element of self-policing among local landholders.

### **2.3 Dynamic inefficiency – lack of incentives for entrepreneurship**

Hodge (2000) points out another incentive problem: the typical agri-environmental contract does not provide producers with adequate incentives to seek out new methods of reducing costs, to introduce new ideas, or to be willing to take risks for the provision of countryside goods. There is also hardly an incentive for local landholders to co-ordinate their actions across several holdings. Co-ordination, however, is required when the environmental objectives of the schemes relate to the landscape at a wider scale. For example, creating favourable conditions for rare wildlife species normally requires a co-ordinated effort across several holdings in the area. Present policies do not take account of such conservation synergies because they concentrate on contracts between government agencies and *individual* farmers.

The root cause underlying these incentive problems is the fact that the final outputs, i.e. the environmental goods and services produced, are not directly contractable because of difficulties in measuring the state of the environment and quantifying changes. This means that farmers' rewards cannot be based upon environmental *outcomes* and must instead be linked to *activities*, i.e. changes to the management of the land. These management changes are known to improve the environment, but the transformation function that maps these actions into outcomes is not known with certainty, even if the actions were carried out diligently. Further, the effects of unexpected events such as droughts or floods cannot reasonably be predicted. If the desired outputs were readily observable, as is the case in most other situations of government procurement contracting, farmers could be paid by results, that is, based on the quantity and quality of the environmental outputs produced. This being the case, the above incentive problems would largely disappear because higher effort, innovation and entrepreneurship would result in higher output and thus higher payment.

## **2.4 Uncertainty over property rights**

Landscape and conservation values are usually only created over significant periods of time. This calls for relatively long-term contracts. However, when contracts expire, there can be no guarantee that the conservation assets will continue to be maintained. Farmers may have an incentive to return to more intensive forms of agricultural production at the expense of any conservation benefits that may have been created. This raises questions about the property rights in the environmental assets generated through environmental contracts. The public may feel that they have a proprietary interest in the environmental assets to the extent that they have been created through the contribution of public funds, and that they should have a right to prevent damage to this environment in the future. Farmers may anticipate this problem and so be reluctant to enter into environmental contracts in the first place, the concern being that restrictive designations might subsequently be introduced to protect long-term environmental gains (Hodge, 2000).

## **2.5 Information asymmetry and transaction costs**

The costs of operating environmental programmes include both the incentive payments made to landholders and the costs to the agency of administering the programme. In economic terms, payments to landholders are mere transfers, whereas scheme administration incurs real economic costs. These transaction costs stem largely from information asymmetries between landholders and public agencies and the heterogeneity of producers. Falconer and Whitby (1999) distinguish three categories of transaction costs in the operation of agri-environmental schemes. These are:

- Information costs for surveying and designating areas of environmental sensitivity and designing appropriate management prescriptions;
- Contracting costs including promotion of the scheme to farmers, negotiation between farmers and agency, and the administration of contracts;
- Policing costs including costs of compliance monitoring and enforcement, environmental monitoring and scheme evaluation.

These costs tend to be disregarded in policy discussions and, where considered, it is generally assumed that they should simply be minimised.

Falconer and Whitby (1999) report the results of pan-European research into the administrative costs of agri-environmental schemes, involving 37 case study schemes in eight European Member States. Average annual administration costs ranged from €9 to €75 per hectare and from €140 to €2,446 per participant. Administration costs as a proportion of total payments to landholders varied from 6% to 87%.

These transaction costs represent a significant element of public expenditure and may be sufficiently important to constrain the resources available for implementing agri-environmental policies, especially in times of public expenditure scrutiny and cut-back. The danger is that the development of administrative structures may not keep pace with the rapid increase in the scope, scale and complexity of agri-environmental schemes. Insufficient scheme administration will inevitably result in reduced environmental effectiveness.

### **3. AGRI-ENVIRONMENTAL CONTRACT DESIGN WITH LIMITED INFORMATION**

The above arguments highlight the importance of research into efficient agri-environmental contract design when information is limited and costly to obtain. Significant progress has been made in designing policy mechanisms which alleviate adverse selection (e.g. Moxey et al., 1999; Wu and Babcock, 1996; Fraser, 1995; Slangen, 1997; Latacz-Lohmann and Van der Hamsvoort, 1997, 1998; Smith, 1995; Bystrom and Bromley, 1998). Progress on designing efficient solutions to the moral hazard problem has been slower and confined to theoretical models with little relevance to the practice of agri-environmental management (Latacz-Lohmann, 1998; Choe and Fraser, 1998, 1999; Ozanne et al., 2001; Fraser 2002, Hart and Latacz-Lohmann, 2005).

#### **3.1 Policy design to address adverse selection**

The policy mechanisms that have been proposed to address adverse selection can be broadly classified into two categories: self-selection mechanisms and auction mechanisms. These are reviewed in turn.

##### *Self-selection mechanisms (through contract menus)*

Self-selection mechanisms are set up as principal-agent (PA) models whereby the principal (the government agency) devises different contracts for different resource settings of agents (farmers) and tailors farmers' choices in such a way as to induce farmers with a particular resource setting to choose the contract meant for them. This type of contract is difficult to design because farmers have an incentive to misrepresent their environmental characteristics to obtain a favourable combination of management prescriptions and payment rates. The self-selection constraint, however, ensures that farmers reveal through the choice of contract their true environmental characteristics, thereby rectifying the previously existing information asymmetry. The self-selection constraint simply requires that farmers with a particular resource setting (say, highly productive land) prefer the contract intended for that resource setting to all other options offered in the menu. Contract variables (e.g. management prescriptions and payment rates) are thus to be chosen such that a contract for highly productive land provides a farmer who owns this type of land with the highest net payoff compared to all other contract options on offer. The self-selection constraint is supplemented with a participation constraint (also known as an 'individual rationality' constraint) which guarantees that farmers will be at least as well off participating in the scheme as not participating – thus in principle ensuring their participation. An agri-environmental scheme is feasible if it satisfies both the participation constraint and the self-selection constraint. When the agency uses a feasible scheme, each farmer will choose the contract option intended for him or her, thereby reducing the problem of adverse selection. The agency's problem is to determine the feasible scheme that maximises its objective function.

In Wu and Babcock's (1996) model, the agency is modelled as maximising 'social surplus from agricultural production' which is the difference between revenue from, and costs of, agricultural input use minus the damage of pollution and the 'deadweight loss' from distortionary taxes of raising government revenue (such costs are a net loss to society). The optimal solution to the agency's problem is a combination of management prescriptions (input use reductions) and payment rates for different



farmer types that maximise the objective function. Under the assumptions made, the optimal payment turns out to be a single, constant payment equal to the minimum amount of money needed to induce the farmers with the best land to participate. Thus, the government can do no better than to offer a uniform payment to all farmers although they are known to differ in their compliance costs. This is tantamount to using a fixed price scheme! The optimal management prescriptions (input schedules) are found to differ from the ones that would be socially optimal in a perfect-information setting: in the presence of information asymmetry, farmers would be allowed to use more input than the socially efficient level under full information. The policy conclusion is that farmers who declare to have more productive land must be allowed to apply more inputs than farmers who declare to have less productive land. The compensation for both farmer types must be the same. If more productive land were compensated at a higher rate than less productive land, then all farmers would claim to have highly productive land, “and the program would soon be a hazard to the morals of farmers” (Wu and Babcock, 1996, p. 944).

Moxey et al. (1999) use a similar model setup and come up with similar results. Their regulator is assumed to maximise the net social welfare of a contract consisting of: a) reduced pollution damage; b) the farmer’s monetary benefit (or rent) as the excess of transfer payment over the costs of abatement; and c) the deadweight loss from distortionary taxes for raising public funds. In contrast to Wu and Babcock (1996), Moxey et al. (1999) assume that the regulator has a subjective prior probability of whether a farmer is a high-productivity or a low-productivity type farmer<sup>2</sup>. These probabilities are used as weights in the regulator’s objective function. They then solve the objective function subject to two participation constraints and two self-selection constraints - one for each farmer type, respectively. The former ensure that farmers must at least be compensated for their reduction in profit; the latter removes the incentives for one type of farmer to declare themselves untruthfully to be another type of farmer. Compared to the full-information (first-best) optimum, the optimal solution to this problem features less demanding management prescriptions (less input reduction) for the high-productivity farmer and a higher transfer payment to the low-productivity farmer. The costs associated with deviating from the first-best (full-information) solution may be interpreted as the cost of information asymmetry relating to the farmer type. The ‘truth-telling’ second-best solution is designed to minimise this cost and represents a significant improvement on the third-best, no-information, solution of offering a single, uniform contract to a group of heterogeneous farmers. The authors stress that this improvement is brought about without costly information gathering on the part of the regulator. It is achieved through recourse to the revelation principle and the use of incentive compatible contracts.

Despite these advantages, no use seems to have been made of incentive-compatible contracts in the practice of agri-environmental management. This is not surprising given the theoretical nature of contract mechanism design and the restrictive assumptions made in the models; e.g. only two farmer ‘types’. This criticism does not hold for auction mechanisms which are discussed next.

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<sup>2</sup> In Moxey et al. (1999) there are only two discrete farmer types, low-productivity and high-productivity, while Wu and Babcock (1996) consider a continuum of farmer types normalised within the range  $0 \leq a \leq 1$ .

*Auction mechanisms*

Auctions represent an alternative mechanism by which landholders are encouraged to reveal their 'type' (i.e. compliance costs, resource setting). Rather than relying on self-selection, auctions harness market forces to induce farmers to reveal, through the bidding process, their compliance cost to the conservation agency. Competition is the driving force behind this cost revelation: farmers are asked to bid competitively for a limited number of conservation contracts. In formulating their bids, they thus face a trade-off between a higher net gain from a higher bid and a reduced chance of winning. Producers facing competition are less likely to 'overbid' relative to their true compliance costs. The expectation thus is that competitive bidding will reduce information rents and increase cost-effectiveness. Ideally, the bid would reveal the bidder's true opportunity cost of producing the environmental good in question, thus rectifying the information asymmetry.

Tendering mechanisms have at least three advantages over single, fixed-rate payments. First, they enable participants to deal with the uncertainty about the value of the object being traded. Countryside benefits are public goods for which there are no markets. Holding an auction means that the better-informed party (the landholder) makes the first move in determining an appropriate price, while the less well-informed party (the conservation agency) retains the bargaining power by setting up rules under which the competing claims are compared and selected. In other words, bidding acts as a price discovery mechanism where prices are determined through a decentralised process which takes account of private information held by the bidders. Therefore, compared to a centrally decided, flat-rate payment, auction prices are more likely to reflect the landowners' true opportunity costs. Second, as indicated above, tendering explicitly introduces an element of competition between landholders. Bidders facing competition are more likely to reveal their true valuation in their bids rather than a strategically inflated value. Put differently, bidding reduces the scope for opportunistic behaviour resulting from informational asymmetries. Theoretically modelling has shown that optimal bids increase with both the bidder's opportunity costs and his/her expectations about the unit bid cap (Latacz-Lohmann and van der Hamsvoort, 1997). Thus, a bidder's bid conveys information about his or her opportunity cost, which is private information unknown to government. The information asymmetry is thus reduced, but not completely: indeed, the auction's cost revelation property is blurred by the fact that the bid also reflects the bidder's beliefs about the unit bid cap chosen by the agency. Third, tendering is perceived to be fair, which is politically important, making a transfer of public money legitimate. By holding an auction, the conservation agency avoids being confronted with questions about the level of pre-determined payments.

However, an auction is a complex incentive mechanism, involving a higher risk of failure than a simple fixed-rate payment. First, there is the potential problem of insufficient bidding competition. The smaller the group of potential bidders, the lower the level of bidding competition and the higher the likelihood of collusion and strategic behaviour. Second, bidding involves the risk of learning on the part of the bidders. Experience with the Conservation Reserve Program in the US have shown that bidders tend to analyse the results of preceding bidding rounds and use this information to update their bids. Finally, auctions involve high transaction costs. To the extent that these are upfront fixed costs, they may deter farmers from participating in the scheme.

The diffusion of auctions into the practice of agri-environmental management has been slow, but interest in auctions for purchasing conservation services from landholders

has recently grown. At a large scale, auctions have been used only on one occasion: for allocating contracts for the US Conservation Reserve Program (CRP) since 1986 (Babcock et al., 1996; Plankl, 1999). Interest in conservation auctions has recently increased throughout Australia, especially after the BushTender biodiversity trial auctions in Victoria (Stoneham et al., 2003). In Europe, conservation auctions are being trialled in the states of Lower Saxony and North-Rhine Westphalia, Germany. These trials are reviewed in section 5.

There is, to date, little empirical evidence about the efficiency gains of auctions vis-à-vis fixed-payment schemes. Stoneham et al. (2003) claim that the amount of biodiversity benefits acquired through the first round of BushTender auctions would have cost about seven times as much if a fixed-price scheme had been used instead. A study by Schilizzi and Latacz-Lohmann (2005a) is in the process of evaluating the Scottish 2001 fishing vessel decommissioning exercise, and preliminary results are suggesting that the gains from the auction relative to a budget-equivalent fixed price scheme are not nearly as high. This is more in line with findings reported in Latacz-Lohmann and van der Hamsvoort (1997) who simulated farmers' bidding behaviour in a hypothetical conservation programme. They found efficiency gains ranging from 16 to 29%, depending on how the auction was implemented and how winners were selected. However, White and Burton (2005) find efficiency gains between 200 and 315% for the Auction of Landscape Recovery (ALR) pilot in Western Australia. These variations suggest that it is probably too early to make a robust assessment of the cost-effectiveness of auctions in agri-environmental management. A more comprehensive and systematic review of conservation auction performance is presented in section 6 of this report.

### **3.2 Policy mechanisms to address moral hazard**

Moral hazard arises due to asymmetric information about compliance (actions), but imperfect information about individual farmers' compliance costs will also affect the solution: farmers with high compliance costs are more likely to cheat, as their payoff to cheating (compliance costs saved) is larger than that of other farmers, whereas the loss on discovery (a fixed fine) is likely to be constant.<sup>3</sup> Furthermore, choices will also be affected by farmers' estimates of the probability of detection as a cheat, and its perceived cost which depends on the fine, but also, potentially, risk aversion and other psychological factors.

A seminal paper on the implications of moral hazard on contract design is that by Grossman and Hart (1983). Since then, principal-agent theory has been applied to the problem of moral hazard in environmental policy. Latacz-Lohmann (1998) develops a decision model to analyse incentives for contract violations at the farm-level (the model is reproduced in Appendix 1). He shows that incentives for non-compliance are shaped by the farmer's compliance costs, the payment level, the detection probability and the level of fine for detected violations. The propensity to compromise conservation agreements is highest when compliance costs are high in relation to the payment level. This in turn suggests that (a) overcompensation can reduce the risk of non-compliance and thus the need for compliance monitoring and (b) that monitoring efforts might be concentrated on 'high-cost farmers', e.g. farmers with high pre-

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<sup>3</sup> Note that White (2002) allows the fine to vary with the degree of cheating, but not according to the qualities of the farmer (e.g. compliance costs).

contractual land use intensities. Payments in excess of compliance costs are most likely to be cost-effective in situations where compliance monitoring is technically difficult (and thus costly) and where each contract involves only a small number of hectares. It is further demonstrated that monitoring effort and payment level are substitutes with respect to discouraging non-compliance and that, under certain circumstances, over-compensation of compliance costs can be a cost-effective means of ensuring compliance if the agency's objective is to minimise programme costs.

Choe and Fraser (1998, 1999) also assume the agency's objective is to minimise its own costs, but unlike Latacz-Lohmann (1998) they allow for risk aversion and inaccurate monitoring. They demonstrate that the optimal monitoring intensity and the incentive payment required to ensure farmer compliance may or may not be higher for risk-averse farmers than for risk-neutral farmers. However, they characterise imperfect monitoring as an inability to identify accurately whether or not a farmer has complied, rather than a failure to detect cheating.

In contrast to earlier papers, Ozanne et al. (2001) model agri-environmental contract design as a social welfare maximization problem that recognizes the trade-off between increased environmental benefits and increased costs of compliance monitoring. The solution to the problem identifies the optimal environmental standard (in terms of input abatement), incentive payment and detection probability (i.e. monitoring effort) for each individual farmer. The authors characterise the solution to the moral hazard problem as second-best in as much as it involves less input abatement than the first-best (perfect information) solution. The effectiveness of the enforcement strategy is measured by the extent to which the second-best solution converges on the first-best solution, and it is shown that this is largely determined by the degree of farmers' risk aversion and the cost structure of the monitoring process. A key finding from their analysis is that high degrees of risk aversion result in convergence of the second-best solution to the first-best solution and thus in a reduction in the severity of the moral hazard problem. Indeed, the authors argue that the study by Latacz-Lohmann (1998), which has assumed that farmers are risk-neutral, may have exaggerated the moral hazard problem.

Fraser (2002) extends Ozanne et al.'s analysis by including production risk. Agri-environmental schemes often stipulate limited use of risk-reducing inputs such as fungicides and pesticides, increasing the variability of farm income. It is shown that full recognition of the income risk faced by farmers, where this income comprises not just policy payments but also production income, diminishes the attraction of cheating among even moderately risk-averse agents and encourages compliance as a risk management strategy. Furthermore, Fraser (2002) introduces the concept of a mean-penalty preserving increase in non-compliance risk, involving a shift in the balance of compliance instruments away from the level of monitoring and towards the size of the penalty. This concept is used to show how the moral hazard problem among risk-averse farmers can be diminished without any change in the expected penalties. It is shown that a principal who has control over both the level of monitoring and the size of the fine has the potential to reduce cheating among risk-averse agents by adjustments to these two instruments which increase the variance of farmers' income but leave the expected penalty for cheating unchanged.

It is reasonable to suppose, and consistent with observations, that the regulatory solution to the moral hazard problem will lead some farmers to participate and cheat, others will participate and comply, whereas a third group will not participate at all. Yet

none of the models in the literature reviewed so far have a solution of this nature: indeed, the majority of models allow for a single farmer type, and hence the regulatory solution is one in which all farmers participate and comply. A model which does allow for different farmer types is that of White (2002), who extends the model of Moxey et al. (1999) to include both uncertainty about actual compliance and about compliance costs. However, the variation across farmers is simple enough that the regulator's solution remains (as in cases with identical farmers) to set the monitoring rates at levels such that *all* participating farmers comply, i.e. there is never any cheating. This is effectively a corner solution which does not fully reflect the complex regulatory problem of dealing with a range of farmer types.

Hart and Latacz-Lohmann (2005) develop a model which allows for a continuum of farmer types with differing compliance costs. The regulator thus deals with multiple heterogeneous agents and is assumed to know the distribution of compliance costs, but not the compliance costs of individual agents. The regulator can affect the payoff to compliance and cheating via both the payment and the probability of monitoring. The fine for detection is constrained to be low (in accordance with observations from agri-environmental management) and assumed not to be under the regulator's control. The regulator has a pre-determined environmental target and minimises total budgetary costs. Only a proportion of farmers are pure profit maximisers, and therefore consider cheating. The remainder are characterised as honest, and never consider the option of cheating. Equilibria with low levels of both monitoring and cheating, in accordance with actual observations, are comprehensible within this model, even when fines are constrained to be low. The honesty/dishonesty distinction has a decisive effect on policy. It is shown that, paradoxically, the total number of cheats may go up at the optimum following an increase in the proportion of honest farmers: if there are more honest agents, it is less worthwhile to perform monitoring which means that the remaining dishonest farmers are more inclined to cheat.

### **3.3 Payments linked to activities or outcomes?**

In contracting for environmental outputs, such as increased bird numbers, reduced water pollution, or slowing of soil erosion, an uncertainty problem exists. Except for some very special cases, the relationship between a set of conservation-oriented activities and the final results at a given point in time are subject to uncontrolled factors. These may include climate, in its normal fluctuations as well as in its more or less catastrophic events, such as floods and droughts, epidemic or invasive species events (locusts, weeds, fungi, disease), and the impacts from activities of neighbouring properties or those situated upstream. Another issue is the measurability of the environmental output. Uncertainty may also lie with the observational and measurement techniques available. For instance, if a number of species is to be achieved in a given area in a given period, such as birds, insects, or fish, it may be difficult, if not impossible, to come up with precise estimates of the numbers.

For these reasons, environmental-oriented contracts have to this day been primarily, if not exclusively, predicated on the landholder's activities or conservation effort. Payment has not been linked to actual conservation outcomes, with the exception of a recent, ongoing project being carried out in Northeim, near Göttingen, Germany, as described in the Case Studies section (Rüffer, 2004; Groth, 2005). Nevertheless, the government agency usually has some control over the final outcome, however imperfect, through the specification of precise management activities, which are

expected to deliver to a large extent the aimed-for environmental outcomes. The assumption is that if the landholder indeed carries out the management activities as specified in the contract, the likelihood that the expected outcome is not achieved is rather small. Of course, this would essentially be wishful thinking were it not for the fact that a large proportion of landholders do not necessarily try to renege or cheat on their contractual obligations. The downside is the fact that management activities need to be specified *ex-ante*, preventing the landholder from using his site-specific knowledge to optimise his effort in response to random events (such as rainfall, frost or disease). And as has been shown by Chambers and Quiggin (2001), the specification of complete contracts in an uncertain environment is extremely costly if not impossible. The landholder is thus not given any incentive for initiative and innovation, since actions have already been contractually pre-specified. Indeed, any deviation from the pre-specified actions with the intention to enhance environmental output, may be regarded *ex post* as a contract violation, especially in situations where the output is judged to be unsatisfactory.

There is a dilemma here between two aspects. Payments made on the sole basis of effort without reference to output create little incentive for achieving the desired output. Payments made on the sole basis of output without reference to effort create a very risky situation for the landholder, insofar as many factors beyond his control, mentioned above, can intervene to perturb the relationship between effort and outcome. The responsibility of the landholder can therefore be difficult, if not impossible, to establish in court.

