"Introducing Eco-system Valuation for Real Habitat Creation through Managed Realignment of the English Coastline"

January 2007

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ABSTRACT

For the last 300 years, traditional flood risk management strategies in England have consisted of ‘hard’ sea walls and the drainage of wetlands for agricultural use. Many of these old sea walls are now reaching the end of their design lives and maintaining and upgrading them can be very costly. In the light of rising sea levels and increases in extreme weather conditions due to climate change the cost-effectiveness of traditional flood risk management is questioned. There is increasing support for a multi-functional approach to flood risk management, such as managed realignment may be more sustainable from an environmental, and an economic point of view. Habitat recreation has wider environmental and economic benefits, the most significant of which are the provision of food and refuge for fish populations, carbon, and very long-term heavy metal and nutrient storage. However, in most cases economic valuation of these benefits does not take place mainly because of lack of original data. This paper uses case studies from managed realignment projects in the UK to demonstrate the potential significance of the economic valuation of benefits from habitat recreation and their effect on option choice.

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1. INTRODUCTION

For the last 300 years, traditional flood risk management strategies in England have consisted of ‘hard’ sea walls and the drainage of wetlands for agricultural use. Over 2000 km of flood defences protects and/or drains the English coastline.

Many of these old sea walls are now collapsing, reaching the end of their design lives and maintaining and upgrading them can be very costly. In the light of rising sea levels and increases in extreme weather conditions due to climate change the cost-effectiveness of traditional flood risk management is questioned.

A multi-functional approach to flood risk management, such as managed realignment may be more sustainable from an environmental, and an economic point of view. Managed realignment is the deliberate breach of defences, to allow the coastline to migrate further inland, creating at the same time inter-tidal habitat, such as saltmarsh. Habitat recreation through managed realignment schemes allows compliance with EU policy, such as the implementation of the Water Framework Directive, the Habitats Directive and the Urban Wastewater Directive. At the same time habitat recreation has wider environmental benefits, the most significant of which are the provision of food and refuge for fish populations, carbon, and very long-term heavy metal and nutrient storage.

Currently, the allocation of capital for flood risk management projects is decided on the outcome of a cost-benefit analysis that compares different options. The current policy guidelines in England (Defra, MSW) state that the environmental benefits of flood and coastal erosion management schemes should be included in the economic appraisal of these schemes. This is rarely done is practice however, because of the difficulties in quantifying environmental benefits from habitat creation.

This paper uses case studies to demonstrate the potential significance of the economic valuation of benefits from habitat recreation and their effect on option choice. One significant problem in the valuation is the lack of original data. So far, valuation has taken place through benefits transfer, with data that does not originate from the UK. This can be misleading. Some original work is expected in the area from the ComCoast project, but further applied research is needed particularly in respect of freshwater, fluvial habitats.

Section 2 of this paper presents the current policy framework for flood and coastal erosion management in England and Wales. It also discusses the difficulties in the implementation of economic appraisal of environmental costs and benefits. Section 3 discusses the economic and environmental benefits of managed realignment schemes. Section 4 presents some issues that arise when trying to value environmental benefits. Section 5 uses information from 3 case studies to demonstrate the environmental and economic impacts of managed realignment schemes. Finally, Section 6 presents the conclusions.

2. FLOOD AND COASTAL EROSION MANAGEMENT IN ENGLAND AND WALES

2.1 Policy context

Responsibility for flood and coastal management in England and Wales is currently shared by a number of organisations and agencies, including Defra, the Environment Agency, Local and Regional Flood Defence Committees, coastal district councils and individual land owners. The Environment Agency invests significant resources in the maintenance and construction of coastal defences and other forms of coastal erosion risk management. The aggregate budget for such projects is approximately £570 million per year under the Spending Review 2004.

Strategic flood and erosion risk management and planning for the coastline (including estuaries) is embedded within the Shoreline Management Plan (SMP) process. Shoreline Management Plans apply to coastal units defined in terms of sedimentary and coastal process. The intention is that they provide a large-scale assessment of risks associated with coastal processes and help to reduce risk to people and the developed historic and natural environment. SMP guidance (Defra, 2006), defines four strategic policies for coastal erosion and flood risk management:

- **Hold the line -** Maintaining or changing the standard of protection. This policy should cover situations where work or operations are carried out in front of the existing defences to improve or maintain the standard of protection provided by the existing defence line.

- **Advance the line** - Building new defences on the seaward side of the original defences. Use of this policy should be limited to instances where significant land reclamation is considered.

- **Managed realignment -** Allowing the shoreline to move backwards or forwards, with management to control or limit movement (such as reducing erosion or building new defences on the landward side of the original defences).

- **No active intervention -** No investment in coastal defences or operations.

So far, a form of economic cost-benefit analysis (CBA) applied on a project by project basis has justified the expenditure of public funds on flood risk management schemes. However, many of the existing hard defences are becoming redundant and their maintenance or reconstruction can be very costly. With isostatic adjustment (the sinking of the South East of England, following the last glaciation), sea level rises due to climate change and the increasing severity and frequency of extreme weather conditions, both the cost and the effectiveness of traditional coastal management have to be reconsidered.

