

**An
Ecosystem Services Approach
for The Broads**

Appendix 6

Report prepared for
the Broads Authority
(Lake Restoration Strategy)

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Executive summary

The Broads, as the UK's largest lowland wetland, is visited by six million people a year. It also provides a home for around 6,000 people and a livelihood, directly and indirectly, for thousands of people. But the semi-natural characteristics of The Broads present a complex set of management challenges. The dynamic nature of the environmental changes that the area experiences is likely to be affected by the impact of climate change and continuing socio-economic pressures.

The costs of management are counterbalanced by the range of benefits that The Broads provide to society including: recreation opportunities, biodiversity, water-related services and others. This ecosystem services approach report sets out an analytical framework for assessing the value to society provided by a sustainable management regime. This 'ecosystem services approach' is being adopted in order to provide a more quantified evidence base for future management activities. Although only a desk-based study, enough data has been compiled to offer good evidence in favour of the proposition that continued and enhanced management of The Broads ecosystems and linked navigation, and the services they provide will result in increased wealth creation and livelihood protection for local people.

It is useful to divide ecosystem services (i.e. aspects of ecosystems utilised actively or passively to produce human well-being) into intermediate services, final services and benefits. The focus in this report is on the benefits that people receive from the ecosystem and in particular on the financial and economic value of the benefits. Two key groups of benefits can be identified in The Broads context: existing and potential benefits. The former are: biodiversity conservation, land and water based recreation and water supply for households, agriculture and industry (linked to intermediate services such as water provision and regulation, nutrient cycling and soil formation and final services such as habitat provision and water flows). The potential benefits include carbon storage, flood protection and biofuel supply (linked to a set of services).

A valuation of the set of benefits is constrained by a lack of comprehensive financial and economic data. However a range of valuation methods have been utilised in order to provide as full a valuation as is practicable. But the use of different valuation methods across the benefits categories means that aggregation is not technically possible. Nevertheless, the analysis does indicate that substantial financial flows and economic benefits are provided by The Broads. The visitors to The Broads, for example, generate some £320 million per annum, which has a significant economic

multiplier effect in the area. The value of drinking water, the flow of which is sustained by The system, is at least £17 million which is the price paid by the consumer population. The value of the environmental damages avoided through the storing of carbon in The Broads marshes is between £50,000 and £ 240, 000 per year. When questioned in a survey, a random sample of people said that they were willing to pay up to nearly £100 per household per year to conserve The Broads environment.

While these valuation estimates are only indicative, together they represent a strong case in favour of continued conservation and management expenditure. This financial/economic evidence should not, however, be seen as an alternative to reasoning based on science and/or moral propositions. Rather, the ecosystem services concept and approach, and the monetary benefits estimates it can generate, provides a useful additional argument, alongside scientific and moral reasoning, for continued protected area investments.

Introduction

The Broads system is the UK's largest and most visited lowland wetland in England and it poses a complex set of management challenges. The costs of management are counterbalanced by the range of benefits that The Broads provide to society, including recreation opportunities, biodiversity conservation, water-related services and others. This reports sets out a framework for assessing more specifically the value to society of the sustainable management regime. The so-called ecosystem services approach is adopted in order to contribute to a more quantified evidence base for future management activities and the allocation of resources that these will entail. The analysis that follows seeks to scrutinise the claim that better management and conservation of ecosystems and the linked navigation will result in increased wealth creation and livelihood protection. On balance, the available evidence does lend support to the proposition above. This ecosystem services value evidence can supplement more traditional arguments put forward for protected area status based on the preservation of scientific knowledge and ethical reasoning.

1. Ecosystem Services: definition

There are several definitions provided for ecosystem services in the literature (Daily, 1997; Costanza et al., 1997; Boyd and Banzhaf, 2007). The Millennium Assessment (MA) developed the following general definition in 2005: "ecosystem services are the benefits people obtain from ecosystems". That definition divides ecosystem services into *supporting*, *regulating*, *provisioning* and *cultural* services. As pointed out by Fisher *et al.* (2008) and Wallace (2007), when the focus is on the valuation of ecosystem services, that definition can lead to confusion because it lists both 'ends' and 'means' as services. In other words, that definition implies that the ecosystem services are the benefits for society, but at the same time that the services are the means by which the benefits are created. Since the main purpose of this study is to assess the value of the benefits that The Broads can bring to society, it is important to clarify what an ecosystem service is and what a benefit is for society. For example, water provision is an ecosystem service and the benefit of that service can either be drinking water or biodiversity maintenance.