This dilemma between incentive creation and risk mitigation has been studied in various contexts. Classic examples include the design of crop sharing agreements between tenants and landlords as well as incentive contracts between employers and employees. If the agent (i.e. tenant or employee) is paid solely for his or her effort, then there is hardly any incentive to work hard in the interest of the principal (i.e. landlord or employer). Conversely, if payments are made solely on the basis of outcomes (e.g. yields or sales revenue), risk-averse agents may not be willing to sign the contract in the first place because, given the noisy relationship between effort and output, the result-based payment scheme exposes them to substantial risk. Agents who are willing to bear that risk will demand a high risk premium in return which, in turn, may make the transaction unattractive to the principal. This example serves to illustrate a well-established fact in the contract theory literature: that it is not efficient to expose agents to the full risk of a transaction when the agent is risk-averse and the principal is risk-neutral. The solution to this type of problem is one in which the principal and the agent share the risk. This is achieved by splitting the total payment into two components: one linked to effort, and one linked to outcomes. The effort-based payment could be made once a farmer has signed a conservation contract and has implemented the stipulated conservation activities (e.g. reduced use of fertiliser or pesticides). The outcome-based payment would depend upon some quantitative measure of the environmental benefits after a stipulated time period. Depending on the objectives of the scheme, these may be reduction below a benchmark level of nitrate concentrations in surrounding water bodies, or the number of certain bird or wildlife species targeted by the programme. Ideally, landholders would be paid a price per unit of environmental service generated, e.g. per bird or per ppm of reduced nitrate concentration. Of course, this solution only works if the environmental outputs of interest are easy to observe or measure and if the time scale is short enough, e.g. one year. Such a scheme would create an incentive for landholders to be productive and

innovative in generating the contracted-for environmental goods or services, while at the same time limiting the financial risk from unsatisfactory outcomes.

An outcome-based scheme could be run by allowing landholders to choose the weights that they wish to put on the effort-based and the output-based part of the payment, respectively. These weights would act to reveal each landholder's perception of his/her potential to generate environmental outputs: if the landholder is confident that his efforts will translate into substantial environmental improvements, he or she will put much weight on the output-based instalment, and vice versa.

In practice, however, the prospects of incentive-based payment schemes are likely to be limited. First, there are likely to be measurement issues. Even if environmental outcomes can be quantified in principle, there may be disputes between the contracting parties over the method and the benchmark used for measuring environmental improvements, or disagreement as to how to deal with random external factors such as droughts or floods or natural fluctuations in bird populations. Given the complexity of ecological systems, it seems virtually impossible to control for all contingencies and eventualities in a contract. Hence the transaction costs of a fully specified contract are likely to be prohibitively high. Second, in many cases there are synergies in conserving adjacent tracts of land. For example, nitrate concentrations in a water body are affected by land use practices on adjoining land which may belong to different holdings. For each of the adjoining parcels of land, conservation benefits are affected by any adverse use on the other lands. If part of the payment is linked to environmental outcomes (i.e. nitrate concentrations), an individual farmer is unlikely to be willing to participate because he or she does not have full control over the way in which adjacent parcels of land are being managed. On the other hand, output-based payments may encourage farmers in the aquifer to join forces in controlling nitrate emissions. To realise such synergies, the agency needs to look beyond the design that allows only contracts to be signed between the conservation agency and *individual* landholders. We shall return to this issue in section 4.3.5 when we discuss alternative ways of capturing conservation synergies.

An (as yet untested) alternative to output-based payments is to split the payment for management activities into several instalments, on the understanding that the second and subsequent instalments will be paid only if the first-period activities are deemed to have been carried out according to best practice. The recognition of 'best practice' management acts as a reliever of responsibility should the final outcome fail because of random external factors. Yet another alternative is to announce a repeated payment scheme, where new contracts or contract renewals will be made on a regular basis, subject to strict eligibility criteria. This creates some incentive for landholders to achieve the desired outcomes if they wish to be eligible in subsequent rounds. This also allows for more long-term outputs to be observed, if for instance renewals happen say every three years. Another (as yet untested) idea could be to associate an (auxiliary) insurance contract with the (primary) conservation contract, where the insurer might be the government agency; this would allow some transfer of risk away from the landholder, but at perhaps a prohibitive cost to the agency. Lesourd and Schilizzi (2003: chapter 7) show that indeed, for several reasons, environmental risks are not always insurable.

The authors of this report are working on a more general solution to this payment problem in the case of a single environmental output, such as number of birds or ground water nitrate pollution. The context is that of a conservation-oriented contract

to be put up for tender in a competitive auction, and the problem is one where the disadvantages of payments made solely on the basis of either effort or outcome are to be overcome, or at least minimised.

Mainly because of the problem of unobservability of environmental outcomes and the risks of litigation linked to unclear landholder responsibility, it appears preferable, for the time being and until some general guidelines have been worked out, to stick to effort based-payments. These can be modulated using ad hoc schemes such as those mentioned above. However, improvements in knowledge (for example, new technology that allows lower-cost monitoring of specific environmental outcomes) may enable conservation agencies to base at least part of their payments on output.



## 4. CONSERVATION AUCTION DESIGN

Having reviewed conservation contract design in the previous section, we now turn to conservation auction design. Auctions can be regarded as a trading mechanism and analysed from a design perspective – that is, how these markets can be designed in such a way that they achieve specific outcomes. Outcomes commonly sought in conservation auctions are allocative efficiency, i.e. selection of participants with the highest benefit-cost ratio, and budgetary cost-effectiveness – that is, buying the most conservation benefit with a given budget of public money. We first review basic auction forms (section 4.1) to establish a benchmark for appreciating the complexity of conservation auctions. We then review the relevant theory and provide an overview of the characteristics of conservation auctions (section 4.2). Finally, we consider the design options one by one and assess the impact of different auction designs on bidding behaviour and auction outcomes (section 4.3). This section also includes an assessment of alternative bid evaluation systems and a discussion of whether conservation agencies should reveal information on bid evaluation to bidders.

### 4.1 Basic auction forms

There are essentially four basic auction forms: English, Dutch, first-price sealed-bid and Vickrey (Chan et al., 2003). These were initially designed as selling auctions but can also be run as procurement auctions.

- **English auctions** are open auctions with an ascending outcry format. The price is successively raised until one bidder remains. Bidders bid so long as the current price remains below their own valuations. As the price is raised, bidders successively withdraw from the auction in order of their relative valuations. The good is sold to the last remaining (highest-valuation) bidder at a price just above that which sees the second last bidder withdraw from the auction. The dominant strategy is to bid one's own valuation. Bidding above valuation involves the risk of winning the auction and having to pay more than one's valuation. Bidding below valuation reduces the chance of winning. Bids in the English auction thus reveal bidders' valuations.
- **Dutch auctions** are the reverse of English auctions, with bids announced in descending order. A bidder wins by being the first to accept an announced bid and pays that price. The name "Dutch auction" stems from the fact that this auction format has traditionally been used in the Netherlands' flower markets.
- **First-price sealed-bid auctions** require bidders to submit confidential bids to the seller. In contrast to the English and Dutch auctions, bidders cannot observe competitors' bids. The bidder with the highest bid wins and pays that bid.
- **Vickrey auctions** (named after the economist William Vickrey) have a second-price sealed-bid format. The bidder offering the highest bid wins but only pays the price of the second-highest bidder. The price is thus determined by the marginal loser's bid which is beyond the winner's control. Bidders' dominant strategy is to bid their own valuations. Any other strategy would reduce a bidder's potential gain from the auction. Bidding below valuation reduces the chance of winning the auction as it involves the risk of a bidder's bid being topped by someone else's. Conversely, bidding above one's own valuation may increase the chance of winning the auction, but the bidder may end up paying

more than his or her own valuation for the good acquired. As in the English auction, bids in the Vickrey auction thus reveal bidders' valuations.

Bidding strategies in the Dutch and the first-price sealed-bid auctions can be characterised as Nash equilibria. Unlike in the Vickrey format, a bid determines not only the chance of winning but also the payment required if the bidder wins. There is thus no dominant strategy to bid one's own valuation. Instead, bidders form expectations about rival bidders' valuations and bid just high enough to win. Each bidder determines a bid as if an own valuation is the highest among all of the bidders' valuations. With this expectation, a bidder's preferred strategy is to estimate the next highest valuation among competing bidders and bid that value estimate. The Dutch and first-price sealed-bid formats thus require some guesswork on the part of bidders in order to determine their bids. This may lead to unstable auction outcomes. Assuming however, that bidders are not boundedly rational and make no systematic error in this guesswork, the winner is the one with the highest valuation.

We may therefore conclude that all auction formats select the bidders with the highest valuation (provided these bidders are fully rational). This is tantamount to saying that the allocation of goods through all auction formats is economically efficient: there will be no incentive after the auction to reallocate the traded good among bidders: none of the losing bidders would be willing to offer a price that would top the winner's valuation.

There is another outcome property of the basic auction forms that is worth mentioning: under a set of assumptions (listed in Box 1), all basic auction forms yield the same price *on average*. This is known as the Revenue Equivalence Theorem. This is not to say that every individual auction achieves the same price, but if the basic auction forms were repeatedly used to sell a good to a given number of bidders with stable valuations, they all produce the same average revenue. If the assumptions behind the Revenue Equivalence Theorem do not hold, particular auction formats may emerge as superior (Chan et al., 2003).

<b>Box 1: Assumptions of standard auction theory</b>
<ul style="list-style-type: none"><li>• The auction sells a single item</li><li>• Independent private values: Each bidder has a valuation of the traded good that is unknown to the seller and rival bidders and that is not influenced by others' views (in particular, no resale value).</li><li>• The seller does not know each bidder's exact valuation and perceives this valuation to be drawn randomly from some probability distribution. Likewise, bidders have prior knowledge about the probability distribution of rival bidders' valuations, but not about competitors' exact valuations.</li><li>• Symmetric bidding: The probability distribution of valuations is identical for all bidders.</li><li>• Competitive bidding: All bidders enter the auction with the intent to win and know the number of rival bidders. There is no collusion and bidders do not have the ability to influence market demand.</li></ul>

## 4.2 Characteristics of conservation auctions

It is obvious that auctions for conservation contracts do not fit any of the basic auction forms discussed in the previous section. Nor do they meet all of the assumptions listed in Box 1. Standard auction theory therefore offers little guidance for the design of conservation auctions. Conservation auctions differ from the basic auction forms in many respects:

First, conservation auctions are **multi-item procurement auctions**: government seeks to purchase (rather than sell) multiple units (rather than a single unit) of the conservation good under consideration. A conservation auction selects numerous landholders to take part in conservation, and each landholder can bid for a different activity level. Auction theory is well developed for single-unit selling auctions, but less so for multi-unit procurement auctions.

Second, the items being traded in conservation auctions are **heterogeneous**. Different parcels of land have different conservation value, implying that a hectare of land offered for conservation in one resource setting may be valued differently from another hectare of land under a different resource setting. Benefits vary across landholders because the same conservation activity performed on different parcels of land can deliver different conservation benefits. Landholders thus effectively bid on price (payment) *and* service quality.

Matters are complicated by the fact that bids may contain more than one dimension of quality. For example, a conservation scheme may target pollution control, biodiversity conservation and carbon sequestration. As these attributes come in different units of measurement, the agency needs to determine weights reflecting their relative preferences for the different attributes. The appropriate way to address the heterogeneity of bids is to devise suitable bid selection rules which combine price and quality attributes into a score for each bid (see section 4.3.6 – bid evaluation systems – for details).

Further complexity may arise from the presence of synergies in conserving adjacent areas: a parcel's conservation value may increase if adjacent parcels are also put under conservation management. Ways of capturing such synergies are discussed in section 4.3.5.

Third, conservation auctions are usually set up as **repeated auctions** in that tenders for the same contracts are invited in a sequence of bidding rounds. This may allow bidders to learn from the outcomes of previous bidding rounds and use this information to update their bids. The risk of this happening is quite high in 'networked' industries such as farming, where information is spread quickly through the efficient communication networks of producer organisations or lobby groups. One important design challenge is to contain the scope for bidder learning, as well as that of collusion, which can be correlated (see section 4.3.4 for details).

Fourth, there is the choice of carrying out the auction with a **fixed target** or, alternatively, with a **fixed budget**. In the first case, the number of contracts or hectares of land to come under contract is decided upon and known; the risk is with what it might end up costing. In the second case, it is the reverse: the budget is decided upon and is known; the risk is with the number of contracts or hectares that might not come under contract, that is, with the degree of effectiveness of the policy. It seems that target-constrained auctions are used where government cannot fall short of its objectives, as is typically the case with military procurement programmes. In the field

of environmental policy, governments' use of the budget-constrained auction probably reflects their general political priorities. As a result, budgets are usually given for environmental procurement programs. This poses a problem to the extent that auction theory has been well developed for target- constrained (TC) auctions, but less so for budget-constrained (BC) auctions (Müller and Weikard, 2002). As a result, there is a gap between what is understood by economic theory and what is common practice.

Fifth, there is the choice between **different payment formats**. In the *discriminatory format* (the most commonly used), each bidder is paid an amount equal to his actual winning bid (or, if more than one unit is offered, the sum of his or her actual winning bids). In a *uniform-price auction*, all units sold earn the cut-off price – either the highest accepted or the lowest rejected bid. Therefore, infra-marginal winners receive payments that are higher than the opportunity costs implied in their bids. This does not necessarily mean that the uniform price auction is less efficient, given that bidding strategies are then different; namely, this form of auction contains incentives for bidders to bid their true opportunity costs (see section 4.3.1 for details).

Sixth, the conservation agency is free to set an explicit **reserve price**. In the procurement case, a reserve price is an upper limit on the amount the agency is willing to pay for a unit of the conservation good being traded. This can be pre-announced or not. It is useful to distinguish between explicit and implicit reserve prices. The first is actively set by the auctioneer to enhance bidding competition. The latter is determined in the bid selection process for budget-constrained conservation auctions. In this auction format, bidders are normally selected in order of their bids (or some benefit/bid ratio) until the budget is exhausted. The last winning bidder determines the cut-off price for the auction. This cut-off price may be interpreted as an *implicit* reserve price in the sense that it is not actively and intentionally set by the auctioneer; it rather is determined residually by the rules of the auction.

The design characteristics discussed above are summarised in Box 2 together with a number of other descriptors characterising bidders and the management of information by the auctioneer. The next section explores the scope of auction design for addressing the issues raised in this section.

**Box 2: Conservation auction descriptors**

<u>CRITERIA</u>	<u>AUCTION CATEGORY DESCRIPTORS</u>	
Timing	One-shot	Repeated
	Simultaneous	Sequential
Items	Single	Multiple
	Identical (homoegeous)	Different (heterogeneous)
Auction type	Target-constrained	Budget-constrained
	Open	Sealed-bid
	discriminatory	uniform price
Reserve price	With R.P.	Without R.P.
<u>CRITERIA</u>	<u>BIDDER DESCRIPTORS</u>	
Value type	Independent private value (IPV)	Common value
	IPV – Affiliated	Pure – Almost
Bidder numbers	Fixed	Variable
	Known	Uncertain
Bidder info	Symmetric	Asymmetric
	Risk neutral	Risk averse
	<i>for sequential &amp; repeated auctions:</i>	
	No learning	Learning
Bidder strategy	No collusion	Collusion
	No gaming	Gaming of auction
<u>CRITERIA</u>	<u>AUCTION INFORMATION DISCLOSURE BY AUCTIONEER</u>	
Announce	Winning bid or bids	or not
	Reserve price	or not
	Best estimate price forecasts	or not

Source: Hailu and Schilizzi, 2004 © *Australian Journal of Management*

### 4.3 Auction design to achieve specific outcomes

In this section we consider the design options outlined above one by one and assess the impact of different auction designs on bidding behaviour and auction outcomes. As indicated above, auction theory is not well developed for conservation auctions and thus offers little guidance for the design of such tendering mechanisms. Most analyses therefore have relied on economic experiments, numerical simulations or, simply, intuition and economic reasoning. Where theory is available, we will review it and summarise the implications.

#### 4.3.1 The choice of payment format: discriminatory or uniform pricing?

The payment format specifies the way of determining contract payments on the basis of bids. It is important to understand that different payment formats induce different bidding behaviours. There are essentially two possible payment rules that can be used to auction multiple contracts in a procurement setting:

- (a) a discriminatory (first-price) sealed-bid tender where the  $n$  lowest bidders are accepted, receiving the payment stated in their bids, or
- (b) a uniform-price sealed-bid tender, sometimes referred to as strike price auction, where all successful bidders are paid the price of the highest successful or, alternatively, the lowest rejected bid. The latter format (based on the lowest rejected bid) is referred to in the literature as a generalised Vickrey procurement auction (e.g. Hailu and Thoyer, 2005a) because successful bidders

are paid the price of the lowest unsuccessful bid. When there is a single unit to buy, then the generalized Vickrey reduces to a classical second-price sealed-bid procurement auction.

For uniform pricing, the choice between the highest accepted bid and the lowest rejected bid has implications for bidding behaviour and auction outcomes (Hansen 1988; Milgrom 1989). Practical differences between these alternative rules depend on landholders' cost profiles, the degree of bidding competition and the agency's budget. These differences have been studied in some detail by Hailu and Thoyer (2005a) using an agent-based model to overcome analytical intractabilities. Their results include the more general case when bidders (e.g. farmers) are allowed to put up bid-quantity schedules rather than a unique bid-quantity combination<sup>4</sup>. Their results have been summarised in table format in Appendix 4.

The discussion below abstracts from the different ways of setting a uniform price and focuses on major differences between discriminatory pricing and uniform pricing in the case where bidders offer only one bid-quantity combination, rather than a whole schedule of such combinations. We also implicitly refer to a budget-constrained rather than a target-constrained auction, insofar as the former are nearly always used for conservation contracts.

### *Impact on bidding strategies*

The main difference between discriminatory and uniform pricing is its impact on bidding strategies. Under the *discriminatory format*, a landholder's bid determines both the chance of winning *and* the price received for selected activities. Bidding strategies are characterised as Nash equilibria in as much as bid formation depends not only on a bidder's own cost of conservation activities but also on his or her best guess of what the highest acceptable unit bid (or price) might be. This creates room for bidders to shade their bids above their true opportunity costs and thereby to secure themselves an information rent. (The detail of how this happens can be seen by reading Appendix 2.) The optimal bidding strategy in a discriminatory auction thus is one of overbidding: the auction will not reveal bidders' *true* opportunity costs. This is truer of low-cost bidders than high-cost bidders. In fact, overbidding is highest for the lowest-cost bidders, whereas the highest-cost bidders will bid closest to their true costs (though still marginally above) (Latacz-Lohmann and van der Hamsvoort, 1997; Hailu, Schilizzi and Thoyer, 2005). However, these highest-cost bidders are not those that are usually selected; rather, the lowest-cost bidders are, but they get paid well above their true costs. It is important to understand that this is due to the incentives inherent in this type of auction.

Under *uniform pricing*, by contrast, a bidder's (unique) bid *only* determines the chance of winning but *not* the payment received. Bidders' dominant strategy thus is to bid their true opportunity costs. Any other strategy would reduce a bidder's potential gain from the auction. Shading bids above opportunity costs involves the risk of a bidder's bid being undercut by someone else's, thus reducing the chance of winning the auction. Conversely, bidding below one's own costs may increase the chance of winning the auction, but the bidder may end up being paid less than his or her income

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<sup>4</sup> That is, instead of bidding £1000 just for a 10-hectare conservation service, they are allowed to also bid £500 for a 5-ha service and £2000 for a 20-ha service, in the case of a linear suite. Their bid is thus (5: 500; 10: 1000; 20: 2000). They could also bid a continuous supply function, such as (for the linear case) £100 per ha up to a maximum of say 50 ha.

forgone from carrying out the specified conservation activities. As in the standard Vickrey auction, bids under uniform pricing rules in the (simple-bid) multiple-unit case can thus reveal bidders' true opportunity costs. As bidders are usually not fully rational, such revelation will not be perfect, but it will be fairly close. If cost revelation is the over-arching priority, and perceptions of fairness are not a political issue, then the implication is to use uniform-price auctions.

#### *Impact on payment*

Theory provides little guidance to tell which of the alternative pricing rules can generally yield greater budgetary cost-effectiveness. The rationale for using the uniform pricing rule is that it offers incentive for bidders to enter very competitive (i.e. low) bids in the hope of increasing their chances of being selected, but on the other hand, under this system successful bidders stand to receive more than the value of their bid. Consider Figures 2A and 2B for a comparative assessment of the cost-effectiveness of the two payment formats under a fixed budget constraint.

