How to design repeated auctions to reward plant biodiversity – lessons learned from a transdisciplinary payment scheme and further need for research

Markus Groth
Leuphana University of Lueneburg
Centre for Sustainability Management
Sustainability Economics Group
Scharnhorststr. 1
D-21335 Lueneburg
E-mail.: groth@uni-lueneburg.de
Phone: +49.4131.677-2636
Fax: +49.4131.677-1381

Paper presented at the *2008 Berlin Conference on the Human Dimensions of Global Environmental Change – International Conference of the Social-Ecological Research Programme*, 22-23 February 2008.

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Abstract

Although the problem of increasingly endangered plant biodiversity is to a growing extent recognised, the question of how to address this challenge appropriately has yet to be answered. One of the suggested approaches is the strengthening of incentive measures and market-creation. The European Union's Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) has introduced auctioning as a new instrument for granting agri-environmental payments and awarding conservation contracts for the recent multi-annual budgetary plan (2007-2013). The paper therefore deals both with the conception and results of a transdiciplinary research project (funded by the German Federal Ministry of Education and Research as part of the BIOLOG-programme) as well as further need for research. Results of two auctions point out that in fact much differentiated offers were made by farmers in the model-region (the county Northeim in Lower Saxony, Germany) and budgetary cost-effectiveness gains of up to 36% had been realised. Even though the case study has yielded promising results, some critical aspects as well as lessons to be learnt will be discussed to improve the design and performance of upcoming (repeated) conservation auctions.

Therefore additional need for research drafted in the paper especially enfolds a worldwide comparative evaluation of conservation auctions, the question of how to value the ecological quality of plant biodiversity – especially against the background of ecological stock dynamics – and the design of a specific environmental benefits index for plant biodiversity.

Keywords:

agri-environmental policy, discriminatory-price auction, multi-unit auction, ecological services, outcome orientation, plant biodiversity, ecological stock dynamics, environmental benefits index, experimental economics, transdisciplinarity

JEL-Classification: C93, D44, H41, Q24, Q28, Q57, R52

1. Introduction

Since the reform of the Common Agricultural Policy (CAP) in 1992, agri-environmental schemes have been supported by the EU within the framework of the second pillar of the CAP. In this context it is the norm, that ecological services provided by agriculture are predominantly rewarded action-orientated and by the use of a single, fixed payment for compliance with a predetermined combination of management prescriptions. Even though the discussion concerning the use of economic instruments in environmental policy has already expanded in the 1990s, the diffusion of innovative policy design

had been slow. Most states still had relied on regulatory, not on market-based policies and even though this strategy had yielded some success, it became clear that market-based strategies and instruments could be more effective for certain applications (Latacz-Lohmann and Hodge, 2003).

In the case of plant biodiversity in Europe the problem of increasingly endangered biodiversity is to a growing extent recognised, but the question of how to address this challenge appropriately has yet to be answered (Kleijn and Sutherland, 2003). Consequently it is mainly the question to develop efficient and effective conservation-compatible land use policies to influence private land management.

One of the suggested approaches is the strengthening of incentive measures and market-creation. The European Union's Council Regulation (EC) No 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD) has introduced auctioning as a new instrument for granting agri-environmental payments and awarding conservation contracts for the current multi-annual budgetary plan (2007-2013): "Where appropriate, the beneficiaries may be selected on the basis of calls for tender, applying criteria of economic and environmental efficiency" (article 39, Council Regulation (EC) No 1698/2005). However, in the range of policy options aimed at the conservation and protection of biological diversity, market-based instruments have only recently gained more attention. The implementation of this institutional reorientation is still characterised by a serve shortage of knowledge and practical experiences. In Europe the practical evaluation of conservation auctions is mainly restricted to isolated and scientifically supported case studies or pilot programmes.

Therefore the paper focuses the specific mechanism of auctioning conservation contracts in biodiversity protection efforts. One part of the paper sets out to investigate and discuss the real-life performance of repeated conservation auctions within a case study area in Germany. Due to restriction and necessary compromises as part of the transdisciplinary research project, the case study auctions could not completely be designed according to theoretical evident guidelines and in a way the author would have done independently from an environmental and resource economist's point of view. These critical aspects will also be reflected in the paper. Furthermore specific need for research will be discussed, concerning a worldwide comparative evaluation of conservation auctions, the question of how to evaluate the ecological quality of plant biodiversity especially against the background of ecological stock dynamics under uncertainty and the design of a specific environmental benefits index for plant biodiversity.

Theoretically the potential benefit of auctions in allocating contracts is evident and well analysed by auction theory (Latacz-Lohmann and Van der Hamsvoort, 1997; 1998; Klemperer, 1999; 2002; Krishna, 2002; Jehiel and Moldovanu, 2003). The two main reasons why auctions are of interests in this case are: first, the traded ecological goods are non-market goods which have no standard value and in some kind of way a public demand and valuation is needed. The second reason to be mentioned is the presence of an information asymmetry between the farmers and the administration (Latacz-

Lohmann and Van der Hamsvoort, 1997). Only farmers actually know how participating in agri-environmental programmes would affect their production and income. They will therefore calculate based on their individual costs and a price for the trades goods will emerge, which enables a more efficient use of public funds as if the administration would fix flat-rate payments, without considering differences in the farmers' production costs.

Auctioning has a longstanding tradition in government procurement contracting, but has been limited to trade commodities as for example public works, electricity and emission rights (Chan et al., 2003). Using auctions to conserve natural resources is a relatively new concept. Anyway in some cases specific auctions have already been used for the provision of public-good type environmental benefits from landowners in the countryside. Since 1986 the U.S. Department of Agriculture has been awarding land retirement contracts for the Conservation Reserve Program (CRP) based on a competitive bidding mechanism. Farmers bid to obtain CRP cost share assistance, which is allocated to them based on a so-called Environmental Benefit Index (Reichelderfer and Boggess, 1988; Babcock et al., 1996). In Australia auctions are used in areas such as salinity control, nutrient control and conservation of native vegetation where land use change is required to achieve environmental improvement as part of the BushTender trials and other projects as part of the Market-based Instruments Pilot Program (Stoneham et al., 2003; Grafton 2005; National Market Based Instrument Working Group 2005). In Europe, a conservation scheme combining auctioning and fixed-price payments had been used in two counties in the state of North Rhine-Westphalia, Germany (Holm-Müller and Hilden, 2004). Moreover the Challenge Fund in the UK was based on auctioning to encourage additional afforestiation on private areas (CJC, 2004).