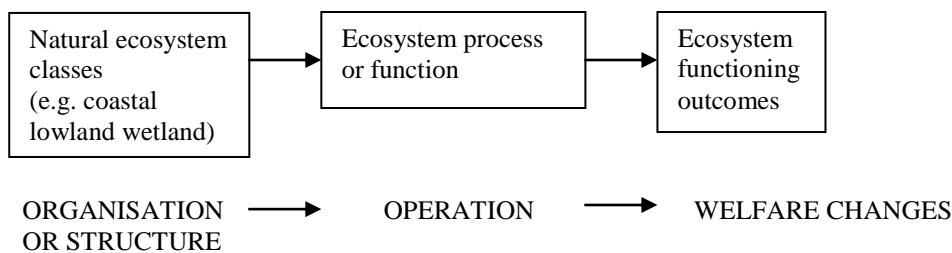
The definition proposed by Fisher *et al.* (2008) clarifies the distinction between ecosystem services and benefits and for that reason will be used in this study: *ecosystem services are the aspects of ecosystems utilised (actively or passively) to produce human well-being*. Fisher *et al.* see ecosystem services as being the link between ecosystems and things that humans benefit from, not the benefits themselves. The focus is on the benefits that humans receive from the ecosystem. Ecosystem

services include ecosystem organisation or structure (the ecosystem classes) as well as ecosystem processes and functions (the way in which the ecosystem operates). The processes and functions become services only if there are humans that (directly or indirectly) benefit from them. In their definition of ecosystem services the key feature is then the separation of ecosystem processes and functions in intermediate and final services. For example, nutrient cycling is an *intermediate service* that allows for water provision, which is the *final service*, and gives the *benefit* of water consumption (e.g. drinking water) to humans.

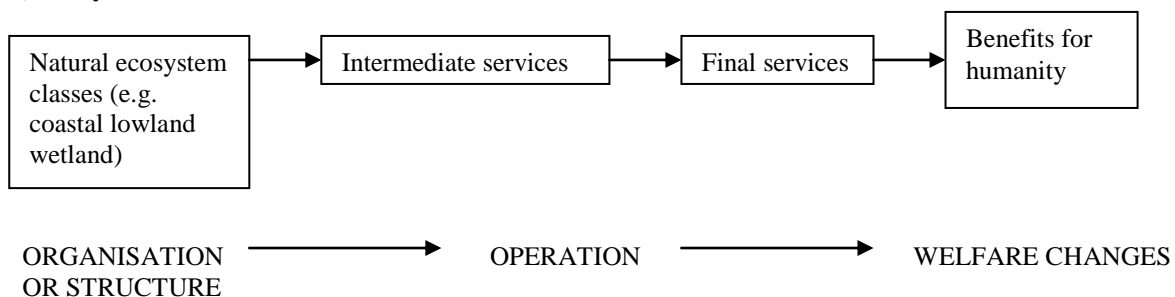
Figure 1 summarises in a simple diagram when an ecosystem produces services and hence benefits to humans. If humans are not the beneficiaries of the examined ecosystem, then we talk of ecosystem processes or ecosystem functions (Figure 1a) that lead to ecosystem functioning outcomes. When the ecosystem processes or functions lead to human benefits, then they become services (intermediate and final services) (Figure 1b). Given the scientific uncertainties involved in practice it is difficult to distinguish between 1a and 1b, and so, under a precautionary approach, 1b is adopted for management purposes. We now take a closer look at The Broads and its particular ecosystem service provision.