With uniform pricing, bids are *in principle* (if bidders are fully rational) equal to bidders' true opportunity costs, and winners are paid a price equal to the lowest rejected bid. This *strike price*,  $p_U$ , is determined by the auction outcome. In Figures 2A and 2B, the agency budget thus is reflected by the area  $p_U \times X_U$  (or  $OECX_U$ ), where  $X_U$  is the units of service which can be bought within the budget. Budgetary cost-effectiveness under uniform pricing ( $CE_U$ ) thus is:

$$CE_U = \frac{\text{Budget outlays}}{\text{Units of service bought}} = \frac{p_U \times X_U}{X_U} = \frac{\text{area } OECX_U}{X_U} = p_U$$

Figure 1A: Cost-effectiveness of uniform pricing (UP) versus discriminatory pricing (DP) when UP is less cost-effective than DP in a budget-constrained auction: areas  $OECX_U = OABX_D$ , but  $X_U < X_D$

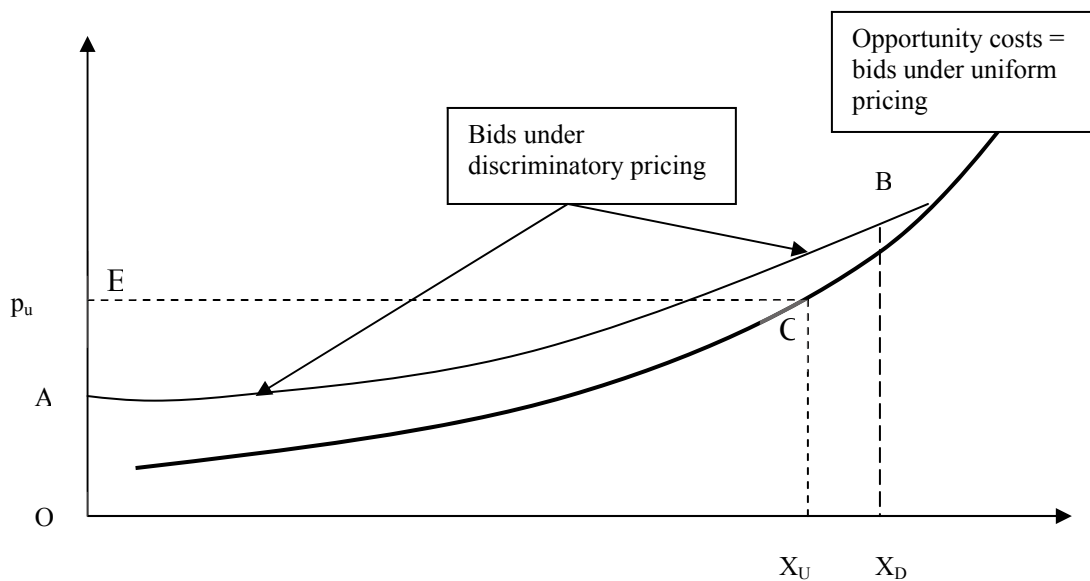
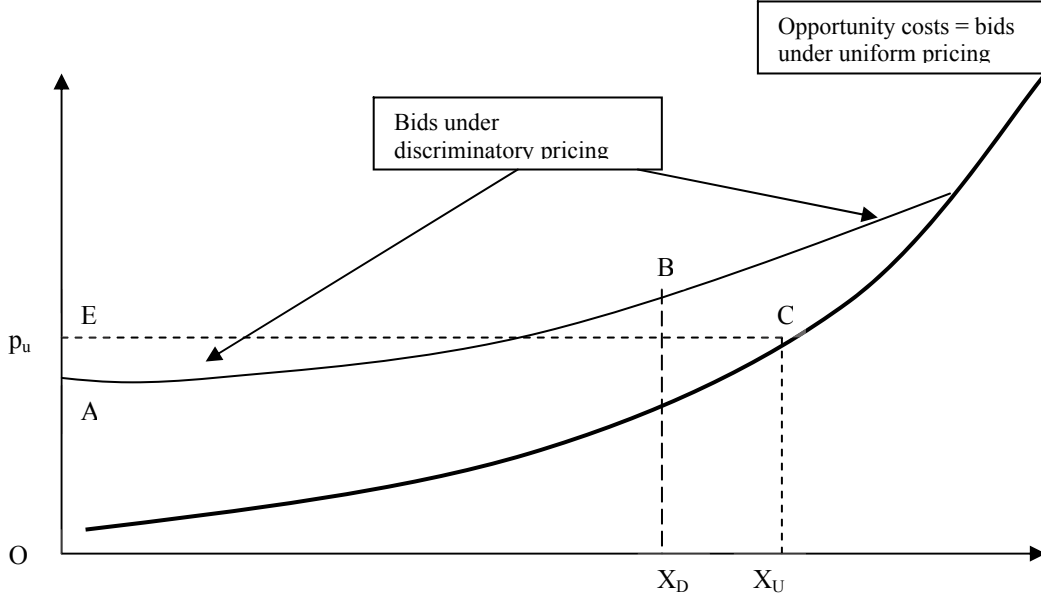


Figure 1B: Cost-effectiveness of uniform pricing (UP) versus discriminatory pricing (DP) when UP is more cost-effective than DP in a budget-constrained auction: areas  $OECX_U = OABX_D$ , but  $X_U > X_D$



Under discriminatory pricing, bidders shade their bids above opportunity costs as shown by curve AB. Budgetary cost-effectiveness ( $CE_D$ ) thus is represented by the area underneath the bid curve AB divided by  $X_D$ , the units of service bought under discriminatory pricing:

$$CE_D = \frac{\text{Budget outlays}}{\text{Units of service bought}} = \frac{\text{area } OABX_D}{X_D}$$

Whether  $CE_D > CE_U$  or vice versa is an empirical question. Figure 1A has been drawn such that the discriminatory pricing format outperforms the uniform pricing scheme: more units of service ( $X_D$  versus  $X_U$ ) are bought with the same budget (area  $OABX_D = \text{area } OECX_U$ ). However, the more bidders shade their bids under the discriminatory pricing rule (resulting in an upward shift of curve AB), the more its advantage diminishes relative to the uniform pricing scheme. This is depicted in Figure 1B. As a result, payment equivalence in multi-item auctions cannot be taken for granted.

Within the empirical literature reviewed, we found no studies that explicitly address the choice of payment format for conservation contract auctions. Instead, lessons are drawn from numerous studies of auctions for selling electricity in electricity markets or financial instruments (for example, bonds). These studies provide mixed results on comparing revenues in multi-item auctions. These are taken here to imply mixed results on comparing payments in auctions of conservation contracts.

- Goswami et al. (1996) explain that bidder communication before an auction facilitates collusive strategies under the uniform pricing rule, but competitive strategies under the discriminatory pricing rule. Their results show that uniform pricing is revenue inferior to discriminatory pricing.



- Tenorio (1993) obtains opposite results, but states that uniform pricing can attract more bidders to participate, thereby increasing bidding competition and auction revenue compared with discriminatory pricing. The above empirical results, obtained from selling auctions, most likely apply to procurement auctions too.
- In a study of the US Treasury experience (selling bonds), Malvey and Archibald (1998) conclude that the uniform price auction will produce greater revenue on average, but at the cost of greater uncertainty in any given one auction. They thus cast the choice between uniform and discriminatory in terms of a mean-variance trade-off in seller's revenue.
- Fabra et al. (2002) extend their search to the more sophisticated auctions of electricity markets in California and the UK, where bidders tender whole supply functions (schedules of quantity price pairs). Their work suggests that the previous recommendations to use discriminatory auctions depend on the fact that electricity supply functions were modelled in a continuous manner, and that when a more realistic discrete, multi-unit auction model is used instead, the ranking in terms of social welfare of uniform versus discriminatory auctions becomes inherently ambiguous.

From the above studies, there seems to be no general clear-cut answer to the question about which pricing rule should lead to higher budgetary cost-effectiveness in conservation contract auctions. Given this conclusion, emphasis should be given to practical considerations in choosing the appropriate payment format.

#### *Practical considerations*

While uniform pricing looks potentially attractive in theory, it has a number of potential drawbacks in practice.

1. It exposes bidders to greater risk in as much as not only the acceptance probability is unknown but also the value of the bid. If landholders are risk-averse, greater risk may act as a deterrent to participation. This contradicts Tenorio's (1993) observation that uniform pricing can attract more bidders to participate.
2. Owners of the least productive, marginal land (and low opportunity costs) would benefit disproportionately from the higher price. The strike price reflects the amount of compensation required by operators of more productive land. This price clearly overcompensates those who farm marginal land, creating the impression that landholders are 'overpaid'. By contrast, discriminatory pricing has the popular appeal of not paying landholders more than what they bid at auction.
3. Uniform pricing may discourage farmers with productive land to participate because they do not anticipate any realistic chance of being selected. There is also an equity argument here: efficient farmers may find it 'wrong' that their less efficient colleagues with marginal land receive the price deemed appropriate for the efficient farmers. This may act as an additional deterrent to participation.
4. Uniform pricing is more complex and more difficult to comprehend than the discriminatory pricing rule. This may act as a barrier particularly to those who

are not familiar with bidding situations. On the other hand, it may increase the risk of collusion from the few who do understand the rules and are able to spot loopholes.

As a result, the choice between discriminatory and uniform price auctions remains a controversial one, dependent on the specific implementation context. However, on balance, the discriminatory payment format appears to be the more appropriate payment rule for conservation auctions, except when there are reasons to believe that bidders will considerably shade their bids (as in Figure 1B). This is likely to happen when the information asymmetry is very substantial and the agency knows it has a very wide knowledge gap compared to bidders; that is, it knows very little about their production conditions. In the limit, however, especially if collusion is expected, an auction should not even be considered.

#### **4.3.2 Reserve prices and reserve quantities**

A reserve price strategy is a key element of auction design. McMillan (1994) attributes the failure of the New Zealand spectrum rights auction to the lack of a reserve price. In that second-price auction, the winner bid NZ \$7 million but paid the runner-up's bid of NZ \$5,000. This outcome could have been avoided had the government set a minimum reserve price that the winner had to pay. In the context of conservation auctions, a reserve price is an upper limit on the amount the conservation agency is willing to pay for a unit of the conservation good being traded. This can be pre-announced or not. There are two potential reasons why conservation agencies should consider setting a reserve price.

First, a reserve price adds to the risk that bidders might lose an auction by bidding too high. It thus increases bidding competition, enabling the auctioneer to capture some of the information rent that would otherwise accrue to the winning bidders.

Second, it may act as a signal of the agency's (or society's) maximum willingness to pay for conservation services, thus representing the demand side of the 'market' in countryside benefits. The benefits of a contract and society's valuation of these benefits raise the question about whether it is worth acquiring the next unit of conservation services. Put differently, demand-side considerations require the conservation agency to take an explicit stance about when the price associated with a contract is considered 'too high' and therefore should not be successful. Viewed in this way, a reserve price can be regarded as a kink in society's demand curve for environmental benefits: at prices above the reserve price, demand is fully inelastic, that is, any quantity offered above that price will not be bought. In this way, a reserve price can contribute to an economically efficient allocation of resources in that it prevents the agency from having to buy environmental services at a price that exceeds society's valuation of the benefits.

Under which circumstances should reserve prices be used in conservation auctions? A reserve price should be considered if bidding competition is expected to be weak and if there is risk of bidder collusion. This is the case when the number of potential bidders is small or when bidders learn to 'game' the auction in multiple bidding rounds. A reserve price may indeed be an effective means of combating bidders' learning in repeated auctions. It would serve to transfer funds between bidding rounds to maximise the conservation outcomes in subsequent auctions. Having said that, one must bear in mind that a reserve price limits the winners' potential gain from an

auction. This effect can discourage bidder participation and reduce bidding competition (Levin and Smith, 1994). A reserve price may also be important if one budget was used across several auctions. Then the agency would want to ensure that the highest price paid in each auction was approximately equivalent. If an agency were to allocate contracts at very high prices in one auction relative to another, it could have obtained more biodiversity by redistributing funding from the ‘high-price’ to the ‘low-price’ auction (Stoneham, 2005).

Reserve prices are less important where there is a strict budget constraint (see Myerson 1981, Riley and Samuelson 1981). As indicated above, the cut-off price in a budget-constrained auction may be interpreted as an *implicit* reserve price which is determined residually by the rules of the auction in conjunction with the available budget. Its effect on bidding behaviour is likely to be very similar to that of an explicit reserve price.

Should reserve prices be pre-announced? We are not aware of any research explicitly addressing this question. Experience from the Conservation Reserve Program, however, suggests that reserve prices should not be announced because they may create an anchoring bias: Reichelderfer and Boggess (1998) found that bidders in the Conservation Reserve Program — which is a repeated 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. We believe, however, that where a reserve price *is* used, it is important to communicate to potential bidders before the auction that such a price has been set – without revealing the precise price.

We now turn to a related issue, that of a reserve quantity, rather than reserve price. Where bidders are allowed to submit a bid covering several units of a good (e.g. several hectares of land), and where some bidders can submit a large number of units at a relatively low price, to the point where a bidder’s bid represents a large fraction of the total available budget, then the government agency can decide to put a lid on the maximum allowable bid. This is what happened (ex post) in the Auction for Landscape Recovery in Western Australia (see section 5 - case studies). One bid represented a very large fraction of the budget, and although the cost per unit area was quite competitive, this bid was not selected. The decision to have a reserve quantity seems to reflect a concern for fairness or equity across landholders, rather than a concern for cost-effectiveness or economic efficiency. It could also reflect a concern for the participation rate in the next round of auctions, if it appears that some landholders may be discouraged from participating.

#### **4.3.3 Target-constrained (TC) or budget-constrained (BC) auctions?**

Conservation auctions can be conducted either with a fixed budget (which is the norm) or, alternatively, with a fixed target. In the first case, the agency accepts bidders based on their benefits to bid ratios until a predetermined fixed budget is exhausted. The size of the conservation scheme in terms of hectares of land enrolled is determined as a residual from the budget and the bids offered. In the target-constrained auction, by comparison, the agency predetermines the size of the conservation scheme and accepts bids until the target is achieved. In this case, the necessary budget is not known before the auction is completed. There are no *a priori* reasons to believe that one auction format is better than the other except, perhaps, that the existence of a budget constraint

may have the psychological effect of ‘disciplining’ bidders, encouraging them to bid closer to their opportunity costs than they might otherwise do.

Latacz-Lohmann and Schilizzi (2005) are the first to set out to investigate the performance of these two auction formats. Given the lack of empirical studies and theoretical guidance, the comparison was made with the use of controlled economic experiments carried out both in Kiel, Germany, and Perth, Western Australia. Both auction formats were submitted to a common experimental setup. The Perth experiment was meant to replicate the Kiel experiment, in order to check for the stability of results. See Box 3 for a summary of the experimental setup.

**Box 3: Setup of the budget-constrained versus target-constrained auction experiments**

The Kiel experiment was carried out with 88 first-year students in agricultural economics. They were divided into two groups, one for each of the two auction formats. The auction setup referred to reductions in nitrogen fertiliser on a wheat crop, in order to meet EU regulations regarding limits to nitrate concentration in groundwater (50 mg/litre). Participants were offered would-be contracts for committing themselves to reduce applications of nitrogen fertiliser from their optimal level down to a predefined constrained level, equal to 80 kg N per hectare. Each participant had a different opportunity cost resulting from the adoption of the nitrogen reduction programme. Participation costs were spread uniformly between €4 (the lowest-cost farmer) and €264 (the highest-cost farmer). Students were told that not all of them would be able to win contracts and that they were therefore competing against each other. To keep things simple, each participant could put up just one hectare of wheat land, the same area for all participants. They were told that if they won a contract, they would be paid the difference between their bid and their opportunity cost. For both groups, three rounds were held, with a few days interval between each. The purpose of this was to investigate the performance of the auction with potential bidder learning. In rounds two and three, exactly the same setup was used, except that bidders knew of their own result in the previous round(s), and successful bidders had been paid their net gains at the end of each session. The Perth experiment was in all points identical to the Kiel experiment, save for a few practical details. The number of bidders was lower in the Perth experiment.

The key findings from the Kiel experiments are reported in Table 1. Very similar patterns emerged from the Perth experiments (not reported here).

The results suggest that the choice of auction format has only a minor effect on outcomes, at least in this setting. The BC auction performs slightly better than the TC auction in the first two rounds: the budgetary costs and opportunity costs per kg of nitrogen abated are lower. However, these differences are minute and are reversed in the third round where the TC auction outperforms its BC counterpart. Note that auction performance under both formats deteriorates significantly with repetition, indicating that bidders have, to an extent, learned to game the auction, shading their bids above opportunity costs. Information rents increase from an average of 37% of payments made in the first round to over 50% in rounds two and three. There appears to be no significant difference between the two auction formats in their robustness to bidder learning.

Table 1: Dynamic BC versus TC auction performance, Kiel

	Budget constrained auction			Target constrained auction		
	Round 1	Round 2	Round 3	Round 1	Round 2	Round 3
Bidders	44	42	40	43	42	39
# of contracts allocated (=hectares enrolled)	30	24	24	30	30	30
Total environmental gain (kg N abated)	1944	1377	1426	1995	1855	2309
Total payments (€)	4080	3957	3828	4482	5559	5816
Total opport. costs (€)	2596	1692	1777	2750	2421	2776
Profits = info rents (€)	1484	2265	2051	1732	3138	3040
Info rents % of paymts.	36,4	57,2	53,6	38,6	56,4	52,3
Return to budget (€/kg N abated)	2,10	2,87	2,68	2,25	3,00	2,52
Auction efficiency (= opportunity costs per kg N abated)	1,34	1,23	1,25	1,38	1,31	1,20

Source: Latacz-Lohmann and Schilizzi (2005)

We conclude that there are no strong reasons to suggest the preferred use of one of the two auction formats. Both perform equally well as one-shot auctions and under repetition. Practical considerations, however, call for the preferred use of the budget-constrained auction: it is the more ‘natural’ format in the environmental area where schemes usually have a limited budget and EU regulations limit the degree of overcompensation of farmers’ opportunity costs. A target-constrained auction may be called for in situations where the agency cannot fall short of its environmental objectives.

#### 4.3.4 Dealing with bidder learning in repeated auctions

Auctions for conservation contracts are normally designed as multiple-signup, or repeated, auctions where bids for the same contracts are invited over a sequence of years. Such a system provides scope for bidders to analyse the results of preceding bidding rounds and use this information to update their bids. Experience with the Conservation Reserve Program in the US has shown that after a few bidding rounds the average bid was almost exactly equal to the maximum acceptable payment level from preceding rounds, implying that farmers had learned the cut-off points (Riechelderfer and Boggess, 1988). Under no circumstances should the conservation agency therefore publish information about the average or the maximum accepted bid or the distribution of bids received in preceding bidding rounds. *An auction is a mechanism in which the distribution of information between buyer and seller plays a crucial role.* The benefits of auctions decline with the amount of information shared by the two parties.

A potential remedy to the problem of learning is to amend the rules of the auction in each bidding round. This would make the system less predictable, thus maintaining a certain degree of uncertainty among landholders. This could be achieved by targeting different groups of farmers or different regions, by changing the criteria for bid selection, by introducing different cut-off for different farm types or production systems. Whether these changes should be announced to potential bidders prior to the

commencement of bidding is a controversial question which will be discussed in greater detail in section 4.3.7. In any case, the use of reserve prices is advised in multiple-signup auctions.

Another approach to the problem is one which has been implicitly used in the Countryside Stewardship Scheme (in Scotland: Rural Stewardship Scheme). Instead of asking landholders to submit a financial bid over a pre-specified contract of activities, they can be asked to choose among a menu of possible activities and indicate those which they are willing to implement for a given, pre-determined price as well as the level of each activity (time, area, effort). In this approach, which has not lead to any theoretical analysis as yet, landholders effectively bid on quantity rather than price. They thus submit management plans indicating the conservation activities they are willing to implement for a given per-hectare payment. The bid thus is not financial but takes the form of management commitments. A ranking system is applied to translate management commitments into expected conservation benefits. A total ranking score is computed based on the conservation benefit likely to be delivered by each proposal. Thus, the more conservation activities a bidder chooses from the menu at a given price, the higher his or her chance of securing a contract. The reason why learning would be more difficult and slower is that instead of having to learn a single bid price (say, a per-hectare rate), bidders must now learn a whole list of activity levels and identify combinations of different activities and their respective minimum levels sufficient to secure a contract (Latacz-Lohmann and van der Hamsvoort, 1998).

#### **4.3.5 Capturing conservation synergies**

As indicated above, the value of a conservation contract to the agency may increase if nearby lands are coming under conservation management at the same time. We call this situation ‘site synergies’. This is the case with catchment programmes and with the establishment of vegetation corridors for the movement of species across the landscape and regional biodiversity enhancement. Very often geophysical or ecological characteristics of the land are the sources of synergies. For example, creating favourable conditions for rare wildlife species normally requires a co-ordinated effort by many landholders in the area. The higher the ratio of land area to land perimeter, the greater is the potential for generating conservation benefits. Likewise, conserving a wetland requires all adjoining land to be put under conservation management. For each of the adjoining lands, conservation benefits are affected by any adverse use on the other lands. In economic jargon, such boundary symmetries may be interpreted as increasing returns to adoption of conservation management. Present policies do not take account of site synergies because they concentrate on contracts between government agencies and *individual* landholders.

The presence of site synergies requires auction design refinements. If the agency’s goal is to attain allocative efficiency, it may wish to encourage all pertinent landholders to participate in an auction so that bids with synergetic values are accepted together. However, this bid selection rule exposes landholders to the double uncertainty of winning a contract and being able to realise the synergetic value (if any) of their lands. Since the latter depends on neighbours’ entry and bidding strategies, individual bidders may not consider site synergies when determining their bids. Their bids will then only depend on their own activity costs and benefit contributions, but not on neighbours’ benefit contributions. These contingencies expose the agency to the risk of making high payments to individual landholders without realising full synergy

values from contiguous lands if neighbouring landholders do not all win in an auction — for example, where landholders in a watershed do not bid for contracts because they are not aware of the synergies with surrounding lands or because high costs diminish their chance of winning (Chan et al., 2003).

To capture site synergies, the conservation agency needs to look beyond the design that allows only separate bids from individual landholders. One solution is to allow neighbouring landholders, or indeed a consortium of landholders in a particular region, to submit joint bids that cover sites belonging to different holdings. Such an arrangement would make bidding more flexible for landholders to the extent that they can choose to bid for conserving their own lands or make joint bids with others, or both. Landholders who submit a joint bid have the local knowledge to decide among themselves how best to share effort and payments among their members, thereby helping the agency with the funding decision (Chan et al, 2003).

The efficiency and payment properties of joint bidding are barely explored in the literature and detailed auction rules are yet to be developed. A potential problem is lack of bidding competition. If there are only a handful of conservation consortia competing against each other, there is scope for collusion. Also, transaction costs of joint bidding are likely to be high and, to the extent that these are upfront costs, may act as a deterrent to participation. Moreover, the feasibility of making long-term agreements with multiple parties would need to be explored before joint bidding can be put into practice. Auction theory has not been extended to this particular circumstance and cannot therefore offer useful guidance for the design of joint bidding schemes. The outcome properties of joint bidding schemes would need to be explored through appropriately designed economic experiments, before such schemes can be recommended for practical use. To the authors' knowledge no such experiments have been reported in the literature.

Another unresolved issue is how best to provide incentives for landholders to act together. Stoneham (2005) suggests that the conservation agency could score bids contingently: landholder *A*'s score would be greater if he or she were successful in conjunction with landholder *B*. This would have to be communicated to potential bidders before bidding commences. Since landholders cannot be expected to be aware of conservation synergies, it is important to provide information to those landholders that they were providing synergy benefits. In the Scottish context, this may be relevant to the Rural Stewardship Scheme, particularly its Common Grazing measures. A more complex approach would be to provide some financial incentive that was associated with the synergy (Stoneham, 2005). Economic experiments would have to be carried out examining the appropriate structure of such incentives before they can be recommended for practical use.

#### **4.3.6 Bid evaluation systems**

The choice of an appropriate bid evaluation system is a key design issue. The main purpose of bid evaluation is to incorporate information on conservation benefits in an auction. As discussed above, conservation benefits often depend upon the resource setting. Matters are complicated by the fact that bids usually contain more than one type of conservation benefit.