Even though very promising from a theoretical perspective and in some cases already approved in practice, there is still little evidence about the efficiency gains of auctions compared to payment schemes using fixed-prices. Furthermore, reported results on cost-effectiveness gains vary greatly as for example Stoneham et al. (2003) mention that the first auction within the BushTender trial had lead to an amount of biodiversity that would have cost up to seven times more if a fixed-price payment scheme had been used instead of the auction. Contrary a simulation of farmers' bidding behaviour within a hypothetical payment scheme auctioning conservation contracts by Latacz-Lohmann and Van der Hamsvoort (1997) points out efficiency gains – depending on the auction design – from 16 to 29%. Within the Catchment Care Program as part of the National Market-based Instruments Pilot Program in Australia an auction for biodiversity and water quality – ones in place – would be expected to be between 23 and 34% more cost-effective than the former fixed price scheme (National Market Based Instruments Working Group, 2005). An evaluation of the Central Scotland Forest and Grampian Challenge Fund for the Forestry Commission Scotland by CJC Consultants (2004) reports efficiency gains in the range of 33 to 36%.

Thus the paper sets out to investigate the first sole real-life implementation of auctioning plant biodiversity on grassland sites in Europe instead of simulations, laboratory experiments with students or a combination of auctioning with fixes payments. The survey mainly aims at the discussion of the specific auction design used within the case study as well as its performance focusing farmers' acceptance, bid-prices and findings on efficiency gains through auctioning compared to existing state-run agri-environmental programmes using fixed payments.[1] Furthermore the paper will discuss urgent need for research concerning one-shot as well as repeated conservation auctions and their implementation in the European agri-environmental policy.

The paper is structured as follows. The second section takes a look at general considerations on auction theory and the application of auctioning conservation contracts. Section three presents the case study background by introducing the specific auction design and its implementation. The results of both auctions are discussed in the fourth section including the submitted and accepted bids as well as comparative efficiency gains. Section five presents current need for research and first conceptual ideas. Section six concludes and highlights additional medium-term need for research.

2. Auctioning environmental services

2.1 Some auction theory and main considerations

In order to design an appropriate auction mechanism, the paper first takes a look at general auction theory and its basic concepts. But as auction theory can be seen to be of „second-order importance for practical auction design" (Klemperer, 2002, p. 2), basic concepts and terms will be introduced briefly and the paper will soon turn to the auction design in the conservation contracts application. Auction theory basically distinguishes between the following four types of auctions, designed as selling auctions (Milgrom, 1989; Klemperer, 1999; 2002; Krishna, 2002; Chan et al., 2003; Jehiel and Moldovanu, 2003; Latacz-Lohmann and Schilizzi, 2005):

i. In the *descending-bit auction*, the auctioneer starts with a very high price, which is lowered continuously until one bidder states the willingness to accept the current price. The good is thus won at that price. It is also called Dutch auction because it is used in the sale of flowers in the Netherlands.
ii. According to the rules of the *ascending-bid auction*, the price is raised by the auctioneer until only one bidder remains who wins the good at the final (highest) price. This kind of auction is also called open, oral or English auction.
iii. In a *first-price sealed-bid auction*, each bidder submits a single bid independently without having information about the bids that other bidders make. The good is then sold to the bidder offering the highest bid price.

[1] This case study was financially supported by the Federal Ministry for Education and Research within the BIOLOG-programme.

iv. The *second-price sealed-bid auction*[2] works in a similar way. The good is also sold to the bidder offering the highest bid price, but in contrast to the first-price sealed-bid auction, the price paid is the second-highest bidder's bid.

These standard selling auctions can be adopted as procurement or reverse auctions, like in the case of auctioning ecological services. But as especially Latacz-Lohmann and Schilizzi (2005) point out, auctions for ecological services differ from basic auction design in many respects – as we will also see in the remainder of this paper. Thus auction theory is not well developed for this kind of specific auctioning and offers little guidance for designing conservation auctions in practice. Therefore some of the main characteristics of auctioning conservation contracts will be presented.

One aspect is that conservation auctions are usually repeated auctions and bids for the same ecological service on one site are invited in a sequence of various bidding rounds instead of just a one-shot auction. This allows bidders to learn from the results of previous auctions and to use this information to adjust their bids (Reichelderfer and Boggess, 1988; Hailu and Thoyer, 2004). Connected with bidders learning from prior auctions is the question of collusion. Collusion generally means that bidders may explicitly or tacitly agree to avoid a bidding-up of prices in an auction. In the specific case of auctioning conservation contracts, they may collude to achieve the highest prices possible. A frequently repeated auction market is particularly vulnerable to this phenomenon because repeated interaction among the participants will expand the set of signalling and will allow the bidders to learn to cooperate. The important decision on the payment format will be discussed in the following section, especially facing the farmers' bidding behaviour.
Equally important is the attraction of a high number of participants in the auction to ensure sufficient competition among bidders. This can be a problem in any auction format, particularly if the costs of entry and the asymmetries between bidders are too large (Klemperer, 2002).

Another aspect to be mentioned is the number of goods traded simultaneous and therefore to distinguish between single-unit auctions and multi-unit auctions (Kagel and Levin, 2001; Hailu and Thoyer, 2006). Auction theory mainly deals with the case of single-unit selling auctions, but conservation auctions are multi-unit procurement auctions and the administration selects various farmers with numerous heterogeneous sites to take part in the auction. Hence the administration needs to value the bids both using ecological as well as economic criterions and conservation auctions are characterised by an at least two-dimensional bid valuation (Groth, 2007).
Finally it needs to be considered that conservation auctions can be used either as budget-constraint auctions or as target-constraint auctions (Latacz-Lohmann and Schilizzi, 2005). The budget-constraint

[2] The second-price sealed bid auction is also called vickrey-auction; named after the Nobel-price winning economist William Vickrey (in 1996 and together with James Mirrlees).

auction is the usual case that agri-environmental schemes have a limited budget to spend and therefore applicants are accepted until the budget is exhausted. Thereby the administration faces no risk about the final costs the programme will cause, but the amount of ecological services taken under contract is uncertain. In contrast the target-constraint auction will be used if the number of contracts, or in general the amount of ecological services, is decided about and fixed a-priori. The budget finally needed to achieve this target is unknown. Another aspect of designing auctioning schemes is the question of whether a reserve price should be set. A reserve price is a price limit that defines the maximum amount that the administration is willing to accept (Stoneham et al., 2003; Latacz-Lohmann and Schilizzi, 2005).