Figure 1 Ecosystem services approach

a) Ecosystem services that benefit nature



b) Ecosystem services that benefit humans

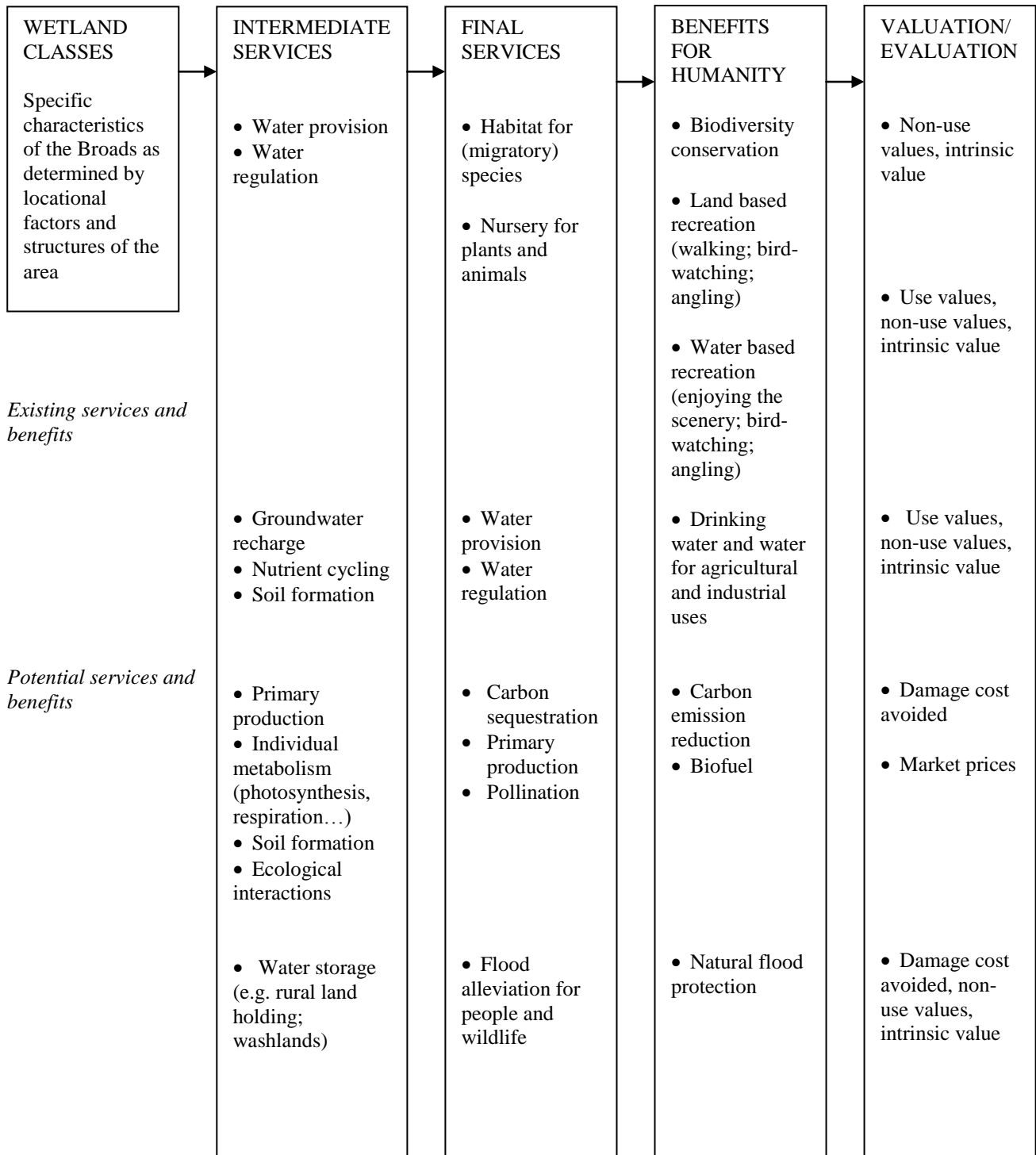


2. The Broads: a description of the area and related ecosystem services

The Broads area consists of a network of rivers and shallow lakes surrounded by calcareous fens and drained marshes. With an area of approximately 300 km² The Broads provide a large variety of habitats and landscape types, which are linked to form a lowland wetland ecosystem. The services and benefits supplied by those wetlands are examined in detail below using the general framework described in the previous section.

Figure 2 is a more detailed version of Figure 1.b, and shows the ecosystem services that benefit humans in The Broads. This list is not exhaustive, but contains the more significant existing and potential ecosystem services. The final column in Figure 2 will be explained in more detail in section 3.

Figure 2 Classification of the ecosystem services in The Broads that benefit humans and valuation method of the benefits



As shown in Figure 2, two groups of key benefits for The Broads are highlighted: *existing* and *potential* benefits. In the first group four benefits are included: biodiversity conservation; land based and water based recreation; water provision for drinking as well as water for agricultural and industrial uses.

Thanks to nutrient cycling and erosion control, the rivers and lakes in The Broads provide habitat for plants and animals allowing the biodiversity of these areas to be maintained. Nutrient cycling and water plants that retain nutrients (P) serve to improve water quality. Those ecosystem services, together with the groundwater recharge, allow the abstraction of water to be used for irrigation as well as drinking water. However, it is recreation that is the most highly visible service The Broads give to society. Bird-watching and angling, either land or water based, attract large numbers of people into the area. During 2005 the registered total number of day visitors was about six thousand (Global Tourism Solutions (UK) Ltd, 2008).

The *potential* benefits group highlights the potential in The Broads for land cover and land use management to assist in the mitigation and adaptation to the effects of climate change. More specifically, reducing green house gases emitted to the atmosphere, providing natural flood protection, as well as offering the potential for alternative energy sources. However, the reduction of carbon dioxide from the atmosphere would be counter balanced because in fresh water wetlands together with the carbon sequestration, greenhouse gases such as methane and nitrous oxide (N₂O) are emitted and might offset the benefits of carbon burial. However, there is currently little data with which to quantify this trade-off (Shepherd et al., 2007; Andrews et al., 2006).

The Broads represent the largest expanse of species-rich fen in lowland Britain. The fens are the first stage in the natural succession from open water to woodland. In former times, the fens were maintained by grazing animals, and were managed for reed for thatching, litter for cattle bedding and marsh hay (Boar et al., 1991). The demand for thatching has declined throughout the century and the unharvested areas of marsh-hay began to dry out and were colonised by trees and other plants leading to a loss of wetland habitats. To maintain the conservation value of these areas The Broads Authority has, in the past, organised teams of volunteers to harvest the marsh-hay. Recently a specially designed machine that is able to operate in the delicate wetland environment was developed. The 'Fen Harvester' is a tracked vehicle equipped with a cutting system, load bin and discharge facility. The collection system consists of a collection pipe along which the harvested marsh-hay is blown. The primary benefits of the Fen Harvester arise from the positive ecological improvements for fenland of regular harvesting. A double benefit to local conservation could be achieved by displacing wood fuel with fen fuel. Fen vegetation in general and reed in particular has a calorific value (dry matter basis) very similar to wood and, as with all vegetative biomass, the CO₂ consumed during growth results in a net zero CO₂ emission. The fossil-fuel-displacement by fen biomass further enhances this potential use as a fuel product. The biomass produced by the fen

in The Broads could be used as a source of energy as a biofuel energy plant can be served by naturally occurring fuel, wood or straw, and through combustion or some other conversion process can deliver energy in the form of heat, electricity or both. Limitations on this potential energy service include the requirement to dry the fen material and mix it with, for example, wood chips, as well as the high costs of bulk transport of the fen material to a user site. A localised arrangement with tailored delivery and end user outlets remains a possibility.

