Environment Agency

Evidence

Ecosystem services assessment of sea trout restoration work on the River Glaven, North Norfolk

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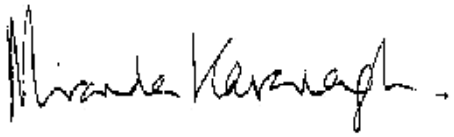

Miranda Kavanagh

Director of Evidence

Executive summary

The many benefits which ecosystems provide to society ('ecosystem services'), have often been overlooked in historic models of development and regulation. These have typically focused on one or a few benefits, excluding wider impacts. This has led to decisions which have many unintended and unforeseen implications for the integrity of ecosystems and the services that they provide. 'Ecosystem services' provide a way of considering the implications that development schemes will have on a full range of interconnected ecosystem functions, as well as their wider consequences for affected stakeholders. The development of ecosystem services concepts has come at the same time that greater consideration is being given to the wider societal benefits of environmental management initiatives. This is important for developing an integrated case for safeguarding the environment, which is based not just on inherent values but also shows clear societal benefits, including the stability of ecosystems necessary to secure the wellbeing of present and future generations.

The North Norfolk Sea Trout project addresses habitat restoration and improvement of access for migratory trout across a number of rivers in North Norfolk. The project is supported by statutory agencies including the Environment Agency and Natural England, partnered by a range of informal associations such as the River Glaven Conservation Group, and coordinated by the Wild Trout Trust. Later in its life, the project was consolidated into a wider Anglian Rivers Sea Trout project as described in the body of the report. Restoring rivers which are accessible by populations of migratory salmonid fishes and fit to sustain breeding may appear to be a major public expense with limited benefits to anyone other than anglers and land-owners. However, if we consider these migratory fishes as target indicators of healthy river ecosystems, which are also able to support other wildlife and provide many other benefits to society, then river restoration with sea trout as a target species is set in a far broader context of societal value. This ecosystem services case study therefore explores the wider implications for ecosystem services arising from current and proposed sea trout restoration activities on the River Glaven.

The study revealed that, although the main aim of the River Glaven restoration scheme was the reintroduction of sea trout, this was dependent upon the river being reconnected laterally and longitudinally and restored to health and full function. This reconnection in turn yields many associated benefits to society, of which angling benefits comprise only a small fraction. Broader 'provisioning services', in practice comprising economic gains from food production, also represented a relatively small proportion of benefits from current and projected restoration activities. More substantial benefits came from providing habitat for other species (a 'supporting service') and particularly for the cultural service of 'recreation and tourism', of which tourism uplifted by an enhanced environment was a major component. 'Regulatory services' accounted for one quarter to one fifth of the gross benefits of current and future restoration initiatives, improving the capacity of the catchment to regulate various aspects of the environment with their associated societal benefits.

A significant outcome of restoring the River Glaven under the North Norfolk Sea Trout/Anglian Rivers Sea Trout project was building relationships between different, often formerly fragmented groups across the catchment, who worked together to restore the river to a functioning, integrated system. This was perceived as a major gain, with associated significant benefits also arising from the provision of amenity for local people, for which the sea trout has proven a potent symbol of a river restored to health along with its many associated benefits to society.

Further work to bypass the major obstructions on the Bayfield Estate is shown to be economically viable, not only providing a solid economic case for further progress with

river restoration, but one that is arguably justified on flood risk management grounds alone. Together with the diverse values associated with current and ongoing restoration initiatives, they also demonstrate the many broader societal benefits flowing from a scheme with ecological restoration at its core. Where semi-quantitative assessment reveals many clear benefits from projects such as the River Glaven sea trout restoration scheme, we may not always need to monetise the benefits to justify continued investment in restoration of habitat and its functioning. Uniformly positive effects across a wide range of ecosystem services, and an associated substantial benefit-to-cost ratio across both intended and incidental ecosystem service outcomes, appear to be a consistent outcome of sensitive restoration of river habitat and functioning.

The study also underlines the power of ecosystem services as a tool to help identify the breadth of issues and potential beneficiaries touched upon by environmental management schemes with, in this case, a broad range of ‘collateral benefits’ that may not have been part of the initial scheme design. By contrast, it also demonstrates the dangers of ‘silo thinking’, often enforced by siloed organisational structures, mandates and/or budgets. Optimal societal value and sustainability of outcomes can occur only when a full range of impacts and benefits is considered simultaneously.