It is becoming increasingly apparent that sole reliance on engineered 'hard' defences is unlikely to be sustainable. There is a strong case for switching to a mixed, "multi-functional" approach, with protection focused on strategic and high value areas and the rest of the coastline left to adapt to change more naturally. Measures such as 'managed realignment' which involves the deliberate breaching of engineered defences to allow coastal migration and the creation of extended inter-tidal marshes and mudbanks is typical of this new approach.

This need for change in policy is expressed in Defra[1]'s new approach to flood defences in Making Space for Water in March 2006. The report highlights the need for integrated appraisal in line with the principles of sustainable development. In the section on managed realignment the report says:*"6.4 In the light of responses to the consultation, the Government will continue with its policy of providing funding for the maintenance of existing defences only where the costs are justified by the full range of benefits provided by the defences. Costs and benefits will, however, be measured in a more holistic way that takes better account of environmental and social, as well as economic, considerations. We will put in place clear exit strategies to ensure that withdrawal of funding is well planned and takes account of all the consequences."*

The appraisal methodology also needs to fit the requirements of the EU Water Framework Directive and the formulation of water basin management plans. The Water Framework Directive establishes River Basin Management Plans, and these will encompass and integrate flood and coastal erosion risk management issues, setting a greater emphasis on achieving sustainable management which not only protects but seeks to enhance the natural and human environment.

Adopting more multifunctional and environmentally beneficial approaches in flood risk management, such as managed realignment, could also contribute to the achievement of other policy objectives such as the Biodiversity Action Plan (BAP) targets that require the Environment Agency to facilitate the creation of 200 hectares of wetland habitat each year. Habitat creation from managed realignment can also have significant contribution towards the implementation and requirements of the Habitats Directive, which may otherwise require costly and some times unsustainable solutions.

2.2 Economic Appraisal

Economic appraisal of FCERM schemes currently takes place according to the FCDPAG3 guidance produced by MAFF/Defra in 1999. The Treasury Green Book[2] provides the overall appraisal guidance for central Government departments and agencies. In addition, appraisal of Flood and Coastal Erosion Management schemes is aided by the 'Multi-coloured Manual' (MCM) and 'Handbook' produced for Defra by the Flood Hazard Research Centre in Middlesex University[3]. These documents cover the

[1] DEFRA: Department for the Environment, Food and Rural Affairs
[2] HM Treasury, 2003
[3] Penning-Rowsell, E., Johnson, C., Tunstall, S., Tapsell, S., Morris, J., Chatterton, J. and Green, C. (2005) *The Benefits of Flood and Coastal Risk Management: A Manual of Assessment Techniques*, Flood Hazard Research Centre, Middlesex University Press.

entire likely range of impacts that may arise from flooding or coastal erosion, including flood damage to residential and non-residential properties, costs of disruption, losses and benefits of erosion, recreational gains and losses, effects on agriculture and environmental costs and benefits.

Despite the growth in formal requirements to value environmental impacts in monetary terms, in most cases cost-benefit calculations do not include the economic value of environmental benefits and costs. Consequently, schemes encouraging the creation of environmental improvements have tended to be passed over in favour of more traditional options, and where decision-making has favoured the environmental option, the rationale has been to conserve the status quo as required by statutory protection, rather than the creation of new habitats. Moreover, where abandonment of a flood and or coastal defence is clearly the least cost solution it has been difficult to make the case for a managed process, which re-creates desirable habitats with a degree of certainty.

The most commonly used arguments for the exclusion of environmental benefits from the economic appraisal are (1) that it rarely makes a difference to the actual decision and option choice and (2) that the cost of acquiring the data is greater than the loss from a sub-optimal choice.

The main reason for this is the lack of reliable information quantifying and valuing the environmental effects of different schemes. Collecting this information on a project by project basis (through individual valuation studies) is too expensive and time consuming. As a result, any additional benefits from the environmental valuation are outweighed by the additional costs incurred during the appraisal process. This could be overcome if there was a commonly agreed method of taking results from valuation undertaken in one circumstance and applying it to other circumstances, a method known as “benefit transfer”. This issue is further explored in Section 3.2.

3. ECONOMIC VALUATION OF MANAGED REALIGNMENT SCHEMES

Managed realignment is the process of re-introducing tidal regimes to previously protected or reclaimed land. It involves the deliberate breaching of existing defences in order to allow the coastline to migrate inland creating a new line of defence landward of the old one. Managed realignment schemes aim to reduce the length of defences required and at the same time to create inter-tidal habitat. There are a few different approaches to managed realignment[4]. They all involve the re-introduction of tidal waters to areas, but use different methods to achieve this:

- Regulated tidal exchange using tidal flaps, valves and weirs/spillways
- Breached retreat: removing a section of the seawall to create a breach
- Banked retreat: removing the entire seawall.

Regulated tidal exchange can be used to adjust the tidal inundation to favour the creation of a particular habitat type.

3.1 Costs and benefits of management realignment schemes

The main economic cost of managed realignment schemes is the opportunity cost of the land that was previously protected by the existing defences. If this is agricultural land the cost can be measured in terms of future agricultural production that will be lost. Other costs include the cost of the works needed depending on whether there is a need for new defences to be set up inland or not, costs of breaching and maintenance costs. Costs of habitat creation may also be included[5].