Hence information asymmetry is the key feature of auctions and particularly relevant for the functioning of markets for environmental goods and services. This is the case since these goods and services are often generated by lands that are private property. A farmer, in this case, usually knows his own land as the base of production opportunities better than any public agency (Fraser, 1995; Wu and Babcock, 1996). If a landowner considers participating in conservation programmes, he will thus know best how participation is likely to affect production opportunities and eventually farming income. On the other hand, the farmers may lack information about priorities in the agri-environmental policy or about the particular environmental significance of the ecosystem structures on their land.

Thus, from a policy-makers point of view, auctions to buy ecological services from landowners basically focus on budgetary cost-effectiveness and the possibility to gather information about the production costs of agricultural firms. Auctioning therefore represent a mechanism that is bound to ex-ante fixed rules with the agrarian administration on the demand side and various farmers on the supply side. Auctions can generally be defined as follows: “An auction is a market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from market participants” (McAfee and McMillian, 1987, p. 701).

2.2 The payment format

To analyse bid values, standard auction theory has employed two basic models. In the private-value model each bidder has an individual knowledge about the value of the object in question. This value remains private information and is not revealed in the auctioning process. In contrast, in the common-value model the value of the object is equal for all bidders involved in the auction. However, the bidders have different private information about what that value actually is. In this case, bidders change their estimates if they learn other bidders’ signals via bids. In contrast, the values in the private-value case would not change based on additional information by other bidders’ preferences or bids (Klemperer, 1999).

Landholders in practise are assumed to have independent private values. This seems to encourage a single round of bidding in connection with the expectation that bids will be based on individual opportunity costs. But in practice the administration usually needs repeated auctions and a common-value element may easily arise; landholders might analyse the results of previous auctions and accordingly update their bids (Latacz-Lohmann and Van der Hamsvoort, 1997). As long as no official information is available to the bidders how the conservation agency values the sites with respect to their conservation value, the landholders will have different assumptions on the relative value of their land. In order to avoid the appropriation of information rents and collusion, it has to be considered carefully what information will be given to landowners. Consequently and due to the fact that only *sealed-bid auctions* are of interest in this case, there are two adequate payment formats to be used within repeated multi-unit auctions for ecological services. These payment formats will now be briefly discussed, in particular regarding the respective strategic incentives and the expected farmers' bidding behaviour (Milgrom, 1989; Latacz-Lohmann and Van der Hamsvoort, 1997; Cason and Gangadharan, 2003; 2005; Stoneham et al., 2003; Latacz-Lohmann and Schilizzi, 2005):

i. The *uniform-price sealed bid auction* where a sealed bid is submitted by each bidder, stating the individual price for a specific ecological service. The good is then bought at a price determined by the price of the highest winning bid or the lowest rejected bid. All successful bids are paid equal. Thus the individual bid price just determines the probability of acceptance but not the final payment and the theoretically optimal bidding strategy is revealing the accurate opportunity costs.
ii. The *discriminatory-price sealed bid auction* where also a sealed bid is submitted for every site, but all accepted bids are receiving payments according to the individual bid price. This creates incentives for bidders to bid a price above the individual opportunity costs and ensure themselves information rents if the bid finally is successful.

Hence the main difference between the uniform-price auction and the discriminatory-price auction is that the bid price affects the amount of the individual payment only within the discriminatory-price auction.

The theory of budget-constrained auctions suggests that it is optimal for bidders in a discriminatory-price auction to overbid relative to their true costs of providing the good (Latacz-Lohmann and van der Hamsvoort, 1997; Cason and Gangadharan, 2005). The bid curve – ordered from the lowest to the highest bid – does not therefore represent the true cost curve; it rather contains a rent for the bidder. Hence the supply curve is not identical within discriminatory-price auctions and uniform-price auctions, whereby the true opportunity costs theoretically equals the bid prices within a uniform-price auction. The latter is based on the true marginal cost curve of environmental service provision, without a rent element. A discriminatory-price auction does therefore reveal differences in opportunity costs, but only imperfectly so, because of the incentive to overbid. Whether one or the other payment format

is more cost-effective, is an empirical question and the more bidders shade their bids under the discriminatory pricing rule the more its advantage diminishes relative to the uniform-price auction.

On the basis of theoretical considerations the payment format of a uniform-price auction seems to be the best choice since it creates no incentives for overbidding the individual opportunity costs. But particularly facing the practical considerations of a case study implementation some further aspects need to be considered (the discussion follows and complements Latacz-Lohmann and Schilizzi, 2005).

A main argument against uniform-price auctions taken into account within the case study is that farmers with low opportunity costs[3] would benefit disproportional from a higher payment, because the strike price reflects the required compensation for owners of more productive sites. It is obvious that this uniform price could overcompensate farmers with least productive land and lead to an unacceptable overpayment and public criticism on the payment scheme. In contrast a discriminatory-price auction has the appeal of not paying landholders more than what they bid and the critical incentive on overbidding the individual opportunity costs in discriminatory-price auctions could be reduced to some degree by using flexible reserve prices or budget-constraints, taking into account information and experiences from former auctions or fixed flat-rate agri-environmental programmes.

Uniform pricing also seems to be more complex and more difficult to comprehend than the discriminatory-price auction. This may act as a barrier for farmers to participate, particularly within the first-time ever implementation of a conservation auction. In addition uniform-price auctions expose bidders to greater risk as not only the acceptance probability is unknown but also the final payment. If landholders are risk averse, greater risk may act as a deterrent to participation (Groth, 2007).

Additionally it was expected in this small case study that within repeated uniform-price auctions bidders will learn the uniform price paid for successful bids in previous auctions and adjust their bids in the next auction. This kind of bidders' learning will most probably lead to negative effects on the efficiency of the repeated auction performance and was decided to be avoided by any means in the field experiment. The argumentation is also based on findings by Cason et al. (2003). Cason et al. used laboratory experiments to examine bidding behaviour in an auction when the value of the output was known, compared with when it was not. The experiments indicate that when bidders did not know the value of output, their bids tended to be based on the opportunity costs. By contrast, when bidders were given information about the significance of their biodiversity assets, they tend to raise bids and appropriate some information rents.

To recapitulate, the choice between both payment formats is obviously controversial in practise. As neither auction theory nor former laboratory experiments and practical experiences are giving a clear guidance, the decision dependents on the specific implementation background. In the case study the discriminatory-price auction appealed to be the appropriate payment format, also since there were no

[3] Owners of least productive or marginal land.

ex-ante reasons – based on payments in former agri-environmental programmes – to believe that farmers will significantly shade their bids and collude.

Especially against the background of repeated auctions, the first time ever implementation of auctioning plant biodiversity on grassland sites in Europe and aiming at a great acceptance by farmers, things should be keep as simple as possible within the case study. Therefore the specific auction design is based on a discriminatory-price auction and will be described in the following section.