The benefits of both current and projected restoration initiatives on the River Glaven are clear and substantial, and so the learning derived from this study is therefore relevant and transferable, with caution, to other environmental initiatives founded on restoration of river habitat and function, and its suitability for characteristic and iconic species.

Acknowledgements

The author of this report is very grateful to Tim Jacklin of the Wild Trout Trust for his considerable input, help in setting up a field visit in December 2009, and for supplying the two photographs published in this report. Also to Rob Dryden and Jez Wood (Environment Agency) for their input of local and regional knowledge, and to Bill Watts (also with the Environment Agency) for input and critique of economic methods and assumptions.

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1 Ecosystem services arising from the River Glaven restoration

This report outlines the background, methods, findings and learning from an assessment of changes in ecosystem services related to restoration of the River Glaven catchment, North Norfolk. The purpose of the restoration is to provide access and habitat enabling the return of sea trout to the river system.

The purpose of this study was to assess marginal changes arising from 'current and ongoing' restoration activities as well as future options for bypassing a major obstruction to migration on the river. All improvements to the river ecosystem potentially affect broad societal groups, who benefit from the multiple 'services' provided by the system. The ecosystem services approach helps identify the stakeholders connected with and potentially affected by these schemes.

1.1 About ecosystem services

'Ecosystem services' describes the multiple beneficial 'services' which society gets from ecosystems. These services are many and substantial, underpinning basic human health and survival needs as well as supporting economic activities, the fulfilment of potential, and enjoyment of life. The essence of the 'ecosystems approach' – management of whole ecosystems and their benefits using the framework of ecosystem services – is to consider these multiple benefits simultaneously, so that realising one benefit does not lead to inadvertently degrading other benefits with net harm to other beneficiaries (which can include future generations).

Historically, industrial development has largely overlooked or disregarded many of these ecosystem services, using instead an 'exploitation economics' model focused, more by oversight then intent, on limited and generally immediate benefits to the exclusion of broader ramifications. Current trends in ecosystem degradation need greater recognition and we achieve have improved stewardship of essential ecosystems if human wellbeing is not to be systematically undermined. Therefore, by definition, studies that select only a limited subset of ecosystem services, overlooking potential conflicts with others, are not consistent with the ecosystems approach, and many are merely using new terminology to perpetuate the outmoded 'exploitation economics' model.

The concept of ecosystem services is anthropocentric, since it is based on the multiple benefits that ecosystems provide to society. Therefore, it is inherently amenable to economic valuation. Environmental economics provide a common and transferable basis for assessing the different categories of benefits and dis-benefits associated with changes in ecosystem services resulting from interventions in environmental systems. We will consider economic approaches and their associated difficulties later in this introductory text. However, for all the generalisation and other flaws of economics, a key consideration to bear in mind is that, if they are not valued, the services provided by ecosystems and, by extension, important aspects of those ecosystems themselves are effectively deemed as worthless in decision-making processes. This explains much of the unintended but systematic historical decline in ecosystems of all types and scales across the world.

The power of the ecosystem services concept is that, by recognising and potentially quantifying the resulting benefits to society, ecosystems are brought into planning and other decision-making processes, practically and tractably linking ecological with social and economic considerations.

Many parallel strands of ecosystem services science have evolved since the late 1980s, and have proven effective in advancing understanding and management of various ecosystem types across the world. However, in order to provide a uniform basis for assessing the status of all major global habitats, and to use this to develop a prognosis for human wellbeing, the UN's Millennium Ecosystem Assessment (MA, 2005) brought together these diverse 'ecosystem services' typologies into a consistent and pragmatic classification. The MA grouped ecosystem services into four main categories:

- 'provisioning services' are those that can be extracted from ecosystems to support human needs (called 'ecosystem goods' in some prior classification schemes). These include tangible assets such as fresh water, food and fibre;
- 'regulatory services' include those processes that regulate the natural environment, including the regulation of air quality, climate, water flows, erosion and pests;
- 'cultural services' include diverse aspects of aesthetic, spiritual, recreational and other cultural values;
- 'supporting services' do not necessarily have direct economic worth but include processes essential to the maintenance of the integrity, resilience and functioning of ecosystems, and so the delivery of other benefits. They include services such as soil formation, photosynthesis and water recycling.