Furthermore, wetlands also supply natural flood protection (flood control) thanks to their water storage service, which also can reduce the flood risk for people and wildlife posed by fluvial or marine storm events. Therefore, wetlands used as storage or temporary washlands can be considered to be a component of more sustainable flood defence strategy.

Looking closer at Figure 2, ‘water provision’ is shown as a *final service* when the benefit is ‘drinking water’ and ‘water for agricultural and industrial uses’, and as an *intermediate service* when the benefit is ‘biodiversity maintenance’ or ‘recreation’. To understand the reason for that, we need to explore the concept of *benefit dependence*. Boyd and Banzhaf (2007) use that expression to indicate that it is the benefits you are interested in that dictate what you understand as an ecosystem service. This is an important point for policy making. When the decision context is the valuation context, what we value are the benefits that the ecosystem provides and not the separated ecosystem services that generate those benefits. In this context then, the MA definition and classification of ecosystem services is not entirely appropriate because it may lead to double counting. When ‘water provision’ (MA provisioning service) is considered as a final service, the intermediate services that generate it are ground water recharge (MA regulating service), nutrient cycling (MA supporting service) and sediment retention and deposition (MA supporting service)¹. Valuing the human benefits of recreation (MA cultural service) and drinking water (MA provisioning service), we are indirectly estimating all the intermediate and final services involved in their generation.

3. Ecosystem services: valuation categories and methods

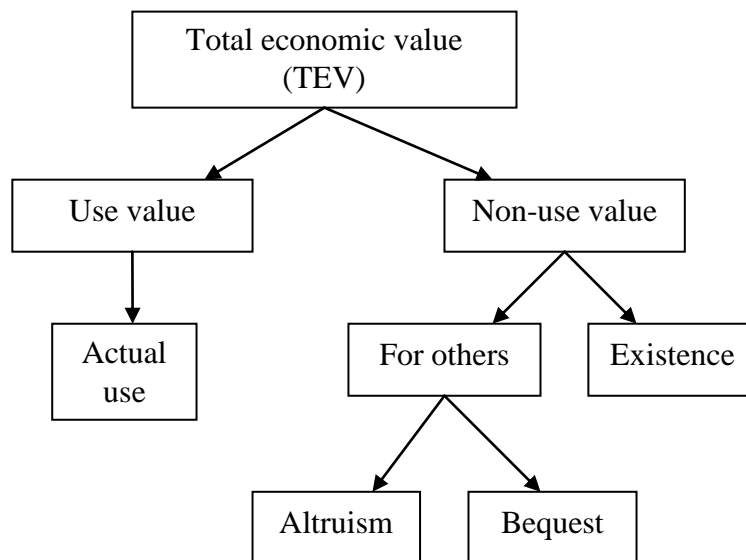
3.1 Valuation categories

Given the multi-faced nature of benefits associated with wetlands there is a need for a usable typology of the associated social, economic, and cultural values. When considering environmental

¹ The interaction among several intermediate services, such as ground water recharge, nutrients cycling and sediment retention and deposition, giving water provision as a final service, it is called the joint production of ecosystem services.

values, based on the concept of *use* and *non-use* (or *passive*) values, economists have generally settled for a taxonomy (Figure 3) the components of which add up to the total economic value (TEV) (Turner et al., 2008).

Figure 3 Total Economic Value (adapted from Bateman et al., 2002)



Use values relate to *actual use* of the good in question (for example, a visit to The Broads), planned use or possible use. Possible uses are important because people may be willing to pay to maintain a good in existence in order to preserve the *option* of using it in the future. Non-uses refer to willingness to pay to maintain some good in existence even though there is no actual, planned or possible use. Among the non-use values a different kind of satisfaction leading to different passive values arises: we talk of *existence values* if the individual has satisfaction in maintaining in existence a resource; *altruistic value* might arise when the individual is concerned the resource in question should be available to others in the current generation; if the altruistic concern is about the possibility for the next and future generations to make use of the resource in question, we talk of *bequest value*. The notion of *intrinsic value* on the other hand refers to assigning values to things ‘in themselves’ rather than because those things serve some human-oriented end. Intrinsic value might be attached to all things, living or otherwise, but not in a monetary way (Bateman et al., 2002).

The last column in Figure 2 shows the valuation categories for each ecosystem benefit identified for The Broads.

3.2 Valuation methods

Several valuation methods exist to estimate the value of ecosystem services. The true economic value of the ecosystem services is given by the expressed *willingness to pay* (WTP) for those services because that valuation incorporates the expenditure of the individual for the service (the market price of the service) plus the consumer surplus (that is the amount that the individual is willing to pay for that service over and above the market price of the same service) (Bateman et al, 2002). To measure the WTP two main techniques can be applied: revealed preferences (RP) and stated preferences (SP). Where market prices of outputs and inputs are available, a proxy value² can be assumed using this price data. Alternatively, *replacement or substitute costs* can be assessed, which refer to potential expenditures if the ecosystem service was lost and a substitute was possible (eg clean water from sources other than The Broads). In some contexts the *damage cost avoided*, which is represented by the costs that would be incurred if the wetland service was not present (eg flood prevention and carbon storage) can be used as a proxy value. Finally, the gross value added (GVA), which represents the contribution of the service to the regional or national economic activity, can be calculated in cases where a given service is locally a significant source of income and/or employment.