The main benefit from managed realignment schemes is mainly flood defence with the newly created inter-tidal zone acting as a natural sea defence. However, the re-creation of inter-tidal habitat has also a number of other benefits both economic and environmental. The extent of these benefits will depend on the amount and the type of the habitat that will be created and the speed of habitat recreation. These benefits include:

- Commercial and recreational fisheries: The creation of new inter-tidal and saltmarsh habitat through the process of managed realignment has the potential to make a substantial long term contribution to the stock enhancement of fish and shellfish through the supply of food and refuge for juvenile populations.

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[4] ComCoast, Work Package 2: Socio-economic valuation, 2006, “The Roach and Crouch Flood Management Strategy: A case study for the Economic Assessment and Valuation of Multi-functional Flood Management Projects”

[5] Different topographies benefit particular functions. For instance fish prefer a site with gentle gradients and refuge ponds for when the tide retreats. The height of the land in relation to sea level also dictates whether mud flat or salt marsh results and thus earth moving prior to inundation can affect that balance between these habitat types.

- Carbon sequestration: Inter-tidal habitats have the ability to store carbon through the decomposition of organic matter. They act in a way as carbon 'sinks' contributing to air quality and reducing the amount of carbon released in the atmosphere.

- Nutrient, contaminant and heavy metal storage (Water quality): Inter-tidal habitats have the ability to recycle essential nutrients (nitrogen and phosphorus) and encourage sedimentation including heavy metals, such as copper, arsenic, lead and zinc, leading to improved water quality.

- Biodiversity: Improved water quality and vegetation attracts birds and other species.

- Recreational and tourism benefits: Inter-tidal habitats provide opportunities for a number of leisure and recreational activities, such as bird watching, walking and recreational fishing.

3.2 Economic valuation of environmental benefits

When trying to value environmental assets, environmental economists have agreed on the use of the Total Economic Value (TEV). Total Economic Value is the sum of Use Value (Direct and Indirect) and Non-Use Value. Direct Use values arise from direct interaction with the ecosystem and they can be consumptive (food, water, fishing) or not (recreation). Indirect use values are associated with services that are provided by ecosystems but that do not entail direct interaction, such as flood protection provided by wetlands or the removal of pollutants by aquifer recharge. Non-use values are derived from the knowledge that a resource is maintained. By definition, they are not associated with use of the resource or tangible benefits that can be derived from it (though resource users may derive non-use values). They can be divided into three types of value: existence value, bequest value and altruistic value. Each value is quantified on the basis of people's preferences for a specific environmental service, which are expressed through their Willingness to Pay (WTP) to enjoy a specific service.

There are a number of techniques available to environmental economists to estimate economic value of non-marketed goods and services in monetary terms. These methods can be divided in three main categories: (i) market-based methods (ii) revealed preference techniques and (iii) stated preference techniques.

It is not always easy to initiate a new study in a project area to determine people's preferences regarding some environmental change. However, if a similar project has previously been undertaken elsewhere, estimates of its economic consequences might be usable as an indicator of the impacts of the new project. This approach is called 'benefits transfer'.

Benefits transfer is a technique that applies the results of previous environmental valuation studies to new policy or decision-making contexts. In the literature, benefits transfer is commonly defined as the transposition of monetary economic values estimated at one site (the 'study' site) to another site (the 'policy' site). The study site refers to the site where the original study took place, while the policy site is a new site where information is needed about the economic value of similar benefits[6]. In practice, several approaches to benefits transfer can be distinguished, which differ in the degree of complexity, the data requirements and the reliability of the results, but in principle they all use either average WTP values or WTP functions.

The most important reason for using previous research results in new policy contexts is that it saves a lot of time and money. Applying previous research findings to similar decision situations is a very attractive alternative to expensive and time consuming original research to inform decision-making. The case studies presented in Section 5 of this paper all use benefits transfer data.

There are some concerns about the benefits transfer method. The first concern is whether the replication of findings is reliable. For example, there are questions concerning the extent to which the method is able to produce the same outcomes at different sites across different groups of people at different points in time. The other main concern is of course whether any inaccuracies resulting from the use of inappropriate analogues are greater than the ones resulting from the system non-valuation of eco-system value.

The monetary valuation of environmental benefits from managed realignment schemes is possible and can have a significant influence on the choice of option. However, there are a number of issues that have to be taken into account to enable a proper appraisal of environmental gains/losses. First, the appropriate spatial and temporal scales for the appraisal have to be selected. In the case of flood risk management projects, for example, the appraisal should be done at least for the whole “catchment” area and for a period of up to 100years. In the UK, there is now a growing consensus on the adoption of a time declining discount rate procedure over at least a 100-year time horizon. This approach is advocated in the Green Book, which is the official guidance on UK public sector project/policy appraisal. Second, aggregation of estimates should be done carefully to avoid double counting. Finally, some aspects of the environmental value, such as cultural and aesthetic values will be very difficult to quantify.

3.3 The Ecosystems Services approach

The ecosystem services approach has been endorsed by the Millennium Ecosystem Assessment (MEA). It provides a conceptual framework (MEA, 2003), that has been developed through an international work program focusing on how changes in ecosystem services affect human wellbeing, and the responses that could be made at local, national, or global scales to improve ecosystem management and achieve human development goals.