3. Case study background

3.1 Payment scheme and auction design

The transdisciplinary payment scheme is a research programme, designed to reward environmental services of agriculture. It deals with the objectives of enhancing efficiency and acceptance of agri-environmental programmes by the use of an innovative market-orientation (Gerowitt et al., 2003). The payment scheme has been designed, together with a regional advisory board within the case study area, at the research centre for agriculture and the environment at the University of Goettingen. Four main aspects make this transdisciplinary payment scheme different from actual programmes: It is outcome-based, decentralised according to the European principle of subsidiarity, market orientated by the use of auctioning and participatory by the integration of a regional advisory board.

This paper basically deals with the aspect of market creation by the use of conservation auctions. Within the payment scheme regional-specific environmental goods of plant biodiversity – voluntary provided by the farmers – are rewarded as results of environmental services of agriculture. The prerequisite for a market-based support of environmental benefits is that ecological services need to by standardize according to their ecological quality and must meet certain conditions and requirements. This implies that ecological services are valuable goods and could be detected without complicated methods. In addition, the ecological goods should act as an indicator and therefore – in addition to their actual usefulness – should imply positive effects on other natural resources.

The auction design is a repeated sealed-bid discriminatory-price multi-unit auction, with a separate budget-constraint for each quality of ecological goods.

The overall objective is to reward landowners for their provision of environmental services, whereas the payment is – contrary to the majority of current agri-environmental programmes in the EU – not based on actions undertaken by the farmers (Kleijn and Sutherland, 2003), but result-orientated, based on specify ecological services. These ecological services are defined as ecological goods of plant biodiversity (Bertke, 2005). Ecological goods have to be clearly defined by transparent floristic criteria, so farmers are able to prove their fulfilment and a justifiable control of the supplied ecological goods can take place as part of the payment scheme. In this case the production of the so-called ecological goods “grassland” aims at the protection of regional endangered plant communities, the preservation of grassland on marginal sites and the promotion of species-rich grassland. Therefore the number of species per plot and a catalogue of grassland species that are adapted to extensive grassland

management and characteristic for regional plant communities are suitable for the definition of ecological goods grassland. Related to the ecological quality the following three categories were defined: grassland I, II and III, whereas grassland III represents the highest quality of ecological services (Gerowitt et al., 2003; Bertke, 2005).[4]

From an economic point of view the bid price per hectare is taken into account. The ecological evaluation is based on the quality of the produced ecological services represented by the classification into grassland I, grassland II and grassland III. Thus within every category of ecological goods different prices are paid for the same quantity of a (heterogeneous) good, based on the bid prices per hectare.

The specific auction design therefore aims at budgetary cost-effectiveness as well as the possibility for the auctioneer to learn about differences of farmers' opportunity costs revealed by individual bid prices for every grassland site. The regional demarcation corresponds to a uniform exclusion border. To realise a high number of participants and low possibilities for collusion, all kinds of farmers were allowed to take part with all their grassland sites located in the case study area (the county Northeim in the south of Lower Saxony, Germany). In both auctions the same (potential) cohort of farmers was used mainly to learn about the bidding behaviour and the practical performance of repeated auction as well as to collect data on further aspects not discussed in the paper (for example to measure the private transaction costs in both auctions). Furthermore, there was no possibility to run another auction in another case study area with different farmers and a changed auction design due to financial as well as organisational restrictions.

Hence the bidders are bidding on one of three ecological goods, which are defined by the number of plant species targeted as well as the ecological quality of species specific to the region. If landowners do not exactly meet the ecological requirements of the ecological good the bid targeted on, they will not be paid at all. Thereby it is left to the farmers to decide how to achieve the desired grassland I, II, or III status. The results were assessed by a ground control on the grassland site at the end of the contract period. As part of the ground control the number and quality of different species were evaluated by counting them in control plots representative for the whole grassland site.[5] Successful farmers got paid in both auctions.

Since bidding behaviour is very sensitive to the type and amount of information communicated to farmers, no information except the definition of the ecological goods as part of the specification of

[4] The production of ecological goods shall achieve (i) the maintenance of grassland on marginal sites, (ii) the promotion of regional species-rich types of grassland and (iii) the conservation of rare plant associations. Important is either the number of different species per control plot (circle with 2m radius = 12.6m²) as well as the existence of regionally defined target species of extensive grasslands. The ecological goods and their represented ecological quality (amount of plant biodiversity) are defined as follows: grassland I: number of species >= 8/12.6m²; grassland II: number of species >= 8/12.6m² + 2 target species; grassland III: number of species >= 8/12.6m² + 4 target species. The definition of the ecological goods grassland used in the case study is based on the work of Bertke (2005) and has been designed in a previous conceptual project period.

[5] The ground control was part of a separate work area within the research project and will not be examined in this paper.

services and the terms to be maintained was given to potential bidders in both auctions. The budget also was not pre-announced in both auctions and the potential bidders for the second auction were not informed about the highest accepted bid prices. They were only able to learn by the evaluation of their own bids within the first auction. Due to the fact that both auctions were part of a research project, a group of six interdisciplinary researchers acted as the auctioneer.

3.2 Timetable

The case study enfolded two auctions. Below the basic proceeding and the timetable of both auctions will be described.

I. The first auction (2004/2005)

All conventional and ecological farmers with managed grassland sites in the model-region were qualified to submitted bids within the first auction, starting in the beginning of June 2004. In June 2004 three information meetings were held to inform interested farmers about the basic procedure and the necessary documents. The deadline for submitting bids ended after six weeks and the bids were evaluated by the group of researchers within one week. The contracts were closed in the middle of July 2004. According to the outcome-orientation, the ground control took place until the end of July 2005 and successful farmers got paid in August 2005.

II. The second auction (2006)

The basic auction design was the same within the second auction, except for a change that needed to be done due to a short-term safeguarding of the auction budget. This adaptation refers to the circle of eligible farmers and the auction was limited to those farmers already participated in the first auction. Therefore the documents were immediately sent to the relevant farmers in the middle of February 2006. The bids had to be received until the end of March 2006 and were evaluated in one week. The ground control took place by the end of July 2006 and after a successful control, the farmers got paid in August 2006.

Due to the involvement of the auctions in a research project and resulting restrictions, the contract period was one year or shorter and not five years, as usual in agri-environment schemes. Therefore the aspect of windfall profits might be discussed, but since the payment scheme is result-orientated corresponding criticism should be small, but still kept in mind.