The valuation methods above may be used to estimate the same benefit but their results are not equivalent. For that reason values estimated with different methodologies cannot be added together in order to provide some aggregate value of the ‘total’ ecosystem service value of The Broads.

This sub-section examines each valuation method giving examples related to the ecosystem services in The Broads. Table 1 shows existing and potential benefits for The Broads, related valuation methods and the valuation methodology used for this study.

² For a complete analysis of different valuation methods see Turner et al., 2001.

Table 1 Broads ecosystem benefits valuation methods

<i>Benefits</i>	<i>Valuation methods</i>	<i>Desk based valuation methodology</i>
<i>Regular</i>		
Biodiversity	WTP (Stated preferences)	WTP - CV meta-analysis (Woodward and Wui, 2001) MWTP - CE PHD (2007) WTP - CV meta-analysis (Brower et al., 1999)
Land based recreation	WTP (revealed and/or stated preferences); GVA	STEAM method (approximate of GVA)
Water based recreation	WTP (revealed and/or stated preferences); GVA	STEAM method (approximate of GVA)
Drinking water	WTP (Stated preferences); Market prices	Market prices (potable water price)
Water for agriculture	WTP (Stated preferences); Market prices	Market prices (water licence price)
Water for industrial use	WTP (Stated preferences); Market prices	Market prices (water licence price)
<i>Potential</i>		
Carbon emission reduction	Damage cost avoided; carbon trading price	Damage cost avoided (max) Damage cost avoided (min) Carbon trading price
Biofuel	WTP (Stated preferences); Market prices	Pilot study data only
Flood protection	WTP (Stated preferences); Damage cost avoided	WTP - CV meta-analysis (Brower et al., 1999)
Composite environmental value	WTP (Stated preferences)	Users & non-users WTP – CV study (Bateman et al., 1992)

If we want to estimate how much individuals value wetlands, we can ask for their WTP to maintain or recreate that environment. There are two main techniques to elicit these values: revealed preference (RP) and stated preference (SP) methods. With the first method the WTP can be inferred from individual's actual decisions in the market. It is assumed that the decision taken by each individual expresses the preference of that individual for a given good or service that yields him/her some level of satisfaction (the actions of the individual reveal what he/she prefers). It is possible sometimes to assess the costs that were borne to enjoy a good or service. For example, to estimate how much people value a place, we might calculate how many nights some people spend in that place, or we could calculate the cost of the petrol used to reach that destination (travel cost method). When the WTP cannot be inferred from the market (that is the case for most of environmental goods and services) it is necessary to use SP techniques. For example, if we want to estimate the value of biodiversity of an ecosystem in a specific area, we need to ask to the people how much they would pay to conserve or restore the biodiversity in that environment. In a SP exercise, individuals are usually asked questions like 'What are you willing to pay for policy A?' or 'Are you willing to pay £x for policy A?' (known as contingent valuation), or they can be asked to express their preferences across some set of alternatives such as 'Would you rather prefer policy A or B?' (known as choice experiments). Land and water based recreation benefits can either be assessed via

revealed or stated preference techniques. Biodiversity conservation, however, can only be assessed with SP techniques or by transferring (benefit transfer technique) the stated value estimated in other similar areas for the same benefit (Bateman et al., 2002).

Another technique to estimate the recreational value of wetlands to the local/regional/national economy is the GVA method. For each company, the calculation of GVA is sales less the cost of bought-in materials, components and services. Although difficult to calculate in practice, it is an important indicator because it provides a measure of productivity as well as of wealth creation. In a valuation exercise it is not possible to add the value of recreation estimated with WTP or GVA because they provide different value dimensions of the same benefit.

If a SP study measuring individuals' WTP is not feasible, the value of drinking water, for example, can be assessed with the price of potable water and the quantity of potable water sold by water companies. This is the market prices (MP) method, which assigns an approximate value to the benefit equal to the total market revenue of the good or service examined. The actual price paid by consumers is a good approximation of people's WTP for drinking water, although probably an underestimate.

In the absence of a WTP study on the value of water for agriculture or for industrial uses, the most comprehensive method to assess the value of water provision for agricultural and industrial uses would require the estimation of crop productivity changes in the area due to the provision of surface water supply. In the Broads Authority executive area the land use is essentially grazing marsh. However, the potential of those areas for cattle and sheep grazing is currently not fully used. The land use in the rest of the Broadland area is predominantly cereals, sugar beet root, peas, potatoes and lettuce. Only the last two require irrigation at specific times, whereas the rest of the horticulture does not require much irrigation. As another application of the MP method, an approximation of the value of the water used for agriculture or for industrial purposes would be possible by estimating the value of the abstraction licences bought in The Broads area for those purposes. In Broadland ground and surface water abstraction is possible, but the value that is of interest in this study is the water coming from the rivers in of The Broads, which is surface water.

The reduction of carbon emissions (linked to sequestration and storage ecosystem service) can be measured using the damage cost avoided method. This method estimates the costs of carbon emissions via the trading price on the carbon offsets market, or making an estimate of the damage

caused by carbon emissions in the future. The quantity of gasses stored underneath the wetlands has to be specifically measured for each area of interest; if that is not possible, an estimated quantity can be assumed transferring greenhouse gas values measured elsewhere. Once monetary and quantitative values are determined, an estimation of the damage cost avoided can be calculated.