The MEA framework specifies four categories of ecosystem services: provisioning services; regulating services; cultural services; and supporting services.

1. Provisioning services include:
    - Food
    - Fibre
    - Fuel

[6] reference

- Genetic resources
- Biochemicals, natural medicines and pharmaceuticals
- Fresh water

2. Regulating services include:
    - Air quality regulation
    - Climate regulation
    - Water regulation
    - Erosion regulation
    - Water purification and waste treatment
    - Disease and pest regulation
    - Pollination
    - Natural hazard regulation
3. Supporting services that are necessary for the production of all other ecosystem services and they include
    - Soil formation
    - Nutrient cycling
    - Primary production
    - Water cycling
    - Photosynthesis
4. Cultural services are the non-material benefits that people enjoy from ecosystems, such as:
    - Recreation and tourism
    - Cultural heritage
    - Inspiration
    - Education

3.4 Work in Progress

<u>The ComCoast project</u>

ComCoast (COMbined function in COASTal defence zones) is an international project that aims to promote and implement an integrated approach to improving coastal defence systems. ComCoast is jointly funded by the Interreg IIIB Community Initiative Programme (North Sea Region) and the project partners, which are: Holland (lead partner), the United Kingdom, Germany, Belgium and Denmark.

The ComCoast partners seek to create and apply new methodologies to evaluate multifunctional flood defence zones from an economical and social point of view. A more gradual transition from sea to land creates benefits for a wider coastal community and environment whilst offering economically and socially sound options. The aim of ComCoast is to explore the spatial potentials for coastal defence strategies for current and future sites in the North Sea Interreg IIIb region.

There are several themes within the ComCoast project, which are divided into 6 work packages. Work Package 2 - Socio-Economic Evaluation aims to offer alternative methods of evaluating potential schemes by providing holistic evaluation methods and future guidance in the form of a handbook and influence policy, planning and people by providing methodologies that are both economically and environmentally sound. This work package is led by the UK and comprises three doctoral assignments that aim to demonstrate the value of new managed realignment schemes in terms of the wider coastal or estuary benefits e.g. nutrient storage, local fisheries, flood protection and carbon tax.

A bio-chemistry assignment aims to quantify the biochemical processes that occur in newly created mudflats and salt marsh as a result of managed realignment schemes at various locations along the Essex coast.

A fisheries assignment has the main objective to assess the related benefits of managed realignments and the resulting commercial and recreational fisheries benefits. It explores methods for quantifying fish utilisation of recreated inter-tidal areas using secondary data relating to the hydraulic, climatic and chemical nature of the Blackwater Estuary and Salcott Channel.

An economics assignment examines the economic case for a more integrated approach to estuary management for the Blackwater, incorporating the other assignment material. The management actions and strategies for the Blackwater estuary will be appraised and evaluated via the economic cost-benefit approach and if felt necessary via multi-criteria analysis (using monetary and non-monetary decision criteria). The aim will be to investigate the social costs and benefits associated with the management strategy. In particular, managed realignment, as a component of a coastal protection or sea defence policy will be appraised.

The first results from this inter-disciplinary process are expected in the summer of 2007 and they will be the first original data of this type for the UK[7].

<u>Introducing the Environment into Flood Risk Decision Making (Handbook)</u>

The Environment Agency has currently commissioned a study by EFTEC to establish a framework for estimating environmental costs and benefits of FCERM[8] measures in monetary terms. The principle output of this study will be a short, concise Handbook 'Introducing the Environment into Flood Risk Decision Making'. The handbook guidance is aimed at appraisal practitioners in the Environment Agency. It augments current appraisal guidance – from the HM Treasury Green Book and FCDPAG series – and further develops the approach to assessing environmental costs and benefits outlined in the recent Flood Hazard Research Centre 'Multi-coloured Manual'.

This Handbook will describe a process for estimating the value of environmental gains and losses associated with FCERM schemes. In order to aid practical applications, the Handbook develops a transparent approach to collate evidence of environmental impacts in qualitative, quantitative and monetary terms, and to report on associated

[7] It is anticipated that the knowledge will be disseminated as practical guidance and information for regulatory bodies and those organisations that are involved in the design, implementation and management of managed realignment schemes. The guidance will assist in improving the environmental performance of schemes and in particular enhance the value of the scheme in terms of fish utilisation and nutrient capture.

[8] Flood and Coastal Erosion Management

uncertainties and limitations. The Handbook will be accompanied by a technical report and three case studies that will demonstrate the application of the methodology suggested.

4. THE ISSUES

This section discusses a few issues that need to be taken into account when considering the economic valuation of environmental benefits from habitat recreation and identifies areas where further work is necessary.

4.1 Lack of original data

One of the main problems encountered when trying to value the environmental benefits of managed realignment projects is the lack of original research. Over the past years, a number of studies have looked at the economic values associated with the environmental benefits provided by wetlands and riverine floodplains. The findings and implications of these studies have been drawn together in a number of meta-analysis studies and have been used in economic appraisals of managed realignment projects[9] through benefits transfer.

However, most of these studies refer to non-UK sites, most of them originate from the US, others from other European countries. This can have important implications, since there are issues of different geographical and climatic conditions, as well as different mentalities expressed in the people's preferences.

