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Valuing nature-conservation interests on agricultural floodplains

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Summary

1. The ecosystem approach and evaluation of ecosystem services is gaining increasing attention from scientists, practitioners and policy makers. An important part of this process is to establish the 'value' of the nature-conservation assets within an area. This value can then be compared with data for other ecosystem services to identify management priorities under different future scenarios. However, there is little consensus on how to perform such an evaluation. In this study, we assess seven methods of valuing nature-conservation interest and compare their utility.

2. Five agricultural land drainage schemes across lowland England were selected for study. The current land-use was determined and four different scenarios of future management were developed. The land-use and habitats predicted under each scenario were assessed using seven methods of determining value, namely: Ecological Impact Assessment method, reserve-selection criteria, target-based criteria, stakeholder-choice analysis, reserve-selection criteria guided by stakeholders, agri-environment scheme payments and contingent valuation. The first three methods derive values based on pre-defined priorities, the next two use stated preferences of stakeholders, and the last two methods derive monetary values based on revealed and expressed preference, respectively.

3. The results obtained from the different methods were compared. The methods gave broadly similar results and were highly correlated, but each method emphasized a different aspect of conservation value, leading to different possible outcomes in some cases. The advantages and disadvantages of each method were evaluated.

4. *Synthesis and applications.* As the ecosystem services approach becomes embedded in decision-making, ecologists are increasingly called upon to value the biodiversity of a site or to compare the value of different sites. This study has shown that seven different valuation methods, although all giving significantly correlated findings, resulted in seven different rankings of nature-conservation value for the 25 situations studied. This difference occurred in spite of the sites being of the same landscape type and occurring within the same country. The discussion concludes that each method has its strengths; monetary valuations are appropriate in some contexts, stakeholder preferences are paramount in others, but where objectivity is key, then assessment against independently defined criteria or targets should be the preferred method.

Key-words: biodiversity valuation, ecosystem services, Environmental Impact Assessment, floodplains, habitat conservation, land use, Rural Economy and Land Use programme

Introduction

According to the World Resources Institute (2005) 'the goal of an ecosystem approach to natural resource management is to foster the sustainable use of ecosystems and the equitable distribution of their benefits'. They have identified key principles of such an approach, including accounting for the true value of ecosystems, making trade-offs clear, and involving all stakeholders in decision-making (WRI 2005). The concept of 'ecosystem functions' represents the capacity of natural processes to provide goods and services (items that confer benefit and advantage) to meet human needs, directly or

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indirectly (Turner *et al*. 2000; de Groot, Wilson & Boumans 2002; de Groot 2006; Brauman *et al.* 2007; Zhang *et al*. 2007). These ecosystem functions have the potential to deliver a range of ecosystem goods and services, but society determines the actual uses and the values derived from these.

Assigning values to the different ecosystem services is crucial in order to assess trade-offs between ecosystem services under different land-use scenarios. Decision-makers often call for these values to be expressed in monetary terms so that they can be compared in a cost–benefit analysis. However, valuing ecosystem services that are non-market public goods (e.g. habitat provision, water quality, greenhouse-gas balance) is notoriously difficult. Various techniques have been developed for environmental evaluation and the aim of this study is to assess the relative merits of various methods of valuing nature-conservation interests in a case study on agricultural floodplains in England.

The management of land and water in rural lowland floodplains in England has undergone considerable change over the past 60 years. Post-1945, publicly funded investments were made to protect farmland against flooding, thereby enabling land drainage to enhance agricultural production. Such schemes were designed to help meet policy objectives of reliable food supply at reasonable prices, fair rewards to those engaged in farming, and support for the rural economy (Morris 1992). More recently, changing priorities in rural and environmental policy, such as the EU Water Framework and Habitats Directives, the Common Agricultural Policy and government initiatives, are encouraging a re-appraisal of land-management options for floodplain areas. The strategy of the Department for Environment, Food and Rural Affairs (Defra) of 'Making Space for Water' (Defra 2004), for example, aims to deliver a more holistic and risk-driven approach to flood-risk management by adopting a whole catchment approach. Actions to reduce flood risk are combined with natural processes by, for example, widening river corridors or creating multi-functional wetlands in floodplains. Given these changing drivers, rural land use in floodplains has recently been shifting from predominantly agricultural production to types of land use that need less protection against flooding and can deliver multiple benefits, such as floodwater storage and enhancement of biodiversity.