The value of The Broads as potential energy source producer is linked to the amount of biomass produced in the fen together with the cost of exploitation. In The Broads a biofuel energy plant using fen vegetation as a by product of nature conservation was considered and pilot testing was carried out. Other trials demonstrated that the most efficient energy conversion process is gasification for which the fen harvest may be readily compacted prior to burning. Also, a high value outlet for good quality material as pet litter was also shown to be viable, thereby offsetting the cost of harvesting (Broads Authority, 2000). However, WTP estimates of the value of a biofuel energy plant in The Broads is currently not available and, although it was demonstrated (pilot studies) to be technologically feasible via the use of the 'Fen Harvester', its financial feasibility is much less certain.

The value of the benefit of flood control in The Broads can be measured by eliciting individuals' WTP for that service offered by the Broad ecosystem. An alternative method would consider the damage cost avoided considering the hypothetical risk of flooding in the area and assessing the damage related to that event.

Table 1 shows possible valuation approaches for each benefit examined. This desk study has surveyed the literature to find all the appropriate valuation data, and an estimate of the benefit values that can be assigned to Broads ecosystem services is given in the following section.

4. Ecosystem services: desk based valuation for The Broads

Given the limited availability of locally applicable data it has been necessary to supplement this data set with value estimates for similar ecosystem services located elsewhere. This procedure is known as benefit transfer and should be applied with extreme caution.

The literature provides some WTP values for biodiversity. Woodward and Wui (2001) elaborated a meta-analysis of wetland valuation studies. They estimated annual wetland values from all different services per acre. That distinguishes their work from other meta-analyses which typically use WTP per person such as Brouwer et al. (1999). Brouwer et al. examined the WTP per household per year

for the preservation of specific wetland aspects and therefore services. Table 2 reports the estimated mean wetland biodiversity values from Woodward and Wui (2001) adapted and used in Turner et al. (2007) as well as the mean value of wetland biodiversity calculated by Brower et al. (1999) for fresh and saltwater wetlands. Another value of wetland biodiversity, calculated for the salt-marshes of the Blackwater estuary (Essex – UK) is also given in Table 2. The last value reports the marginal willingness to pay (MWTP) per household per year for saltmarsh biodiversity³ estimated from a binary choice experiment conducted in Essex over the summer 2006 (Luisetti, 2008). Given the WTP values per household of Brower et al. meta-analysis and of the CE, a total value for The Broads area could be estimated if an assumption is made about the number of households likely to value The Broads⁴. Thus, if only The Broads executive area is considered the relevant sample is 5000 households. If the wider Broadland area is considered many more households are relevant and so on. Woodward and Wui values, alternatively, are simply applied once the extent of the area under investigation is known. The total value for The Broads is reported in Table 2 as an area based calculation.

To estimate the value of land and water based recreation, an approximation of the GVA was used. The Scarborough Tourism Economic Activity Monitor (STEAM) method based on tourism turnover revenues and elaborated by the Global Tourism Solutions (UK) Ltd for the Broads Authority was utilised in this study to estimate the value generated by land and water tourism in The Broads. The STEAM model approaches the measurement of tourism at the local level from the supply side. In the estimate, the method takes account of the sectors of expenditure that generated the tourism revenue in the area such as: accommodation, food and drink, recreation, shopping, transport, VAT. Being an estimate of the revenue, STEAM figures are an approximate of the GVA, which is the method commonly used to estimate the economy at a local/regional/national level. As shown in the STEAM report prepared for the Broads Authority, in year 2005 almost six million people visited The Broads generating a revenue in the local economy of almost £320 millions. The land based tourism generated a revenue of £228 millions, against £92 millions generated with the water based tourism. The visitor numbers registered and shown in the STEAM report are around 5,700,000 for those that chose the land base recreation, whereas the rest chose the water based. The number of visitors having their own boat and those hiring one is almost equally split. It is

³ The attribute representing biodiversity was dummy coded in the econometric analysis of the CE. The MWTP reported in this study is that calculated for the highest level of biodiversity conservation presented to the respondents.

⁴ A calculation that takes account of the distance decay revealed by the choice experiment was applied in the original study. Assuming that Blackwater and Broads marshes have similar characteristics, the same could be done here.

interesting to notice that STEAM results indicate a reduction in the tourist numbers of around 6% between 2004 and 2005.

The approximate value of potable water was estimated via the price paid by consumers as an approximation of their WTP. This approach probably leads to an underestimation of drinking water value because it does not take account of consumer surplus values. As reported in Table 2 the value of drinking water with this method is around £17 millions.

In the literature there are no available WTP studies on the value of water provision for agricultural and industrial use specific for The Broads area. Given the commercial sensitivity involved in information on the amount of production delivered from Broadland, data to calculate the crop productivity changes were not available. For the water used by industries, an alternative method could analyse the production of the different industries present in The Broads and calculate the value of that production. However, those data are equally as sensitive as those from agriculture. Thus, the estimated value of the water used for agriculture and for industry was approximated by considering the amount spent by farms and companies to buy surface water abstraction licences from the Environment Agency. The results shown in Table 2 are about £190,000 for water used in agriculture and a little over £83,000 for water for industrial use. As in the case of drinking water these figures are probably an underestimate of real value of the benefits that The Broads provide in terms of water uses.

