An ecological economics approach to the management of a multi-purpose coastal wetland

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Abstract Three interrelated management problems—eutrophication of multiple use shallow lakes, sea level rise and flood risk mitigation and tourism pressures—are analysed in the context of an internationally important wetland area, the Norfolk and Suffolk Broads in the UK. The ecological-economic research findings presented should provide essential information to underpin the regulatory and management process in this internationally important conservation area. The relevant authority somehow has to integrate the maintenance of public navigation rights, nature conservation, and tourism promotion in a highly dynamic ecosystems setting. Because of the stakeholder conflicts, potential and actual, a more inclusionary decision-making procedure is required, and is currently being implemented.

Keywords Ecological economics · Wetlands · Eutrophication · Tourism pressure · Deliberative and Inclusionary processes

Introduction

Wetland ecosystems account for about 6% of the global land area and are among the most threatened of all environmental resources. The wetlands found in temperate climate zones in developed economies have long suffered significant losses and continue to face threats from industrial, agricultural, and residential developments, as well as from hydrological perturbation, pollution and pollution-related effects (Turner 1991).

Wetlands are complex ecological systems whose structure provides us with goods or products involving some direct utilisation of one or more wetland characteristics (Maltby et al. 1996). Wetland ecosystem processes also provide us with ecologically related services, supporting or protecting human activities or human properties without being used directly. Wetland systems, as well as their distinctive landscapes, are also often significant socio-cultural assets. So, the stock of wetlands is a multifunctional resource generating substantial socio-economic values (Balmford et al. 2002; Turner et al. 2003). Sustainable management of these assets has therefore become a high priority.

In this paper, three interrelated management problems—eutrophication of multi-use shallow lakes and connecting rivers, sea level rise and flooding risks, and tourism preferences and patterns—will be explored and analysed from an ecological-economic perspective in the context of the Norfolk and Suffolk Broads (see Fig. 1). The overall management tasks in this national park equivalent area encompass the maintenance of public navigation rights and the area's biological diversity, sustainable utilisation of the various functions the wetlands provide, and the resolution of conflicts between stakeholder groups as a result of different usages of the area. The statutory duties of the management agency (the Broads Authority), however, constrain the range of options because no one interest (nature conservation, recreation and tourism promotion, or maintenance of navigation rights) can be given significant relative priority. The Authority has to operate by making often-pragmatic trade-offs, which can be subject to legislative constraints including EU Directives and the general guidance provided by the UK's sustainable development strategy.

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Towards a framework for integrated wetland management assessment

The structure of and processes within wetland ecosystems generate a wide array of resources that directly or indirectly support the economic and social welfare of diverse groups of people. Sustainable development based on the

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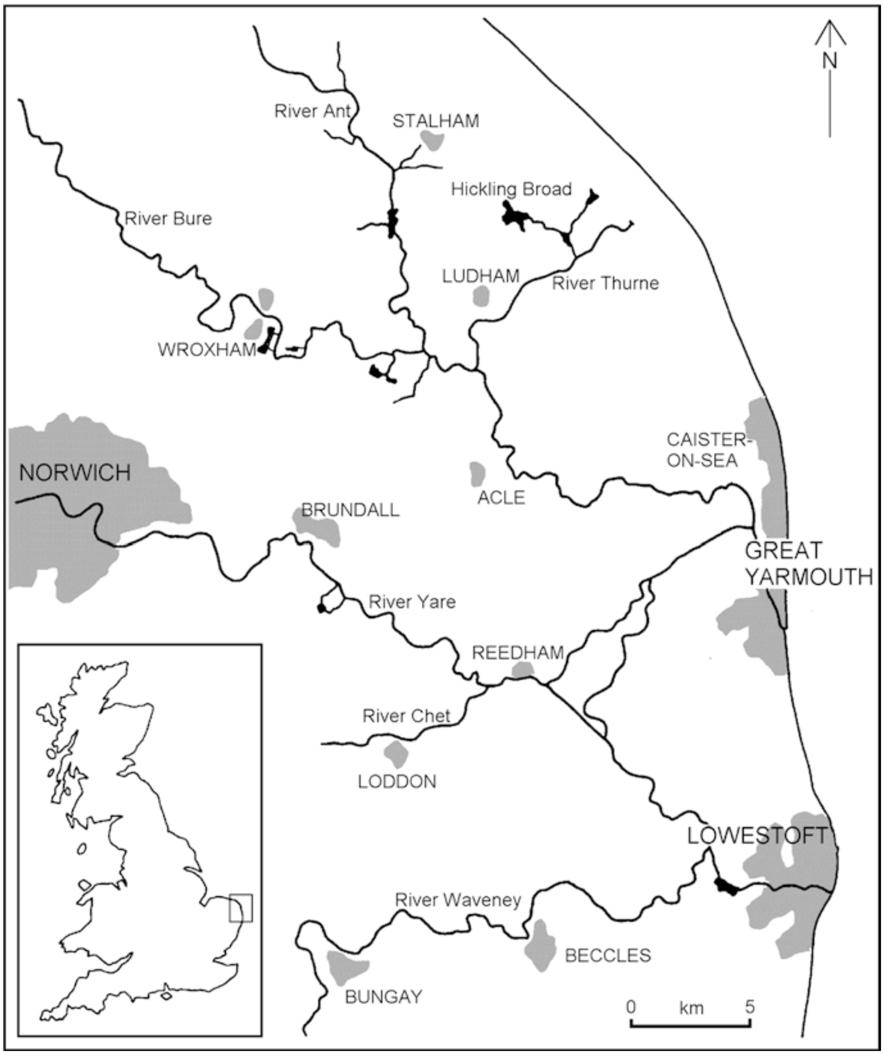

Fig. 1
The Broads and its waterways

maintenance of the functional diversity provided by wetland ecosystems will require careful management and evaluation of the different functions in terms of the welfare benefits they provide. In view of their complex, dynamic and co-evolving multi-functionality, a management approach is needed that addresses the pressures exerted on wetland ecosystems that threaten future flows of benefits. The Broads Authority has produced a strategic management and action plan (Broads Authority 2004). The implicit aim is to achieve greater co-ordination between its three main functions—nature conservation, enhancement of recreation and quiet amenity and the maintenance of rights of navigation—in order to fulfil sustainability goals. Integrated planning and management means combining assessments of the resources available to meet stated objectives; the formulation of a strategy or plan of action to use the resources in a wise way; and the implementation of the strategy in an orderly and efficient manner (Burbridge 1994). Underpinning integrated management and planning is research that supports and informs such a management approach. A wetland research methodology somehow has to make compatible the very different perceptions of how a dynamic wetland ecosystem interacts with a co-evolving society (Clayton and Radcliffe 1996; Brouwer and Crooks 1998).

In this paper, the Driving Forces-Pressure-State-Impact-Response (DPSIR) framework was used as a scoping device (Turner et al. 1998). This framework has been used to make explicit the means by which human activities in a given context and spatial area relate to the environmental pressures that impact wetland ecosystem states (see Fig. 2 for an application to the Broads wetland (Broads Authority 2004). These impacts cause environmental change, which, in turn, impact human beings, usually in some kind of societal response that feeds back into human activities. This feedback loop and any lags are important aspects of the human and natural systems interface.