4. Results – auction performance

4.1 Submitted bids

To participate, landowners had to submit an individual bid for every grassland site, whereas one farmer was qualified to submit a various number of bids for all categories of ecological services. The

offer includes the choice of the ecological good (grassland I, II or III), the calculation of the price per hectare as well as the description of the grassland site. Main results of the two first-price sealed-bid discriminatory-price auctions within the case study are presented in table 1.

Table 1. Results – ecological goods grassland I, II and III (submitted bids)

	1st auction (2004/2005)	2nd auction (2006)
Grassland I		
- Range of prices in €/ha	40 – 250 (Ø 100.92; SD 47.18)	25 – 160 (Ø 93.94; SD 29.47)
- Number of sites	130	216
- Hectare	221.16	340.65
- Number of farmers	27	26
Grassland II		
- Range of prices in €/ha	55 – 300 (Ø 141.75; SD 59.55)	75 – 300 (Ø 147.67; SD 46.92)
- Number of sites	32	56
- Hectare	53.33	82.58
- Number of farmers	16	18
Grassland III		
- Range of prices in €/ha	100 – 350 (Ø 202.78; SD 78.73)	150 – 450 (Ø 257.35; SD 89.34)
- Number of sites	18	23
- Hectare	36.98	31.61
- Number of farmers	8	7

Source: own. Ø = mean; SD = standard deviation.

Analysing the wide ranges and standard deviations of individual bid prices within every category of ecological goods and both auctions, it becomes clear that the farmers were confronted with different opportunity cost for the provision of an in each case equal quality of ecological services. Within currently used fixed price payment schemes in the European agri-environmental policy these cost differentials remain unknown to the administration and could therefore not be considered for conservation contracting. In contrast, auctioning implies incentives for farmers to share information about their opportunity costs, which can be used by the agri-environmental administration to reduce their information asymmetry.

Looking at the development from the first to the second auction, the range of prices expanded only within the highest quality of ecological services – the ecological goods grassland III. For both ecological goods grassland II and grassland I the range of prices decreased on small scale and for the latter the influence of the strike price on bidders' learning becomes apparent. In the first auction all bids up to a price of €145 per hectare were accepted for the ecological goods grassland I. In the second auction especially the former rejected farmers learned and either reduced the bid prices or – if a reduction of the bid prices was not possible due to higher opportunity costs – did not supply the specific grassland site again. Thus the highest bid price in the second auction was adjusted to €160 per hectare. Furthermore the above findings on submitted bids show that even if the range of prices decreased for the ecological goods grassland I and (slightly) for the ecological goods grassland II,

there is still no collusion with negative monetary effects. The price level, as expected, increased within both auctions from good grassland I about good grassland II up to good grassland III.

Finally the development of the number of bids as well as the number of participating farmers from 2004/2005 to 2006 will be included. It becomes clear that the number of sites (= the number of bids) especially arose for the relatively lowest quality of ecological services, but also within all other classes of ecological goods. It this case it needs to mentioned that in consequence of changing the auction design in 2006 the number of eligible farmers was limited to those farmers already participated in the first auction. Hence the increase of submitted bids from the first to the second auction can be interpreted as a growing interest, confidence and also acceptance of auctioning as a new policy instrument.

4.2 Successful bids

Besides the above considerations on submitted bids the paper will now turn to answer the question, which bids could finally be accepted. Therefore the most important results of the successful bids are presented in table 2 for both auctions and all three categories of ecological goods.

Table 2. Results – ecological goods grassland I, II and III (successful bids)

	1st auction (2004/2005)	2nd auction (2006)
Grassland I		
- Range of prices in €/ha	40 – 145 (Ø 84.59; SD 26.45)	25 – 90 (Ø 66.86; SD 15.56)
- Number of sites	109	89
- Hectare	198.25	130.05
- Number of farmers	20	10
Grassland II		
- Range of prices in €/ha	55 – 300 (Ø 141.75; SD 59.55)	75 – 200 (Ø 137.87; SD 30.92)
- Number of sites	32	52
- Hectare	53.33	76.80
- Number of farmers	16	17
Grassland III		
- Range of prices in €/ha	100 – 350 (Ø 202.78; SD 78.73)	150 – 450 (Ø 257.35; SD 89.34)
- Number of sites	18	23
- Hectare	36.98	31.61
- Number of farmers	8	7

Source: own. Ø = mean; SD = standard deviation.

Firstly it needs to be remembered that both auctions are budget-constraint auctions with no reserve price and therefore the main influence on the number of accepted bids is the budget-restriction for every ecological good. The total budget restriction of €30,000 for the first auction was basically decided to be spend on two-thirds (€20,000) for the ecological goods grassland I and both on one-sixth (€5,000) for the ecological goods grassland II and grassland III, but with the option of shifting some of the budget to higher-quality goods, depending on the number and size of sites. For the second auction

a total budget of €26,000 was available and this time the budget was decided to be spent equal (about €8,667) on all three ecological goods.

In consequence of the total budget-restriction of €30,000 not all bids with the total amount of €33,747.91 could be accepted within the first auction. Finally 159 sites by 28 farmers – covering an area of 288.56 hectare – were taken under contract. With the total bid sum of €51,481.23 the budget-restriction of €26,000 was also exceeded in the second auction and therefore altogether 164 sites by 21 farmers were accepted. This covers species-rich grassland of 238.46 hectare.

Looking at the price ranges and standard deviations of the successful bids and their relevance for the final payment, the results clarify a still wide difference between individual bid prices and thus the consequences of discriminatory-price auctions for the final design of conservation contracting. Within both auctions and all classification of ecological services the budget was spent related to differences of individual opportunity costs, revealed by the bid prices.

The additional analysis of accepted bid price levels in both auctions also shows an increase from the ecological goods grassland I, about the ecological goods grassland II up to the ecological goods grassland III. From the first to the second auction the price level decreased both for the ecological goods grassland I and grassland II mainly due to an adjustment by reducing the specific budget-constraint.

On the other hand the price level and the highest successful bid-price per hectare for the peak quality of biodiversity – represented by the ecological goods grassland III – increased from the first to the second auction. This development is caused by the adjustment of the subdividing of the total budget-restriction on the three categories of ecological goods in the repeated auction. As a reaction concerning an unexpected high amount of bids for the ecological goods grassland III in the first auction, the specific budget-restriction and the valuation of the highest-quality grassland sites was enhanced absolutely as well as compared to the remaining ecological goods.