To calculate the value of the benefits of carbon emission reduction, thanks to the carbon sequestration process underneath the marshes of The Broads, an estimate of the carbon buried in that area is required. For this desk study, we will assume that the annual carbon buried per hectare is 0.266/tC for a sedimentation rate of 1.5 mm. That value has been estimated from biogeochemical analysis of the relic and spartina marshes created by managed realignment in the Blackwater estuary (Essex – UK) over the years 2006-2007. That value is net of the greenhouse gases produced in the burial of carbon. Assuming those figures, the total quantity of carbon sequestered in The Broads⁵ would be 8,007/tC. As shown in Table 2, the consequent monetary values vary when different estimates for the value of the damage cost of carbon emissions avoided are used. Three different values were considered in this study: the highest value that can be applied is the figure suggested formerly by Pearce et al. (1996) and confirmed by Tol (2005) of \$50/tC, which is equivalent to about £30; another much lower figure that could be applied is £7, which is in the range of the

⁵ Broads area in hectares: 30,100.

estimates recommended by the Second Assessment Report (\$5-125/tC) as well as in the range suggested by Pearce (2003) (£4.30-27/tC) and confirmed by Li et al. (2004); another possible figure is given by the price of traded carbon that in March 2008 was equal to €22.53⁶ which is about £17.73.

As reported in section 3, while it was shown that a bio-fuel plant would be a technically possible solution to the disposal of fen vegetation in The Broads (Broads Authority, 2002), the excessive distance involved (86 miles round trip) to reach the existing bio-fuel sites in Norfolk and the very low density of the material make the project economically suspect. For a project to be economically efficient when the biomass is used as a fuel source bio-fuel sites should be located in the local area so to help reduce transport costs. When producing heat, to minimise transport costs and to avoid energy loss through transmission, a local and specific use of the biofuel would be best serving an onsite customer. Also, the calorific value of the fen material could be augmented by mixing with wood chips or other materials so to not leave any gap in the availability of fuel for burning over the not harvesting season. Finally, because of the costs involved a biofuel energy plant as a commercial electrical power generator is not a viable proposition. Currently the fen produced by the fen harvester is taken to local farms in The Broads where it is composted and used to enrich the fields with nutrients.

In 1990 the National River Authority (NRA)⁷ initiated a wide ranging study to develop an 'effective and cost-effective strategy to alleviate flooding in Broadland for the next 50 years' (Bateman et al., 1992, p.31). On the economic side of the study, the principal task of the cost-benefit analysis (CBA) was to estimate values for the non-market goods concerned. To address those values, in 1991 a CSERGE contingent valuation (CV) study was commissioned to assess the benefits of preserving the existing landscape, ecology and recreational characteristics of the area relative to their expected values in the absence of a Broadland-wide flood alleviation scheme (Bateman et al., 1992). It is possible to interpret the results of this study as an overall approximate value of the 'total' ecosystem services provided by The Broads. The CSERGE study consisted of two surveys: (i) a postal survey of households across the UK designed to capture the values which non-users might hold for preservation of the present state of Broadland, and (ii) an investigation of the values held by users for the same scenario as elicited through an on-site survey. As reported in

⁶ That value is reported by <http://www.pointcarbon.com>. It should be noticed that this price is higher than usual due to the dollar price that in the same period was anomalously going down.

⁷ National River Authority (NRA), precursor of the UK's Environment Agency with responsibility for the rivers.

Table 2, the whole-sample mean WTP elicited in the first study was of £23.29 in 1992, which corresponds to £34.24 in 2007 per household per annum.

Table 2 Broads ecosystem benefits valuation methods and estimates

<i>Benefits (year of reference)</i>	<i>Desk based valuation methodology</i>	<i>Estimate (£)</i>	
		<i>Total</i>	<i>Marginal</i>
<i>Regular</i>			
Biodiversity	WTP - CV meta-analysis (Woodward and Wui, 2001) ^a	18,692,100/yr	
	MWTP - CE PHD (2007) ^b		3.57/household/year
	WTP - CV meta-analysis (Brower et al., 1999) ^c		57.17/household/year
Land based recreation (2005)	STEAM method (approximate of GVA)	228,200,000	
Water based recreation (2005)	STEAM method (approximate of GVA)	91,740,000	
Drinking water (2006)	Market prices (potable water price)	17,482,389	
Water for agriculture (2006)	Market prices (water licence price)	189,452	
Water for industrial use (2006)	Market prices (water licence price)	83,435 ^d	
<i>Potential</i>			
Carbon emission reduction (2007)	Damage cost avoided (max) ^e	240,210	30/tC
	Damage cost avoided (min) ^e	56,049	7/tC
	Carbon trading price ^f	141,964	17.73/tC
Biofuel	n/a		
Composite environmental value (1992)	Non-users WTP – CV study (Bateman et al., 1992) ^g	As per Table 3 (1992)	23.29 (Mean) /household/year
Composite environmental value (2007)	Non-users WTP – CV study (Bateman et al., 1992) - 2007		34.24 (Mean) /household/year
Composite environmental value (1992)	Users WTP – CV study (Bateman et al., 1992) ^g		67.19 (Mean); 30 (Median) /household/year
Composite environmental value (2007)	Users WTP – CV study (Bateman et al., 1992) - 2007		98.77 (Mean); 44.10 (Median) /household/year
Flood protection	WTP - CV meta-analysis (Brower et al., 1999) ^c		69.56/household/year

^a Broads area in hectares: 30,100; estimated value of wetland habitat £621/ha/yr (Turner et al, 2007)

^b MWTP for the higher level of environmental quality (biodiversity) proposed in the CE. Values are per person per year. The aggregated value can be estimated knowing the population of the area.