The conservation agency can enhance the efficiency and cost-effectiveness of the auction by tailoring bid selection methods for different regions or different resource

settings, thereby accounting for spatial variations in the potential for delivering conservation benefits. There are essentially three policy design variables that can be used for targeting conservation auctions: eligibility criteria, bidding pools, and bid discrimination mechanisms. These are considered in turn below.

### *Eligibility criteria*

Eligibility criteria are an *ex ante* instrument for excluding landholders with resource settings which are deemed to generate insufficient environmental benefits if put under conservation management. *Ex ante* means *before* bids are submitted or landholders apply for the scheme. By contrast, bid selection criteria are *ex post* instruments, which become operative at the time landholders have submitted their bids.

Eligibility criteria can relate to any aspect or characteristic of the resource setting (e.g. soil type, proximity to water bodies, hydrological conditions), the activities carried out on the land (e.g. only pasture or only arable land) or its owner (e.g. level of education, age, other demographic characteristics). They can also relate to the environmental objectives pursued by the scheme (such as particular species targeted). For example, eligibility for the US Conservation Reserve Program is limited to land classified as highly erodible.

Eligibility criteria are an effective means of directing funds towards specific groups of landholders and resource settings – those who are deemed to contribute most to the scheme's objectives. Their use is advised in particular when service quality cannot be precisely measured or if the agency is unable to verify service quality after auction. Eligibility criteria constitute certain quality thresholds that bidders are required to pass before submitting bids.

However, there are two economic criticisms of this approach. The first is that activity-based eligibility criteria may create perverse incentives for landholders to change their land use activities (e.g. convert grassland into arable land if only arable land is eligible) in order to become eligible in future bidding rounds. The second criticism is that eligibility criteria reduce the number of potential bidders. This may affect bidding competition or increase the risk of collusion. From a bidding point of view, a system that allowed everybody to bid and then discriminated through bid selection criteria would be preferable. Finally, there is an equity issue. Ineligible landholders may find it unjust or inequitable to be denied the chance of participating in the scheme.

### *Bid pools*

Another way of increasing the cost-effectiveness of conservation management is to use bidding pools. This is a useful exercise if the cost of implementing the stipulated conservation measures varies widely between different farm types, production systems, soil types, regions, etc. If for example, it is known that arable farmers face significantly higher costs of conservation management than dairy farmers, one may assign bids to two separate bid pools, one for arable farmers and one for dairy farmers.

The conservation agency would expect bids from arable farmers to be higher on average and would accept bids up to a higher level than in the dairy farmer pool. Such a system effectively limits competition between different farming sectors and encourages farmers with higher opportunity costs to tender bids. This system is particularly useful if it is intended to attract a balanced mix of land and farm types into the scheme rather than 'buy' a large share of the least profitable land (which may not



be the land that generates the greatest environmental benefits). A potential disadvantage of bid pools is that they can reduce the number of bidders (in each category) to an extent that bidding competition suffers.

#### *Bid discrimination mechanisms*

The agency selects bids by comparing payments either to activity levels or expected conservation benefits. Activity-based bid selection must be used if the transformation function that maps conservation activities into environmental outcomes is not well known. In the simplest case, bids are compared simply in terms of payment per unit area of land. In the absence of any information on the transformation function, land area is taken to represent activity level, which is a proxy measure for the amount of conservation benefits. In other cases, benefit indicators can be used to quantify site-specific effects of conservation activities.

For example, in the Australian Bush Tender pilots, expressions of interest were first called for from eligible landholders; then government officers visited the farms and the proposed land areas up for tender. Ecological data were collected on these areas and analysed by scientists to compute a Biodiversity Benefits Index (BBI).<sup>5</sup>

Bid selection can be a complex task if multiple objectives are pursued or if bids contain multiple dimensions of quality. The agency not only faces the challenge of measuring the various quality attributes, it also needs to determine weights reflecting its relative preferences for the different attributes. The relationship between these attributes or objectives can be complementary, competitive or neutral. If there is a competitive relationship between objectives or quality attributes, tradeoffs must be made – higher achievement of objective A means that less of objective B is achieved, and vice versa.

To take account of such complications, a multi-criteria bid scoring system can be used to aggregate the various dimensions of quality into one figure representing an estimate of the overall conservation benefit of each bid. These aggregate measures of conservation value draw on environmental assessments conducted by ecologists and are limited by whatever data a conservation agency is able to collect. Aggregation methods differ mainly in the choice of relative weights for individual benefit variables. Examples include the biodiversity quality (BQ) index used in the BushTender pilots and the environmental benefit index (EBI) currently used in the Conservation Reserve Program. The BQ index is the product of the biodiversity significance score and the habitat services score. The first factor measures current conservation value and the second measures activity level. Bids are ranked by the ratio of the BQ index to the payment. The EBI ranks bids according to their contribution to each of the six programme objectives. Bids are assessed on the basis of indicators (proxies) which relate either to certain observable attributes of the land (such as proximity to water bodies or to erodibility) or to certain land management practices (such as land cover type). Each attribute or land management practice carries a score. This scoring rule allows the multiple attributes of quality to be aggregated into one figure which can then be compared to payments.<sup>6</sup>

Box 4, quoted from Chan et al. (2003), depicts the structure of the bid selection problem in a multidimensional auction.

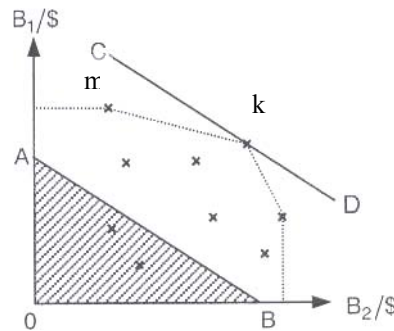
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<sup>5</sup> The BushTender pilots are reviewed in greater detail in the case studies section of this report.

<sup>6</sup> The CRP bid selection procedure is described in the case studies section of this report.

**Box 4: Selecting productive, effective conservation activities**

Consider two types of conservation benefit, B1 and B2. The following figure measures these benefit variables divided by project cost along the corresponding axes. Each cross point represents a project of activities undertaken by a landholder.



The dotted envelope (called the frontier) indicates the most productive, effective projects in terms of achieving conservation benefits relative to activity costs. The agency applies a set of weights to derive an aggregate measure of the conservation benefits. Relative weighting is indicated by the slope of lines such as AB and CD, which gauge the agency's overall valuation of benefits for individual projects.

Line CD identifies project(s) that yield the highest level of conservation benefits per dollar of funding. Line AB eliminates projects within the shaded area that are deemed to provide too little conservation benefits relative to their costs. Line AB indicates the agency's reserve price for the conservation benefits, because public funds can be better spent elsewhere in pursuits other than conservation.

Source: Chan et al., 2003, p. 53

### *Using Data Envelopment Analyse to rank bids*

One way to estimate a value-for-money frontier as the one shown in Box 4 is to apply Data Envelopment Analysis (DEA) to the quality attributes of the bids so as to compute a value-for-money score for each bid. DEA is a sophisticated approach to measuring and comparing the efficiency of different units where there are multiple incommensurable inputs and outputs. In the public sector, the method has been applied to measure and compare the efficiency of schools, hospitals, government departments, etc.; it has also been extensively used to compare the relative efficiency of farms and industries. Appendix 5 sets out the formal structure of DEA-based bid ranking models.

The DEA approach is tantamount to adopting the landholders' point of view on the weighting function and presenting their bids in the most favourable light in comparison to competing units – rather than applying a common set of weights across all units. For example, a farmer submitting a bid for a parcel of land adjacent to a lake would wish a high weight to be placed on water quality (if this is one of the objectives of the scheme) and little weight on other criteria. Indeed every bidder will wish to place much weight on the quality attributes that his or her bid is best poised to deliver. DEA

thus recognizes the legitimacy of the argument that different units value different outcomes differently and therefore adopt different weights.

DEA effectively constructs a value-for-money frontier as the one shown in Box 4. The frontier has as many dimensions as there are quality attributes. All bids which have been assigned a value of one lie on the frontier and thus offer good value for money. This is not to say that all bids with a score of one will necessarily be selected: the value-for-money frontier does not, in itself, take account of the agency's preferences for different quality attributes. It rather is based on the concept of *technical* efficiency, not taking into account the agency's preference weights for each quality component.

One can easily extend the DEA approach to compute scores that reflect the agency's relative valuation of different quality attributes. This is equivalent to the use of the concept of *economic* efficiency in production economics. Scores are then computed relative to point  $k$  in the figure in Box 4. Point  $k$  not only represents good value for money (because it lies on the frontier), but also offers the mix of quality attributes preferred by the agency, given its preference weights (represented by line CD). Point  $m$  also offers good value for money (it also lies on the frontier) but, to the agency's liking, contains too much of  $B_1$  and too little of  $B_2$ . Applying the concept of *economic* efficiency, it would therefore be assigned a score of less than one (although it still is *technically* efficient, i.e. on the frontier). The concept of economic efficiency thus allows one to include the agency's preference weightings in the bid selection process.

There is standard DEA software (e.g. Coelli et al., 1998) which can easily be adapted to the specific case of bid ranking. The information needed to construct the value-for-money frontier comprises, for each bid, estimates of the different quality attributes and the bid amount. All quality attributes must be readily observable and not subject to manipulation or misrepresentation by the bidders. For all bids not on the frontier, the programme indicates by how much the bid would have to be lowered until it lies on the frontier. In order to take account of the agency's preferences, one can input preference weights (output prices) and click on economic efficiency to come up with appropriate scores for bid selection. Bids are then ranked by these efficiency scores, and the offers with the highest scores would be selected until the budget is exhausted.

DEA is a sophisticated method of bid evaluation. It is less transparent and more difficult to explain to bidders than alternative bid ranking systems. From a practical perspective, it offers the advantage of generating virtually incontestable bid rankings: If a bid turns out to be bad value for money (even when the most favourable weights have been chosen from the bidder's perspective), then there is a strong argument for rejecting the bid. DEA effectively 'polishes' each bid (by choosing optimal weights) before subjecting it to competition with rival bids. This minimises the scope for complaints and appeals by unsuccessful bidders.

Using the DEA technique to weight multidimensional bids was suggested in a study that Latacz-Lohmann (2001) did for the SEERAD auction for decommissioning fishing vessels in Scotland, and it was used in preliminary work analysing the auction data by Schilizzi and Latacz-Lohmann (2005a). Work along these lines is also being carried out by Peter Bogetoft in Denmark (Bogetoft and Nielsen, 2004). Critics may argue that the flexibility in the choice of weights for individual bids may allow a bid to appear good value for money, but that this is to do more with the choice of weights than with the bid's inherent value for money. Policy administrators may also argue that DEA gives away their judgment of the 'right' weights to the bidders. Both criticisms are not tenable if the concept of economic efficiency is applied. This allows the policy

administrators' judgment of appropriate weights to be included in the bid selection process, ensuring that bids which appear to offer good value for money also match the agency's preferences. Another criticism might be that the agency can, after the bids have been put in, manipulate its preference function (i.e. change the slope of the CD line) so as to distort the selection in one way or another. However, the procedure would, even if only ex-post, make such a choice transparent. Whether such information should be communicated ex-ante, that is, in advance, is our next question.

#### **4.3.7 Information hidden versus information revealed to bidders**

Prior to landholders forming their bids, the government agency needs to decide how much information about what it values in the auction it is going to reveal to them. As it happens, the choice is not straightforward, as there are things to be said for and against each option. It is best to quote from a draft report by Stoneham *et. al.* (2005, p.32) regarding their experience with BushTender in Australia:

“One of the most interesting design issues with the BushTender pilot contracts was the extent to which information was made known to landholders prior to formulation of their bids. For the pilot auctions some of the information about the biodiversity metric was withheld from landholders: they knew the Habitat Services Score, which revealed the value of their management actions, but not the Biodiversity Significance Score, which reflected the ecological value and potential of their chosen land plots. As noted earlier, this strategy was supported by the experimental findings of Cason *et al.* (2003). Although the strategy to withhold information was adopted for cost-effectiveness reasons, other considerations suggest that full disclosure of information about biodiversity significance may be appropriate. In the short-run, withholding some information limits the scope for landholders to extract information rents from the auction. Clearly, if a landholder knew that she had the only remaining colony of some plant or animal, she would be able to raise her bid well above opportunity cost, compared with a situation where this information were not known. The alternative strategy also has merit in that (i) the information rents that accrue to landholders would influence land markets and encourage investment in nature conservation; and (ii) landholders would know exactly what scarce biodiversity assets they have and could self-select into the auction process, that is, there may be a better matching between government priorities and the bidders in an auction.”

The choice as to what to reveal to bidders ex ante therefore depends on how the government agency weights its different policy objectives; for instance, the relative weight between short term cost-effectiveness in terms of budget outlay and the longer term investment incentives created for landholders.

Chan *et al.* (2003) argue that the agency's optimal information policy depends upon who holds information about the significance of environmental assets that exist on farm land. On the one hand, landholders can have private information about the environmental impact of their production, such as the potential effects on rare or threatened species on particular tracts of land. On the other hand, the conservation agency can know better than landholders the ecological significance of their lands and the match of policy objectives with land characteristics. We consider both cases in turn.

*Bidders with private information on service attributes*

If bidders hold private information on service quality, transparency in the bid selection process is essential for efficient contracting. The scoring rule and the relative weights put on different quality attributes should be announced to potential bidders. Bidding competition then effectively ranks bidders by their cost structures. The winning bids then reflect the agency's preference ordering, contributing to allocative efficiency. The agency overpays for quality because bidders who offer high quality will tend to shade their bids above opportunity costs, exploiting their information advantage. If however service quality cannot be precisely measured or if the agency is unable to verify service quality after auction, then there is no sense in laying open the scoring rules or indeed in trying to score bids based on service quality. In these circumstances, the agency should require bidders to pass certain quality thresholds (eligibility criteria) before submitting price-only bids (Cripps and Ireland, 1994; Chan et al., 2003).

*Agency with private information on service attributes*

Often the agency has superior information about the environmental significance of certain activities on particular parcels of lands – for example because only the agency has the know how to measure environmental impacts. Furthermore, landholders may not have all the relevant information about government priorities and are unlikely to understand how this information might influence subsequent contracts. In these circumstances, the agency's information policy plays an important role in determining bidding behaviour and auction outcomes.

Box 5 quotes from Chan et al. (2003) two stylised cases to illustrate the importance of the information setting to auction outcomes. Thus, if bidders know their own quality estimates and the agency's preferences, they will strategically avoid price competition and emphasise quality competition, thereby capturing a larger share of information rents. Each bidder effectively chooses to offer a particular mix of service attributes – the one that best matches the agency's preferences. They thus compete directly only with those offering the same quality mix, thereby reducing price competition. By contrast, lack of information on the agency's preferences compounds the guesswork that bidders face in formulating their bids: not knowing the agency's preferences, bidders face increased uncertainty in their own quality assessments. The greater this uncertainty, the less they are able to supply favourable but costly service attributes in order to increase their chance of winning a contract. Price competition becomes the driving force of the auction, preventing bidders from capturing large information rents.

The choice between disclosing or concealing information on the agency's quality assessment rules also has important implications for allocative efficiency, i.e. selection of the participants with the highest benefit-cost (or quality-cost) ratios. If bids are positively correlated with quality-cost ratios, the auction selects low-cost, high-quality participants. This is likely to be the case if bidders are well informed about the agency's preferences and its quality assessment procedures. If, by contrast, bidders are unable to assess the quality of their bids, they have to determine their bids on the basis of guesswork involving random choices. The less bidders are able to assess the quality of their bids, the more their bidding strategies will be driven by strategic motives and randomness, and the less they will be driven by quality-cost considerations, leading to greater efficiency distortions (Chan et al., 2003).

**Box 5: Impact of information setting on bidding behaviour and auction outcomes***Case 1: Symmetric bidders perceiving a strong impact of service attributes on bid selection*

In this scenario, bidders are symmetrically (but not fully) informed of their relative service quality — that is, they know as much as their competitors know about the buyer's preferences for quality. Moreover, they are confident of predicting the buyer's quality assessment. In particular, each of them anticipates the buyer to select one specific mix of service attributes, so links the chance of winning a contract to the supply of that buyer favoured quality mix rather than any low-price service; however, they may make different predictions of the buyer's preferences.

To adopt the mutually profitable strategy, bidders avoid price competition and select their own service attributes in the hope of matching the buyer's preferences. For a given number of bidders, price competition would reduce bidders' expected profits without necessarily improving their chance of winning a contract. Bidders tend to bid close to the buyer's reserve price, expecting profits to vary inversely with costs. As long as bidders expect positive profits, they have little incentive to base prices on costs. Auction outcomes are characterised by subdued competitive pressure on price, high expected profits for bidders, and a large transfer of information rent from the buyer to the winner.

*Case 2: Asymmetric bidders perceiving a weak impact of service attributes on bid selection*

Bidders are asymmetric, in the sense that some are perceived to produce higher service quality than others. Nevertheless, bidders are uncertain about the buyer's way of determining relative quality and so cannot determine whether their own quality assessments match the buyer's preferences. The quality differences perceived by asymmetric bidders are therefore not a reliable forecast of bid selection results. Bidders anticipate their own quality assessments to be imprecise, and so emphasise price competition.

Strong bidders, who are distinguished by the perception of high-quality service, can pre-empt bidding competition by quoting low prices relative to their costs of supplying the perceived superior service quality. This cautious strategy allows them a better chance of winning a contract even if the buyer happens to make an unfavourable assessment of their service quality. Weak bidders, who are perceived to produce low-quality service, quote relatively low prices too. Consequently, price competition drives down the expected contract price, enabling the buyer to gain a large share of information rent.

Source: Quoted from Chan et al., 2003, pp. 69-70.

*Empirical evidence*

Cason et al. (2003) used laboratory experiments to examine bidder behaviour in a discriminatory price conservation auction when the regulator reveals to landholders the environmental benefits estimated for their alternative projects, compared with when this information was not revealed. These experiments indicate that when bidders did

not know the value of output, their bids tended to be based on the opportunity costs of land-use change. By contrast, when bidders were given information about the significance of their biodiversity assets, they tended to raise bids and appropriate some information rents. Total abatement was lower and seller profits were higher when landholders knew their projects' environmental benefits. This performance difference arises from landholders' ability to condition their offers on their projects' environmental quality when the regulator reveals quality information. Sellers in this treatment clearly made higher offers for high-quality projects, since they knew that high quality gave these projects priority in the bid selection process. This strategic incentive to raise bids for high-quality projects also led to greater bid variance in this treatment. As a consequence, some high-quality projects that should be undertaken on efficiency grounds could not be funded within the given budget, so less environmental benefit was acquired through the auction when landholders learned their projects' environmental quality. The authors conclude that concealing quality information will improve regulatory efficiency.

Vukina et al. (2004) arrive at similar conclusions in their analysis of bids from the Conservation Reserve Program (CRP) auctions. The CRP pays farmers to remove land from production and put it to a conservation use. An interesting aspect of these auctions is that winners are determined by a combination of low bids and environmental scores of individual plots (see section 5.2 for details). The results indicate that farmers condition their bids on the strength of their environmental scores and that they consistently value those environmental improvements which are concentrated locally such as reduced soil erosion, while they place less emphasis on those benefits which resemble public goods such as air quality and wildlife habitat.

### *Conclusion*

By concealing information on service quality, the agency may succeed in reducing contract payments and gaining a larger share of information rent. Any payment savings for the agency, however, come at the potential cost of allocative efficiency losses. A trade-off exists between efficiency and cost-effectiveness. Extracting a higher share of information rents from bidders, by itself, achieves little in promoting efficient use of resources.

In a quality-concealed auction, bidders have an incentive to acquire information on quality assessment so that they can avoid price competition and increase their share of information rents. If bidders can infer quality measures from previous auction results, then the agency's information advantage degenerates. As a counter tactic, the agency can secretly alter the weights attached to each dimension of quality from year to year. Bidders will eventually perceive such secret changes in the way of assessing quality to be a source of uncertainty in their quality assessments, encouraging them to submit closer to opportunity costs (Chan et al., 2003).

A reasonable compromise might be to publicise the quality criteria but not the weights attached to individual attributes. On the one hand, knowledge of the package of attributes that the conservation agency intends to purchase is necessary to attract the 'right' landholders and give them some guidance to formulate bids that match the agency's preferences. On the other hand, too detailed knowledge of the criteria and the weights for each attribute may encourage bidders who offer high-quality packages to shade their bids above opportunity costs.

## 5. CASE STUDIES OF CONSERVATION AUCTIONS

This section reviews case studies of conservation auctions covering the USA, Australia, continental Europe and the UK. For each auction, we review the problem addressed, objectives, auction design, auction outcomes, and lessons learned. The schemes reviewed differ in their policy goals, their ways of setting reserve prices and their methods of assessing environmental benefits and ranking bids.

### 5.1 Results of postal survey

We conducted a postal survey of agricultural ministries in the EU-15. We asked respondents whether they were aware of any tendering schemes for conservation contracts in their country. We asked for the name of such schemes, if any, and the contact details of the person who may be able to answer questions about the design and operation of such schemes and experiences gained. We attached a one-page questionnaire specifying the points on which we would like some information. The purpose of the survey was to gauge lessons learned, to identify solutions to limitations and practical difficulties experienced in the running of conservation auctions, and to gauge opinions on ways of increasing the performance of auctions.

We received only two responses, from Sweden and Belgium, stating that no such mechanisms were used in these countries.

### 5.2 Conservation Reserve Program auction (USA)

#### *Problem*

The aim of the CRP is more than just to obtain environmental services from landholders. It also aims to (i) reduce water and wind erosion; (ii) improve water quality; (iii) reduce sedimentation; (iv) preserve soil productivity; (v) improve habitat for fish and wildlife; (vi) curb production of surplus commodities; and (vii) provide needed income support for farmers. These goals are subject to the enrolment of lands for specific environmental policy priorities and in specific regions (Reichelderfer and Boggess 1988). Under this program, landholders receive government funds for retiring their lands from farm production for a period of 10 to 15 years (FSA-USDA 1999). Farmers submit bids to the US Department of Agriculture (USDA) for individual parcels of land, indicating the payment required to take the land out of agricultural production and put it to conservation use.