The work described here is part of a research project entitled Integrated Management of Floodplains, (funded by the UK Rural Economy and Land Use programme), that explores opportunities to integrate farming, nature conservation and flood management in lowland floodplain areas that were previously engineered for land drainage purposes.

Methods

To test the methods in a range of situations, five lowland floodplain sites in England were selected to provide variation in climate, land use and water-management regime (see Supporting Information, Appendix S1). All had been the subject of land-drainage improvement schemes prior to the 1980s and are predominantly under agricultural land uses (Morris & Hess 1986).

For each study site, a number of potential land-use scenarios were developed to simulate the land use and habitats that are likely to occur under different management regimes (Table 1). This approach allowed the valuation methods to be tested under a broader range of conditions than the present land use. The methodology explained by Morris *et al*. (2008) was used to estimate the impacts of drainage conditions and flood probability on the physical productivity of farmland, and hence, financial returns (net margin, £ ha^{-1}) from land-based activities.

VALUING NATURE-CONSERVATION INTERESTS

A number of different approaches can be taken to value the nature-conservation assets of an area. In this study, seven valuation methods were applied to assess the projected outcomes of each scenario for each of the five floodplain sites (Table 2). The methods were: Ecological Impact Assessment method, reserve-selection criteria, target-based criteria, stakeholder choice analysis, reserve-selection criteria guided by stakeholders, agri-environment scheme payments and contingent

Table 1. Scenarios developed to investigate land and water management in rural floodplains

Scenario	Definition
Current situation	Based on farmer interviews and ecological surveys carried out in 2006–2007.
Maximum agricultural production	Comprises intensive agricultural land use, which was originally the objective when the land drainage of these floodplains was improved. The land use is defined by soil, climate and current and past land-use patterns. The water management regime is characterized by rapid drainage and controlled low flood frequency.
Maximum biodiversity within an agricultural system	Seeks to enhance biodiversity with the imposed constraint that the predominant land use remains agriculture. Land-use options are selected that are promoted by current agri-environmental schemes, in particular the Higher Level Stewardship Scheme (Defra 2005b). The water-management regime depends on the trade-offs between the requirements for agriculture and wet habitats, but typically consists of medium duration flooding and moderate drainage. Local soil conditions, topography and historical context, together with local and regional conservation and land-use priorities have been used to determine the specific habitat types that would be created.
Maximum biodiversity outside of an agricultural system	Seeks to enhance biodiversity, without any imposed constraints, guided by local and national Biodiversity Action Plan targets. The water-management regime is characterized by frequent flooding and slow natural drainage. The same criteria are used for determining the habitat types as for the previous scenario.
Maximum farm income	Seeks to maximize the income derived from the land based on 2006 prices for agricultural produce and payments received through Environmental Stewardship if applicable. The land use for this scenario is determined by one of the previous scenarios with the highest estimated profitability (net margin) for land management (after Morris *et al*. 2008).