The DPSIR framework provides a conceptual and organisational backdrop for the contributions of different disciplines to the description and analysis of environmental problems, given that the socio-economic aspects of environmental problems are an integral part of this co-evolutionary framework. It should be stressed that the DPSIR is a framework, not a model. Its main purpose is to make more manageable the complexity of environmental problems; for example in wetland ecosystems and related

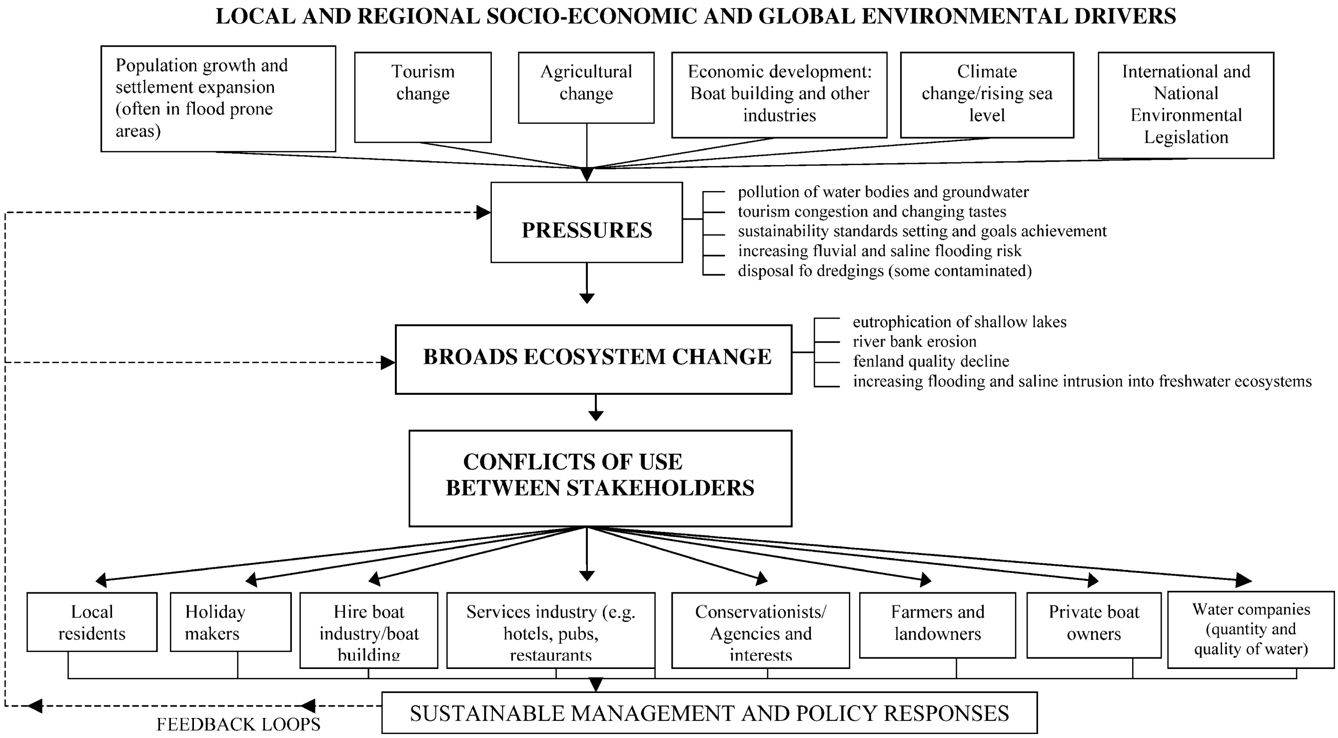

Fig. 2
Pressures facing the Broads and consequent conflicts of use

protection and sustainable management issues. It provides an important starting point on the road towards a common level of understanding and consensus between researchers, natural resource managers, and policy makers as they debate the links between the various driving forces that pose a threat to the intrinsic functioning of a wetland ecosystem. In the case of the Broads, these pressures have included land conversion, agricultural development, hydrological perturbation and pollution, increasing flood risk perceptions, and their consequent impact on the various interests or tourism, stakeholder groups who utilise the goods and services provided by these ecosystems and/or contribute to the pressures on them. Moreover, there are likely to be differences in stakeholders' perceptions of pressures, impacts and environmental values (see Fig. 2).

In the context of complex decision-making that aims to maintain functioning and ecological diversity in wetland ecosystems and satisfy multiple stakeholder groups, a range of protection and management options are likely to be available. Such options can be translated into management or development scenarios with each option likely to have different impacts on human and natural systems across different spatial and time scales. These impacts are often complex, but can, in principle, be measured with the help of indicators. Capturing the whole range of relevant impacts on natural and human systems within different protection or management scenarios, given the overall goal of sustainable development, will require a combination of environmental, social and economic indicators. Figure 3 summarises the indicators being developed by the Broads Authority alongside its 20-year plan.

Functions, uses, stakeholders, pressures and environmental changes

The Broads wetlands perform a variety of functions valued by a range of stakeholder groups living and working in the area or for those visiting the area. The main wetland functions are presented in Table 1. The table details the biophysical structure and processes maintaining the functions, their socio-economic uses and benefits, and threats to future availability of the functions.

The Broads wetlands provide a buffer against extreme hydrological conditions; providing water storage in times of flood, and water release during a drought. Wetlands also have the capacity to change water quality through the removal of chemical pollutants such as nitrogen and phosphate. A third major function is the provision of a nationally and internationally important habitat for flora and fauna (including a number of rare species), which, in turn, along with the waterways themselves, attracts tourists to the area.

The Broads floodplain is at risk from two types of flooding: tidal flooding, caused by high sea levels, and fluvial flooding, caused by high river flows (Turner, Adger and Doktor 1995). Surge tides can cause saline flooding of land by breaching or overtopping flood banks. Saline intrusion also occurs in surge conditions as more salt water forces upstream between the banks. This can damage the ecology of normally freshwater reaches and cause extensive fish kills. Fluvial flooding, caused by heavy rainfall, is less damaging from an agricultural or conservation perspective, although flooding of any kind can damage property. If low river flow conditions occur in the autumn, normal

Plan objectives and outcomes	Potential performance indicator
Living landscapes	
• long term vision for the Broads	qualitative sustainability assessment degree of consensus among stakeholders
• maintenance of Broads' landscape	extent and percentage of flood plain maintained as open water, fen, grazing marsh or open space
	extent and voluntary uptake of agri-environmental schemes
• sustainable landuse plan	percentage of appeals against planning decisions upheld by Planning Inspector
	percentage of new homes built on previously developed land
• flooding alleviation	number of properties damaged by flooding
Water, habitats and wildlife	
• 'Good' status for all water bodies (Water Framework Directive)	percentage of length of rivers and number of broads in 'good' status
• biodiversity conservation enhancement	percentage of sites of Special Scientific Interest in favourable condition
• sustainable fen management	total area of fen under appropriate management
Tourism and recreation	
• risk reduction and boat safety enhancement	number of incidents resulting in injury or death per annum
• sustainable boating activity	mean number of weeks per year that cruisers are hired
	percentage of hire boats accredited under Quality Grading Schemes
	percentage of boats meeting best available technology standards
	percentage of boats violating speed restrictions
	percentage of public rights of way easily accessible
• enhanced access to land and water	length of footpaths accessible to the disabled
• tourism infrastructure quality enhancement	number of catering establishments accredited under the Broads Quality Charter
Public understanding	
• maximum awareness of national park principles and practice	percentage of residents and visitors aware of national park status (survey monitoring)
• maximum stakeholder inclusion	number of organisations and community groups active in the plan implementation process

Source: Adapted from (Broads, 2004)

Fig. 3
Potential performance indicators

high tides can cause the same saline intrusion effect (Turner and Brooke 1988; Turner, Adger and Doktor 1995).

Besides the threat of increased salt water incursion and tidal salt water flooding, the Broads is threatened with another water problem: variable river flows and depleted groundwater. The Broads are part of a much wider catchment area. About 6 million people live in this area, which puts considerable demand on the region's water resources and poses a potential threat to the Broads. The region is furthermore the driest in Britain and droughts are a common feature of the area. Agriculture is another significant water user, in particular through spray irrigation of land in dry periods.