The ComCoast project will provide original data for the UK set in Essex, but there is a need for much more applied research if the environmental benefits are to be included in the appraisal processes. This is to cover both habitats, other than inter-tidal ecosystems, but also to capture regional differences covering preferences and the size of the affected (human) population.

4.2 Valuation on an individual site level versus estuary level

When benefit-cost analysis is undertaken for a flood compartment ("cell") or length of coast, the estimated benefits might not necessarily reflect the overall economic benefits felt elsewhere. A broad scale, holistic economic appraisal is therefore better.

For example, benefit-cost analysis for a flood cell within an estuary should involve consideration of opportunities and constraints of the options to other flood cells within the estuary. Estuarine processes are complex and any changes at one location will result in changes elsewhere the estuary. For instance, implementing a managed realignment scheme to turn a flood cell into wash land might not be economically justifiable if it is only the benefits arising from the flood cell itself that are taken into consideration. However, the scheme could contribute to the reduction of hydrodynamic stresses elsewhere in the estuary by reducing extreme tide levels and result in habitat creation to compensate the estuary-wide habitat loss due to coastal squeeze. Although it is recognised that broad scale economic appraisal represents a better way of evaluating the economic benefits of flood and coastal defence projects, there are constraints in the broad scale economic appraisal process. Broad scale benefit-cost analysis can be a complex process since the study areas are often large and a good understanding of the interaction of the complex estuary or coastal processes is required.

4.3 Environmental quality variable

[9] See Section 5, case studies

One very important function of the inter-tidal and saltmarsh zones created through managed realignment is their potential for sediment storage and carbon and nutrient cycling[10]. The understanding of geochemical/geological functions of inter-tidal habitats is of global relevance. In coastal seas in general, and more inshore waters in particular, wetland nutrient cycling has been estimated to represent their most valuable environmental service[11]. Similarly, wetlands represent the largest component of the global terrestrial organic carbon inventory, with tidal saline wetlands storing in excess to 45 Tg C a−1: [12]carbon burial in saline wetlands is thus potentially an important sink for atmospheric CO2.

The evaluation of managed realignment at the estuary level requires an understanding of the sedimentological, hydrological, ecological and biogeochemical systems together with the socio-economic goods and services provided. Turner et al (2006) present a plausible, albeit extreme, managed realignment scenario for the UK Humber estuary, to demonstrate the maximum possible biogeochemical effects and economic outcomes of estuarine management decisions. Their 'Extended Deep Green Scenario' for the Humber identifies the maximum possible area that could be returned to the inter-tidal zone over the next few decades to be 7,494 ha and is compared to a 'Hold the Line' scenario where no habitat is created. The following table[13] shows the potential effects in annual storage of nutrients, sediment, carbon and heavy metals.
Cost-Benefit Analysis was used to determine the economic efficiency of managed realignment. The values used are shown in table 4 below:

Table 3
Storage terms for sediment, organic matter, nutrient elements and contaminant metals in the present day and realigned Humber estuary

	Sediment ($t\,a^{-1}$)	C_{org} ($t\,a^{-1}$)	N_{org} ($t\,a^{-1}$)	Net P ($t\,a^{-1}$)	Net Zn ($t\,a^{-1}$)	Net Pb ($t\,a^{-1}$)	Net As ($t\,a^{-1}$)	Net Cu ($t\,a^{-1}$)
Present-day total estuary area (muds only)[a]	2.4×10^5	2400	216	144	31	16	4	6
EDG[b] new intertidal area (7494 ha)	1.2×10^5	3597	180	72	21	10	4	4
Total area post-EDG realignment	3.6×10^5	5997	396	216	52	26	8	10
% Increase of current annual storage	50	150	83	50	68	62	100	67

[a] Total present-day mud (intertidal + subtidal) area = 150 km^2 (Andrews et al., 2000; Table 5). Sediment accumulation is based on an estimated long-term sea-level rise of 1 mm a^{-1} and bulk density of 1.6 g cm^{-3} (see text). The metals' values are based on means of core top data from around the estuary (Cave et al., 2005), and cross-compared to other data (Ridgway and Rees, 2001; Cox, 1999) to check values are representative. (Note that some hotspots in the estuary have much higher concentrations than these.)

[b] EDG = Extended Deep Green Scenario. Net element data for EDG realignment are based on our unpublished 1984–1994 data measured from Welwick Marsh (Fig. 1), corrected for pre-industrial (Holocene) background concentrations in Middleton and Grant (1990) and Ridgway and Rees (2001). These values are not directly comparable to those in Cave et al. (2005), due to a change in the assumed bulk density values (1.6 g cm^{-3} in this paper).