Due to the fact that the whole budget was spend for every ecological good, a comparison of tables 1 and 2 suggests that there was no real competition for the grassland II and III contracts, since all applicants but one won a contract. This will have had a negative effect on bidding behaviour, especially compared to grassland I contracts for which there was a lot of competition. To avoid this rise of accepted bid prices and to increase competition among farmers a reserve price of for example €300 should have been used for grassland III. But based on controversial discussions within the research project the idea of using reserve prices – at least in the second auction and based on the results of the first auction as well as other information – was rejected by the majority, bringing forward the argument that the main objective should be to take as much high-quality grassland sites under contract as possible, without considering a potential rise in prices and less budgetary cost-effectiveness. This needs to be critically mentioned as a problem of interdisciplinary decision making and as a mistake within the case study auctions.

However the findings on accepted bids reveal both the flexibility and the accountability for agri-environmental agencies within auctioning ecological services as well as its potential for a more efficient use of public means. If the case study auctions actually gained budgetary cost-effectiveness compared to fixed flat-rate payments will be discussed exemplarily in the following section.

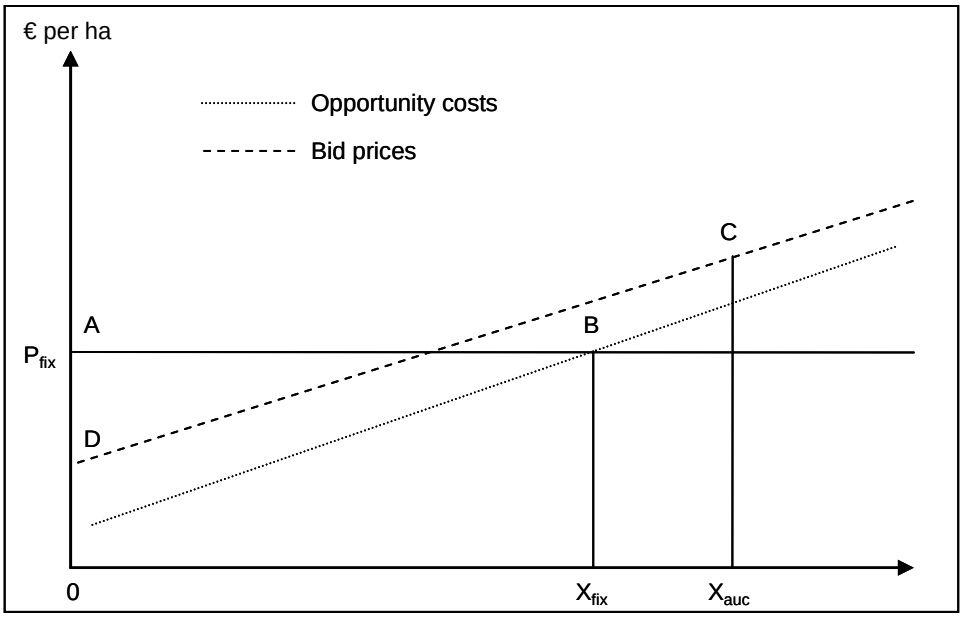
4.3 Does auctioning lead to efficiency gains?

Besides the analysis of bids and especially bid prices per hectare, practical efficiency gains by auctioning instead of fixed flat-rate payments in the model-region will be discussed.

It is important to remember that the opportunity cost curve is the relevant supply curve when a fixed flat-rate payment is offered. Then all landowners 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_{fix} hectare of species rich grassland will be traded at the price P_{fix} (figure 1). The total budget-constraint is represented by area $0ABX_{fix}$. Under a discriminatory-price auction, the ordered bids represent the supply curve, not the opportunity cost curve. The auction therefore creates incentives for landowners to shade their bids above their true opportunity costs and thereby to secure themselves an information rent. Bidders are accepted in the order of their bids until the budget is exhausted. The budget-constraint is represented by area $0DCX_{auc}$. Assuming the same budget as under the fixed-price scheme, X_{auc} hectare of species rich grassland can be taken under contract. 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. However, if bidders learn the bid caps from previous auctions, bid shading can be significant and resulting in poor auction performance. Figure 1 shows the example of how a discriminatory-price auction is more cost-effective than a fixed-price scheme for the same given budget.

The evaluation of efficiency gains of the auction vis-à-vis a fixed-price scheme therefore should be done against a supply curve reflecting true marginal costs. An auction does reveal differences in opportunity costs, but only imperfectly so. Because of incentive to overbid, the true opportunity costs could not be identified within the case study and remain subject to asymmetric information – and thus unknown to the author – in any field experiment. An appropriate comparison of the auction performance and a fixed-price scheme thus is difficult, based on data generated by field experiments. A precise comparison requires the use of laboratory experiments where the true marginal costs are perfectly controlled for and known to the experimenter. These limitations should be considered for the latter of this section.

Figure 1. Hypothetical cost-effectiveness of a discriminatory-price auction vs. a fixed flat-rate payment



Source: own, based on Latacz-Lohmann and Schilizzi, 2005.

If we assume that the bid prices within the case study auctions are equal to the true opportunity costs, a comparison with a fixed flat-rate payment scheme will at least give a clue on efficiency gains by the use of auctioning.

Due to the specific auction design (outcome orientation, definition of the ecological goods grassland I, II and III) it needs to be considered that currently no agri-environmental programme exactly fits with the ecological goal of the case study auctions. Therefore the so called "Lower Saxony agri-environmental programme, measure B: support of extensive grassland use"[6] will be consulted. This support of an extensive use of grassland fits best with the ecological good grassland I, whereas the latter even represents a higher ecological quality because the auction rewards an extensive use of grassland sites plus the proof of a specific amount of plant biodiversity indicated by eight different species.

By the time the case study took place, farmers where paid within the agri-environmental programme by a fixed payment of €103 per hectare. In the remainder of the section the budget spend within both auctions will be compared to the necessitated budget if the same area would have been demanded using the flat-rate payment. Thereby the impact on practical efficiency gains by the use of auctioning will be discussed.[7]

In the first auction (2004/2005) 198.25 hectare were taken under contract, whereas the relevant budget sums up to €16,100.84. To achieve the equivalent area by using a fixed payment of €103 a total budget

[6] In German it is called „Niedersächsische Agrarumweltprogramme, Maßnahme B: Förderung extensiver Grünlandnutzung".

[7] Farmers participating in the case study were not allowed to take part in the agri-environmental programme with grassland sites taken under contract within the auction.

of €20,419.75 would have been needed. Auctioning does in this case lead to savings of €4,318.91 or in other words efficiency gains of 21.2%.