Table 2. Summary of the seven methods used to value floodplain habitats

Method	Approach	Decision criteria	Outputs	Key references
Ecological Impact Assessment method	Assessment using pre-defined prioritization criteria	Designation status of the habitat, proportion of national and regional resource	Non-monetary score	Treweek (1999), Tucker (2005), IEEM (2006)
Reserve-selection criteria	Valuation using ecological criteria pre-determined by experts	Diversity, rarity, naturalness, size and fragility	Non-monetary score	Ratcliffe (1977), Margules & Usher (1981)
Target-based criteria	Assessment against government targets	Net area of priority BAP habitat created; percentage of national and regional targets created	Area; % of targets	Defra (2007), UK BAP (2004, 2006)
Stakeholder choice analysis	Expression of preferences of a range of stakeholders	Stakeholder preferences for key habitats, based on a wide range of criteria such as biodiversity, rarity, aesthetics, cultural history and personal preference	Non-monetary score	Sinden & Windsor (1981), Anselin, Meire & Anselin (1989)
Reserve-selection criteria guided by stakeholders	Uses stakeholders to guide and provide weightings for expert-derived criteria	Reserve selection criteria, plus additional criteria identified by stakeholders. Relative importance weighted by stakeholders	Non-monetary score	Marsh *et al.* (2007)
Agri-environment scheme payments	Revealed, expenditure-based preference for different habitats	Money payable to farmers and land managers through agri-environment schemes	Monetary value	Pretty *et al.* (2000), Farber, Costanza & Wilson (2002), Defra (2005a,b)
Contingent valuation	Benefits transfer of willingness to pay (expressed preference)	Members of the public willingness to pay for environmental goods, adjusted by socio-economic factors	Monetary value	Oglethorpe *et al.* (2000), Hanley *et al.* (2001), Oglethorpe (2005)

valuation. The first three derive values based on predefined priorities, the next two use the stated preferences of stakeholders, and the latter two derive monetary values based on revealed and expressed preference, respectively (see below and Supporting Information, Appendix S2).

When applying these methods, it was assumed that each management scenario had reached a quasi-equilibrium state, in which full restoration of habitats, where applicable, had occurred. It should be noted that only habitats have been assessed, not their component species.

Ecological Impact Assessment method

Seven geographical categories of habitat importance were identified; International, National, Regional, County, District, Neighbourhood, and Non-priority. To assign an ecological feature to an appropriate category, a set of simple decision rules were developed based on a combination of conservation priorities and significance of the habitat. Conservation priority was established by consulting the EU Habitats Directive, Guidelines for the Selection of Biological SSSIs (Nature Conservancy Council 1989), the UK Biodiversity Action Plan (BAP), Regional and County BAPs, and Environmental Stewardship Targeting Statements. The latter provide land management priorities at a District level for all areas of England. Significance of the habitat was determined by calculating the proportion of the national and regional resource that occurred for each habitat type at each site, and particular site-specific features. Predicted habitats were assumed to have been restored or created successfully.

Reserve-selection criteria

The reserve-selection criteria selected in this project primarily followed Ratcliffe (1977) and are defined in Table 3. For each criterion, a score out of 10 was developed.

Target-based criteria

Three simple indicators were produced. The first was a measure of the area (ha) of priority Biodiversity Action Plan habitat created under each scenario (Outcome Measure 5, Defra 2007, 2008). The second and third were the percentage of national and regional targets (UK BAP 2004, 2006) respectively achieved by a scenario. The percentages of target achieved for each habitat type were then summed. This method assumed that all habitat targets were of equal importance.

Stakeholder choice analysis

Stakeholder preferences can be obtained through direct questioning. For this purpose, a workshop was held in April 2008 for 22 stakeholders representing a wide range of interests in rural floodplain management. They included regulators, policy-makers, farmer and land-owner associations, wildlife conservation groups, rural development organizations and academics. A simple choice experiment was performed on five different habitats that could be created or restored on floodplain areas (all UK Biodiversity Action Plan priority habitats). Stakeholders were shown pairs of habitats and asked to allocate 10 points between each pair, based on the relative value that they placed on each. Information was also collected on the participants' familiarity with the habitats and their priorities and motivation in making their decisions.

Reserve-selection criteria guided by stakeholders

During the workshop referred to above, stakeholders discussed and provided weightings for the reserve-selection criteria (Table 3) and were encouraged to suggest additional criteria. Stakeholders were divided into two groups, with one group containing biodiversity professionals and the other group containing non-biodiversity

Table 3. The reserve-selection criteria assessed (based on Ratcliffe 1977)