Adequate groundwater levels and river flows are crucial for a number of reasons. First, sufficient water of good quality is

Table 1
Wetland functions and associated socio-economic benefits in the Broads

Function	Biophysical structure or process maintaining function	Socio-economic use and benefits	Threats
Hydrological functions			
Flood water retention	Short and long-term storage of overbank flood water and retention of surface water runoff from surrounding slopes	Natural flood protection alternative, reduced damage to infrastructure (road network etc.), property and crops	Conversion, drainage, filling and reduction of storage capacity, removal of vegetation
Groundwater recharge	Infiltration of flood water in wetland surface followed by percolation to aquifer	Water supply, habitat maintenance	Reduction of recharge rates, overpumping, pollution
Groundwater discharge	Upward seepage of groundwater through wetland surface	Effluent dilution	Drainage, filling
Sediment retention and deposition	Net storage of fine sediments carried in suspension by river water during overbank flooding or by surface runoff from other wetland units or contributory area	Improved water quality downstream, soil fertility	Channelization, excess reduction of sediment throughput
Biogeochemical functions			
Nutrient retention	Uptake of nutrients by plants (n and p), storage in soil organic matter, absorption of n as ammonium, absorption of p in soil	Improved water quality	Drainage, water abstraction, removal of vegetation, pollution, dredging
Nutrient export	Flushing through water system and gaseous export of n	Improved water quality, waste disposal	Drainage, water abstraction, removal of vegetation, pollution, flow barriers
Peat accumulation	In situ retention of c	Fuel, paleo-environmental data source	Overexploitation, drainage
Ecological functions			
Habitat for (migratory) species (biodiversity)	Provision of microsites for macro-invertebrates, fish, reptiles, birds, mammals and landscape structural diversity	Fishing, wildfowl hunting, recreational amenities, tourism	Overexploitation, overcrowding and congestion, wildlife disturbance, pollution, interruption of migration routes, management neglect
Nursery for plants, animals, micro-organisms	Provision of microsites for macro-invertebrates, fish, reptiles, birds, mammals	Fishing, reed harvest	Overexploitation, overcrowding and wildlife disturbance, management neglect
Food web support	Biomass production, biomass import and export via physical and biological processes	Farming, fen biomass as alternative energy source	Conversion, extensive use of inputs (pollution), market failures

Source: Modified from Turner et al. (1997) and Burbridge (1994)

vital for the wildlife diversity of the fens and marshes. The particular character of a fen is determined by its reliance on water supply: groundwater, river water, rainfall, or a combination of the three. Also, the drained marshland depends upon an adequate freshwater supply to the dyke (field drains) systems. Many grazing marsh dykes rely on freshwater conditions to maintain the diversity of their aquatic flora. Dykes are also a source of drinking water for livestock on the marshes, especially during the summer.

Secondly, water abstraction decreases summer river flows, which in turn concentrates sewage discharges, reduces the flushing of algae from the Broads system, and exacerbates the problem of saline intrusion. The increase in nutrient levels as a result of the introduction of river-based sewage works during the early part of the 20th century has, in particular, triggered an enormous change in the Broads water ecosystem, known as eutrophication. Eutrophication is essentially a fertilisation of the water through nutrient enrichment. Two nutrients are involved: phosphates (P) and nitrates (N). Phosphates enter the system from sewage treatment works, while nitrates mainly come from the run-off from agricultural land within the Broads catchment, and to a lesser extent from sewage treatment works. Phosphorus comes from a limited number of sewage treatment works and can be removed before it is discharged into the water, and nitrogen comes from all over the catchment and is therefore difficult to control in the short term. Phosphorus levels have declined or are low in the main rivers, but nitrogen levels remain problematic. Only 12 of the 63 permanent water bodies are in good condition with stable aquatic plant populations and clear water (Broads Authority 2004). We will return to the eutrophication problem in a later section.

Species conservation is a key management objective but the success of conservation or restoration generally, particularly in wetlands, depends upon restoration of wider ecosystem function (Moss 1983; Madgwick and Phillips 1996; Holzer et al. 1997; Pitt et al. 1997; Moss et al. 1996; Stansfield et al. 1997 and Scheffer et al. 1993). One administrative issue arises from the difference between ecological and management authority boundaries which affects Broadland. The executive area of the Broads Authority of Norfolk and Suffolk follows the river valleys, but much of the Broads groundwater catchment, as well as the upper catchments of the main rivers that supply the Broads, are outside the direct influence of the Authority. The quantity and chemical quality of water received by the lakes and rivers of Broadland is thus, at least in part, outside the direct influence of the area's major management authority. Such administrative problems may prove a substantial impediment to the implementation of a holistic and integrated programme for Broadland management.

In succeeding sections, we highlight three policy challenges—the multiple use management of the shallow lakes and rivers (Broads) given the threat posed by eutrophication; the provision of a selective flood alleviation scheme to protect nature conservation, recreation and other economic interests; and the need for better information on recreation/amenity users and their preferences, in order to promote sustainable tourism.

Sustainable tourism

Managing the water resources is also important for the public enjoyment of the area and navigation. Low freshwater flows can exacerbate problems of blue-green algae, botulism, salt water incursions and other water quality factors that severely affect people's enjoyment of the waterways, particularly those who participate in recreation or sports involving contact with the water.

On the other hand, the visitors themselves, in aggregate, have put considerable strains on the area for a number of reasons with the risk of impairing those environmental features that people come to see and experience in the first place. Large numbers of visitors disturb local wildlife, especially during the breeding and nesting season. The expansion of boating activity in the past is believed to have confined wildfowl to less disturbed and non-navigable broads. The Broads provide an important habitat for a number of rare bird species such as the marsh harrier, bearded tit and the bittern.

The large numbers of visitors on boats, especially motorboats, result in considerable boat wash, and hence, river bank erosion and potential increased flood risk. Most hire boats are designed to meet comfort requirements, not to meet the specific environmental needs of the Broads. The river stretches are not particularly wide, while most of the broads cover less than 10 ha. The size and shape of a craft significantly influences the amount of wash produced (May and Waters 1986). Boat wash has an impact on the bankside vegetation and eventually the floodwall itself.

A more sustainable approach to tourism is therefore an urgent requirement. It has been estimated that the overall value of tourism generated in the Broads area is approximately £147 million/annum. This financial flow supports 3,107 full-time job equivalents. Some 4.4 million nights are spent in the area by visitors and around 1.3 million day visits are made to the Broads (Broads Authority, personal communication). However, the local hire boat industry has been negatively affected by changing consumer tasks and trends in recent years. The national leisure and tourism market is now characterised by trends such as the increase in holidays taken outside the UK, more frequent and shorter holidays, and a much greater emphasis on high standards of service and value for one's money. These factors together with demographic changes have served to cause a significant fall in demand for the traditional Broads boating holidays, with subsequent negative economic multiplier impacts throughout the adjacent area.

Recreation value can be estimated using an indirect travel cost (TC) method. Here, the relevant demand curve is assessed by comparing the number of trips taken by visitors with the cost of those trips in terms of direct expenditure upon travel and entrance fees and the indirect opportunity costs of travel time (Bateman 1993; Bergin and Price 1994). One aspect of TC analysis that has been a focus in recent research is the potential of the method for undertaking "benefit transfer" analyses. Benefit transfer has been defined as "the transfer of existing estimates of non-market values to a new study which is different from the study for which the values were originally estimated" (Boyle and Bergstrom 1992). Within the Broads, the objective has been to construct models based upon data from a set of surveyed sites and use these to estimate the number of visitors to unsurveyed sites and their corresponding recreational values. This is an attractive procedure because it saves time and money on repeated studies, particularly as there are many forces that are likely to increase the demand for non-market benefit estimates over the next few years (McConnell 1992).