^c Values are per person per year. The aggregated value can be estimated knowing the population of the area.

^d Most of it is due to energy use (power station)

^e Values taken from literature (Pearce et al., 1996; Tol, 2005; Pearce, 2003; Li et al, 2004). Those values have to be applied to the estimated tonnes of carbon buried in The Broads area.

^f That value was reported by <http://www.pointcarbon.com> in March 2008. It should be noticed that this price is higher than usual due to the dollar price that in the same period was anomalously going down.

^g That value is specific for the Broads since that figure comes from a CV survey commissioned in 1991 to assess the benefits of preserving the existing landscape, ecology and recreational characteristics of the area relative to their expected values in the absence of a Broadland-wide flood alleviation scheme.

The results of the first survey⁸ showed a marked decrease in mean WTP as distance from Broadland increases. The aggregation for the CBA was conducted using three approaches: aggregation using sample mean WTP; aggregation adjusting for distance zones; aggregation by bid functions. Results from these various approaches to aggregation are detailed in Table 3.

Table 3 Non-user's benefits of preserving the present condition of Broadland aggregated across Great Britain using various procedures (£ million/annum - 1992)

<i>Aggregation approach</i>	<i>Untruncated</i>	<i>Truncated</i>
Aggregation using simple mean WTP	159.7	98.4
Aggregation adjusting for distance zones	111.1	98.0
Aggregation by bid functions:		
i. using distance zone and national income	27.3	25.3
ii. using country distance and regional income	25.4	24.0

The second study was an on-site survey primarily intended to estimate the benefits to direct users of the area of preventing saline flooding in the study area. That study also had the academic objective of investigating the impact upon stated values of varying the way in which responses are elicited. However, in this desk study only the values (mean and median) elicited with the open-ended (OE) format are reported in Table 2, because OE responses are likely to represent more conservative estimates of underlying WTP (Turner et al., 2008). Hence these figures can be used as the basis for estimating lower values for the aggregate benefits to users of preserving The Broads from saline flooding.

The actual value of flood protection can be either assessed with a study that elicit the WTP of people to avoid flooding or with a damage cost avoided study that takes account of the costs incurred if the flood does happen. In table 2 the mean value for wetland flood protection from Brower et al. (1999) meta-analysis is given. That value is not specific for The Broads area and benefit transfer is applied in this case. However, the wetlands considered in that meta-analysis might not have similar characteristics to The Broads and for that reason that value should be handled with care. The alternative methodology of the damage cost avoided requires an estimate of the risk of the event happening and the calculation of so-called expected values.

⁸ Full details of this study are provided in Bateman and Langford (1997).

5. Broads ecosystem services: stakeholders and beneficiaries

A final issue is that stakeholders at different spatial scales perceive different benefits from the same ecosystem processes - leading at times to conflicting benefits. For example, to global stakeholders the service 'nursery for plants and animals' in The Broads may be valued for the biodiversity conservation, but locally it may be valued for its recreation opportunities. Stakeholder perceptions may also vary across time within a generation and between current and future generations.

At the local level, there is a potential conflict of use in The Broads between local residents, farmers and land owners, water companies, conservationists as well as agencies on one side and holiday makers (local and non local), hire boat and boat building industry, services industry, private boat owners on the other side. The tourism industry is very important for The Broads, but at the same time the congestion and pollution threats related to it highlight the need for regulation and conservation action in the area. The same categories of stakeholders now might have different interests in the future. For example, if the unique characteristics of The Broads become degraded or disappear because of the intensive use of the area, holiday makers (boaters and others) may alter their perceptions and reduce their visit rate or go elsewhere in the future. The conservation and the flood prevention aspirations, requiring more areas for washlands, conflict with the interests of present and future farmers. At the national level, The Broads is recognised as a national park equivalent area, whose habitats and landscapes should be conserved in the interests of the nation and the wider international community.

At the national and international level, for present and future generations, The Broads provide important habitats for flora and fauna (including a number of rare species) and provide cleaner air and climate regulation by sequestering carbon from the atmosphere. These global benefits are important and are the reason why The Broads is part of the protected area strategy championed by international agencies and governments.

Concluding remarks

As examined in the study, the benefits that society can obtain from The Broads encompass regular benefits such as biodiversity conservation, land and water recreation, drinking water and water for agricultural and industrial uses, and potential benefits, such as climate regulation (reduction of carbon emissions), biofuel possibilities and flood protection. Those benefits highlight the importance of preserving The Broads for present and future generations of stakeholders at local, national and international levels.

Considering that the value estimates for each benefit come from different valuation methodologies and refer to different points in time, summing up those figures together to obtain a single general value for The Broads would not be correct. However, looking across all the value categories provided, there is evidence of the significant importance of The Broads to the local, regional and wider economy. This ecosystem-based evidence offers strong support for continued deployment of scarce resources to maintain and enhance the terrestrial habitats and waterways through sustainable management actions.

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