Criteria	Comments
Diversity	This is one of the most frequently used evaluation criteria. As is commonly the case, species richness was used as a surrogate for diversity. For semi-natural habitats, typical plant species richness per sampling unit was obtained for each plant community from published NVC floristic tables (Rodwell 1991–2000). For intensive arable habitats, average plant species diversity measured in the Countryside Survey 2000 was used (JNCC 2007). Diversity was then scored as the species richness of the projected habitat compared to the maximum species richness of habitats that could be created at that site.
Rarity	Rare species and habitats are given greater priority and sites that contain a large number of rare species are particularly important. Information was collected on the total resource of each habitat type in England for agricultural (Defra 2006) and natural (Natural England 2008) areas. A rarity index was then developed based on the total amount of each habitat type in England.
Naturalness	There is much debate over the definition of this term, and particularly its relationship with 'wildness' (Margules & Usher 1981; Ridder 2007). Almost all habitats in the UK and Europe, including those with high ecological, cultural and aesthetic value, are human-modified to at least some extent. Following Anderson (1991), a score was developed for each habitat type based on three components of naturalness: • Degree to which system would change if humans were removed • Amount of energy required to maintain that habitat • Complement of native species
Size	Larger sites are generally more highly valued as many species require a minimum area to support a minimum viable population or metapopulation. Larger sites typically contain a greater diversity of habitats and species, have reduced edge effects, and are buffered against environmental stochasticity. Size was defined as the area ($3{\cdot}33 \times \log_{10}$ ha) of the habitat that was present or would be created at each site, scaled such that an area of 1000 ha would score the maximum 10 points.
Fragility	Habitats or species that are highly sensitive to human disturbance or change are more highly valued. This is strongly linked with the concept of re-creatability – how difficult it is to re-create a habitat. This is considered to be the best single measure of nature-conservation value when selecting biological SSSIs (Nature Conservancy Council 1989). The fragility score was based on expert judgement of how many years it would take to restore or create that habitat, moderated by how difficult the process was to achieve. Creation was assumed to have occurred once a simple working functional habitat type could be produced, rather than a habitat with fully restored species diversity.

professionals, in order to determine whether preference varied accordingly. The new criteria identified were then applied to our study sites, together with the weightings for all reserve-selection criteria, to produce a new measure of reserve-selection criteria guided by stakeholders. This approach has the advantage of taking well-established criteria and then applying weightings to place greater emphasis on those considered most important. It is, therefore, a useful way of bringing policy makers and other stakeholders into the decision making process (see Marsh *et al*. 2007 for another example of this approach).

Agri-environment scheme payments

In 2005, the UK government introduced a new agri-environment scheme known as Environmental Stewardship, with two tiers: the Entry Level Scheme (ELS) and the Higher Level Scheme (HLS). Scheme participants are able to select a number of options for which they receive standard payments based on generic estimates of income foregone. Although these payments do not attempt to reflect the value of the habitats concerned, farmers and others may think that the offered payments signal to some extent the value of the options. Payments are therefore compared to other valuation measures in this study to establish if there is indeed any such correlation. Agri-environment scheme values were calculated by determining the payments that farmers would receive under each scenario through eligible ELS and HLS options (Defra 2005a,b). To be consistent with the other valuation methods, and to estimate farmer income, it was assumed that each proposed habitat is fully established and target species are present on site. Therefore, the annual payments for *maintenance* of a habitat type are used, rather than initial payments for *restoration* or *creation*.

Contingent valuation

The contingent valuation method was applied using the Environmental and Landscape Features (ELF) model developed by Oglethorpe *et al.* (2000), Hanley *et al.* (2001) and Oglethorpe (2005) to estimate the value of environmental features provided by agri-environment schemes in the UK. The ELF model is based upon the principle of benefits transfer, whereby a willingness to pay (WTP) function was derived from a large number of contingent valuation studies. By combining this with regional socio-economic data, different values were determined for different regions in England (Oglethorpe *et al.* 2000; Hanley *et al.* 2001), and this has now been applied to seven different habitat types. Monetary values (WTP) for each habitat type in each region were obtained from the ELF model. The relevant monetary value was multiplied by the projected area of habitat for each scenario for each site to produce a mean WTP per hectare.