Visitor arrivals functions can be estimated linking visits to a series of predictors, values for which can be collected for the target unsurveyed sites. An example of such a function is given as Eq. (1) (see Table 2). This equation links the

Table 2
Explanation of visitor arrival functions

Visits	= f (	Price	Soc-econ,	Quality,	Subs,	X)
No. of visits to under take a given activity at a site. Expressed as either total visits of individuals or a visitor rate (e.g. per household pa.)		Cost of a visit in terms of travel expenditure and the opportunity cost of travel time	Socio-economic factors (e.g. car ownership, unemployment, etc.)	Type and quality of facilities provided at the site under consideration	Type, availability and quality of substitute sites	A matrix of other explanatory variables

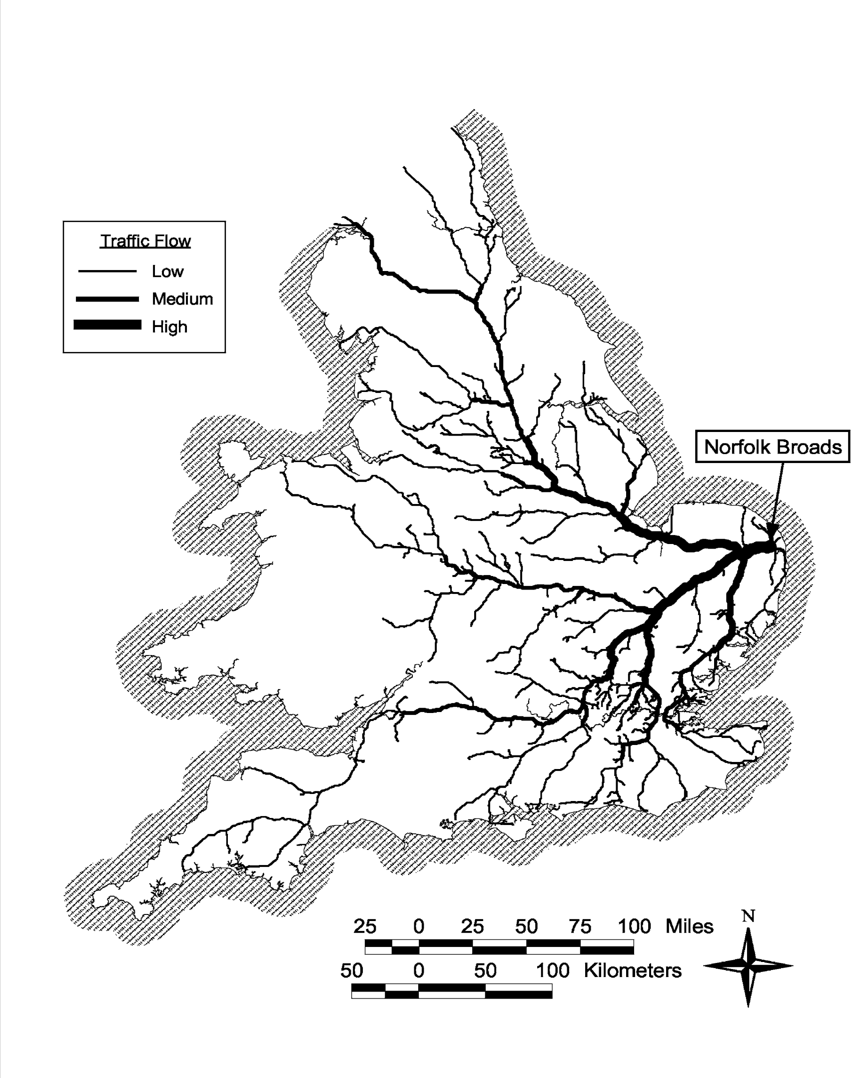

Fig. 4
Holiday visitor traffic flows to the Norfolk Broads, simulated in a GIS

number of visits to a site to the time and distance cost of those visits (thereby allowing the estimation of visit values) and other predictors, including the type and quality of facilities at the target site, the availability and quality of substitutes, socio-economic and possibly cultural factors, and other explanatory variables.

$$\mathrm{VISITS} = f(\mathrm{PRICE}, \mathrm{SOC} - \mathrm{ECON}, \mathrm{QUALITY}, \mathrm{SUBS}, \mathrm{X}) \quad (1)$$

To date, relatively few benefit transfer analyses have been undertaken. This is largely because it is difficult to obtain accurate information on several important elements in the transfer function, such as travel times taken for visitors to reach the site, the availability of substitute sites, and the definition of visitor zones of origin. However, recent advances in geographical information systems (GIS) technology have provided a superior foundation for implementing benefit transfer methods of placing economic values on recreational demand (Bateman et al. 1999; Brainard et al. 1999). In particular, GIS can help to resolve some of the spatial and data-handling problems associated with benefit transfer, while facilitating several methodological improvements.

The baseline data for our GIS-based transferable travel cost model is taken from a Broadland survey undertaken in 1996 and discussed in detail in a following section. This survey provides a total of 2,098 visitor interviews conducted at 10 sites across the area. Trip origin information was collected from each survey respondent in the form of a full postcode of their home address (Bateman et al. 1996). The GIS was then used to interrogate the Bartholomew's 1:250,000 digital map database to extract data concerning the distribution and quality of the entire UK road network to permit computation of minimum travel time routes from all origin addresses to the survey site. Figure 4 illustrates some of the output from this analysis showing the diversity of outset origins and routes taken to reach Broadland.

The advanced spatial analytic capabilities afforded by a GIS permit the analyst to extract high-quality data on many of the other determinants of Eq. (1), both for surveyed and unsurveyed sites. For example, interrogations of data sources such as the satellite-image based Institute of

Terrestrial Ecology UK Land Cover Database, have, and are, being used to identify potential substitute destinations, and their accessibility is being estimated within the GIS (Brainard et al. 1999). Similarly, socio-economic data on both actual and potential visitors can be extracted from the UK Census of Population to examine the influence of deprivation indicators such as levels of unemployment and urbanisation on visitor recreation demand in Broadland and to identify which groups do not visit sites (a factor that opens up previously unexplored avenues for distributional and equity analyses). A particular factor that merits attention is the possible existence of different subgroups, with diverse priorities and recreational preferences within the catchment areas of the sites. The use of GIS allows a more sophisticated analysis of the nature of recreational interactions than is normally seen in conventional environmental value studies.

A range of interests have recently come together to set out a new strategy to combat the decline in tourism demand and to generate new economically and environmentally sustainable business growth. The ambitious vision is to foster a thriving boat hire industry and ancillary services via a quality experience based on customer needs. Over the medium term, the boat fleet will need to be made more environmentally efficient, with increased use of electric boats, solar boats and sail craft. A more niche-orientated marketing strategy is perceived to be required in preference to the old preoccupation with volume maximisation, which will highlight environmental quality as the key Broads holiday characteristic (Strategic Leisure and TEP 2001).

With this emerging context in mind, some recent research based on a combination of quantitative and qualitative social research approaches has focused on tourism overcrowding in the Broads. Face-to-face interviews of visitors who hire motorboats and group discussions with local residents who own motorboats were used to reveal stakeholder preferences and attitudes to perceived and actual problems (Brouwer 1999; Brouwer, Turner and Voisey 2002). A majority of respondents felt that overcrowding was a real problem and that it was reducing the quality of the holiday/environmental experience, in terms of general amenity and peace and quiet. But there was also a sensitivity to increased hire prices as a mechanism to mitigate overcrowding. Water space zoning was another policy option that was met with significant opposition. The negative response to this instrument also served to uncover a deeper problem. Issues of trust, responsibility and blame seem to underlie opposition to change. The Broads Authority (BA) was seen as too remote and bureaucratic by the boaters and its motives were questioned. To the boaters, the hidden agenda appeared to be the eventual exclusion of boating from the Broads in favour of nature conservation. This group polarisation has emerged despite the fact that the BA's stated and actual policy is one of balancing the main interests in a long-term management strategy. In recognition of this problem, the BA has begun to institute a more overt stakeholder consultation process. This more inclusionary approach has been piloted in a localised problem case connected with one particular lake, Hickling Broad (Turner et al. 2003), and has been broadened out to discuss management issues across sub-catchment scales (know as the Upper Thurne River Catchment Group). It turned out that the "local" problem was in fact symptomatic of causal mechanisms that were catchment-wide, including areas beyond the executive control of the BA. The new EU Water Framework Directive will also serve to emphasise the catchment-scale and management processes that are inclusionary. We now turn to examine these wider questions and the general problem of managing a rate of environmental change in a highly dynamic setting.