#### *Design*

Bid selection criteria have evolved over time (Francis 2001; HRSCEH 2000; Osborn, Llacuna and Linsenbigler 1995). Before 1990, bids were compared in terms of dollars *per hectare* of conserved land, implicitly assuming all hectares were of comparable value. All eligible bids at or below a predetermined level were accepted. Such a payment cap was not made public until the auction was completed. Current CRP auctions employ an *environmental benefit index* to compare bids. This index accounts for land quality heterogeneity and weights various environmental objectives according to their relative importance. Figure 2 shows the bid scoring system for the CRP.

The left hand column shows the scheme's six environmental objectives – from wildlife benefits to air quality improvements. The weights reflect USDA's preferences for the different attributes. Air quality improvements, for example, carry a weight of only 25,



indicating that USDA considers this attribute significantly less important than erosion control, which carries a weight of 100. Each bid is ranked according to its contribution to each of these objectives. Bids are assessed on the basis of indicators (proxies) which relate either to certain observable attributes of the land (such as proximity to water bodies or to erodibility) or to certain land management practices (such as land cover type). Each attribute or land management practice carries a score which is multiplied by the weights shown in Figure 2. Bids would normally be ranked for acceptance according to the ratio of the overall score to the amount of the bid. However, the actual selection procedure for CRP bids is slightly different in that the bid amount enters the score as another attribute (with a negative sign). Bids that exceed a minimum overall score are accepted.

Figure 2: Bid scoring criteria for the Conservation Reserve Programme

Wildlife	Cover factor 50		Proxi- mity to wet- lands 10	Proxi- mity to protec- ted areas 10	Upl'd/ wetl'd ratio 10	Endange red species area 15	Con- tract area 5
Water quality	Priority area 30	Groundwater quality 20	Surface water quality 40				Cropped wetland 10
Erodibility	100						
Long-term tree, shrub, and wetland restoration	50						
Conservation priority area	25						
Air quality	25						

Source: USDA, Economic Research Service

### Results

In 1999, the programme enrolled 36 million acres of land (equivalent to 10 per cent of farmland in the US). In 2001, the annual bill for the program was US\$1.5 billion. Currently (2005), approximately 33.5 million acres are enrolled in the CRP. Each contract covers an average of 74 acres with an average rental rate of \$45.95 per acre.

### *Lessons learned*

From its beginning in 1986, the CRP was conceived as a multiple sign-up scheme, whereby auctions would be carried out repeatedly over time. This has allowed landholders to learn where the (implicit) bid cap lies and to gradually adjust their bids to this cap (Reichelderfer and Boggess, 1988). Repeated auctions allow bidders to learn from previous rounds so that they can adjust their bids using this information. The result is an increased information rent, which reduces the efficiency of the auction. Hailu and Schilizzi (2004) have shown that even with the simplest learning, based only on one's own past results and without any knowledge of others' results, bidders can converge towards the marginal bid, turning the auction into something equivalent to a fixed price scheme. The implication is that auctions repeated identically over time erode their efficiency potential. To avoid this, the government agency can modify the rules of the game (e.g. the bid selection criteria) from round to round, so as to introduce some uncertainty and reduce the relevance of information from past rounds.

## **5.3 BushTender Trial (Australia)**

### *Problem*

In 2001, the Victoria government (Australia) wanted to test the idea according to which auctions could efficiently purchase public environmental goods from private landholders. The good in question was biodiversity as captured through improved 'bush' management. 'Bush' in Australia refers to the original deep rooted ligneous vegetation prior to clearing and farming, which in agricultural areas survives today usually in isolated patches. Key questions included the farmer rate of participation and whether an auction could be more cost-effective, budget wise, than a traditional fixed price scheme.

### *Design*

Several micro-regions in Victoria were designated, and a budget (not counting administrative costs) of A\$400,000 was allocated in a first round (2001) and A\$800,000 in a second round (Gippsland trials, 2002-03). Expressions of interest were first called for, then government officers visited the farms and the proposed land areas up for tender. Ecological data were collected on these areas and analysed by scientists to devise a Biodiversity Benefits Index (BBI), defined as:

$$\text{Biodiversity Benefits Index} = \frac{\text{Conservation Value Score} \times \text{Habitat Amelioration Score}}{\text{Cost announced by landholder (= bid)}}$$

This BBI defined a benefit to cost ratio for the government. The Conservation Value Score (CVS) reflected the ecological value of the site (its potential to yield ecological benefits) and the Habitat Amelioration Score (HAS) reflected the value of the farmer's efforts in moving the current state of the area towards its ecological potential. Contracts were then negotiated one to one with each interested farmer, whereby a land management plan was set up for which the farmer would be paid, if successful, through the competitive auction mechanism. Contract durations of 3 years were

offered in round 1 and of 3 or 6 years (with a possible commitment of 10 years using covenants) in round 2.

A sealed-bid discriminatory price auction was used to ‘sell’ the contracts to farmers and buy their pre-negotiated services. Bids were ranked according to the BBI ratio, from highest value per dollar bid down, until the budget constraint was hit. In the first round, information was not given to farmers regarding their BBI, whereas it was given in the second round, mainly for (government) learning purposes. Between the two rounds, laboratory experiments were carried out to explore the effect of withholding or not such information from landholders. Effects on collusion and other bidding distortions were observed to be small in the lab (Cason et al., 2003).

### Results

A full analysis of both rounds of the BushTender experience is due to be available some time by end 2005. Meanwhile, the following results can be provided (Table 2):

Table 2: BushTender results

<b>BushTender (AUS)</b>	1 <sup>st</sup> round	2 <sup>nd</sup> round	Total
Amount allocated	\$400,000	\$800,000	\$1.2 m
Expressions of interest offered	126	101	227
No. of properties assessed	115 (91%)	68 (67%)	183
Sites assessed *	223	135	358
Bidders	98	51	149 (66% of EOI)
Successful bidders	73 (74%)	33 (65%)	106 (71%)
Habitat zones assessed**	357	276	633
Area under contract (ha)	3160	1684	4844 (63% high value)
Habitat area under contract (ha)			2876
Habitat gain accrual (ha)			414
Mean cost/ha under contract*** (excluding admin costs)	\$126/ha	\$475/ha	\$248/ha
* The number of sites assessed was greater than the number of properties as most properties offered more than one site.			
** A habitat zone represents a unique Ecological Vegetation Class (EVC) / quality combination within a site.			
*** Note that 1 <sup>st</sup> round and 2 <sup>nd</sup> round figures cannot be compared, as they relate to two different regions.			

Source: Table compiled by the authors. Currency is in Australian dollars.

There was an acceptance rate of 97% of offered agreements by participants. In round 2, all but one landholder opted for a 6-year contract. Landholders demonstrated a strong preparedness to commit to a range of management actions, including stock exclusion, retaining trees and fallen timber and controlling weeds and introduced species (beyond current duty of care requirements). Fencing and supplementary planting recorded lower levels of uptake due to the site-specific nature of these actions. To date (mid 2005), almost 95% of participating landholders have complied with their contractual agreements.

Subsequent analysis of first round results by Stoneham et al. (2003) claimed a benefit of 700% of that which would have been obtained through a fixed price scheme, though this claim depends on the choice of the counter-factual fixed price to which it is compared. We will revisit this figure in Section 6.

### *Lessons learned*

Gary Stoneham, of the Department of Primary Industries of the State of Victoria, Australia, has been kind enough to share his views on what he believes his team has learned through the BushTender experience over the last four to five years. His views are valuable as he was directly involved in the development and the running of the BushTender auctions. These are summarised in Box 6.

Box 6: Lessons learned from the BushTender pilots according to Gary Stoneham (personal communication, June 2005)

#### **Auctions that have now been run in Victoria (Australia) include:**

- BushTender 1 (Northern Victoria)
- BushTender 2 (different area – Gippsland – and menu of contracts of different lengths)
- RiverTender - riparian vegetation
- PlainsTender - applied to grasslands
- BushIncentives - applied to coastal vegetation
- EcoTender - multiple outcomes

#### **Lessons learned:**

1. Auctions work - prices are discovered and contracts allocated.
2. They generate a marginal cost curve, information of value to government.<sup>(1)</sup>
3. They show improved cost-effectiveness over fixed price schemes.
4. Collusion is a non-issue - we thought that this would be a problem to start with but we know that it is almost impossible to collude because bids are formed on an action basis but assessed on a service delivery relative to bid price.
5. We think that revelation of all information to landholders is best. In the first BT we only revealed some of the information about biodiversity service provision because we were worried about collusion. We now know that there is lots of economic surplus (or rent) and it is reasonable to share this between government and landholder. We would like to do some work on incentive compatible approaches to the distribution of rent.
6. Contract design is a big and relatively untouched area where there are lots of possible ways forward.
7. Auctions are popular with landholders: biodiversity is translated from a complex idea to practical actions.
8. We have had only one defaulting contract out of about 300 now.

(1) The use of a discriminatory price auction does not reveal the opportunity cost curve, as it is optimal for bidders to shade their bids. As a result, the cost curve remains unknown. It can however be estimated using a model, like that of Latacz-Lohmann and van der Hamsvoort (1997), that allows one to work backwards from bids, assumed to be optimal, back to the original costs. Of course, one obtains estimated costs, not the real costs. The amount of error made in the estimation can be measured using controlled laboratory experiments, as has been done by Schilizzi and Latacz-Lohmann (2005a). One then obtains an estimate of the error made in the empirical cost recovery.

In addition, the following can be said:

- Carefully designed conservation auctions can work out in the field and yield non-negligible benefits, both in terms of ecology and in terms of budgetary outlays.
- Transaction costs for the first round of BushTender, which included on-site research, ecological scoring and auction administration costs, amounted to roughly between 50% and 60% of the amount used in the auction. Falconer and Whitby (1999) report a variation in Europe of between 30% and 80%). It appears that such levels of transaction costs are to be expected as part of both the government agency's and the farmers' learning investment. They should diminish as they gain experience over time. Assessment of the second round (Gippsland) could shed some light on the government side, although this round is administered somewhat differently from the first, so that the two rounds are not strictly comparable.
- The involvement of government officers and their dedication to explain to farmers the ins and outs of this new payment system are important for securing sufficient participation and thereby the level of competition necessary for the auction to play its efficiency role. The factors favouring and explaining landholder participation, or lack thereof, have been analysed by Ha et al. (2003).
- Field trials like BushTender have a learning function. They stand somewhere in between full scale policy implementation, like the Conservation Reserve Program which applied throughout the United States, and controlled laboratory experiments. In principle, the sequence running from theory to lab experiments to small scale field trials constitutes itself a learning process for full policy implementation. The question has been asked whether a previous stage can predict the outcomes of the following stage, and in particular, whether lab experiments can predict outcomes in the field. As Vernon Smith, who won in 2002 the Nobel Prize for pioneering experimental economics, has said, the issue is not whether lab experiments can predict outcomes in the field, but whether they allow us to make all the important mistakes at low cost, before field implementation. Smith reckons this is nearly always the case. Lab experiments remain very valuable, but field trials remain necessary before full scale policy implementation.

## **5.4 Auction for Landscape Recovery (Australia)**

### *Problem*

This auction field trial was part of a larger national programme in Australia, aimed at trialling various market-based instruments. Nine such projects implemented one

variety or other of conservation auctions (see Appendix 3 for an overview). Unlike the BushTender trials, the Auction for Landscape Recovery (ALR) aimed at securing multiple benefits from land management improvements, namely biodiversity enhancement, salinity control, and groundwater recharge abatement (recharge compounds salinity).

### *Design*

The Avon River Catchment in the state of Western Australia was designated as the target area. As with BushTender, the programme was conducted over two rounds. Landholders could put up more than one bid each and were encouraged to put in joint bids. Before the bids were put forward for evaluation, an independent group of experts assessed if the proposed action would lead to the identified outcomes. A total of A\$200,000 was available for farmer payments, with A\$93,000 spent in round 1, leaving A\$107,000 for round 2.

The ALR was conducted as a simple sealed-bid price discriminating auction, similar to BushTender. Landholders who had expressed interest were encouraged to submit a tender describing their proposed management activities, anticipated environmental outcomes and a bid. The tender process was communicated as rewarding those who deliver the greatest environmental benefit per dollar. Producers were reminded that the scheme is competitive. However, they could include a rent element in their bids if they wished.

Tenders were evaluated using a regional metric of ‘biodiversity complementarity’ (Faith and Walker, 1996) within a systematic conservation planning framework (Margules and Pressey, 2000). This metric, unlike the BBI, accounts for synergistic aspects due to number, size and distance of several areas; the BBI focuses on the individual value of each land area. However, as part of the research project, an environmental benefits index (EBI) was also calculated, for comparability purposes with BushTender, namely in terms of cost-effectiveness (comparison yet to be completed).

### *Results*

Full disclosure of results are still in the waiting (the second round was just carried out in March-April 2005). In the first round (April 2004), a total of 56 bids were received from 38 landholders – some landholders putting more than one bid. Over the two rounds, there were 89 tenders submitted by 57 landholders.

Out of 56 tenders submitted in round 1, a total of 10 were successful. These mainly offered to carry out fencing, revegetation and feral baiting. The relative weighting of these activities, implicit in the scoring method, was not known to bidders.

### *Lessons learned*

From some preliminary analyses carried out by White and Burton (2005) at the School of Agricultural and Resource Economics of the University of Western Australia, some interesting outcomes emerge from this experience:

- 1) The building by natural scientists of a comprehensive scoring index for ranking multidimensional auctions is an exercise fraught with pitfalls. Subjectivity cannot be avoided, even if it is buried in the appearance of an objective measure (the

scoring index). In particular, the relative weighting of different ecological benefits remains implicit and unknown to decision makers, and even to the scientists themselves if they do not have an explicit weighting procedure. If some of this information is to be communicated to farmers, it matters how this is done and how the information is to be interpreted. Thus, it must be acknowledged that the policy maker has some degree of discretion in choosing the relative weightings: they themselves form part of the (more or less implicit) policy preferences.

- 2) Calculations done using bid data from the first round seem to show that a number of landholders bid below their opportunity costs. Follow-up interviews suggested that some of them would have carried out conservation works even without payment, raising the issue of the justification of using a payment scheme altogether. The implication seems to be that government should consider three categories of landholders: those who are ready to carry out conservation works with little or no payment, or at any rate a payment below their opportunity costs; those who need to be paid at least their opportunity cost plus a rent; and those who will not enter into such agreements under any reasonable level of payment. From a budgetary point of view, this information can be of use to government, although it raises serious equity issues which cannot be ignored.
- 3) Again as an initial preliminary analysis, White and Burton (2005) were able to use data from the first round to benchmark the budgetary cost-effectiveness of the auction to that of an equivalent fixed-price scheme. They show that the cost-effectiveness of the ALR compared to that of a uniform price scheme varies between 315% and 207% in round 1 and 165% and 186% in round 2, depending on whether the fixed price scheme is input-based or output-based (see section 6.4 for details). They also show that comparing BushTender to an output-based scheme would considerably reduce the cost-effectiveness gains of 700% claimed by Stoneham et al. (2003). In addition, in a multi-round auction like the ALR (2 rounds), auction effectiveness can vary from round to round. This variability needs further research.
- 4) White and Burton (2005) conclude that “In general it is not possible to state if the uniform-price input scheme will generate lower or higher measures of efficiency for the auction: it appears to depend on the relative degree of heterogeneity in the opportunity costs, the environmental benefit, and the covariance between them.” We would add: and the amount of bid shading by bidders.
- 5) They also suggest that “The choice of a counterfactual fixed-price scheme to measure auction efficiency should be guided largely by what is as a pragmatic alternative.”
- 6) Fixed-price schemes are less vulnerable to rent-seeking than are auctions. In the ALR auction, there was evidence either of significant rent seeking or significant variations in the opportunity cost of labour (most likely the former).
- 7) In this case at least, there was no evidence to show that the auction imposed higher administrative costs than equivalent schemes using the same amount of information to underpin the selection process. This was because most of these costs were not linked to the specifics of running an auction, as indicated by the numbers that follow. About 70% of ALR costs were administrative costs, defined as all costs which are not payment transfers to farmers for on-ground works. They included all in-kind contributions, even if paid outside the project’s budget. In

addition, many costs were linked to the great distances involved and the remoteness of locations in rural Western Australia. Operational costs were estimated to total A\$3291 per tender, split into A\$1693 for variable costs and A\$1598 for fixed costs (roughly a 50-50 split). Costs for Community Support Officers (on site) totalled A\$1316 per tender and A\$2055 per farmer. Research costs were estimated as A\$1983 per tender and A\$3096 per farmer. These costs only reflect project establishment: they do not include monitoring and compliance enforcement.

- 8) However, the amount available for payment transfers to farmers was only \$200,000. It must be noted that the smaller the amount of transfer payments, the higher the proportion of administrative costs. This is a fixed-cost effect linked to the scale of the project. At the same time, such small scale ‘pilot’ projects represent a learning investment and part of an experimental investigation in a broad sense (see our general conclusions).
- 9) ALR administrative costs were incurred during five stages: scheme design, implementation, tender selection and evaluation. These stages appear to be common to most agri-environmental schemes (see Huylenbroeck and Whitby, 1999).

## 5.5 EcoTender (Australia)

### *Problem*

EcoTender is an offshoot of BushTender and similar in intent to the Auction for Landscape Recovery. Like BushTender, it is carried out in the state of Victoria (Australia), and like the ALR, it broadens the scope of BushTender by aiming to secure multiple environmental benefits, including improvements in salinity control, biodiversity enhancement and water quality. It uses information from catchment-based modelling that can estimate both local and catchment-wide impacts on environmental outcomes as a result of changed land use and management. This reflects an educational goal, in that landholders are expected to discover how changes to native vegetation use and management can influence multiple environmental improvements.

### *Design*

Under the EcoTender project, landholders are invited to submit bids, based on an agreed plan for improved native vegetation management and revegetation works on their properties. The design of the auction is similar to BushTender and the ALR, described above. However, the environmental benefit is defined somewhat differently. It is the sum of the biodiversity, saline land impact and in-stream water quality outcomes resulting from the proposed landholder management commitments, and estimated through the use of the catchment model. This allows the construction of an environmental benefit index (EBI), which is combined with the cost represented by the farmer’s bid in the following formula:

$$EBI = \frac{Biodiversity\ Score + Saline\ Land\ Impact\ Score + Instream\ Water\ Quality\ Score}{Cost\ announced\ by\ landholder\ (=bid)}$$



Successful bids will be those that offer the best value for money to the community, based on the amount of change in the environmental outcomes, the value of the assets affected by these changes and the cost. Successful landholders will receive periodic payments for their management actions under agreements signed with the Department of Sustainability and Environment.

Contracts are for a duration of 5 years, with an additional 5 years required for revegetation agreements. Fencing is required to remain in stock-proof condition for 10 years. Contracts come under common law. They are simply written and 3 to 5 pages long.

Bids can be lumped or separate; that is, a landholder can submit a bid for a number of areas or separate bids for each. (This constitutes a so-called combinatorial auction.) Pooled bids across several farmers are also allowed. Payments are annual, subject to satisfactory completion of agreed actions. Payments are not only input-based (management actions), but also include an output-based element: e.g. revegetation must meet certain performance standards relating to the number and diversity of plants established. In addition, an annual report must detail not only actions undertaken, but progress towards the agreed environmental targets. The regulator monitors a number of agreements each year. A breach may result in the cessation of annual payments.

This is an ongoing programme for which no results are yet available (2005).

## **5.6 Challenge Funds (UK)**

### *Problem*

Challenge funding was introduced into Scottish forestry policy in 1997 – with the launch of the Grampian Challenge Fund and, a year later, the Central Scotland Challenge Fund. These funds operated under the umbrella of the Woodland Grant Scheme (WGS) and offered additional grants to the standard WGS grants for extending the woodland area in specific geographical areas. They were competitive in that applicants were required to submit bids to the Forestry Commission (FC) for this additional money. Under the Grampian Challenge Fund, the target was to plant 1,500 ha of new forest. No quantitative target was set for the Central Scotland Challenge Fund, but the aims here were to produce marketable timber, diversify land use and provide opportunities for countryside access and recreation. Both funds were closed for applicants in 2002 (CJC Consulting, 2004).

There have been other Challenge Funds in Scotland, but currently only one challenge fund is in operation. This is the Woodlands In and Around Towns (WIAT) Challenge - a new initiative aimed at stimulating sustainable management of woodlands near towns, thereby contributing to the regeneration of the urban environment and improving the quality of life for people living and working in urban areas<sup>7</sup> The challenge fund approach was used for WIAT to discover appropriate prices for hitherto un-priced goods and to ensure best value for money (Wright, FC Scotland, personal communication).

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<sup>7</sup> See <http://www.forestry.gov.uk/forestry/infid-5zqntw> for details.

### *Design*

Under the Grampian and Central Scotland Challenge Funds, landholders were asked to prepare and submit planting plans. Applicants had to pass a set of eligibility criteria relating to size, location and suitability of planting to deliver timber output. Bids were judged in terms of their value for money in relation to the aims of the Challenge Fund. A judging panel awarded grants to those applicants whose plans best met the aims of the Challenge and offered the best value for money.

Table 3 shows the bid scoring criteria for the Grampian Challenge Fund. The first four criteria relate mainly to costs and the likelihood of good establishment, the last four directly measure outputs. From these it is clear that four outputs are valued (recreation, landscape, habitat quality and productivity) with productivity given double the weight of the other three.

Table 3: Scoring system used for the Grampian Challenge Fund

	Maximum score
Application quality	0.5
Location (in or outside target area)	1.5
Roading (proximity to suitable roads for timber transport)	3.0
Wildlife control	2.0
Recreation	3.3
Landscape	3.0
Habitat quality	3.0
Productivity (timber potential)	6.0
Total	22.3

Source: CJC Consulting (2004)

The panel selected high-scoring, low-cost bids first. Beyond that they traded off score against cost in a subjective way (CJC Consulting, 2004). A similar scoring system was used for the Central Scotland Challenge Fund, with different weights given to the different outputs, and additional points being given for community involvement.

The WIAT Challenge Fund uses an alternative bid scoring method: Applicants are asked to rank their own proposals by answering (and scoring) a number of questions relating to the expected economic, social and environmental benefits of their proposed plans.<sup>8</sup> In the application documents, bidders are asked to consider that preference is given to proposals where the value for money is well demonstrated and arguments are logically and rationally presented. Applicants are also asked to support value judgments in proposals by evidence.