Results

STAKEHOLDER PREFERENCES

A stakeholder workshop provided scores for two of the valuation methods. Using stakeholder choice analysis, lowland meadows attracted the greatest overall preference score (Table 4), with greatest preference given to floodplain habitats with high species richness (lowland meadow, lowland fen and wet woodland) rather than habitats with lower species richness (reedbed and floodplain grazing marsh). The two groups of stakeholders ('biodiversity professionals' and 'non-biodiversity

Table 4. Mean scores (out of 10) given by stakeholders for different habitat types in a simple choice experiment

Habitat preferences	Biodiversity professionals (n = 8)	Non-biodiversity professionals (n = 10)	All (n = 18)
Lowland meadows	6·03	5·83	5·92
Lowland fen	5·78	5·45	5·60
Wet woodland	4·97	4·73	4·83
Reedbed	4·34	4·35	4·35
Floodplain grazing marsh	3·88	4·65	4·31

Table 5. Additional criteria identified by stakeholders

Criteria	Definition and rationale	How measured
Cultural history	Particularly valued by the group of non-biodiversity professionals, this places high value on habitats that would have been common on traditionally managed rural floodplains prior to industrialization. Often referred to as the 'rural idyll'.	Score out of 10 with maximum score for habitats produced by traditional low-intensity agricultural practices
Sustainability	Indicates how easily a habitat type can be maintained. Non-biodiversity professionals placed low value on habitats that required extensive ongoing management.	A score was developed based on how easily the habitat could be maintained combined with the annual use of energy
Connectivity	Connectivity relates to the amount and pattern of habitat patches within the wider landscape. Methods of measuring connectivity are reviewed by Moilanen & Nieminen (2002). Regarded as important by both stakeholder groups.	Difficult to measure given a lack of detailed habitat information from the wider area. Score derived from the total area of land of each habitat type, combined with distance to nearest neighbour outside of the site

professionals') gave similar values for each habitat. Hence, the mean score for all participants was used in the stakeholder choice analysis of the scenarios. However, workshop participants commented on the difficulty of valuing habitats out of context and stated that they would favour habitats that were historically associated with each particular study site had that information been provided.

Using the reserve-selection criteria guided by stakeholders, three additional criteria were identified by stakeholders that they felt important for assessing the value of habitats (Table 5). Overall, rarity, sustainability, connectivity and diversity were considered to be the most important criteria. The weightings given to each criterion are shown in Table 6.

Table 6. Overall weightings (out of 100) given to the reserve-selection criteria and the additional criteria identified by the stakeholders (n = 13)

Criteria	Mean weighting
Primary reserve-selection criteria	
Rarity	20·3
Diversity	14·0
Size	9·5
Fragility	8·1
Naturalness	6·3
Additional criteria identified by stakeholders	
Sustainability	18·9
Connectivity	17·6
Cultural history	5·4

SCENARIO OUTCOMES

Although the underlying principles for each management scenario are the same, the outcomes vary per site, depending on predominant farming systems, soil type and climate. The principal habitat types predicted to occur under each scenario and the nature-conservation value derived using each method are shown in Supporting Information, Appendix S3. As expected, a broad pattern of conservation values is apparent, reflecting the relative importance placed on nature conservation within a land-use scenario. The *maximum production* scenario produces the lowest or equal lowest score for habitat conservation value under all of the scoring systems at all study sites. This is a little lower than the conservation value of the *current land-use*, and considerably lower than the values achieved under the biodiversity scenarios. The habitat conservation values achieved under both biodiversity scenarios are similar, with the highest score varying from site to site. The scenario of *maximizing biodiversity within an agricultural system* often scores the highest, primarily due to the high nature-conservation value of alluvial hay meadows.

COMPARISON OF VALUATION METHODS

The outcomes of the different valuation methods are broadly consistent, and this is confirmed by a high degree of correlation between the different methods (Table 7). The only method with consistently weaker correlations is that using target-based criteria involving the area of BAP habitat created.