The similar comparison for the second auction approves, and even strengthens, this positive evaluation. Using the fixed payment of €103, a budget of €13.395.15 must be paid to realise the ecological target of 130.05 hectare grassland taken under contract in 2006. In contrast this objective has been achieved by auctioning with a budget of €8,527.30, which equals savings of €4,867.85 or 36.3%.

To sum up under consideration of all unavoidable empirical inaccuracy, these results point out the specific real-life economic potential of auctioning and support the theoretically evident hypothesis of efficiency gains by the use of auctions compared to fixed flat-rate payments.

5. Further (need for) research

5.1 Worldwide comparative study of conservation auctions

Due to specific ecological, political and economical requirements and objectives, there will not be the one and only way of how to design a successful (repeated) conservation auction. Taking into account the currently growing importance of using cost effective instruments for meeting conservation provision targets, further research by the author will be a comparative study of the current state of the practical implementation of conservation auctions. The objective of the survey is to analyse practical conservation auctions based on standardised criteria and to learn about the specific auction performances from an ecological, economical and political perspective. Based on the findings, critical factors for success as well as requirements for the practical design and implementation of upcoming conservation auctions will be deduced and made available to the scientific community as well as to policy makers.

Within the currently planned survey the different ways of how conservation auction components have already been used in the United States, Britain, Australia and Germany will be analysed. The comparative study will at least cover the following agri-environmental programmes and case studies:

- The *Conservation Reserve Program* in the United States
- The *Central Scotland Forest and Grampian Challenge Fund* in Scotland
- The *BushTender trial* in Australia (including the *Southern Victoria Bush Tender*, the *Gippsland Trial*, the *Habitat Tender*, the *Northeast River Tender*, the *Plains Tender*, the programme *Bush Returns* and the *EcoTender* as BushTender trial types of programmes)
- The *Market-based Instruments Pilots Program* in Australia (including the programme *Auction for Landscape Recovery)*

- The research project *Ergebnisorientierte Honorierung ökologischer Leistungen der Landwirtschaft [Result orientated reward of ecological services of agriculture]* in Germany[8]
- The research project *Ausschreibung von Agrarumweltprogrammen am Beispiel der MSL-Grünlandextensivierung [Auctioning agri-environmental payment schemes by the example of an extensive use of grassland]* in Germany
- The programme *Blühendes Steinburg [Prospering Steinburg]* in Germany

The conservation auctions will be evaluated by various criteria, as follows:

- General auction design (one-shot or repeated auction; single-unit or multi-unit auction)
- Rewarded ecological service and ecological objective
- Payment format (uniform- or discriminative price auction)
- Bid valuation
- Budget-constraint in euro, target-constraint in hectare or reserve-price in euro
- Auctioneers institutional integration
- Regional demarcation
- Number of participants
- Number of (submitted and successful) bids
- Ecological effectiveness
- Efficiency gains compared to fixed flat-rate payment schemes, other auctions formats and laboratory experiments
- Private and administrative transaction costs

The above evaluation criteria represent the status quo and will be adapted or extended due to specific practical experiences and lessons learned during the research, if necessary.

5.2 How to deal with information and ecological stock dynamics under uncertainty

Another specific field of further research by the author is the question of how the auctioneer (the administration) should deal with information about the sites, the ecological goods and ecological stock dynamics under uncertainty.

The initial situation within a conservation auction is characterised by the situation that the auctioneer is the only supplier of a specific agri-environmental or conservation programme and therefore decides about the demand for ecological services. On the other hand, the supply-side of environmental services is made up of a large number of landowners and is therefore – at the beginning of the first auction – characterised by a comprehensive competition about payments for ecological services.

[8] The case study discussed in the paper was part of the first of two main periods of the research project at the University of Goettingen.

Within the following bidding process and bid valuation not all farmers' bids for all their ecological services or sites will be accepted. The successful landowners are now making specific investments to provide the environmental goods or environmental services on their sites. If the ecological service is provided contractual and in due time, this may result in incentives for lock-in-effects both from the perspective of the auctioneer and the farmers to keep up the contractual relationship. In the case of repeated auctions the main question arises how the administration should deal with the information about the hitherto successful sites, now offered again, as well as new bids for yet unknown sites. In this case two principle action alternatives seem to be possible, as follows:

I. Equal evaluation of already successful landowners and new bids

By an equal evaluation of bids concerning former successful contracted sites and bids for sites that are yet unknown to the auctioneer, the repeated auction will be treated as if it was the first auction and the programme will stay open for all sites from all landowners. Therefore the administration can keep up a high competition on the supply-side.

On the other hand, this can lead to a situation – depending on a budget-constraint, a reserve price or the number of new bids – where so far successful sites will not be taken under contract again. Hence former successful landowners will no longer be able to receive payments within the programme, even if they changed the land use on the site and made specific investments to provide ecological services. The administration therefore has to deal with an increasing uncertainty regarding the environmental performance of the repeated auction.

II Unequal evaluation of already successful landowners and new bids

In this case former successful bids or sites, respectively, will be immediately accepted within the repeated auction or valuated with priority on the basis of specific criteria. New and therefore yet unknown bids will only be accepted to the extend of the still available budget and/or by the expectation of an outstanding economical and ecological performance.

The administration is thus focussing the secure reach of ecological objectives, based on the former ecological auction performance. In contrast, this approach lacks – from an economic perspective – of the greatest possible competition and therefore may not result in the most efficient allocation of public funds.

Taking into account the already successful landowners in the previous auction, who changed their land management and made corresponding specific investments, this unequal evaluation of bids will most probably result in a continuity of the contractual relationship. On the other hand, the first time bidders find themselves confronted with additional hurdles that may lead to a decreasing long-time public acceptance.

In summary, high asset specificity needs to be considered within repeated auctions, which refers to highly specialised investments that can be re-deployed only by greatly sacrificing productive value. Also the practical relevance of the, referring to Williamson (1975), so-called fundamental transformation becomes apparent, in which the initial winner of a bidding competition thereafter may enjoy an advantage over rival bidders because of its ownership of (or control over) transaction specific assets. From the agri-environmental or conservation administration's perspective there are basically the two above ways of dealing with information from former auctions and therefore designing repeated auctions; either primary following ecological or economic objectives.
In this case there is a main need for research of how the administration should deal with ecological stock dynamics in repeated auctions under uncertainty. That there is an empirical evidence of ecological stock effects or stock dynamics in the case of long-term biodiversity change has been recently proven by Hanley et al. (2007). Hanley et al. show – by studying the determinants of biodiversity change in upland Scotland for the period 1600-2000 – that previous period's biodiversity is a significant determinant of current period's biodiversity.