<sup>8</sup> See [http://www.forestry.gov.uk/pdf/WIATScoringSheetversion2.pdf/\\$FILE/WIATScoringSheetversion2.pdf](http://www.forestry.gov.uk/pdf/WIATScoringSheetversion2.pdf/$FILE/WIATScoringSheetversion2.pdf) for details.

### Results

The funds were very successful in rapidly expanding the land area under forestry and increasing harvestable timber output. Challenge funded planting increased the woodland area in both locations by almost 10%. Under the Grampian Challenge, operated for 6 years, 260 bids were received and 141 contracts awarded, extending the woodland area by over 3000 hectares – more than twice the target (Table 4). The Central Scotland Challenge, operated for 4 years, attracted 117 bids; 63 contracts were awarded. Bids ranged from £316 to £1,758 per ha in Central Scotland and £492 to £1,997 per ha in Grampian.

On average, the total payments in WGS grant aid (excluding Farm Woodland Premium Scheme) were £2,307 per ha in the Central Scotland Challenge Fund and £2,478 in Grampian (Table 5). The challenge top-up element was around 45% of the total grant aid in both areas.

Table 4: Areas planted under the Scottish Challenge Funds

Scheme	Applications received	Approved plans	Plans where payments have been made				
	Number	Number	Number	Total area (ha)	Minimum area (ha)	Maximum area (ha)	Mean area (ha)
Grampian	260	141	117	3,315	10.0	138.4	28.3
Central Scotland	117	63	54	2,128	7.8	98.8	39.4

Source: CJC Consulting (2004); Wright (personal communication, September 2005)

Table 5: WGS and Challenge Fund payments

	Number of plans	Total payment (£m)	Payment per plan (mean, £)	Payment (mean, £ per ha)	Challenge top-up per plan (mean, £)	Challenge top-up (mean, £ per ha ± SD)
Grampian	117	8.215	70,218	2,478	31,748	1111.7 ± 302.3
Central Scotland	54	4.911	90,936	2,307	39,780	1017.1 ± 286.0

Source: CJC Consulting (2004)

CJC Consultants carried out an economic evaluation of the two challenge funds in 2004. Respondents were asked whether they had deliberately tried to make their bids attractive to the Forestry Commission (FC) given the competitive nature of the funding. With the exception of a few ‘don’t knows’ all respondents answered ‘yes’.

Garforth (2001)F undertook a study of challenge funding for the FC. He assessed the budgetary costs of each challenge fund as compared with a fixed-rate payment (a so-called location premium) set 20% below the bid price. The assumption was that

applicants would have accepted a price 20% lower as a trade-off for the additional costs of bid preparation, the risk involved and some overbidding. His conclusions present a mixed picture: For the Grampian CF they were inconclusive, with a flat-rate grant calculated to bring in less land but at a lower cost. For the Central Scotland CF he concluded that a flat rate grant would have brought in the same area of land at lower costs!

CJC Consultants (2004) compare actual bids with a hypothetical flat-rate scheme. To secure all the bids with a fixed-rate premium would have required (with the benefit of hindsight) a premium of £1,758 in Central Scotland and £1,997 in Grampian. These were the highest bids received. Total payment would have been 36% higher in Central Scotland and 33% higher in Grampian. They conclude: "Such a fixed rate is clearly less efficient than challenge funding even allowing for some savings in transaction costs." (p. 63).

Some care has to be taken in interpreting these figures – and the conclusion. In computing the figures, the authors made the same mistake as Stoneham et al. (2003): They implicitly assumed that the bid curve (i.e. the bids ordered from the lowest to the highest) represents the supply curve under a flat-rate scheme. We explained in section 5.3 why this is not the case: Bid curves contain an element of strategic overbidding and thus do not represent true opportunity costs! The study will thus have overestimated the efficiency gains of bidding.

Another important finding is this: FC staff reckon that operating the challenge funds took 20 per cent more staff time per application than fixed-rate incentives (CJC Consultants, 2004). This makes the cost-effectiveness of the challenge funds appear questionable.

There has been no assessment of the WIAT Challenge Fund. There have been two bidding rounds, one in 2004 and another in 2005. FC received 38 bids in 2004 and 33 were successful. In 2005 there were 16 bids and 14 were successful (Wright, personal communication 2005).

### *Lessons learned*

Douglas Wright of the Forestry Commission Scotland comments: "Benefits from our point of view are that it (challenge funding) ensures best value for money and it encourages good standards" (personal communication, 2005). This view is reinforced by the findings of CJC Consultants (2004, p. 67): "The challenge funds were an entirely appropriate incentive mechanism for delivering on the objectives of the schemes in the two forest areas. The challenges led to a rapid and substantial increase in planting. Additionality was very high and there was no evidence that bids were excessive. We conclude that the funds were a more effective and lower cost route for achieving substantial levels of planting in the two areas than fixed level grant aid."

On the other hand, one third of the respondents interviewed by CJC Consultants (2004) made comments that reflected a degree of dissatisfaction with a grant scheme based on tendering. The main comment was that it was 'unfair' in some way - either because neighbours received more cash or because it was 'hard to know what to bid' or because, in retrospect, entrants realised they had underbid. Some commented on the creation of animosity between neighbours. Others found it unfair because it suited those who could take the risks involved. (CJC Consultants, 2004). According to Douglas Wright, the main lesson is that because challenge funding is competitive there

is less certainty for applicants. Unsuccessful applicants complain that there is a lot of work required in preparing bids. On balance, there was a consensus from stakeholders that challenge funds were too uncertain for the applicant and that they should be replaced by locational premia (i.e. fixed rates per ha) although CF would be kept in the 'grant tool box'. As a result a new scheme was introduced in 2003, the Scottish Forestry Grant Scheme (SFGS), replacing the former WGS and the two challenge funds. The FC has instituted locational premia of £2,000 per ha for farmed landscapes in Central Scotland and £1,500 per ha in Grampian. According to Douglas Wright, the Challenge Fund bids have informed the level of the locational premia.

## **5.7 Grassland Conservation Pilot Tender (Germany)**

### *Problem*

The focus of this pilot auction is on maintaining low-intensity grazing systems in the state of North Rhine-Westphalia, Germany. The conservation agency had initially offered fixed-rate payments. After only very few farmers had signed up, an auction was run to determine the excess payment required to induce broader participation. The objective thus was to establish whether an auction is a cost-effective mechanism to encourage broader participation in agri-environmental schemes. Funding was provided by the Ministry of Environment, Nature Conservation, Agriculture and Consumer Affairs of North Rhine-Westphalia. Three auction rounds were run between 2003 to 2005 in two counties (Holm-Müller and Hilden, 2004).

### *Design*

Farmers were asked to specify in a sealed-bid process the amount of compensation the agency would have to pay them in excess of the fixed payment to induce compliance. A bid cap of 53 per cent of the fixed-rate payment was imposed for the first round. That is, bidders who demanded extra compensation in excess of 53 per cent of the standard rate were rejected. All bids below that reserve price were accepted. The reserve price was not known to the bidders before auction, but it was made public afterwards. The reserve price for the second round was set at 43 per cent of the standard payment (Holm-Müller and Hilden, 2004).

### *Results*

In each of the bidding rounds, 15 landholders submitted bids covering an area of 335 and 353 hectares, respectively. First-round bids ranged from €47 to €150 per hectare, with an average bid of €92/ha. Second-round bids were lower on average (€46/ha), with a slightly wider range (€20 to €195/ha). Nine of the 15 landholders who had applied in the first round were accepted with a total area of 218 ha. Payments (in excess of the fixed rate) ranged from €47 to €80/ha (average €73/ha). In the second round, all 15 bids were accepted. The extra payment thus was €46/ha on average. Apparently, the reserve price (of 43% of the fixed payment) was not applied in the second round (Holm-Müller and Hilden, 2004). The third round was carried out in 2005. No results are available as yet.

*Lessons learned*

Fewer farmers than expected submitted a bid, implying that the scheme was not effective in encouraging broader participation in agri-environmental management. A survey was conducted after the second round to establish why farmers were not interested in the scheme although top-up payments had been offered through the auction. Many farmers said that, while the level of payment is an important factor, it is not the only factor determining their willingness to participate. Land was very scarce and lowering the intensity of their grassland was an option many could not afford. Uncertainty over the yield and energy losses from de-intensification was another deterrent to participation, as was uncertainty over the impacts of the latest CAP reform. A few farmers expressed general concerns about competitive bidding, feeling that such a mechanism was 'unfair'.

Interestingly, four of the rejected first-round bidders subsequently entered the scheme at the standard rate (i.e. without top-up payment), indicating that their bids had not been based on marginal cost considerations.

The survey also tried to establish whether there had been prior consultation or even collusion among bidders. No such evidence was found. The survey revealed, however, that second-round bids were informed by first-round bids. Bids for the second round were revised downwards on average, with no bid exceeding the 53% bid cap imposed in the first round (Holm-Müller and Hilden, 2004).

**5.8 Auction trial with outcome-based payment scheme (Germany)***Problem*

The aim is to reward landholders for the provision of environmental services in the form of intensive cultivation crop retirement and replacement with grassland of high ecological and floral biodiversity quality. Payment is made not according to actions undertaken, but to the quality of grassland achieved. Grassland quality is categorised into three classes (I, II and III), with class III being the highest quality.

A specific aim of this program was to generate data on the transaction costs of farmers participating in such auctions. These costs include the time to gather information so as to be able to form a monetary valuation for the bid; the hiring of advice e.g. consultants; and the filling out of forms. Transaction costs were measured by surveying farmers who had participated in the auction. They were asked to fill in detailed questionnaires.

This project takes place in Lower Saxony, Germany (county of Northeim), funded by the Federal Ministry of Education and Research. (Rüffer, 2004)

*Design*

This is a budget-constrained (€30,000), sealed-bid, discriminatory price auction. The auction was held in 2004. The contract duration is for one year. The benefit criterion is represented by the grassland category and the cost by price per hectare. Performance assessments (i.e. which grassland category has actually been achieved) are carried out by 31 July 2005, with payments made subsequently. This auction clearly is of an exploratory and even of an experimental nature (Groth, 2005).

### *Results*

Out of the 38 farmers who submitted bids for a total of 199 plots covering 350 hectares of land, 28 farmers with 159 plots totalling 288 hectares were accepted for payments. The range of prices per ha requested by farmers are:

- Grassland I: 40 – 145 € (average 85 € /ha)
- Grassland II: 55 – 300 € (average 142 € /ha)
- Grassland III: 100 – 350 € (average 203 € /ha)

A comparison with a fixed price scheme has been done for class I grassland. Instead of 85 €, the envisaged uniform cost would have been 130 €/ha, 53% higher.

In terms of transaction costs, a farmer's valuation of his time for preparing a bid varied between 10 and 25 € per hour, with an average of about 17 € per hour. The average time spent being 4 hours, the average cost of preparing a bid was calculated to be about 67 €. This compares with an average payment per farmer of 875 € for grassland I (7.6%) and of 2090 € for grassland III (3.2%) (Groth, 2005).

### *Lessons learned*

The output-oriented auction seems to have been popular with farmers and policy administrators alike. Groth (2005) concludes that the auction has worked well in that it has revealed a wide range of bid prices which gave the policy administrator much scope to select the most cost-effective producers.

It seems from this exercise that farmers' transaction costs are relatively small compared to payments made, but in this case, we have a very simple scheme based on a simple categorisation of output quality. This is unlikely to be representative of the majority of conservation schemes.

It would also have been instructive, given common practice to date and the experimental nature of this pilot, to include in the program a 'control group' paid on inputs (management actions) rather than outputs (grassland quality). This would have provided some data as to the relative merits of each approach in a very simple case.

## **5.9 Other conservation auction schemes**

Auctions have also been used in areas of natural resource management other than agri-environmental policy. For example, contracts for the decommissioning of fishing vessels are usually allocated through competitive bidding: fishers are asked to nominate in a sealed-bid process the amount of compensation required for permanently removing their vessel from the fishery (Schilizzi and Latacz-Lohmann, 2005a, Latacz-Lohmann, 2001).

Auctions have been used to buy back water abstraction licenses from farmers in order to preserve minimal instream flows in rivers for environmental or recreational purposes (Laury, 2002). For example, the Flint River Drought Protection Act in the state of Georgia, USA, requires that state authorities use an "auction-like process" to pay farmers to suspend irrigation in declared drought years. The Environmental Protection Division is required to assess the risks of an upcoming drought and to determine consequently the number of hectares which must be taken out of irrigation to maintain acceptable instream flows. An auction is organised whereby farmers may offer to voluntarily forgo irrigation of all land covered by a specific water-use permit

for the remainder of the cultivation year in exchange for a lump sum payment (Cummings et al., 2002). The development of such auction schemes to water restriction allocations is studied by Hailu and Thoyer (2005b).



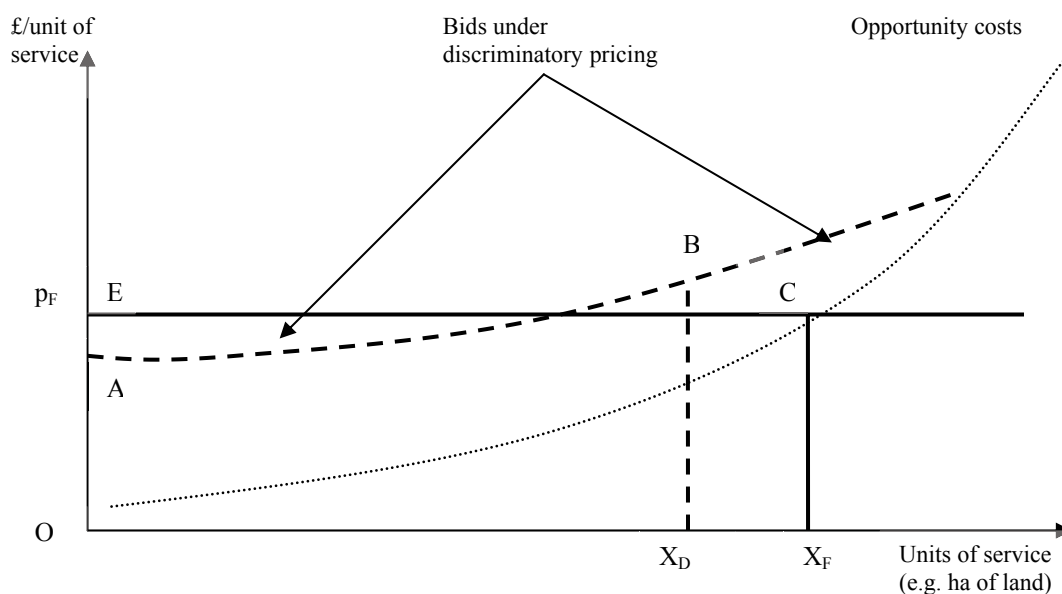
## 6. CONSERVATION AUCTION PERFORMANCE

Conservation auctions are still in their infancy and data from the field are scarce. Anecdotal evidence on auction performance is often spurious and intuition unreliable, especially for complex resource allocation problems. Recent research has therefore employed experimental methods (laboratory auctions) and computer simulation to investigate the performance of conservation auctions. In this section, we review both experimental and simulation studies of conservation auctions. We also summarise the key findings from auction pilots. We start with a note on different ways of measuring auction performance vis-à-vis fixed-rate payments.

## 6.1 Measuring auction performance

Figures 4 A and B show how an auction may be more or less cost-effective than a fixed-price scheme for the same given budget. In Figure 3A, bidders shade their bids to a greater extent than in Figure 3B, so that, for the same budget, a smaller number of winners are able to be selected by the auction.

Figure 3A: Discriminatory auction and fixed-price scheme: when the FPS is more cost-effective for a given budget: area  $\text{OABX}_D = \text{area OECX}_F$  but  $\text{OX}_D < \text{OX}_F$



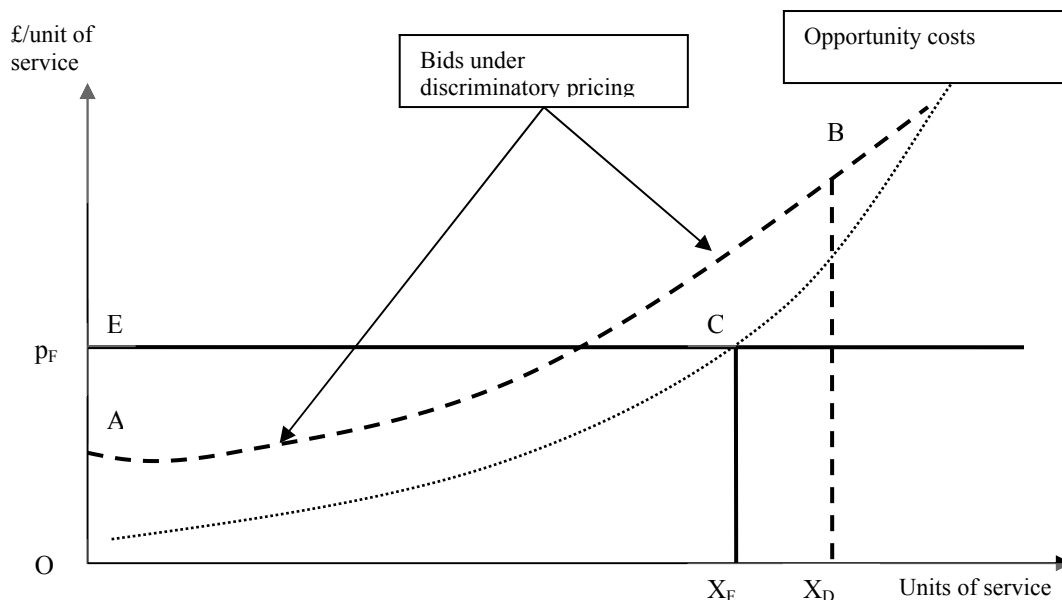
It is important to understand that the opportunity cost curve is the relevant supply curve when a fixed payment is offered. Then all landholders with opportunity costs below the fixed payment stand to gain from participation in the scheme. The marginal participant is the one whose opportunity cost is equal to the payment rate offered. Thus, under the fixed-price scheme,  $X_F$  units of service will be traded at price  $p_F$ . The total budget cost thus is represented by area  $OECX_F$ .

Under a discriminatory auction scheme, by contrast, the ordered bids (not the opportunity cost curve) represent the supply curve. The auction creates room for bidders to shade their bids above their true opportunity costs and thereby to secure

themselves an information rent (Latacz-Lohmann and van der Hamsvoort, 1997; Hailu, Schilizzi and Thoyer, 2005). (The detail of how this happens can be seen by reading Appendix 2.) Bidders are accepted in the order of their bids until the budget is exhausted. The total budget cost thus is represented by area  $OABX_D$ . Assuming the same budget as under the fixed-price scheme,  $X_D$  units of service can be bought.

The cost-effectiveness of the auction thus depends upon the degree of bid shading. One would normally expect bid shading to be low and the auction to be superior to the fixed-price scheme (as shown in Figure 3B). However, if bidders have learned the bid caps from previous auction rounds, bid shading can be significant, resulting in poor auction performance (as shown in Figure 3A).

Figure 3B: Discriminatory auction and fixed-price scheme: when the FPS is less cost-effective for a given budget:  $\text{area } OABX_D = \text{area } OECX_F$  and  $OX_D > OX_F$



## 6.2 Simulation studies

Hailu and Schilizzi (2004) construct an agent-based model to evaluate the long term performance of conservation auctions under settings where bidders are allowed to learn from previous outcomes. The results relating to the impact of learning were already reported in section 4.3.3. The focus here is on auction performance relative to a fixed-payment scheme. The details of the setup used to generate the results are shown in Box 7.

Box 7: Details of agent-based computational bidding model used by Hailu and Schilizzi (2004)

Two types of agents representing the actual players in a real auction are included in the model. These are:

- a) Farmer agents bidding for environmental conservation contracts. Each farmer has an environmental quality value and an opportunity cost associated with putting the land being offered under conservation.
- b) A government agent which selects winning farmers and awards contracts based on the criteria applying under the particular auction format being used. The government agent has a fixed budget.

Each auction round incorporates the following three major steps or activities.

Step 1: Farmers construct their bids. The bids farmers make depend on their respective opportunity costs, their previous bid prices as well as their success or failure in the previous auction. For example, if a farmer agent was successful in the previous bid, then he or she tends to bid the same or a higher price. In the very first period, farmers have no prior experience and start by bidding their true opportunity costs.

Step 2: The government agent ranks the bids submitted by farmers based on the auction criteria, selects winners accordingly and informs each bidder whether it has been successful or not.

Step 3: Farmer agents update their contract status based on the message from the government agent.

The population of bidders is 100. For simplicity, the bidder population was set to be heterogeneous only in opportunity costs, while the environmental benefit score of the conservation activities was the same for all bidders. The opportunity cost values were randomly drawn from a uniform distribution. The government budget was fixed at \$30 (e.g. million). The level of the budget was roughly equal to 30% of total opportunity cost. Thirty successive discriminatory auctions were simulated. One hundred runs or replications of these 30 successive auctions (using different random seeds) were used to generate the average results discussed below.

For comparison purposes, fixed price schemes were also simulated with identical parameter specifications as for the auction. Two fixed prices, set at 90 and 100 per cent of average opportunity costs were used. Results obtained under these schemes allowed the authors to compare the performances of the auction and fixed-price mechanism.

Source: Hailu and Schilizzi (2004)

The results (see Table 6) show that the performance of the auction relative to the fixed-price scheme depends on the level of the fixed price employed in the latter.

Table 6: Performance of discriminatory auction relative to fixed price schemes

	Relative to fixed payment set at 90% of mean opportunity costs		Relative to fixed payment set at 100% of mean opportunity costs	
	All period average	Period 30	All period average	Period 30
Proportion of winners among participants	0.99	0.89	1.09	0.97
Net income transfer per program outlay	0.86	1.05	0.76	0.92
Environmental benefit value per program outlay	0.99	0.89	1.10	0.99
Average payment to winners	1.02	1.12	0.92	1.01

Source: Hailu and Schilizzi (2004)

With a fixed price set at 90% of the average opportunity cost, the auction is found to be inferior in terms of efficiency, participation, and the provision of environmental benefits. Looking at the results from fully adjusted bids in round 30, the auction provides lower rates of participation and environmental benefits per dollar of program outlay (by a factor of 0.89). The proportion of net income transfer in programme payments is higher under the auction than under the fixed price scheme. Put differently, the informational rents extracted are higher, by 5%. Thus, the fixed-price scheme with reserve prices set at 90% of average opportunity cost outperforms the auction mechanism in terms of participation and efficiency. The auction mechanism compares more favourably only to fixed-price schemes with higher payment levels (e.g. column 5 of Table 4), but the efficiency advantage still appears marginal. This is because the higher reserve prices involve built-in net income transfers that are similar to those achieved by bidders who learn to ‘game’ the auction over time.