The complete MA classification of ecosystem services is listed in Table 1.1.

Table 1.1. Millennium Ecosystem Assessment classification of ecosystem services.

Provisioning services
Fresh water
Food (e.g. crops, fruit, fish, etc.)
Fibre and fuel (e.g. timber, wool, etc.)
Genetic resources (used for crop/stock breeding and biotechnology)
Biochemicals, natural medicines, pharmaceuticals
Ornamental resources (e.g. shells, flowers, etc.)
Regulatory services
Air quality regulation
Climate regulation (local temperature/precipitation, greenhouse gas sequestration, etc.)
Water regulation (timing and scale of run-off, flooding, etc.)
Natural hazard regulation (i.e. storm protection)
Pest regulation
Disease regulation
Erosion regulation
Water purification and waste treatment
Pollination
Cultural services
Cultural heritage
Recreation and tourism
Aesthetic value
Spiritual and religious value
Inspiration of art, folklore, architecture, etc.
Social relations (e.g. fishing, grazing or cropping communities)
Supporting services
Soil formation
Primary production
Nutrient cycling
Water recycling
Photosynthesis (production of atmospheric oxygen)
Provision of habitat

Although neither perfect nor complete, the MA typology provides a broadly inter-comparable set of services across bioregions and ecosystem types. It also exposes the complexity and multiplicity of interactions between social and natural systems, the knowledge gaps about how all ecosystem services are ‘produced’, and the need for methods to monitor them. It is legitimate to use additional services where they are locally appropriate, as we will do in this study.

1.2 Introduction to the River Glaven sea trout restoration project

The River Glaven is one of the river systems falling within the wider North Norfolk Sea Trout project. The North Norfolk Sea Trout project was later consolidated into the wider Anglian Rivers Sea Trout Project also encompassing the rivers Stiffkey, Glaven, Burn, Nar, Great Eau and Welland. This report considers just restoration and access works on the River Glaven ('the River Glaven sea trout project'), which has also been the beneficiary of funding under the Wild Trout Trust's 'Cinderella Chalk Streams' project (RRC, 2006).

A prior assessment by the Wild Trout Trust (www.wildtrout.org) had identified a number of reaches of the River Glaven which would benefit from replacement of gravels for spawning redds, sections that were over-widened and could usefully be narrowed, silted reaches where deflectors might create bed scour and habitat diversity, as well as major obstructions to be overcome to aid access to the river by sea trout migrating into fresh water to spawn or else exiting the system as smolts. An illustrative map of the Glaven catchment is provided in Figure 1.1 indicating key sites.