The starting point of further research within this not widely applied field will be a conservation auction model. Thereby especially the auctioneer's point of view and action alternatives will be focussed. As a matter of course the farmers' bidding behaviour will also be considered, but the main objective will be to analyse the interaction of the ecological quality q(t) as a stock figure, the ecosystem service s(t) as a flow figure, the management effort x(t) as a flow figure as well as the convex management cost c(x) over time and under uncertainty. Uncertainty will be integrated by the factor λ, whereby uncertainty is determined by, for example, production risk due to environmental influences as well as the actors' bounded rationality or opportunistic behaviour. Thereby within every period t there will be an auction, the landowner's management effort, an initial and a final ecological or biodiversity quality and an ecosystem service. Consequently only the initial ecological or biodiversity quality q(t) is secure and can be measured by the administration. The ecological quality at the end of the contractual period on one site is determined by the initial ecological quality, the uncertain landowner's management effort and the uncertain ecological services:

$$q(t+1) = q(t) + \lambda[s(t)x(t)].$$

This approach will be more closely examined and developed by taking into account current state-of-the-art adaptations of standard auction theory and conservation auction models, experiences from laboratory experiments and already implemented conservation auctions as well as approaches of how to value ecological or, in this specific case, biodiversity quality.
The latter also leads to the research question of how to use and design environmental indicators – especially for plant biodiversity – to value the ecological quality to be expected as part of the bid valuation.

5.3 An environmental benefits index for plant biodiversity

Within the German case study discussed in this paper, the ecological quality was measured by the number of different species and the use of specifically defined ecological goods. This very simple way of evaluating the value of plant biodiversity was necessary since the first time ever implementation of the payment scheme had to be simple. But this simple categorisation of output quality needs to be criticised for several reasons, as follows. The bid valuation based on the number and quality of different species and the bid price per hectare disregards other more differentiated and important criteria, there is no clear linkage between the amount of plant biodiversity and the final payment, the bid valuation is not representative for the needs of the majority of conservation schemes and the bid valuation does not use a reserve price as a maximum bid price to be paid.

A promising solution to resolve these problems, and meet the practical requirements of most repeated conservation auctions, seems to be the use of an environmental index. Current research especially deals with the definition and design of a specific environmental benefits index for plant biodiversity. Therefore two different environmental indices will be used as role models: the Environmental Benefits Index (EBI) as part of the Conservation Reserve Program in the United States (Reichelderfer and Boggess, 1988; Szentandrasi et al., 1995; Babcock et al., 1996; Smith, 2003) as well as the Biodiversity Benefits Index (BBI) within the BushTender trial in Australia (Stoneham et al., 2003).

Based on an evaluation of these environmental indices as well as further approaches and objectives, a specific so-called 'Environmental Benefits Index for Plant Biodiversity' (EBIPB) will be developed. This EBIPB will combine both elements of the EBI and the BBI as well as new criteria to reach the objective of a differentiated bid valuation within repeated auctions, based on economic, ecologic and social criteria. Possible criteria and objectives will for example be (i) the number of different species, (ii) the relative abundance of different species, (iIi) the expected additional negative and positive ecological spill over effects, (iv) the relevance of conservation priority areas, (v) the expected sustainability of management efforts, (vi) the ecological performance per euro in previous auctions, (vii) regional populations' preferences, (viii) the bid price per hectare and (ix) a risk factor.

The use of an environmental benefits index and the change of its parameters and their valuation also seem to be a promising way of how to reduce the opportunity for bidders to learn in repeated auctions and will be part of upcoming research as well.

6. Conclusion

As agri-environmental agencies in Europe and around the world look for better ways of contracting landowners for the provision of ecological services, some clear conclusions emerge from this case study. The results of both auctions point out that in fact much differentiated offers were made by the farmers in the model-region. Hence all main objectives of auctioning (budgetary cost-effectiveness

and the possibility to gather information about the production costs of agricultural firms) were fulfilled.

These findings as well as a relative high number of farmers participating in the case study point out that auctioning conservation contracts became popular with landowner and that the topic of biodiversity conservation turned from a primary complex and somewhat diffuse idea to practical actions and monetary incentives for farmers.

Even if the auctioning scheme is a comparatively simple case study, the results are sufficient to point out a potential for a more efficient spending of public funds compared to traditional measures in environmental and biodiversity conservation policy. Therefore and with regard to international economic aspects of biodiversity protection, this case study can be rated as a proof of how promising market-based approaches could be. Keeping in mind the empirical difficulties of field experiments in comparison to laboratory experiments and the specific assumption on the farmers' opportunity costs, the empirical work indicates cost advantages of auctioning in comparison to fixed flat-rate payment schemes of up to 36%, depending on which scenario is chosen as reference.

As already mentioned, the reported results on cost-effectiveness gains by auctioning compared to fixed flat-rate payments vary greatly as for example Stoneham et al. (2003) mention savings of up to seven hundred per cent for the first auction of the BushTender trial in Australia. Contrary a simulation of farmers bidding behaviour within a hypothetical payment scheme by Latacz-Lohmann and Van der Hamsvoort (1997) points out efficiency gains in the range of 16 to 29%. An Evaluation for the Forestry Commission Scotland (CJC Consultant, 2004) reports efficiency gains in the range of 33 to 36% and the National Market Based Instruments Working Group (2005) expects that an auction would be between 23 and 34% more cost-effective than a former fixed price scheme. Therefore the results from this case study suggest that specific savings from auctions are not nearly as high as reported by Stoneham et al. (2003), but fit well with cost-effectiveness gains mentioned for the Central Scotland Forest and Grampian Challenge Fund (CJC Consultant, 2004) as well as for the Catchment Care Program (National Market Based Instruments Working Group, 2005). Even though the case study presented in this paper had yielded promising results while a real life repeated auctioning format was successfully implemented in a case study area, there are also critical lessons to be learned and a number of aspects to be improved within upcoming conservation auctions. Thus the author will address additional short-term research, which mainly comprises of a worldwide comparative study of conservation auctions, the question of how to deal with information and ecological stock dynamics within repeated conservation auctions and under uncertainty as well as the development of a specific environmental benefits index for plant biodiversity.

Additional need for research especially enfolds the dynamic and long-run development of the farmers' bidding behaviour and bid prices during other real-life (case studies or state run programmes) conservation auctions as well as the influences of different environmental services and regional demarcations on the practicability of auctioning. Thereby it needs to be analysed, in which

circumstances auctioning is not feasible or will not lead to efficiency gains and a payment scheme only using fixed prices or a combination of both instruments is the appropriate way within the European agri-environmental policy for the period 2007 to 2013 and beyond.

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