In conclusion, the authors issue a cautious message about the cost-effectiveness of multiple-round conservation auctions: with bidder learning the efficiency benefits of single shot auctions do not necessarily extend to repeated auctions. Learning can ensure that bidder prices adjust to extract almost all information rents despite competitive bidding conditions.

### 6.3 Laboratory studies of conservation auctions

Latacz-Lohmann and Schilizzi (2005) investigate the performance of two auction formats (budget-constrained and target-constrained) vis-à-vis a fixed-payment scheme. The comparison was made with the use of controlled economic experiments described in section 4.3.3. See Box 3 in section 4.3.3 for a summary of the experimental setup.

The outcomes of the budget-constrained (BC) auction were compared with a fixed-price scheme with the same budget as the auction. The target-constrained (TC) auction was also compared with a fixed-price scheme, but in order to ensure comparability, the

fixed price was set such that the same target was achieved – that is the same number of hectares were bought out. The collaterals for the two auction formats thus are not identical. The findings from the Kiel experiments (Germany) are reported in Table 7.

Table 7: First-round auction performance vis-à-vis fixed-price scheme, Kiel

	Budget-constrained auction		FPS <sup>1</sup> , same budget	Target-constrained auction		FPS <sup>1</sup> , same target
	Total	% of FPS	Total	Total	% of FPS	Total
Bidders	44			43		
<b>Number of contracts allocated</b>	30	111	27	<b>30</b>	<b>100</b>	<b>30</b>
Environmental gain, kg N abated	1944	127	1534	1995	105	1905
<b>Total payments €</b>	<b>4080</b>	<b>100</b>	<b>4077</b>	4482	80	5610
Total opportunity costs €	2596	140	1854	2750	106	2591
Information rents €	1484	67	2223	1732	56	3091
Overcompensation, percent of opportunity costs	57%		120%	63%		119%
Budgetary costs, €/kg N abated	2.10	79	2.66	2.25	77	2.94
Opportunity costs, €/kg N abated	1.34	111	1.21	1.38	101	1.36

<sup>1</sup> FPS = fixed-price scheme

Source: Latacz-Lohmann and Schilizzi (2005)

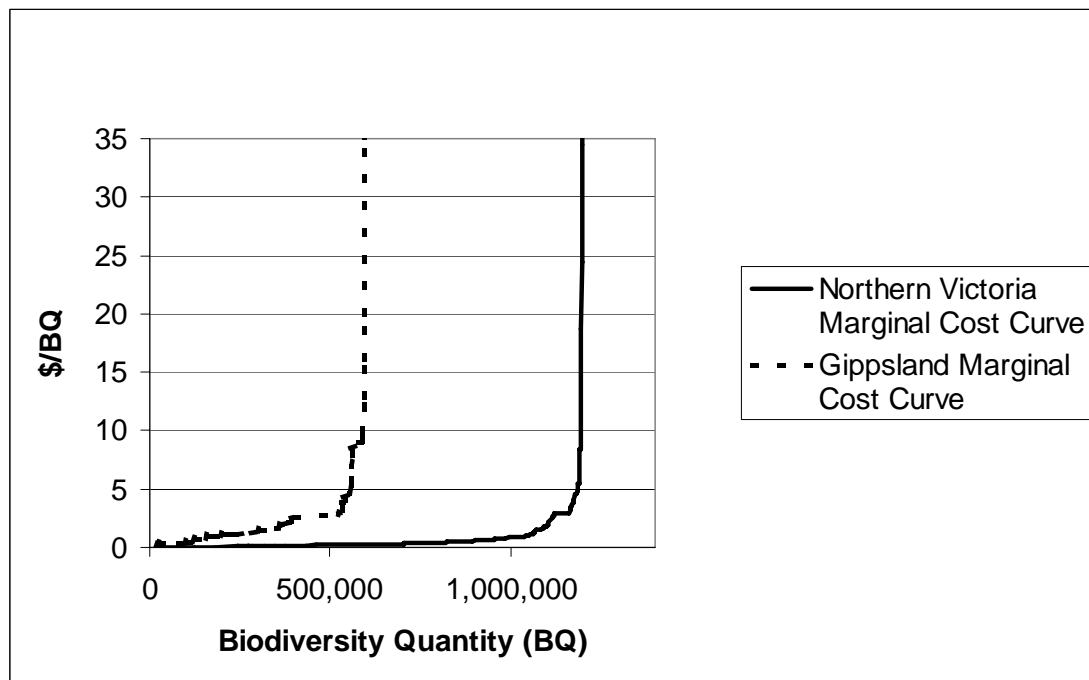
First consider the BC auction in the left-hand part of Table 7. With the same budget, the BC auction was able to generate 27 per cent more environmental benefit (nitrogen abated) than the fixed-price scheme. Information rents under the auction were only 67 per cent of the fixed-price scheme. Total opportunity costs were higher, reflecting the higher level of abatement under the auction. Likewise, the TC auction achieved roughly the same environmental outcome (save for a few indivisibilities) with only 80 per cent of the payments of the corresponding fixed-price scheme. These findings highlight the cost-effectiveness of auctions as an allocation mechanism, but also suggest that the choice of auction format has only a minor effect on outcomes – a finding we already flagged in section 4.3.3.

Auction performance deteriorated in the second and third round: bids tended to move up relative to the cost curve, and did so more for low-cost bidders than for high-cost bidders. By the third round, much of the initial advantage of the auction had been lost relative to the fixed price scheme. Bidders had effectively learned the implicit reserve prices and adjusted their bids accordingly. The Kiel experiments were replicated in Perth, Western Australia, to check for the robustness of these results. Very similar results were obtained.

#### 6.4 Evidence from field pilot auctions

The BushTender trial in Victoria (see section 5.3 for details) was the first pilot auction to test the proposition that competitive bidding, compared to fixed-rate payments, can significantly increase the cost-effectiveness of conservation contracting. Stoneham et al. (2005) analysed the bids of the first two bidding rounds and compared these to a hypothetical fixed-price scheme. Drawing on information from the bids, Figure 4 illustrates the cost (= bids) of generating additional units of biodiversity (measured as a biodiversity quality-adjusted unit, or BQ).<sup>9</sup> The curves thus represent the supply curves for biodiversity in a discriminatory first-price auction.<sup>10</sup>

Figure 4: Supply curves from BushTender



Source: Stoneham et al. (2005)

As shown in Figure 4, the supply curves for biodiversity are relatively flat over much of the quantity range, but then transform to relatively steep as the quantity of BQ rises. Although it is difficult to compare the results from the auction with other mechanisms, it has been possible to examine how a hypothetical fixed-price scheme would perform compared with the discriminative price auction used in the pilot.

The results are shown in Table 8. For the Northern Victoria (first-round) pilot, a fixed-price scheme would have required a budget of approximately US\$2.1 million (almost seven times more than the actual budget) to elicit the same quantity of BQ units as the discriminative price auction. Looked at it another way: for the same budget of around

<sup>9</sup> These units are the numerator of the Biodiversity BBI as given in section 5.3.

<sup>10</sup> The bids shown in Figure 1 are inclusive of any 'information rents' that bidders may have included in their bid price. We assume here that opportunity costs and information rents make up bids. This is different to the characterisation of Latacz-Lohmann and Van der Hamvoort (1998), who differentiate the supply curve on account of it being exclusive of rents.

US\$325,000, a fixed-price scheme would have given an agency approximately 25 per cent less biodiversity. This discrepancy (700% versus 25% performance gain) clearly reflect the flat shape of the supply curve over much of the quantity range combined with the sharp increase of its slope as the quantity of BQ rises beyond a certain level. Similar results were obtained from the Gippsland (second-round) pilot, although the proportionate increase in cost is less, but percentage fall in quantity is greater.

Table 8: Comparison of fixed-price scheme to BushTender price discriminating auction

		<b>Northern Victoria (1<sup>st</sup> round)</b>	<b>Gippsland (2<sup>nd</sup> round)</b>
<b>Comparison Holding Biodiversity quantity constant</b>			
	Actual Budget (\$USD)	325,817	629,403
	Budget required in Fixed Price Scheme (\$USD)	2,113, 600	1,632,900
	Proportionate increase in cost of fixed price scheme	6.5	2.6
<b>Comparison Holding Budget constant</b>			
	Actual BQ	1,165,019	530,099
	BQ of Fixed Price Scheme	874,412	371,679
	Percentage Fall in Quantity from fixed price scheme	25	30

Source: Stoneham et al. (2005)

These results should be interpreted with caution. The suggestion here is that the size of the gain may be overstated due to an inappropriate counterfactual comparison. Stoneham et al. (2005) take the bid curve to be equal to the true opportunity cost curve. They argue that the bids shown in Figure 1 are inclusive of information rents that bidders may have included in their bid price. They thus assume that opportunity costs and information rents make up bids. This is correct, but it is not right to claim that the bids also represent true opportunity costs. The standard characterisation of supply curves in economic theory is exclusive of rents. Rents arise if there is a difference between the price received (bid or fixed payment) and the true opportunity costs (exclusive of rents).

Recall Figure 3 for clarification: There are two distinct supply curves, one for the auction (which does include information rents) and one for the fixed-price scheme (which does not include information rents). Simulating the outcome of a fixed-price scheme requires one to relate the price to the true opportunity cost curve. The area between price and opportunity cost curve represents information rent. Relating the fixed price to the bid curve (i.e. assuming that the bids represent true opportunity costs) leads to an overestimation of the fixed price needed to achieve the same outcome, in terms of BQ quantity, as in an auction. Given the very steep slope of the

supply curves in Figure 4 for higher levels of BQ output, this overestimation is likely to be significant. The performance gains from using an auction are thus overestimated.

White and Burton (2005) used data from the Auction for Landscape Recovery (see section 5.4 for details) to benchmark the budgetary cost-effectiveness of the auction to that of an equivalent fixed-price scheme. They show that the cost-effectiveness of the ALR compared to that of a uniform price scheme varies between 315% and 207% in round 1 and 165% and 186% in round 2, depending on whether the fixed price scheme is input-based or output-based (see Box 8). See Table 9 for the full results. White and Burton (2005) also show that comparing BushTender to an output-based scheme would considerably reduce the cost-effectiveness gains of 700% claimed by Stoneham et al. (2003) and Stoneham et al. (2005). It is also clear from Table 9 that auction effectiveness can vary from round to round.

Box 8: Alternative benchmark schemes for evaluating the cost-effectiveness of an auction

Contract 1 is the **auction** itself where successful tenders are paid their bid in return for environmental inputs (discriminatory price budget-constrained auction).

Contract 2, is where a **fixed-price per unit of environmental benefit** is paid (Stoneham et al, 2003).

Contract 3 is where a **fixed-price per unit of environmental input** is applied, these payments ensure compliance by being greater than or equal to the bid. If the regulator is restricted to fixed price contracts, there is no guarantee that the optimal set of tenders selected from the price discriminating auction will be optimal. In other words, the regulator would make an alternative choice of successful bids if they were restricted to fixed output or input price contracts.

Contract 4 is where the regulator makes an **optimal selection of successful bids** and pays a **fixed-price per unit of environmental benefit**.

Contract 5 is where the regulator **selects bids** on the basis of fixed prices for environmental **inputs**.

Contract 6 assesses the gains from a partial price discrimination based on a fixed price for conservation inputs where the regulator divides the successful bids into **two groups with different payment rates (tiered contract scheme)**.

Contracts 7 and 8 are environmental benefit and environmental input based schemes which account for the possibility that bids include an **element of rent**.

Source: White and Burton, 2005



Table 9: Cost effectiveness of the ALR pilot auction assessed against different counterfactuals

Contract	Round	Total Cost \$	EBI	Cost as per cent of Contract 1	Transfer payments \$:			
					EBI	Fence km	Revegetation ha	Feral control ha
1. Discriminatory, budget-constrained auction (input-based)	1	99462	58540	100	-			
	2	98878	60854	100	-			
2. Fixed payment per unit of environmental benefit	1	313368	58540	315	5.353	-	-	-
	2	163129	60854	165	2.680	-	-	-
3. Fixed payments per unit of environmental input	1	206197	58540	207	-	3659.87	266.;66	0
	2	183672	60854	186	-	1888.89	874.87	0.453
4. Optimal fixed payment per unit of environmental benefit	1	313368	58540	315	5.353	-	-	-
	2	142207	61584	144	2.309			
5. Optimal fixed payments per unit of environmental input	1	206197	58540	207	-	3659.87	266.;66	0
	2	143327	60965	145	-	2329.41	198.71	0.88
6. Two-tier input pricing	1 tier 1	148370	58566	149	-	3911.53	37.88	0
	1 tier 2					2212.92	266.67	0
	2 tier 1	135348	60956	137	-	2207.09	376.86	0.88
	2 tier 2					1513.94	1.50	40.69

Source: White and Burton (2005)

## 7. CONCLUSIONS

### *Key considerations*

Theoretical analysis suggests that competitive bidding can be a powerful means for conservation agencies to increase the effectiveness of public spending for the provision of countryside benefits. The outstanding feature of conservation auctions is their potential to reveal, at least partly, bidders' compliance costs, thereby reducing the information asymmetry between landholder and agency. Conservation auctions also act as a price discovery mechanism for environmental goods and services which have no standard value and which are difficult to cost. They thus allow the parties to deal with the uncertainty about the value of the object being traded. In general, the use of conservation auctions fits well with the trend towards a value-for-money approach that policy has adopted in the provision of public services.

Bidding schemes yield the highest benefits when the conservation agency has little information about landholders' compliance costs, the number of potential participants is large, the contracts offered are homogeneous, and farms are heterogeneous in their compliance costs. The fewer of these conditions apply, the less well an auction will perform relative to a fixed-rate payment scheme.

Theoretical analysis further suggests that, under standard discriminatory price auctions, landholders will shade their bids above their costs of compliance: the optimal bidding strategy is one of overbidding; the auction will not reveal bidders' *true* opportunity costs. In fact, overbidding is highest for the lowest-cost bidders, whereas the highest-cost bidders will bid closest to their true costs. However, these highest-cost bidders are not those that are usually selected; rather, the lowest-cost bidders are, but they get paid well above their true costs.

Empirical evidence about the performance of conservation auctions is inconclusive. Efficiency gains reported in the literature range from a few per cent to seven hundred per cent. The latter value, reported by Stoneham et al. (2003), should be interpreted with care due to the 'non-standard' way in which it has been computed. We conclude that it is too early to make a robust and reliable assessment of the cost-effectiveness of auctions in agri-environmental management. This is at least true for one-shot auctions.

There is unanimity in the empirical literature that bidder learning poses a substantial threat to the efficiency of multiple-round conservation auctions. Both experimental studies and agent-based simulation studies have confirmed the experience with the US Conservation Reserve Program: when bidders have the opportunity to learn from preceding bidding rounds, they will use that information to update their bids and reap a higher share of the 'surplus' – at the detriment of auction performance. Proposals to combat bidder learning have been made in the literature, but none of these have been tested empirically.

Conservation auctions are complex incentive mechanisms. Their design poses many challenges and there is little practical experience, implying the risk of implementation failure. Auction theory is not well developed for conservation auctions and thus does not provide sufficient guidance for most policy design purposes. Theoretical analysis in mainstream economics is predicated on analytically tractable models, which requires the analyst to make drastically simplifying assumptions that reduce, and sometimes annihilate, their relevance to real policy contexts. Researchers are only beginning to explore practical auction design issues through the use of controlled

economic experiments or agent-based computational simulations. Results are fragmentary and do not provide, as yet, a sound and encompassing basis for informing practical auction design.

The potential benefits of auctions come at the cost of likely higher administration costs and higher transaction costs on the side of landholders, although empirical evidence is patchy so far. Complaints from unsuccessful applicants for the Scottish Challenge Funds focused on high costs of bid preparation in connection with uncertain outcomes, resulting in the bidding mechanisms being replaced by locational (i.e. fixed-rate) premia.

### *Implications for agri-environmental management in Scotland*

SEERAD has indicated that it is considering allocating Land Management Contracts (LMC) through competitive bidding. LMC is a menu scheme designed to provide a range of measures suited to the diversity of agricultural activity and land types throughout Scotland. Landholders can choose which activities they wish to carry out from the menu (see Table 10), depending on what suits their individual circumstances and plans for future business development. The LMC Menu Scheme is a multiple-objective scheme: it is designed to deliver *widespread* benefits leading to economic, social and environmental improvement. An extension of the LMC Menu Scheme, which is currently being developed, will focus on the provision of *tailored* economic, social and environmental benefits. The current Scheme, launched in 2005, puts an upper limit on the total allowance an individual landholder can receive per annum in return for carrying out options from the menu.

We do not consider competitive bidding to be the ideal mechanism for allocating Land Management Contracts – for a number of reasons:

First, there is unlikely to be much variation among landholders in the costs for carrying out the options listed in Table 10. In other words, compliance costs are relatively homogeneous. For bidding to be effective, farms must be heterogeneous in their compliance costs. Second, most of the measures are reasonably straightforward to cost. Put differently, there is little uncertainty about the value of the goods and services being traded. There is thus no need to use an auction as a price discovery mechanism. Third, LMC contracts are heterogeneous. Different landholders will include different combinations of management options in their bids. Bids thus will differ in their contribution to each of the three broad programme objectives (economic, social and environmental improvement). Under these circumstances, bid selection can be a complex task. SEERAD would face the challenge of determining weights reflecting its relative preferences for the different measures or, if measurable, their contribution to the Scheme's objectives. That is, a multi-criteria bid scoring system would have to be devised to aggregate the various dimensions of a bid into one figure representing an estimate of the overall (economic, social and environmental) benefit of each bid. While this is not an infeasible task, in practice it is likely to involve high transaction costs and, because of lack of sufficient transparency in the complex ranking method, the risk of complaints and appeals from unsuccessful applicants.

Whether competitive bidding is the appropriate mechanism for allocating contracts for the extended LMC Scheme (to be launched in 2007) is a matter of debate. This scheme is designed to deliver *tailored* (rather than *widespread*) economic, social and environmental benefits. Tailored benefits usually require very specific measures

targeted to specific resource settings. To the extent that tailoring involves spatial targeting or the use of strict eligibility criteria, the number of potential applicants may fall below the level required to secure sufficient bidding competition. The smaller the group of potential bidders, the lower is the level of bidding competition and the higher the risk of collusion and strategic bidding. In such circumstances, an auction is not the appropriate incentive mechanism and fixed-rate payments or individually negotiated grants should be considered instead.

Table 10: LMC Menu Scheme: measures and payment rates

	Measure	Payment Rates
1	Animal health and welfare programme	Up to £1135
2	Membership of quality assurance scheme	Up to £150 per scheme
3	Training	Up to £500
4	Farm and woodland visits	£100 per visit
5	Off-farm talks	£50 per talk
6	Buffer areas	£200 per hectare
7	Management of linear features	£0.10 per metre of hedgerow
		£1 per metre of ditch
		£0.10 per square metre of dyke
8	Management of moorland grazing	£1 per hectare
9	Management of rush pasture	£125 per hectare
10	Biodiversity cropping on in-bye	£40 per hectare
		£150 per hectare with stooking
11	Retention of winter stubbles	£40 per hectare
12	Wild bird seed mixture	£329 per hectare
13	Summer cattle grazing	£1 per hectare
14	Nutrient management	£2 per hectare
15	Improving access	£2.75 per metre of path
		Up to £150 for capital items
16	Woodland plan	£10 per hectare of woodland
17	Farm woodland management	£30 per hectare of woodland

Source: [www.scotland.gov.uk/library5/agri/lmcsl-00.asp](http://www.scotland.gov.uk/library5/agri/lmcsl-00.asp)

Similar problems arise when landholders have the choice to enter different tiers of a scheme, reducing the number of bidders per tier. This problem, however, can be addressed through an appropriate bid selection mechanism whereby all bids (from all tiers) are ranked based on the ratio of some overall benefit index to the amount bid. Such a mechanism would allow SEERAD to compare and select bids on a common denominator across tiers, effectively increasing the pool of bidders. This, however,

comes at the cost of high transaction costs and the risk of complaints and appeals – as discussed above.

Once again: auctions work best when the number of bidders is high, contracts are homogenous and landholders are heterogeneous in their compliance costs. Of all agri-environmental schemes offered in Scotland, the Organic Farming Scheme is probably the one which best meets these requirements. Reserve prices could be set for different types of land use and different land management systems, e.g. arable land, improved grassland, rough grazing. The risk here is that the current fixed payment rates might act as a point of reference in the bidding process, with bids anchored around them.

### *A possible way forward*

Given the lack of theoretical backdrop and practical experience, we advise a cautious approach to the use of auctions in conservation contracting.

Experimental economics and policy ‘test-bedding’ seem to offer a way forward. Since 2002 when Vernon Smith received the Nobel Prize for pioneering this new field, experimental economics is taking economists by storm. Economic experiments take place, strictly speaking, under totally controlled conditions in a laboratory. They can have three functions: 1) testing existing theories and their predictions; 2) testing new policy mechanisms or institutions; and 3) exploring beyond existing theory where theory is unable to provide sufficient guidance. In the case of auctions for conservation contracts, roles (2) and (3) are involved.

In a broader sense, of greater relevance to the policy maker, experimental economics can be taken to mean an ordered sequence of investigations starting with some theoretical model and ending with a reduced scale field trial, the last stage before full-scale policy implementation. The steps involved include, in roughly the following order (steps 2 and 3 can interact):

- 1) theoretical model or hypotheses of bidding behaviour and auction outcomes
- 2) computer-based simulations with “virtual agents”
- 3) laboratory experiments with (typically) university students
- 4) laboratory experiments with stakeholders
- 5) reduced-scale field pilots

Focusing on steps 3 to 5, the question is often asked whether laboratory experiments are able to accurately predict outcomes in the field, on the understanding that if they do not, laboratory experiments are likely to be of little value. Vernon Smith’s response to this legitimate question is this: of course the lab does not accurately predict outcomes in the field, and it was never meant to. Instead, its function is to allow us to make at low cost all the serious and potentially expensive mistakes both in the financial and in the political sense. Lab experiments allow us to narrow the range of errors which can be made in the field and thereby save us a lot of money.