Managing dynamic ecosystem change: combating eutrophication and feedback effects

It is expected that climate change, through, for example, alterations to the nutrient cycle will exacerbate existing water quality problems such as eutrophication (Horne and Goldman 1994). In addition, secondary effects upon water quality are expected through the role of climate change in increasing human demand for water services such as water provision, sewage treatment, etc. (Climate Change 2001). The stresses put upon the integrity of freshwater sources are exacerbated by population growth. For example, in our study area of East Anglia, a region with higher than average population flows, there has been increasing pressure upon open-water resources such as rivers and lakes. A valuation study was undertaken whose main objective was to measure the benefits that individuals derive from preventing excess algae (eutrophication) impacts upon open water in rivers and lakes in East Anglia (see Bateman et al. 2004 for full details). A questionnaire based on the contingent valuation (CV) method was used to estimate an individual's willingness to pay for a scheme to prevent excess algae in the rivers and lakes in order to ensure continued access to the amenity and recreation facilities which each site provides. The scheme was based on a sewage treatment programme that would remove nutrients and reduce eutrophication.

The contingent valuation survey comprised a variety of sections including: assessments of present use of water bodies; reactions (including belief indicators) regarding process by which water bodies and related activities may be affected by eutrophication; assessments of how such changes might impact upon usage of those water bodies; valuation scenario section outlining the proposed scheme and valuation task that examines households willingness to pay to avoid the specified eutrophication impacts.

The valuation scenario included information on the rising population of East Anglia and increased pressure on sewage treatment works and the effects of changing weather patterns on water quality. Survey respondents were given a plausible solution to the potential problem of eutrophication in the form of, for example, a phosphate removal scheme at the sewage works. Respondents were told that such a treatment would increase their annual household water bill. After the presentation of the valuation scenario and payment mechanism, respondents were faced with the elicitation question, asking them how much they would be willing to pay for the good if given the opportunity to obtain it, under specified terms and conditions. The particular method of elicitation used was a relatively new approach, known as the one and one half-bound (OOHB) elicitation method (Cooper et al. 2002). Rather than facing a single yes/no response question about the cost of provision, the OOHB mechanism presents survey respondents with upper and lower bound cost estimates per household (or per individual) associated with the provision change under consideration. The precise values of these amounts (bids) are varied across the sample to permit estimation of survival functions and associated univariate WTP measures such as the mean and median. Such an approach is considered to have greater statistical efficiency, plausibility and incentive compatibility than alternative mechanisms (Bateman et al. 2002).

The contingent valuation survey approached 2,321 households for face-to-face interviews; 1,067 of these refused to take the survey. A total of 1,254 households thus answered the survey, which contained one of the 13 bid (cost) treatments selected randomly so as to ensure equal sample size of each bid level. In order to obtain estimates of the WTP for the phosphorus removal scheme, it was assumed that a respondent's yes/no choice regarding the payment of a given bid amount to obtain a given improvement in environmental quality is made in the context of a utility maximising choice by the respondent. In accordance with the random utility framework, the individual's WTP is a random variable with a cumulative distribution function whose parameters can be estimated on the basis of the responses to the contingent valuation survey (Bateman et al. 2002).

Table 3 presents the mean and median WTP values. Of the 1,254 respondents sampled, only 1,112 responses were used for the econometric analysis, since 142 responses had missing observations for significant explanatory variables. The mean household annual WTP for the total sample (n =1,112) was found to be £75.4. Protest bids were identified based on the answers to questions regarding the reasons for acceptance/refusal of a bid amount. The removal of the 232 protest bids produced no significant change to the WTP amount, which remained at £75.4/household/year.

Aggregation of the sample WTP is crucial for benefit estimation to be used in a CBA. As the study was carried in the East Anglia region, and had to do with the protection of lakes and rivers against eutrophication in this region, the aggregation was constrained to consider only the local population, and not to include the whole of the UK, although it is noted that non-use values would exist for individuals living elsewhere in the country. The sample mean WTP per household was thus multiplied by the number of households in East Anglia, which is 2.253 million, to give annual benefits of £169 million.

Table 3
Mean and Median WTP for avoiding eutrophication damages

Mean WTP (£)	75.41
Median WTP (£)	69.07
95% Confidence interval	69.41–84.36
Standard error	3.71

Turning now to the costs of reducing eutrophication, compliance cost estimates from a previous study conducted by Pretty et al. (2002) were obtained. The authors carried out a preliminary assessment of the environmental costs of eutrophication of freshwaters in England and Wales. The relevant compliance costs are those associated with sewage treatment. Sewage treatment companies incur costs to comply with environmental legislation for the removal of phosphorus before it enters watercourses. Pretty et al. (2002) predicted that nutrient removal at sewage treatment works, which come under the EC Urban Wastewater Treatment Directive, would cost water companies £50 million/year, with a further operating cost of £0.3 million/year for each year over the period 2000–2010. These costs are for the whole of England and Wales. As such, the comparison of aggregate benefits from the prevention of eutrophication just for the East Anglia region with the costs of a nutrient removal scheme for the entire English and Welsh region indicates that there are significant positive net benefits. Within the Broads (national park equivalent) area, however, complicated feedback effects have served to make practical management more difficult.

The Broads Authority's (BA) powers are similar to other UK National Park authorities, plus a navigation duty. But the BA is not subject to the Sandford principle, which mandates primary status for nature conservation in all the other UK National Park areas. The BA's statutory duties are focussed around the requirement to balance navigation, nature conservation and recreation/amenity interests. This complex political, economic and environmental trade-off process is becoming even more difficult as the result of recent EU Directives (notably The Birds and Habitats Directive). This regulatory approach has at its core a rather "static" interpretation of nature protection. Such an interpretation does not sit easily with the BA's remit of "balancing" different interests in order to sustainably manage all the assets within its executive area. The navigation duty sometimes proves to be at odds with the provision of quiet public enjoyment and the conservation of the area's natural beauty.

The difficulties likely to be posed more generally by the Habitat Directive for management authorities such as the BA have been highlighted in the case of Hickling Broad (see Fig. 1). This is a water body that over the last 30 years or so has become a focal point for private and other sail and power boaters. Rights of navigation are restricted to a specified channel, but boating has become possible over a large part of the surface of the water body. In more recent years, as water quality has been improved, aquatic plant growth has accelerated, and large sections of the water body have at times become virtually inaccessible to navigation.

Restoration policies promoted by the BA have reduced nutrient flow into the Norfolk Broads and greatly improved water quality. In Hickling Broad, these measures have proved to be especially successful insofar as they have encouraged the return of previously threatened aquatic plants. However, the thickness of plant growth sometimes slows boat traffic and adversely affects local sailing competitions. As part of its overall commitment to supporting the sustainable development of the Broads, the BA has a statutory duty to maintain the area for the purposes of navigation. It also tries to encourage environmentally friendly boating. However, the increasingly dense beds of aquatic plant (including a rare species of stonewort) growth can periodically destruct non-powered and electrically-powered craft, and local boatyards may be temped to revert back to using diesel-powered craft on Hickling Broad, thereby increasing noise and water pollution (Turner et al. 2003).

Clearly, management of a dynamic and multiple-use ecosystem is hindered if a "static" interpretation of the EC Directives is adopted. A more flexible interpretation is essential to allow, in the Hickling case, experimental plant cutting and monitoring. Other management action to maintain navigation and recreation interests throughout the Broads executive area will also fall foul of a static interpretation of the provisions of the Habitats Directive. Some room for manoeuvre may be possible in terms of whether all management actions necessarily need to be interpreted as "projects" and therefore as requiring impact assessments. For an authority like the BA, the cost implications alone would make such a ruling impracticable.