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[10] J.E. Andrews, D.Burgess, R.R.Cave, E.G. Coombes, T.D. Jickells, D.J. Parker, R.K. Turner, 2006, "Biochemical value of managed realignment, Humber Estuary, UK", www.sciencedirect.com

[11] Constanza et al., 1997

[12] Chmura et al., 2003

[13] J.E. Andrews, D.Burgess, R.R.Cave, E.G. Coombes, T.D. Jickells, D.J. Parker, R.K. Turner, 2006, "Biochemical value of managed realignment, Humber Estuary, UK", www.sciencedirect.com

Table 4

Values used to estimate the costs and benefits of realignment before and after standardising to the financial year 2004–2005 by using GDP deflators recommended by HM Treasury (http://www.hm-treasury.gov.uk/)

Item	Value of item at time of reference	Year of study	Value of item after adjustment to the financial year 2004–2005
Capital costs of realignment (realigning defences)	£811, 893 km^{-1}	2001–2002	£878, 159 km^{-1}
Opportunity costs (Grades 1 and 2 land)	£2, 110 ha^{-1}	2001–2002	£2, 282 ha^{-1}
Opportunity costs (Grade 3 land)	£2, 382 ha^{-1}	2001–2002	£2, 576 ha^{-1}
Maintenance costs of defences	£3560 km^{-1} a^{-1} (years 0–4) £3170 km^{-1} a^{-1} (year 5 onwards)	2005	Years 0–4 £3560 km^{-1} a^{-1} Year 5 £3170 km^{-1} a^{-1}
Replacement costs	£618, 000 km^{-1}	2001	£668, 441 km^{-1}
General habitat creation benefits	US$ 211 ha^{-1} a^{-1} – US$ 306 $acre^{-1}$ a^{-1}	2003/1990	£132–621 ha^{-1} a^{-1}
Carbon sequestration benefits	£7 per tonne CO_2e	2000	£7.77 per tonne CO_2e

The results of the CBA showed (see table 5 below) that although the managed realignment schemes are not cost-effective over a 25-year period, over a 50-year and a 100-year period it is more cost-effective than the Hold the Line option.

The CBA does not include the valuation of heavy metals stored in the habitat, but as shown from the amounts in Table 3, there is a potentially significant economic benefit from heavy metal storage that should be included in the valuation.

This paper highlights the potential significant economic effects that the inclusion of environmental benefits in option appraisal can have and the possible effect on option choice.

Table 5
Net present values (NPV) of providing flood defence for the 'Extended Deep Green' scenario as compared to the 'Hold-the-Line' scenario for the Humber Estuary

Scheme	25 years	50 years	100 years
Hold-the-Line scenario (HTL)			
Costs			
Capital (£)	0	0	0
Maintenance (£)	23,199,000	34,813,000	43,632,000
Replacement (£)	43,181,000	43,182,000	43,181,000
Benefits			
Habitat creation (£)	0	0	0
Carbon sequestration (£)	0	0	0
Total value (HTL)(£)	**−66,380,000**	**−77,995,000**	**−86,813,000**
Extended Deep Green scenario (EDG)			
Costs			
Capital (£)	108,909,000	108,909,000	108,909,000
Maintenance (£)	22,161,000	33,255,000	41,678,000
Replacement (£)	22,727,000	22,727,000	22,727,000
Benefits			
Habitat creation (£)	81,351,000	118,764,000	150,703,000
Carbon sequestration (£)	489,000	713,000	905,000
Total value (EDG) (£)	**−71,957,000**	**−45,414,000**	**−21,706,000**
NPV (EDG vs. HTL) (£)	***−5,577,000***	***32,581,000***	***65,107,000***

All values are in Great Britain Pounds and rounded for clarity.

4.4 Environmental quality as perceived by the local community

Economic valuation of environmental assets is usually achieved by stated preference methods. Stated preference methods require survey respondents to make judgements on the environmental good they are asked to value (Willingness to Pay). In order for this method to work, individuals have to make informed, rational decisions. However, it has been shown that many times the public does not have sufficient knowledge of the good they are asked to value. This lack of information and/or understanding can lead to misleading results.

In the case of benefits provided by habitat recreation this issue is even more relevant. Inter-tidal habitats, as mentioned before, provide a wide range of services including flood protection, water quality regulation etc. Many of these services are complex and it is unlikely that people will be aware of have a good understanding of them.

Research has shown[14] that people tend to value assets in their local area higher than assets elsewhere and the regional variations can be significant. This is because people value the fact that they can personally enjoy (see) a specific species or landscape locally and also because they are most likely to be aware of them and to be affected by a change. For example, oyster fishermen in Abbots Hall in Essex were the first to notice the change in environmental quality following the creation of saltmarsh habitat. This is because oysters are very sensitive and the increase in water quality has lead to a significant increase in oyster population.

[14] M.Christie, N.Hanley, J.Warren, T.Hyde, K.Murphy, R.Wright, 2004, "A valuation of biodiversity in the UK using choice experiments and contingent valuation", BIOECON 2004

Although valuation of environmental benefits through stated preference can be difficult, it can still lead to useful results as long as the survey provides as much information as possible to the respondents and possible differences are taken into account. This is even more relevant when using benefits transfer where the site where the original data was obtained is usually very different from the site where the values are implemented.

5. CASE STUDIES

This section presents 3 examples of managed realignment schemes in the UK. These examples have been chosen because of the relative availability of data. The first two case studies below, form part of the work conducted by Eftec on the valuation of environmental benefits of managed realignment[15]. These are the first attempts to provide some estimates of possible benefits from habitat recreation. The first two case studies relate to site-specific schemes that have already been implemented, while the third example (Abbotts Hall) does not include valuation, but original results are expected from the ComCoast PhDs in the summer. The value used for carbon is £35 per tonne[16]. The values for the different types of habitat are calculated at £700 per hectare per year[17] and are obtained through benefits transfer

5.1 Paull Holme Strays (Humber Estuary)

Paull Holme Strays is a managed realignment site in the north bank of the Humber Estuary. It forms part of the package of habitat replacement schemes in the Humber Estuary. The defences at the site were breached in September 2003, with the objective of recreating approximately 80 ha of inter-tidal habitat to compensate for loss of habitat due to necessary works elsewhere in the Humber. The site is adjacent to the Humber Estuary SPA and pSAC.
A number of flood and coastal erosion management options were identified for the Paull Holme Strays site. The different options are briefly described below.