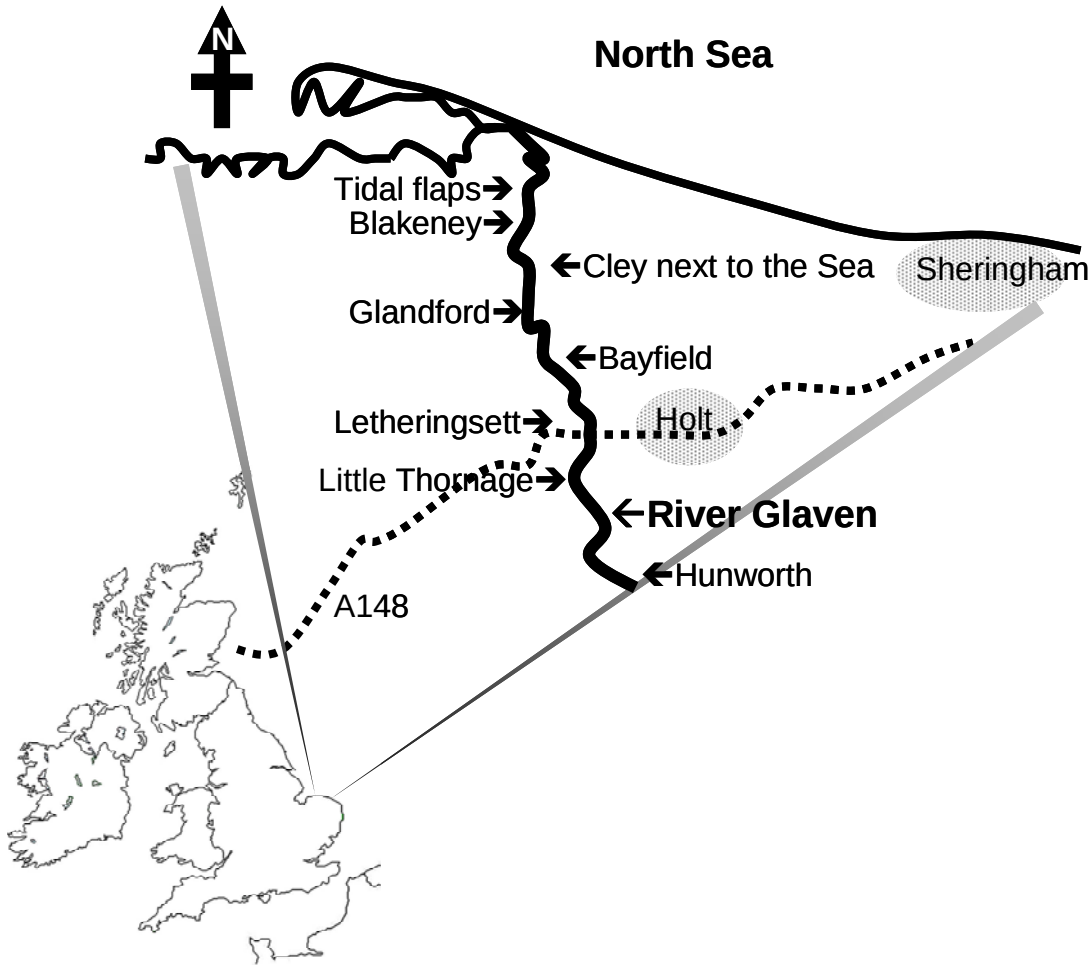

Figure 1.1. The Glaven catchment indicating key sites.

At a meeting on 25 August 2009 between key members of the Environment Agency, the Wild Trout Trust and contractors concerning the North Norfolk Sea Trout/Anglian Rivers Sea Trout project, the following actions were agreed to progress restoration of the River Glaven:

- summary of progress with Phase 1, which identified barriers, spawning habitat and sedimentation to be the main limitations to sea trout in Anglian rivers;
- projects in development upstream of Astley Farms and also investigating the culvert between Bayfield and Glandford Mill;
- progress with landowners on the river who are willing to allow removal of barriers;
- project successfully publicised at Holkham Country Fair & the Game Fair and leaflet for Anglian Rivers Sea Trout project produced;
- potential partnership with the coastal Area of Outstanding Natural Beauty (AONB) and the Norfolk Coast Partnership (http://www.norfolkcoastaonb.org.uk/) for a Heritage Lottery Fund bid on the Glaven catchment;
- exploration ongoing on optimal, cost-effective redesign of tidal flaps on coastal defences to allow entry and escape of sea trout which, unlike salmon which respond to high freshwater flows, will also creep up when flows are low (usually in June/July).
- identified need to also consider other migratory fish, including elvers which have peak runs on spring tides between April and September;
- consideration of how much saline intrusion should be tolerated, particularly given Natural England's concerns about the effects on the (freshwater) site of special scientific interest (SSSI). This requires modelling of saline intrusion to assess the impact;
- report back on meetings between the Wild Trout Trust (WTT) and both Bayfield Estates and the Stody Estate (Hunworth) to discuss mitigation for existing populations of brook lamprey and bullhead; and
- requirements for in-project and post-project monitoring of lower reaches of the Glaven which are to be de-silted.

Further progress since that meeting includes:

- securing the agreement of the owner of Glandford Mill to keep the mill sluices lifted. This will aid access by sea trout to the upper river and also expose the bed of the formerly inundated pound upstream of the mill, which will be allowed to naturally re-vegetate; and
- various channel-narrowing, riffle-creation (import of gravel on shallows) and deflector installation above the ford at Little Thornage, this restoration work undertaken by the River Glaven Conservation Group (http://www.riverglaven.org.uk/home.html) together with the Wild Trout Trust and the Environment Agency.