However, there are some differences, and these reflect the fact that each method is emphasizing a slightly different

Table 7. Correlations between the different valuation methods for five scenarios at five sites

	Valuation method							
	EcIA method	Reserve selection 1	Reserve selection 2	Stakeholder choice	Agri-environment payments	Contingent valuation	BAP area created	National targets
Reserve selection 1	0·876***	–	–	–	–	–	–	–
Reserve selection 2	0·870***	0·985***	–	–	–	–	–	–
Stakeholder choice	0·881***	0·830***	0·804***	–	–	–	–	–
Agri-environment payments	0·796***	0·750***	0·771***	0·750***	–	–	–	–
Contingent valuation	0·866***	0·898***	0·880***	0·862***	0·734***	–	–	–
BAP area created	0·665**	0·595**	0·648**	0·594**	0·872***	0·685**	–	–
% national targets	0·847***	0·838***	0·856***	0·781***	0·697**	0·788***	0·767***	–
% regional targets	0·866***	0·901***	0·875***	0·786***	0·686**	0·769***	0·645**	0·860***

Correlations are Spearman's rank correlation coefficients (n = 25). The r_s values and the associated P values (** $P < 0·01$, *** $P < 0·001$) are shown.
EcIA, Ecological Impact Assessment.
Reserve selection 2, reserve selection criteria guided by stakeholders.

aspect of conservation value. Contingent valuation places much greater value on wetland habitats (lowland fen and reedbed), and hence, the scenario to maximize biodiversity outside of an agricultural setting is always ranked highest. On the other hand, the agri-environment scheme payments method does not value these habitats very highly and always ranks the scenario to maximize biodiversity within an agricultural context more highly. The ranking of the scenarios by the remaining methods is determined by site-specific characteristics, with reasonable consistency.

When comparing amongst sites, no site consistently achieves the highest habitat-conservation score over several of the different valuation methods. Reserve-selection criteria guided by stakeholders place a high emphasis on connectivity. Both the reserve-selection criteria and Ecological Impact Assessment Method are influenced by size, resulting in the largest site scoring highly. The smallest site was given the highest score for stakeholder choice, where size has no impact, because its main target habitat happened to be the one stakeholders ranked highest: lowland hay meadow. The Higher Level Scheme offers its highest payment rates to areas of floodplain grazing marsh managed for breeding waders, and hence, schemes with that objective scored particularly highly under the 'agri-environment scheme payments' method, whilst contingent valuation placed much more value on fen and reedbed habitats, particularly in regions where they are scarce.

The five sites, each with five management scenarios, gave a total of 25 situations to assess. No two of the methods trialled gave identical rankings of these 25 situations in terms of value, showing that each may give rise to different judgements being formed.

Discussion

Seven different methods of valuing the nature-conservation interest of an area have been tested here. The methods gave broadly similar results, but each produced a slightly different ranking of the scenario outcomes in terms of their nature-conservation value, as each method emphasized a different aspect of that value. The key advantages and disadvantages of each method are summarized in Table 8.

It is encouraging that the valuation methods provide broadly similar outcomes. The reserve selection criteria, reserve selection guided by stakeholders, and the Ecological Impact Assessment method in particular, were in close agreement. However, the exact outcome depends on the criteria and underlying assumptions of the valuation method chosen. It is clearly difficult to get one objective and comprehensive value for nature-conservation and different methods may be appropriate in different situations. Where monetary values are required to integrate with other economic criteria, then the agri-environment-scheme approach or contingent valuation are the most appropriate, although the agri-environment method only seems to be appropriate within an agricultural setting. Where the views of stakeholders are paramount, then a stakeholder-choice technique or stakeholder-derived criteria is best. However, if ecological objectivity is the aim, then Ecological Impact Assessment or reserve-selection criteria are most suitable. Target-based criteria have great potential to provide a balanced approach, but only when a common set of targets have been independently set across the area being assessed.