From the UK government perspective, there is an element of "wait and see" in its position, as it monitors how events play out in the Broads context. From the BA's perspective, there is a need to achieve a working compromise, or at least to engage stakeholders in an ongoing process of dialogue. Efforts are under way to promote such a deliberative and participatory process in order to achieve a reasonable compromise between navigation and conservation needs. It is also now clear that the management objective can only be the maintenance of relative stability in the Broad's conditions. The stakeholder dialogue process has been constantly widened and now has to encompass flooding risk management issues in the area.

Flood alleviation and sea level rise mitigation strategies for Broadland: valuation analysis

In 1991 the National Rivers Authority (NRA), later named the Environment Agency (EA), initiated a wide ranging investigation to develop an: "effective and cost-effective strategy to alleviate flooding in Broadland for the next 50 years" (Bateman et al. 1992).

The appraisal process consisted of five main components: hydraulic modelling, engineering, cost-benefit assessment, environmental assessment, and consultations. The item of most relevance here is the cost-benefit assessment, which compared benefits of undertaking a scheme to provide a particular standard of flood protection to the costs of such an undertaking. Although market benefits from flood protection were considered in terms of agriculture, industry/residential and infrastructure (Turner and Brooke 1988), the value of the non-market benefits from the area were uncertain.

As part of the cost-benefit assessment for the Flood Alleviation Study, a Broadland contingent valuation (CV) survey of recreational visitors was commissioned in 1991 to assess the willingness of individuals to pay (WTP) to preserve the existing Broadland landscape, ecology and recreational possibilities (Bateman et al. 1992, 1994, 1995). Respondents were presented with two scenario:

1. "do nothing" in which due to saline intrusion virtually all the Broadland landscape and ecology would change in character;
2. implementation of an unspecified scheme for flood alleviation, which would preserve the current Broadland landscape and ecology.

The 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. Further theoretical and methodological investigations were undertaken via a second on-site survey conducted in 1996. Details of all three of these studies are presented below.

Non-user values were estimated by means of a mail survey questionnaire sent to addresses throughout Great Britain in order to capture both socio-economic and distance decay effects on stated WTP. Table 4 details the sampling strategy employed in this survey and the response rates achieved (Bateman and Langford 1997).

The survey questionnaire was designed to best practice standards (Dillman 1978). It was pre-tested through a focus group with pilot exercises, and included visual, map, and textual information detailing the nature of Broadland, the flooding problems and flood defence options together with necessary details supporting a WTP question such as payment vehicle, payment time frame, etc. The survey achieved a typically modest response rate of some 31%, however initial analysis showed that this was heavily supported by past users of Broadland who represented well over one-third of the responses in each distance category. Although experience of visiting the Broads declines significantly with distance from the area ($p<0.0001$), this sample can best be characterised as a sample of dormant past users.

Analysis of the response rates detailed in Table 4 together with respondent characteristic data showed that response rates were negatively related to increasing distance from the Broads, and positively related to respondent income. These relationships were further reflected within the replies of those who did return their questionnaires. When asked whether or not they agreed with the principle of incurring extra personal taxes to pay for flood defences in Broadland (the "payment principle" question), 166 respondents (53.5%) answered positively to the payment

Table 4
Non-user survey response rate by sample group

Sample group identification label	Distance zone[a]	Socio-economic class or area	No. of usable responses	Group response rate (%) [b]	Proportion of total usable responses (%)
1 M	1	Middle (2A)	58	34.7	18.7
2 M	2	Middle (2A)	66	39.5	21.3
3 M	3	Middle (2A)	59	35.3	19
4 M	4	Middle (2A)	47	28.1	15.2
3 U	3	Upper (1A)	54	31.1	16.8
3 L	3	Lower (4A)	28	16.8	9
Group mean			52	30.9	16.7
Total			310	-	100

[a]Zone 1=central (Broadland) distance band (width approximately 40 km); remaining zones are approximately 110 km wide; 4=most distant bank
[b] 167 questionnaires mailed out to each sample group (total mailings=1,002)

principle question. Determinants of these responses were investigated, yielding the model described in Eq. (2):

$$\begin{aligned}\text{LOGIT (YES)} &= \underset{(0.61)}{0.370} - \underset{(2.59)}{0.866}\,\text{DISTANT} + \underset{(2.16)}{0.602}\,\text{FISH} + \underset{(1.68)}{0.446}\,\text{SOMEVIS} \\ &+ \underset{(2.23)}{1.112}\,\text{OFTVIS} \div \underset{(2.81)}{1.458}\,\text{INCMID} + \underset{(3.45)}{1.924}\,\text{INCHI}\end{aligned} \quad (2)$$

where:

- LOGIT(YES)= In $\{\pi_i/[1-\pi_I]\}$ where π_I = the probability of the respondent saying "yes" to the payment principle question.
- DISTANT= 1 if respondent lives outside zone 1 (= 0 otherwise).
- FISH= 1 if respondent participates in fishing at least occasionally (= 0 otherwise).
- SOMEVIS= 1 if respondent sometimes but not often visits the countryside for relaxation/scenery (= 0 otherwise).
- OFTVIS= 1 if respondent often visits the countryside for relaxation/scenery (= 0 otherwise).
- INCMID= 1 if household income is £10–30 k/annum (= 0 otherwise).
- INCHI= 1 if household income exceeds £30 k per annum (= 0 otherwise).
- Scaled deviance = 378.89; df = 300; Figures in brackets are t-values

Equation (2) also shows that even after controlling for proximity, participation in certain of the activities for which Broadland is synonymous (i.e. fishing, relaxing and enjoying scenery) is positively related to respondents agreeing to the payment principle.

Those respondents who accepted the payment principle were presented with an "open-ended" format valuation question asking them to state the maximum amount of extra taxes they would pay WTP per annum to safeguard Broadland from the effects of increased flooding.

Including, as zero's, those respondents who refused the payment principle (i.e. those who stated they were not willing to pay to prevent flooding), this question elicited a whole-sample mean WTP of £23.29/annum (95% CI: £17.53 to £32.45). It was also found that mean WTP decreases as the distance from Broadland increases, and previous Broadland visitors expressed a substantially higher WTP than those who have never visited the area.

Aggregation of WTP estimates was conducted using three approaches, via the sample mean WTP, distance zone adjusted, and by bid functions. (see Table 5 and Bateman et al. 2000). Analysis of the data that produced the results in Table 5 suggests that the simple "sample mean" and "distance zone" approaches to aggregation yield substantial overestimates of total non-users benefits, which were very sensitive to the omission of any unusually high WTP responses. By contrast, the "bid function" approach gave robust and stable estimates of aggregate value.

In summary, the study of present non-users yields a consistent picture and provides the basis for some defensible estimates of aggregate benefits, which in turn yield an interesting commentary upon current practice. We now turn to consider the various on-site CV surveys of visitors to Broadland.

The 1991 user study generally conformed to the CV testing protocol subsequently laid down by the NOAA blue ribbon panel (Arrow et al. 1993). Survey design was extensively pre-tested with any changes to the questionnaire being

Table 5
The present non-user's benefits of preserving the present condition of Broadland aggregated across Great Britain using various procedures (£ million/annum)

Aggregation approach	
(1) Aggregation using sample mean WTP	98.4–159.7
(2) Aggregation adjusting for distance zones	98.0–111.1
(3) Aggregation by bid functions:	
i. using distance zone and national income	25.3–27.3
ii. using county distance and regional income	24.0–25.4

re-tested over a total pilot sample of some 433 respondents. One of the many findings of this process was that a tax-based annual payment vehicle appeared optimal when assessed over a range of criteria (details in Bateman et al. 1993).