1. Maintain the line options:
   a. Option 2A: Emergency repair of breach
   b. Option 4A: Raise by crest fill, widen landward, plus rock armour in places.
   c. Option 4A2: Raise by crest fill, widen landward, rock armour revetment, new clough.
   d. Option 4C: Replace existing front with rock armour and periodic raising to sustain 1 in 10 standard. New clough.
2. Do Nothing – Option 2B: Emergency repair if breach, but with ringback around the main beneficiary (gas station) and raised road.
3. Full retreat – Option 6B1: Realign with embankment 500m landward on upper reach/250m lower, with rock armour. Improved round lighthouses (raised, rock armour); clough demolished, new pumping station.
4. Partial retreat – Option 6B2: Retreat 250m, the rest the same as Option 6B1 (full retreat).

The option that was chosen in practice was option 6B1 (full retreat). Although environmental valuation did not take place during the economic appraisal, the potential benefits from habitat creation were taken into account in the option choice. The Do Nothing option has also the potential to achieve the same amount of habitat creation as option 6B1, but there is great uncertainty surrounding the outcomes of the Do Nothing option. The Do Nothing option can create up to a maximum of 176 ha, but because it is created in an uncontrolled manner, it is associated with large uncertainties over how much, where created and over what timescales. Therefore, the full retreat option presents the greatest environmental benefits because it delivers the maximum amount

[15] Eftec, 2006, Introducing the Environment into Flood Risk Decision Making, Draft Technical Report
[16] the lower value in the range of values recommended by the UK government
[17] explain the calculation

of habitat in a way that gives the maximum amount of certainty that the predicted habitat will actually be created.

The options have been grouped according to their outcomes in terms of habitat loss/creation and the quality of habitat lost/created. The different outcomes are described in the table below.

FCERM effects on ecosystem services				
Option	**Maintain the Line (2A; 4A; 4C; 4A2)**	**Do nothing (2B)**	**Partial retreat (6B2)**	**Full retreat (6B1)**
Qualitative assessment				
Habitat Option	These options will lead to continued (increasing) loss of desirable habitat (saltmarsh and mudflat). The amount of habitat lost is unknown. They will also prevent the creation of habitat behind the defence.	This option will lead to the loss of some desirable habitat, but also to the creation of a large area of desirable habitat. The amount and type of the habitat is unknown (max of 80 ha).	This option will lead to some loss (unknown) of desirable habitat, but also to the creation of 56ha of saltmarsh, mudflat and saline lagoons. The exact breakdown between habitat types is not known.	This option will lead to some loss (unknown) of desirable habitat, but also to the creation of 80ha of coastal habitat (25 ha saltmarsh, 40 ha mudflat and 15 ha saline lagoons).
Carbon storage (tonnes per year)	Carbon storage will be reduced	Unknown, but max 176	Approx. 123	Approx. 176
Quantitative assessment				
Habitat option	0	Unknown	Total £930,000	Total £1,330,000 (saltmarsh £415,000, mudflat £664,000 and saline lagoons £249,000)
Carbon storage	0	Unknown, but max £146,000	Approx. £102,000	Approx. £146,000

There is also a potential for heavy metal storage on the site. Our calculations (based on the information on storage given in Turner et al 2006) suggest that the site will deposit approximately 220 kilos of zinc, 110 kilos of lead, 40 kilos of copper and 40 kilos of arsenic per year.

This valuation does not cover all the benefits provided by habitat creation (such as nutrient cycling, water purification etc) and the values used are the average values from a wide range of estimations. However, it is probably safe to conclude that the value of the environmental benefits is substantial and it can make a difference when deciding between options.

5.2 Alkborough Flats (Humber Estuary)

Managed realignment at Alkborough Flats in the Humber estuary sets back the tidal defence to a natural alignment provided by the toe of the Lincoln Heights. In autumn 2006 a 20-metre breach was constructed in the existing defence, together with an overspill weir. The dual-objectives of the scheme were[18]: (1) to provide flood storage to reduce peak tide levels in the estuary during extreme events, resulting in approximately £12 million saving from deferring works to improve existing defences elsewhere in the estuary and (2) to contribute to habitat creation responsibilities under the Birds and

[18] Project Appraisal Report, Environment Agency 2005

Habitats Directives, by creating up to 170ha of new inter-tidal habitat and approximately 200ha of other natural habitats (grazing marsh, grassland and reedbed).

The landward toe of the tidal defence embankment forms boundaries with several sites adjoining the Alkborough Flats: the Humber Estuary SAC; the Humber Estuary SPA and pSPA; Ramsar and proposed Ramsar site; and the Humber Estuary SSSI. The outer strip of the Flats therefore lies within the boundaries of internationally and nationally designated sites. Whilst the Alkborough scheme is a key part of the Humber Estuary Flood Defence Strategy (HEFDS) the project was implemented in advance of the finalisation of the strategy.