Monetary valuation methods, in particular, have raised some interesting issues. Assessing value through agri-environment scheme payments is a useful approach as uptake of schemes by farmers is likely to be heavily influenced by the effect on their income. However, payment regimes, which in many respects are 'compensation' for not farming more intensively, were not designed to reflect ecological value and therefore differ from the other methods. For example, a farmer might receive £335 ha^{-1} annually for managing land as floodplain grazing marsh for the benefit of breeding waders, but only £60 ha^{-1} for managing it as reedbed or lowland fen (Defra 2005b). Yet, all other valuation methods place a greater value on fen than on floodplain grazing marsh. The lower payments,

Table 8. Key advantages and disadvantages of each of the habitat valuation methods

Method	Advantages	Disadvantages
1. Ecological Impact Assessment method	Principles well understood, differentiates well between scenarios	Too many categories; therefore, it can be confusing. Some subjectivity
2. Reserve-selection criteria	Objective, repeatable, well established criteria	Time-consuming to develop
3. Reserve-selection criteria guided by stakeholders	Links objective criteria with stakeholder values	Some additional criteria hard to evaluate
4. Simple stakeholder choice	Involves stakeholders, straightforward	Did not score agricultural habitats. Context important
5. Target-based criteria:		
(a) Net area of BAP habitat created	Quick and easy	Insensitive as scenarios all score either zero or maximum. Favours large sites
(b) % of national targets	Quick and easy	Assumes all targets are equal. Habitats have been treated inconsistently by national target setters
(c) % of regional targets	Quick and easy	As above, plus highly variable across regions
6. Agri-environment scheme payments	Good indicator of likely farmer uptake. Easy, transparent, repeatable. Expresses results in monetary terms	No clear link between agri-environment payments and the value of ecological outcomes (measures income forgone rather than ecological value)
7. Contingent valuation	Indicates the value that society places on habitats. Expresses results in monetary terms	Based on whole series of assumptions embedded within the original model. Habitats in the ELF model are broader than those being used in our study

partly reflecting relatively low maintenance costs for reedbed or fen and possibly limited 'opportunity' value for agricultural purposes, tend to undervalue their potential contribution to environmental value by this method compared to the others.

Contingent valuation places a lower monetary value on most habitats (with the exception of fen and reedbed habitats) compared to agri-environment scheme payments, as the latter are compensation-based payments. In addition, the contingent valuation method is valuing only one non-market asset, that is, environmental features. Other studies (see reviews in Brouwer *et al.* 1999; Woodward & Wui 2001; Eftec & Entec 2002; Brander, Florax & Vermaat 2006) reveal that if all externalities are valued, then wetlands and other semi-natural habitats have an extremely high monetary value. The choice of technique therefore needs to reflect the type of value being measured and this selection needs to be stated explicitly.

As the ecosystem services approach becomes embedded in decision-making, ecologists are being increasingly called upon to value the biodiversity of a site or to compare the value of different sites. Although this task is inherently difficult to achieve, it is important that robust results are produced and that these can be compared with different assessment criteria and by people working in different subject areas. Such results can then be used to inform multi-criteria decision analyses, cost–benefit analyses and other integrated ecological and economic modelling (e.g. Weber, Fohrer & Möller 2001; Münier, Birr-Pedersen & Schou 2004; Santelmann *et al.* 2004; Prato & Herath 2007). Such an approach goes some way to accounting for the true value of ecosystems, enabling synergies and trade-offs to be identified, and providing a mechanism for stakeholder involvement in decision-making. In this respect, such an ecosystem-based approach can help to promote the sustainable management of natural resources (WRI 2005).

The seven methods tested represent a wide range of techniques that have previously been used to determine nature-conservation value. Comparison of different methods, such as the analysis presented here, is necessary to inform the debate over the valuation of nature-conservation interests. This is of interest to the fields of land-use planning, reserve selection, Environmental Impact Assessment and wherever an integrated approach to land management is required. Our conclusion is that each method has its strengths and may be appropriate in particular situations. However, with a multiplicity of methods, cross-project comparisons are difficult, even impossible. The outcome of a valuation technique is clearly influenced by the assumptions made. These assumptions need to be explicitly stated such that cross-project comparisons can be undertaken and, as interest and capacity in environmental valuation continues to develop, a consensus may emerge in terms of the preferred techniques for application to each type of situation.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. Location, geo-physical and current land-use information for each study site and map showing location of each study site

Appendix S2. Background information on valuing nature-conservation interests

Appendix S3. Predicted habitat types and conservation values using different valuation methods for five alternative land-use scenarios on five floodplain study sites

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