The final questionnaire was applied through on-site interviews with visitors at representative sites around Broadland, with 2,897 questionnaires being completed. This sample was composed of 846 interviewees given the open-ended (OE) WTP questionnaire, and the remaining 2,051 facing in turn the single-bound dichotomous choice (1DC) and interactive bidding (IB) questions. The 1DC elicitation method faces respondents with a single question such as "are you willing to pay £x?" and then the bid level £x is varied across the sample. The IB method supplements the initial question with two further dichotomous choice questions reducing £x or increasing £x according to the answers given. The respondent is then finally given an OE question, the answer to which determines the WTP value used by the analysts. Prior to any WTP question, respondents were presented with a "payment principle" question. Negative responses to this question reduced sample sizes to 715 (OE) and 1,811 (1DC/IB), respectively. Except where indicated, all those refusing the payment principle are treated as having zero WTP in calculating subsequent WTP measures.

The theoretical validity of responses to the various WTP questions was assessed through the estimation of a series of bid functions. The analysis indicated that a consistent set of predictors explain WTP responses, including measures of respondent income, experience of Broadland and participation in related activities, and interest in environmental issues.

As noted previously, the Norfolk Broads CV study was conducted in answer to a real-world question regarding the funding of flood defences in Broadland. The study fed into a wider cost-benefit analysis that also examined the agricultural, property and infrastructure damage-avoided benefits of such defences. The benefit-cost ratio of the latter items was calculated at 0.98 (National Rivers Authority 1992). However, even if only a conservative measure of WTP for the recreational and environmental benefits of flood prevention is considered the benefit-cost ratio increases substantially to 1.94, indicating that the benefits of a flood alleviation strategy are almost twice the associated costs. The results, including findings from the CV study, were submitted to the relevant Ministry of Agriculture, Food and Fisheries as part of an application of central government funding support for the proposed flood alleviation strategy. Following lengthy consideration of this application, in 1997 the Environment Agency announced that it had received conditional approval for a programme for "bank strengthening and erosion protection" (Environment Agency 1997). The actual scheme has been taken forward since 2000 on the basis of a long-term private/public partnership scheme (between the EA and relevant government support ministries and a private engineering firm consortium).

Since the publication of the Kahneman and Knetsch's (1992) "embedding" critique of CV, there has been a wide ranging debate over whether respondents give sufficient consideration of the specific characteristics of the goods valued when responding to CV questions. More specifically, the subsequent academic debate has focused on the sensitivity of WTP estimates to the scope of the good considered, where scope can be defined in terms of quantity and/or quality. A follow-up survey to the Broadland 1991 survey was therefore undertaken, which considered the circumstances under which sensitivity to scope occurs, where scope was defined in terms of the area protected by a flood alleviation scheme (FAS) for either the whole (W) of that area of Broadland which is under threat from saline flooding or a series of part (P) areas within that whole. As such, the P FASs are nested within the W FAS.

It was suggested by Carson and Mitchell (1995) that the most appropriate test of scope sensitivity is through the comparison of independent valuations from different levels of amenity. Such a test was undertaken in the Broadland 1996 survey by collecting two samples of users, the first of which faced a questions concerning their WTP for the W scheme followed by their WTP for the P scheme (the "top-down" W/P sequence sample); while the second sample faced the same questions but presented in reverse order "bottom-up"; P/W sequence sample).

Full results of the Broadland 1996 survey are presented in Powe (2000), however, they do not provide conclusive evidence for either CV supporters or their critics, and suggest instead that a mixture of economic and psychological influences are at work here. This points towards a complexity of preference motivations that is at the same time both unsurprising and challenging, and ought to be the future research agenda for CV research.

While the valuation work indicates that the public does put significant value on the environment that Broadland provides, the costs of flood protection provision are also very high. Over the 1990s, the Environment Agency has formulated a selective approach to flood alleviation and not a strategy that will provide an area-wide uniform level of protection. A number of communities and business sites are currently at high risk from flooding (so called "undefended areas") as levels of protection vary across the area. The Broadland area is the subject of an experiment in terms of flooding alleviation scheme funding. A joint public and private funding initiative (PPP/PFI) has been launched that provides public funding over a 20-year period, which will be spent by a private consortium (Turner et al. 2003).

Conclusions and policy implications

The Broads wetland area is a multiple-use resource under heavy and sustained environmental pressure and subject to dynamic ecosystem change. The DP-S-I-R organising framework was successfully used to scope the magnitude and significance of the environmental change problems and consequent sustainable management policy response issues. The saline water inundation/flooding and its alleviation, tourism requirements and preferences and water quality related conflict problems, have been highlighted. Managing the rate of change in order to satisfy the many interest groups that live, work or visit in the Broads, or who merely appreciate from afar its unique characteristics, is the key challenge for the Broads Authority and its partners. The interdisciplinary research presented in this paper seeks to improve our understanding of the Broads and therefore to better inform the management process. The Authority's vision for the Broads, which is shared by many other interest groups, is an environment that is conserved but not fossilised in terms of natural systems, traditional activities and heritage landscapes. Rather the aim is to allow for organic growth and changing human requirements and preferences, while ensuring that future generations receive the environmental, social and economic bequest that is their right. At the core of the vision is the acknowledgement that human activities, if they are to be sustainable, depend on the continued health and functioning of the Broads environment. Boating and other forms of recreation, for example, are intimately dependent on a good-quality environment, but equally the continued existence of such activities is a prime component of the local environs in terms of landscape, cultural heritage and amenity. An area largely devoid of humans and their activities is not the Broads, nor for that matter is it any of the other national parks in Britain.

Putting the vision into practice will require "partnership" and "consensus" in order to engage all interested parties in the implementation of a new (2004) Broads Plan (Broads Authority 2004). Partnerships must be built on trust and accountability. The Authority has made, and is continuing to make, organisational changes to increase transparency and participation in order to enhance a trust across all interests, while also ensuring best value (Turner et al. 2003). Increased scientific knowledge of wetland ecosystems and their benefits to society therefore has to be gained hand-in-hand with efforts to increase public awareness of these benefits. Such a communication is, however, only likely to be successful if due account is taken of the potential difference in worldviews between the scientists and the local people. Likewise, special attention should be paid to existing stakeholder structure, and potentially existing local ecological knowledge and local institutional arrangements for maintaining wetlands. Such institutions may constitute a basis for building wetland management processes that have already gained social acceptability at the local level, in contrast to governmental regulations imposed in a top-down fashion.

References

Arrow KJ, Solow R, Portney PR, Leamer EE, Radner R, Schuman EH (1993) Report of the NOAA panel on contingent valuation. Federal Register 58(10):4602–4614

Balmford A, Bruner A, Cooper P, Costanza R, Farber S, Green R, Jenkins M, Jefferiss P, Jessamy V, Madden J, Munro K, Myers N, Naeem S, Paavola J, Rayment M, Roscendo S, Roughgarden J, Trumper K, Turner RK (2002) Economic reasons for conserving wild nature. Science 297:950–3

Bateman IJ (1993) Valuation of the environment, methods and techniques: revealed preference methods. In: Turner RK (ed) Sustainable environmental economics and management: principles and practice. Belhaven Press, London, pp 192–265

Bateman IJ, Carson RT, Day B, Hanemann WM, Hett T, Jones-Lee M, Loomes G, Mourato S, Ozdemiroglu E, Pearce DW, Sudgen R, Swanson R (2002) Economic valuation with stated preference techniques: a manual. Edward Elgar Publications, Cheltenham

Bateman IJ, Day B, Dupont D, Georgiou S, Matias NGN, Morimoto S, Subramanian L (2004) Does phosphate treatment for prevention of eutrophication pass the benefit cost test. Mimeo, University of East Anglia

Bateman IJ, Garrod GD, Brainard JS, Lovett AA (1996) Measurement, valuation and estimation issues in the travel cost method: a geographical information systems approach. J Agr Econ 47(2):191–205

Bateman IJ, Langford IH (1997) Non-users willingness to pay for a National Park: an application and critique of the contingent valuation method. Regional Stud 31(6):571–582