Proposed future work to help 'unblock' the perceived obstruction to migratory fish at Bayfield Lake entails detailed planning and appraisal of options for which ecosystem services screening (not necessarily including the more complex monetisation stage) may be extremely helpful. The obstruction relates to the split of the River Glaven's flow

(roughly 50:50) through a lake on the Bayfield Estate and into a culverted stream. The lake is heavily silted, but has to be retained for its aesthetic as well as angling values despite having an impassable spillway at the downstream end (Figure 1.2) immediately above where the flow joins the diverted stream. The culvert through which this diverted stream flows is substantial, approximately 720 metres long, taking the stream under park grassland and representing a key barrier through which migratory trout are considered unlikely to pass (Figure 1.3). Strong circumstantial evidence supporting the assumption that the culvert and lake posed obstacles was observed on a site inspection in December 2009, which revealed a high density of trout redds (clearly it is not possible to determine if they were from migratory or resident trout) in the confluence immediately below where the culverted steam and lake overspill rejoined. We therefore have confidence that removing the culvert or otherwise easing migration is likely to result in enhanced fish passage, with the associated benefits that this study seeks to value. However, one of the scheme constraints is that the culvert has to remain in a functional state as it is colonised by bats; residual flows through it have to be factored into the design of any lake/culvert bypass scheme. Details of scheme design have yet to be considered, let alone funded, though there are potential advantages not only for the potential passage of migratory and other fishes but also, by diverting some of the flow through the lake, siltation of the stillwater fishery may be arrested substantially.

Figure 1.2. Impassable spillway at downstream end of Bayfield Estate lake (photo with thanks to Tim Jacklin, Wild Trout Trust).

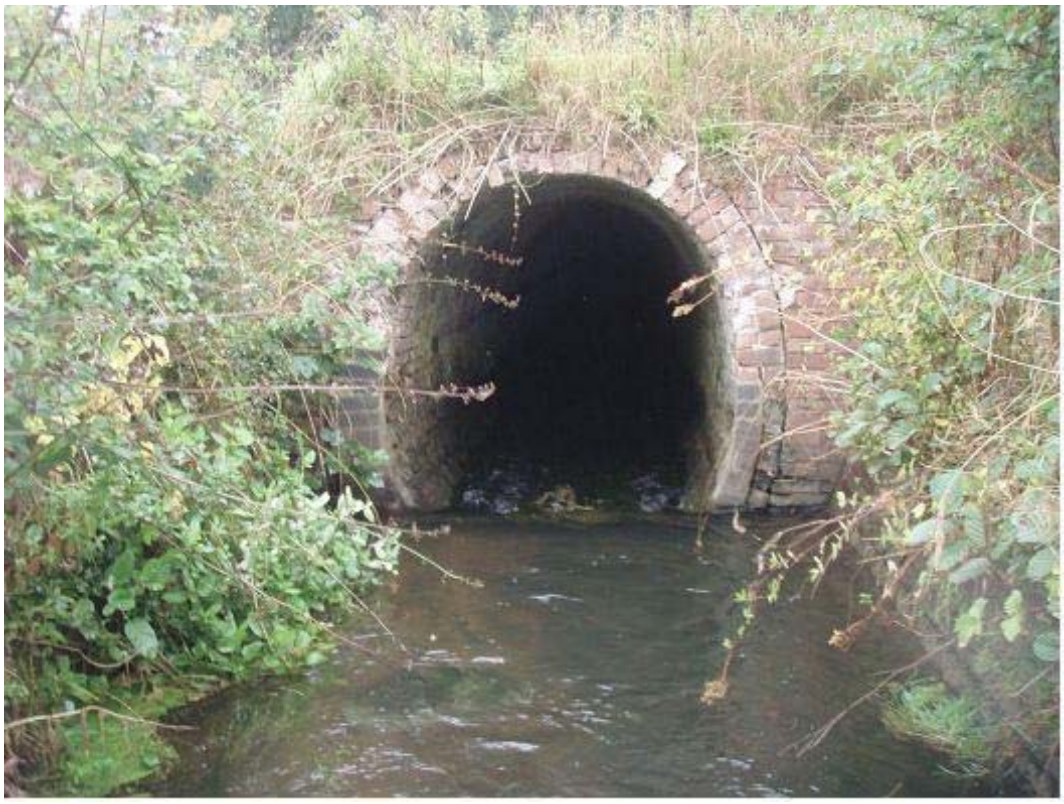

Figure 1.3. Head of 720 metre culvert taking 50% of the Glaven's flow on the Bayfield Estate (photo with thanks to Tim Jacklin, Wild Trout Trust).