The implication for auctioning conservation contracts is that, given the insufficient guidance provided by theory, any policy initiative in this area should be preceded by carefully targeted and designed experiments. This is called ‘test-bedding’ policies and has also been called ‘wind-tunnelling’ or ‘glass-housing’ policies, depending on whether one has an engineering or an agronomic bent. Such experiments must be carried out by experienced specialists. They represent a stage in the learning process towards successful auction design. Laboratory experiments with stakeholders (step 4 above) has potential advantages in terms of: eliciting the opportunity costs (and

heterogeneity in costs) faced by landholders; identifying likely participation rates in an auction system, across different auction formats; and identifying the transaction costs associated with a tender mechanism.

An alternative way forward may be this: rather than using a discriminatory-price auction to allocate conservation contracts in multiple bidding rounds, SEERAD could consider running a one-shot *uniform-price* auction and use the information gained in the bidding process to devise and calibrate an appropriate fixed-price scheme. The main purpose of the auction thus is to reveal information about compliance costs. As we have demonstrated in section 4.3.1, the incentive structure of a uniform-price auction is such that it induces bidders to reveal their *true* compliance costs with the bids. Bids could subsequently be analysed to determine appropriate, cost-orientated payment rates for different farm types, land use systems and resource settings. However, if landholders (or more generally bidders) know this is SEERAD's strategy, they will have an incentive to bid strategically to bias the future fixed price in their favour.

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## Appendix 1

### A formal analysis of the moral hazard problem (Latacz-Lohmann, 1998)

The decision to violate conservation agreements fits naturally into the framework of choice under risk. Risk arises because the probability of being caught in violation often is less than one. Therefore, an individual who violates an agreement stands either a chance of succeeding with the violation, and hence having increased wealth, or a chance of being caught and punished. In the exposition below,  $\mathbf{x}$  is a vector of variables describing agricultural technology. The management prescriptions involved in a conservation agreement are modelled as a quantity constraint,  $\bar{\mathbf{x}}$ , imposed on certain aspects of agricultural technology.  $\bar{\mathbf{x}}$  may include, for example, an upper limit on fertiliser or pesticide usage, a stocking rate limitation, or a provision to leave field margins uncultivated.

Define a contract violation as  $\mathbf{x}_v > \bar{\mathbf{x}}$  and assume that violations are detected with probability  $p$ . Next assume that the sanction imposed in case of detected violations,  $S(\mathbf{x}_v)$ , depends on the degree of the violation, with  $S' > 0$ . Finally, assume that a conservation grant,  $G$ , is paid on the understanding that  $\mathbf{x} \leq \bar{\mathbf{x}}$  during the period of the agreement and that  $G$  must be fully repaid in case of detected violation.

Imposing risk-neutrality, the farmer's decision problem can be modelled as discrete choice among the following three options, which provide distinct levels of expected income.

Option 1: 'Compliance'

$$(1) \quad Y_C = \Pi(\bar{\mathbf{x}}) + G$$

Option 2: 'Non-compliance gamble'

$$(2) \quad \begin{aligned} E(Y_{NC}) &= (1-p) \cdot \left( \Pi(\mathbf{x}_v^*) + G \right) + p \cdot \left( \Pi(\mathbf{x}_v^*) - S(\mathbf{x}_v^*) \right) \\ &= (1-p) \cdot G + \Pi(\mathbf{x}_v^*) - p \cdot S(\mathbf{x}_v^*) \end{aligned}$$

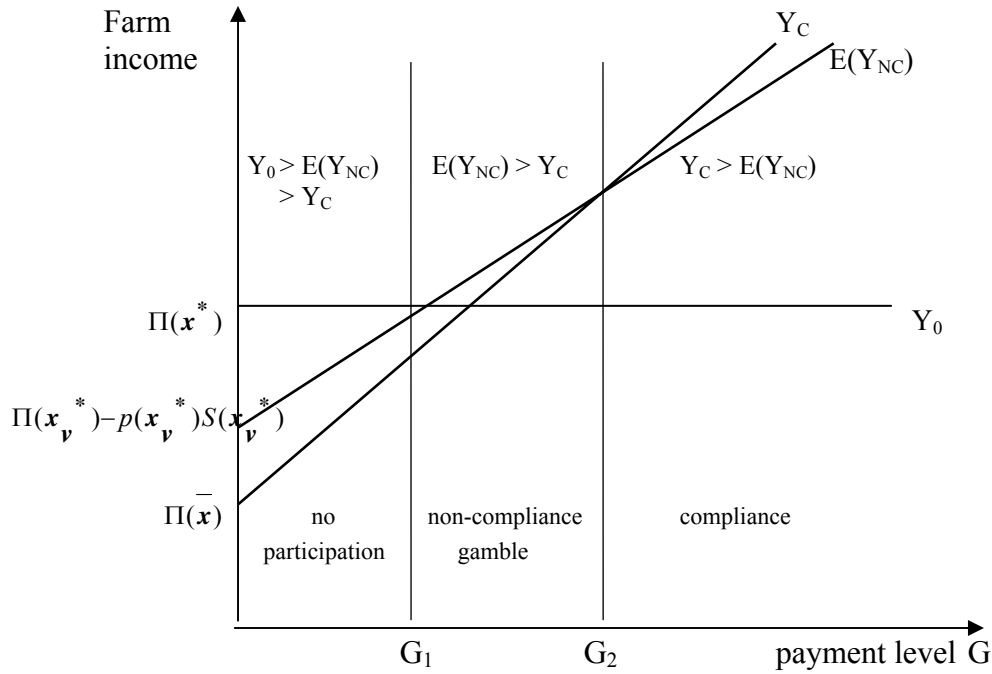
Option 3: 'No participation'

$$(3) \quad Y_0 = \Pi(\mathbf{x}^*) \quad (\text{which represents the farmer's reservation income})$$

$\Pi(\cdot)$  denotes profits from farming (excluding the conservation grant);  $Y$  is total farm income (including the conservation grant);  $E$  is the expectation operator;  $\mathbf{x}^*$  represents the features of the optimal, unconstrained, farming technology in the absence of a conservation agreement; and the indices  $C$ ,  $NC$  and  $0$  indicate compliance, non-compliance and no participation, respectively. It is assumed that  $\Pi(\mathbf{x}^*) \geq \Pi(\mathbf{x}_v^*) > \Pi(\bar{\mathbf{x}})$ . Equality of  $\Pi(\mathbf{x}^*)$  and  $\Pi(\mathbf{x}_v^*)$  implies full violation of the contract, while inequality implies partial violation. Note also that the expected non-compliance income in expression (2) is evaluated at the optimal degree of violation,  $\mathbf{x}_v^*$ . This is the degree of non-compliance that maximises expression (2). In the remainder of this exposition, we will refer to  $\Pi(\mathbf{x}^*) - \Pi(\bar{\mathbf{x}})$  as 'compliance costs', and to  $\Pi(\mathbf{x}_v^*) - \Pi(\bar{\mathbf{x}})$  as 'violation benefits'.

Figure 1 is a graphical illustration of expressions (1) to (3). At payment levels below  $G_1$  in Figure 1, the farmer has no incentive to participate because unconstrained farming yields a higher income than participation. The segment  $[G_1, G_2]$  pictures a range of payment levels in which a non-compliance gamble yields a higher expected income than both compliance and non-participation. Finally, compliance is likely to occur at payment levels beyond  $G_2$ . Underlying Figure 1, as it is drawn, is the assumption that the probability of detection and the level of sanction are sufficiently low such that  $\Pi(\bar{\mathbf{x}}) < \Pi(\mathbf{x}^*) - p \cdot S(\mathbf{x}_v^*)$  where  $G = 0$ . This inequality is required for the range labelled ‘non-compliance gamble’ to exist. It is obvious that this need not be the case. Higher levels of sanction and/or detection probability would remove the above inequality, thus eliminating incentives for non-compliance.

Figure 1: A geometrical illustration of the moral hazard problem



It follows, using the above model, that the regulator can manipulate four contract variables in order to prevent farmers from cheating. These are:

1. The probability of detection  $p$ , as just explained. Variations of the detection probability affect the slope of the  $E(Y_{NC})$  function in Figure 1.
2. The level of sanction  $S(\mathbf{x}_v)$ . Variations in  $S(\mathbf{x}_v)$  will lead to parallel shifts of the  $E(Y_{NC})$  function.
3. The stringency of the management prescriptions  $\bar{\mathbf{x}}$ . Changes in this characteristic will lead to parallel shifts of the  $Y_C$  function in Figure 1.
4. The payment rate  $G$ . Since detected violations will, by assumption, involve the full grant being repaid, increases in  $G$  will act as an additional deterrent to non-compliance.

The critical levels of each of these contract variables can be determined by equating expressions (1) and (2) and solving for the variable of interest. This simple exercise (which is left to the reader) will show that the probability of detection, the size of sanction and the level of payment are perfect substitutes with respect to reducing non-compliance. A reduction in one of the variables can be compensated for by an increase in the other.

## Appendix 2

### A bidding model for multi-unit conservation auctions with a budget constraint (Latacz-Lohmann and van der Hamsvoort, 1997)

Let us consider that landowners or farmers hold private information about their own farm income, and let  $\pi_0$  be the associated profits. Let  $\pi_l$  be the profit remaining after a landowner has given up a proportion of his land, exclusive of any compensation payments by government. More precisely:

$\pi_0$  = profits from business-as-usual land management or farming

$\pi_l$  = profits with a new, conservation-oriented land management

Note that  $\pi_l$  may include income from employment outside farming.  $\pi_l = 0$  if the farmer gives up all of his land and has no alternative employment prospects.

In order for the landowner or farmer to participate in the scheme, the payment he receives must be at least equal to  $(\pi_0 - \pi_l)$ , his or her opportunity cost of participation. If he or she submits a bid  $b$  that is accepted, utility will be  $U(\pi_l + b)$ , where  $U(\cdot)$  is a monotonically increasing, twice differentiable von Neumann-Morgenstern utility function. If the bid is rejected, the bidder's utility is  $U(\pi_0)$ , the reservation utility.

Now let us consider that landowners' bidding strategies are predicated on the belief that the government agency will decide on a maximum acceptable bid, or payment level,  $\beta$ , a common practice when the agency is subject to a constrained budget. This maximum bid is determined *ex post*, after all bids have been received, as the last (highest) bid accepted within the available budget. In other words, no individual bids above  $\beta$  will be accepted.  $\beta$  represents a reserve price per unit of environmental service, unknown to potential bidders. A landowner will tender a bid  $b$  if the expected utility in case of participation exceeds his or her reservation utility, as shown in equation (12), where  $p$  stands for probability:

$$U(\pi_l + b) \cdot p(b \leq \beta) + U(\pi_0) \cdot [1 - p(b \leq \beta)] > U(\pi_0) \quad (1)$$

Bidders do not know the value of the bid cap  $\beta$ , but they will form expectations about it, which can be characterized by the density function  $f(b)$  and by the distribution function  $F(b)$ . The probability that a bid is accepted can then be expressed as

$$p(b \leq \beta) = \int_b^{\bar{\beta}} f(b) db = 1 - F(b) \quad (2)$$

where  $\bar{\beta}$  represents the upper limit of the bidder's expectations about the bid cap, or the maximum expected bid cap. Substituting (2) in (1) yields

$$U(\pi_l + b) \cdot [1 - F(b)] + U(\pi_0) \cdot F(b) > U(\pi_0) \quad (3)$$

The essence of the bidding problem is to balance out net payoffs and probability of acceptance. This means determining the optimal bid which maximizes the expected utility (on the left hand side of (3)) over and above the reservation utility (on the right hand side of (3)). Let us assume that there are no costs in bid preparation and

implementation, and that payment is only a function of the bid. We also assume that bidders are risk neutral<sup>i</sup>.

A risk-neutral bidder simply maximizes expected payoff, so that (3) can be rewritten as

$$(\pi_l + b - \pi_0) \cdot [1 - F(b)] > 0 \quad (4)$$

The optimal bid  $b^*$  is then obtained by maximizing (4) through the choice of  $b$ :

$$b^* = \pi_0 - \pi_l + \frac{1 - F(b)}{f(b)} \quad (5)$$

To gain further insights, one must specify the distribution function  $F(b)$ . The simplest case is where bidders' expectations about the bid cap  $\beta$  are uniformly distributed<sup>ii</sup> in the range  $[\underline{\beta}, \bar{\beta}]$ , where the lower and upper bounds represent the bidder's minimum and maximum expected bid cap. For example, if a landowner believes that the cut-off point will lie somewhere between \$X and \$Y per hectare, then  $\underline{\beta} = X$  and  $\bar{\beta} = Y$ . Note that these bidder's expectations are exogenous to the model.

The density and distribution functions of a uniform (rectangular) distribution are:

$$f(b) = \begin{cases} 0 & \text{if } b < \underline{\beta} \\ \frac{1}{\bar{\beta} - \underline{\beta}} & \text{if } \underline{\beta} \leq b \leq \bar{\beta} \\ 0 & \text{if } b > \bar{\beta} \end{cases} \quad (6)$$

$$F(b) = \begin{cases} 0 & \text{if } b < \underline{\beta} \\ \frac{b - \underline{\beta}}{\bar{\beta} - \underline{\beta}} & \text{if } \underline{\beta} \leq b \leq \bar{\beta} \\ 1 & \text{if } b > \bar{\beta} \end{cases}$$

Of course, there is no sense in the bidder bidding below  $\underline{\beta}$  (this would not increase the acceptance probability) or above  $\bar{\beta}$  (his chances of winning would be nil).

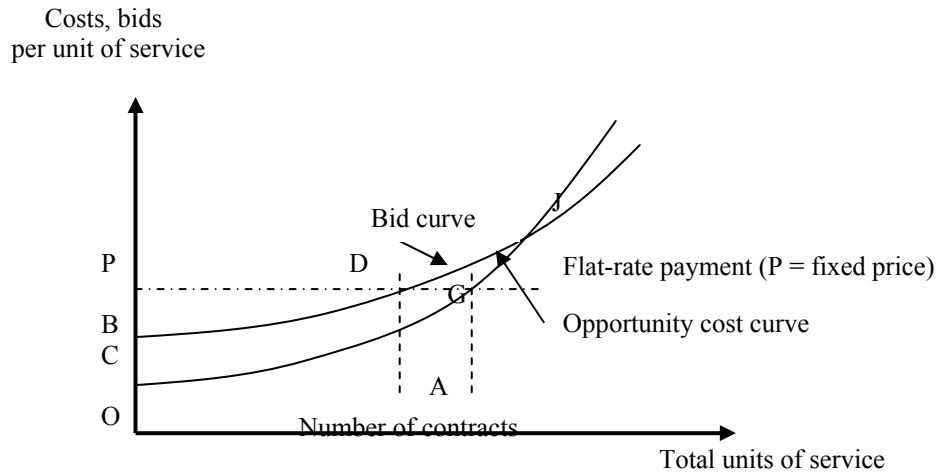
With this specification of  $f(b)$  and  $F(b)$ , one obtains an explicit optimal bid formula for a risk-neutral bidder:

$$b^* = \max \left[ \frac{1}{2} (\pi_0 - \pi_l + \bar{\beta}), \underline{\beta} \right] \quad \text{s.t. } b^* > \pi_0 - \pi_l \quad (7)$$

Expression (7) shows that the optimal bidding strategy of a risk-neutral bidder increases linearly with both the bidder's opportunity costs  $(\pi_0 - \pi_l)$  and his or her expectations about the bid cap,  $\underline{\beta}$  and  $\bar{\beta}$ . Thus, a bidder's bid conveys information about his or her opportunity costs, which are private information unknown to government. The information asymmetry is thus reduced, but not completely: indeed,



the auction's cost revelation property is blurred by the fact that the bid also reflects the bidder's beliefs about the bid cap chosen by the agency. This creates room for bidders to bid above their true opportunity costs and thereby to secure themselves an information rent – area CBDG in Figure 1.



**Figure 1** - Bid and opportunity cost curves

### Appendix 3

#### Australian Conservation Auction Projects (end 2004)

Project Details				NRM issues targeted				Contract organisation
Project	Type	Instrument	Region	Water	Salinity	Biodiversity	Other	
<b><u>BushTender</u></b>	Price	Auction	Victoria				X	Victorian Department of Primary Industries
Land Management Tenders	Price	Auction	Liverpool Plains, New South Wales	X	X	X		Liverpool Plains Land Management Committee
Establishing Landscape Corridors	Price	Auction	Burdekin-Fitzroy, Queensland (Southern Desert Uplands)			X		Desert Uplands Build Up and Diversity Committee
Multiple-outcome auction of land-use change	Price	Auction	Goulburn-Broken Catchment, Victoria	X	X	X		Victorian Department of Primary Industries
TARGET	Price	Auction	Central-West, New South Wales	X	X	X		NSW Department of Infrastructure Planning and Natural Resources
Catchment Care	Price	Auction	Mt Lofty Ranges, South Australia	X		X		Onkaparinga Catchment Management Board
<b><u>Auction for Landscape Recovery</u></b>	Price	Auction	Avon Catchment, Western Australia		X	X		World Wide Fund for Nature
Carbon Tender	Price	Auction	Gippsland, Victoria		X	X		Victorian Department of Sustainability and Environment
Environmental Services Scheme	Price	Auction	New South Wales	X	X	X		NSW Department of Infrastructure Planning and Natural Resources

Note: Projects implementing MBIs other than auctions have been omitted.

<u>Appendix 4</u>  Simultaneous sealed-bid multiple identical unit procurement auction with symmetric IPVs		DISCRIMINATORY PRICE AUCTION				UNIFORM PRICE AUCTION				GEN'd VICKREY PRICE AUCTION (also called Vickrey-Groves-Ledyard)			
Key determinants of bidder behaviour and auction performance ==>		Low competition		High competition		Low competition		High competition		Low competition		High competition	
		Constant MC curve	Increasing MC curve	Constant MC curve	Increasing MC curve	Constant MC curve	Increasing MC curve	Constant MC curve	Increasing MC curve	Constant MC curve	Increasing MC curve	Constant MC curve	Increasing MC curve
Bidder behaviour	Bidder truthfulness	Overbidding is optimal				Higher frequency of truthful bidding		Lower frequency of truthful bidding		High frequency of truthful bidding			
	Type of bid distortion	Lower frequency of supply inflation(1)	Higher frequency of high flat bidding	Higher frequency of supply inflation	Lower frequency of high flat bidding	With heterogenous bidders, truthful bidding from small capacity bidders (but lower than under GVA)			Supply inflation from large capital bidders - but more truthful				
Auction performance	Budget cost-effectiveness	Highest distortion of true costs				When bidders are heterogenous, more expensive due to large bidders who overbid on last units			Roughly as expensive as GVA	Least expensive (per unit). Lowest distortion of true costs but can still be significant			
		More cost-effective than Uniform Auc when bidders heterogenous		Less cost-effective than Uniform Auc when bidders homogenous						Especially true with const MC			Roughly as expensive as Uniform
	Economic efficiency	Least efficient				Intermediate efficiency				Most efficient			
		Distortion of true social costs remain small across all auction formats (under linear specification of demand function)											

© Steven Schilizzi, from paper written by A. Hailu and S. Thoyer (2005), "What format for multi-unit auctions: Uniform, discriminatory or generalized Vickrey?"

**NOTES :**   IPVs = Independent Private Values  
 MC curve = Marginal Cost curve  
 GVA = Generalized Vickerey Auction (3rd format)  
 (1) but with less competitive cost structures

## Appendix 5: Structure of DEA-based bid ranking models

We define value for money as the ratio of all expected outputs (environmental quality attributes) valued by the conservation agency over the bid amount:  $w'y_i/b_i$ , where  $y_i$  are the output estimates offered by bidder  $i$ ,  $w$  is a vector of output weights and  $b_i$  is the bid amount. The agency is interested in acquiring as much of these quality characteristics as possible per unit of ‘input’, i.e. per pound of public money expended. The purpose of DEA is to construct a non-parametric envelopment frontier over these data points as a linear, piece-wise combination of observed maximum ‘outputs’ given observed bids (‘inputs’) such that all observed points lie on or below the value-for-money frontier. The frontier thus serves as a benchmark for assessing the relative merit of landholders’ claims. Because of the need to aggregate multiple, incommensurable outputs, weights  $w$  must be determined for each output. To select optimal weights for each bid we specify the DEA model:

$$\begin{aligned} & \text{Max } (w'y_i/b_i) \\ \text{subject to } & (w'y_j/b_j) \leq 1, \quad j = 1, 2, \dots, i, \dots, N \\ & w \geq 0 \end{aligned}$$

DEA thus creates for each of the bids offered an optimal set of output weights – such that the value-for-money score of the  $i$ -th bidder is maximised subject to the constraint that all value-for-money scores must be less than or equal to one. That is, bids on the value-for-money frontier are assigned a value of one. Thus, given the information available on quality attributes and the corresponding bids, those ranked highest will provide the greatest value for money to the conservation agency.

Rather than solving the above problem directly, one can make use of duality in linear programming and solve the equivalent dual form. The dual solution provides additional information about slacks and targets and is generally the preferred form to solve. One would choose the input-oriented, variable-returns-to-scale model proposed by Banker, Charnes and Cooper (1984), the so-called BCC model. One would choose the input orientation (rather than the output orientation) because bidders have only control over the ‘input’ (the bid) while the ‘outputs’ (the quality attributes) are given and cannot be controlled by the bidders. The input-oriented specification addresses the question: by how much would the bid have to be lowered, given the quality characteristics, until the observation is on the value-for-money frontier?<sup>11</sup> This is not the place to review the DEA methodology in any detail. The reader may consult Charnes *et al.* (1994), Coelli, Rao and Battese (1998), and Cooper, Seiford and Tone (2000) for basic introductions to DEA.

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<sup>11</sup> The corresponding output orientation would address the question by how much all quality attributes would have to be proportionately enhanced, given the bid, until the observation lies on the value-for-money frontier. The output orientation makes little sense in this context because bidders do not normally have control over the quality attributes of their bids.