Bateman IJ, Langford IH, Nishikawa N, Lake I (2000) The Axford debate revisited: a case study illustrating different approaches to the aggregation of benefits data. J Environ Plan Manage 43(2):291–302

Bateman IJ, Langford IH, Turner RK, Willis KG, Garrod GD (1995) Elicitation and truncation effects in contingent valuation studies. Ecolog Econ 12 161–179

Bateman IJ, Langford IH, Willis KG, Turner RK, Garrod GD (1993) The impacts of changing willingness to pay question format in contingent valuation studies: an analysis of open-ended, iterative bidding and dichotomous choice formats. Global Environ Change Working Pap 93–05, Centre for Social and Economic Research on the Global Environment, University of East Anglia, Norwich and University College, London

Bateman IJ, Lovett AA, Brainard JS (1999) Developing a methodology for benefit transfers using geographical information systems: modelling demand for woodland recreation. Regional Stud 33(3):191–205

Bateman IJ, Willis KG, Garrod GD (1994) Consistency between contingent valuation estimates: a comparison of two studies of UK national parks. Regional Stud 28(5):457–474

Bateman IJ, Willis KG, Garrod GD, Doktor P, Langford I, Turner RK (1992) Recreational and environmental preservation value of the Norfolk Broads: a contingent valuation study. Unpubl Rep, Environmental Appraisal Group, University of East Anglia

Bergin J, Price C (1994) The travel cost method and landscape quality. Landscape Res 19:21–22

Boyle KJ, Bergstrom JC (1992) Benefit transfer studies: myths, pragmatism, and idealism. Water Resour Res 28(3):657–663

Brainard J, Lovett A, Bateman I (1999) Integrating geographical information systems into travel cost analysis and benefit transfer. Int J Geogr Inform Sci 13(3):227–246

Broads Authority (1997) Broads plan 1997. The strategy and management plan for the Norfolk and Suffolk Broads, February 1997

Broads Authority (2004) Broads plan: a strategic plan to manage the Norfolk and Suffolk Broads, Broads Authority, Colegate, Norwich

Brouwer R (1999) Public right of access, over crowding and the value of peace and quiet; the validity of contingent valuation as an information tool. GEC Working Pap 99–05, Centre for Social and Economic Research on the Global Environment (CSERGE), University of East Anglia, Norwich

Brouwer R, Crooks S (1998) Towards an integrated framework for wetland ecosystem indicators, Working Paper GEC 98–27, Centre for Social and Economic Research on the Global Environment, University of East Anglia, Norwich, UK
Brouwer R, Turner RK, Voisey H (2002) Public perception of overcrowding and management alternatives in a multi-purpose open access resource. J Sust Tourism 9(6):471–490
Burbridge PR (1994) Integrated planning and management of freshwater habitats, including wetlands. Hydrobiologia 285:311–322
Carson RT, Mitchell RM (1995) Sequencing and nesting in contingent valuation surveys. J Environ Econ Manage 28:155–173
Clayton AMH, Radcliffe NJ (1996) Sustainability: a systems approach. Earthscan Publications Ltd., London
Climate Change (2001) Impacts, adaptation and vulnerability, contribution of Working Group II to the third assessment report of intergovernmental Panel on Climate Change, McCarthy J, Canziani OF, Leary NA, David DJ, White KS (eds) Cambridge University Press, pp 295–303
Cooper JC, Hanemann M, Signorello G (2002) One-and-one-half-bound dichotomous choice contingent valuation. Rev Econ Stat 84(4):742–750
Costanza R, d'Arge R, de Groot R, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, van den Belt M (1997) The value of the world's ecosystem services and natural capital. Nature 387:253–260
Dillman DA (1978) mail and telephone surveys—the total design method. Wiley, New York
Environment Agency (1997) Broadland flood alleviation strategy: bank strengthening and erosion protection. Environment Agency, Suffolk
Holzer TJ, Perrow MR, Madgwick FJ, Dunsford DS (1997) Practical aspects of broads restoration. In: Madgwick FJ, Phillips GL (eds) Restoration of the Norfolk Broads. BAR 14e, Broads Authority and (P-91) Environment Agency, Norfolk, UK
Horne AJ, Goldman CR (1994) Limnology, 2nd edn. McGraw-Hill, New York, p 576
Kahneman D, Knetsch JL (1992) Valuing public goods: the purchase of moral satisfaction. J Environ Econ Manage 22:55–70
Madgwick FJ, Phillips GL (1996) Restoration of the Norfolk Broads—Final Report to E.C. Life Programme, BARS14, Broads Authority, Norfolk, UK
Maltby E, Hogan DV, McInnes RJ (eds) (1996) Functional analysis of European wetland ecosystems. Final report Phase One, EC DG XII STEP Project CT90–0084. Wetland Ecosystems Research Group, University of London
May RWP, Waters CB (1986) Boat wash study. Broads Authority, Bars 12, Norwich
McConnell KE (1992) Model building with judgement: implications for benefit transfers with travel cost models. Water Resour Res 28(3):695–700
Moss B (1983) The Norfolk Broadland: experiments in restoration of a complex wetland. Biol Rev 58 521–526
Moss B, Stansfield J, Irvine K, Perrow M, Phillips G (1996) Progressive restoration of a shallow lake: a 12-year experiment in isolation, sediment removal and biomanipulation. J Appl Ecol 33(1):71–86
National Rivers Authority (1992) A flood alleviation strategy for Broadland: Final Report Annex Four—cost benefit studies. NRA, Anglian Region, Peterborough
Pitt J-A, Kelly A, Phillips GL (1997) Control of nutrient release from sediments. In: Madgewick FJ, Phillips GL (eds) Restoration of the Norfolk Broads, BARS 14a, ISBN 0 948119 42 X, Broads Authority and Environment Agency, Norwich, England
Powe NA (2000) Contingent valuation and non-market wetland benefit assessment; the case of the Broadland flood alleviation scheme. PhD Thesis, School of Environmental Sciences, University of East Anglia
Pretty JN, Mason CF, Nedwell DB, Hine RE (2002) A preliminary assessment of the environmental costs of the eutrophication of fresh waters in England and Wales. University of Essex, UK
Scheffer M, Hosper SH, Meijer M-L, Moss B, Jeppesen E (1993) Alternative equilibria in shallow lakes. Trends Ecol Evol 8(8):275–279
Stansfield J, Caswell S, Perrow M (1997) Biomanipulation as a restoration tool. In: Madgewick FJ, Phillips GL (eds) Restoration of the Norfolk Broads, BARS 14a, ISBN 0 948119 42 X, Broads Authority and Environment Agency, Norwich, England
Strategic Leisure and TEP (2001) Broads boat hire industry study: draft strategy and action plan, c/o Broads Authority, Colegate, Norwich, 30 pp
Turner RK (1991) Economics and wetland management. Ambio 20(2):59–63
Turner RK, Adger WN, Doktor P (1995) Assessing the economic costs of sea level rise. Environ Plan A 27:1777–1796
Turner RK, Brooke J (1988) Management and valuation of an environmentally sensitive area: Norfolk Broadland, England, case study. Environ Manage 12(2):193–207
Turner RK, Geogious S, Brouwer R, Bateman IJ, Langford IJ (2003) Towards an integrated environmental assessment for wetland and catchment management. Geogr J 169(2):99–116
Turner RK, Lorenzoni I, Beaumont N, Bateman IJ, Langford IH, Mcdonald AL (1998) Coastal management for sustainable development: analysing environmental and socio-economic changes on the UK coast. Geogr J 164:269–281
Turner RK, van den Bergh JCJM, Barendregt A, Maltby E (1997) Ecological-economic analysis of wetlands: science and social science integration. In: Söderquist T (ed) Wetlands: landscape and institutional perspectives. Proceedings of the 4th workshop of the Global Wetlands Economics Network (GWEN). Beijer International Institute of Ecological Economics. The Royal Swedish Academy of Sciences, Stockholm, Sweden, 16–17 November, 1997