The PAR reports that the only one viable option was to develop Alkborough Flats to provide flood storage facilities and to create new inter-tidal habitat via managed realignment. The option of ‘do nothing’ is considered as a baseline for evaluating managed realignment option. Maintaining and/or sustaining the existing standard of protection were not considered, as they would not have met the dual-objectives of the scheme. The definition of the project objectives removes the need for appraisal in terms of considering different FCERM options therefore this case study just provides a comparison between the baseline (Do Nothing) and managed realignment cases.

Table A1.2.4: Quantifying environmental effects of FCERM options at Alkborough

Option	**Do nothing**	**Managed realignment**
Inter-tidal habitat lost	>5ha	5ha
Inter-tidal habitat maintained	80ha	80ha
Inter-tidal habitat created	130-170ha (assume 150)	130-170ha (assume 150)
Other habitat created	0ha (no management)	200-240ha (assume 220)
Navigation access	>0.3% reduction	<0.3% reduction
Annual visitors	Approx. 0	Approx. 25,000 per annum
Long-term carbon storage	Potential maximum 319 tC per annum	Approx 319 tC per annum

Table A1.2.7: Calculating monetary costs and benefits (2005 £)

Option	**Service**	**Impact**	**£ Value / unit**	**Population or units**	**Total (£000/yr)**
Do nothing	Carbon storage	up to 319 tC/yr	35 /tonne	global value	<11
	Intertidal habitat lost	at least 5ha	700 /ha yr	per hectare per year	<(3.5)
	Intertidal habitat	up to 150ha	700 /ha yr	per hectare per year	<105
	Other valuable habitat	0	100/ha yr	per hectare per year	0
	Recreation	0	2/visit	per visit	0
	TOTAL (annual)				**? <112**
	NPB[1] (50 yrs)				**?<2,650**
	NPB[1] (100yrs)				**? <3,240**
Managed realignment	Carbon storage	c. 319 t/yr	35 /tonne	global value	11
	Intertidal habitat lost	5ha	700 /ha yr	per hectare per year	(3.5)
	Intertidal habitat	150ha	700 /ha yr	per hectare per year	105
	Other valuable habitat	220ha	100/ha yr	per hectare per year	22
	Recreation	25,000 visits per year	2/visit	per visit	50
	TOTAL annual)				**185**
	NPB[1] (50 yrs)				**4,360**
	NPB[1] (100 yrs)				**5,320**

5.3 Abbots Hall (Blackwater Estuary)

Abbotts Hall Farm is situated on the Blackwater Estuary, an internationally important area for wildlife, protected as a Site of Special Scientific Interest (SSSI), a Special Protection Area for birds (SPA) and is a candidate marine Special Area of Conservation (cSAC). Essex Wildlife Trust purchased the 700-acre farm in 2001.

The Blackwater estuary is one of the largest estuaries in East Anglia, covering almost 4,400 ha. One of the main threats to the estuary is 'coastal squeeze' due to sea-level rise. On the Essex coast sea level is rising by around 6mm/year due to the combined effects of global warming and the settling of the landmass in the south-east. The man-made seawalls were constructed to reclaim land and subsequently protect it from flooding. 'Coastal squeeze' is the result of the sea pinning the salt marsh against the seawall and causing erosion. Over the last 25 years up to 40% of Essex salt marsh has been lost in this way.

The coastal realignment project at Abbotts Hall Farm was designed to allow for the regeneration of saltmarsh on the Essex coast. The seawall was breached in October 2002 but already the results are visible. The scheme works by allowing salt water back onto land originally reclaimed by the construction of the seawall over three hundred years ago. Two counter walls have been constructed at either end of the site to protect neighbouring land but elsewhere the land rises gently away from the seawall naturally checking the incoming tide without building new sea defences. This has allowed the creation of 200 acres of mudflat, pioneer saltmarsh and coastal grassland.

The breaching of the sea wall was carefully timed to precede the October spring tides allowing each tide to float in enormous numbers of seeds from the existing marsh outside the breached sea wall. By mid-summer the fields that were last year growing barley were carpeted with thousands of new saltmarsh seedlings. This new vegetation is dominated by marsh samphire, annual sea blit and lesser sea spurrey. Other signs of marine life include shore crabs, common jellyfish, lugworms and common shrimp. Fish species include herring, sand smelt, three spined stickleback and common goby. Birds seen feeding on the marsh include redshank, oystercatcher, little tern and shelduck.

6. CONCLUSIONS

Flood and coastal defence is a significant benefit provided by habitats recreated through managed realignment, but there are other environmental and economic benefits, the most significant of which are benefits to fisheries, carbon storage and nutrient and contaminant recycling.

The case studies presented in this paper demonstrate the significance of environmental valuation for use in the economic appraisal of flood risk management schemes. The inclusion of economic benefits of habitat recreation in project appraisal could have a significant effect on option choice and could mean that more managed realignment schemes would be justified on economic grounds.

In conclusion, the significance of valuation is that:

- it can help transform a process of abandonment into one of a positive re-creation of habitat through realignment and
- it provides an incentive within the generality of FRM schemes to recreate/create habitat wherever possible to do so.

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