1.3 Determination of ecosystem service impacts

Absolute values deduced for ecosystem services have little or no objective meaning, given the uncertainties and stacked assumptions involved in their assessment. However, meaningful information can be deduced from determining marginal impacts on ecosystem services between a 'baseline' condition (i.e. prior to restoration works) and post-intervention condition (actual or projected).

Following familiarisation with the River Glaven from site visits, a limited set of stakeholders (listed in the acknowledgements at the start of this report) was engaged in assessing the likely marginal impacts for the various ecosystem services. One of the practical difficulties encountered at this stage was that the works were targeted largely at improving the quality of existing habitat, rather than a transition between habitat types. In the economics literature, most studies from which transferable values could be derived do not deal with quanta of improvement, focusing instead on more gross habitat re-creation and other capital works. This also creates a practical difficulty for determining ecosystem impacts on a more subjective basis. However, the project team sought to weight the likely impacts of restoration work on the basis of the MA classification of ecosystem services, and using the Defra (2007) 'likelihood of impact' weighting score which is reproduced in Box 1.

Box 1. Defra 2007 'likelihood of impact' weighting system.

Score	Assessment of effect
++	Potential significant positive effect
+	Potential positive effect
O	Negligible effect
-	Potential negative effect
--	Potential significant negative effect
?	Gaps in evidence / contention

Likely impacts were assessed on the basis of 'current and ongoing' restoration work on the River Glaven (see Annex 1) and of the likely outcome of successfully bypassing the Bayfield Hall Lake and culvert (Annex 2).

1.4 Monetisation of ecosystem service impacts

Defra states that, 'An ecosystems approach to valuation provides a framework for looking at **whole ecosystems** in decision making, and for **valuing the ecosystem services they provide**, to ensure that we can maintain a healthy and resilient natural environment now and for future generations'.

There is a long-standing and broad consensus that financial values derived from such economic appraisals have no absolute meaning, as they are sensitive to a broad spectrum of factors including what is omitted or included, explicit and implicit assumptions, valuation methods and the scale of evaluation (e.g. Costanza et al., 1997; Defra, 2007). However, determining relative values (also known as 'marginal' values), by comparing a 'baseline' condition to an altered state, provides information on the tendency and scale of changes. Marginal values are therefore helpful in informing analysis and decisions.

In the cases of both 'current and ongoing' restoration and the projected bypassing of the obstructions at Bayfield Hall, identification of total 'baseline' values for the different categories of ecosystem service would be likely to result in subjective values given the

large area, the many necessary assumptions and the inevitable data gaps. For this reason, the ‘baseline’ value was taken to be zero (except where marginal values were based on an uplift of existing value), with pre-intervention status acting as a datum from which relative benefits and dis-benefits are calculated.

Environmental economics provide a common and transferable basis for assessing the different categories of benefits and dis-benefits associated with changes in ecosystem services resulting from interventions in environmental systems. The ecosystem services themselves are largely amenable to economic valuation as they relate to different categories of human benefit. Where possible, values are ‘transferred’ from other relevant studies, although some values are deduced on the basis of a number of stated assumptions related to real or surrogate markets. However, we have already highlighted the practical difficulty of a sparse economics literature from which transferable values could be derived, assessing marginal improvement of existing habitat rather than gross habitat displacement or restoration. Values transferred from other studies into this analysis are highlighted in the analyses in Annex 1 and Annex 2. The economic benefits of most ecosystem services are calculated on the basis of a range of stated assumptions linked to surrogate market prices and drawn from related willingness to pay surveys. Transferred values are NOT corrected to current price levels in the case study as this would give a spurious impression of the precision of the estimate and underpinning assumptions; the values derived in this analysis serve adequately for illustrative purposes.

The UK government’s ‘Green Book’ (HM Treasury, undated) is used as a reference for methods to assess the total economic value of the benefits and costs entailed in these case studies. This includes a discount rate of 3.5% spread over 25 years. Pearce *et al*. (1989) discuss the ‘tyranny of discounting’ for environmental schemes, where higher discount rates and a relatively short assessment period can undervalue the often enduring benefits of environmental schemes, whilst Turner *et al*. (2008) argue that reliable total valuations for wetlands can only be derived from ‘willingness to pay’ studies. However, in an operational context there is rarely either time or budget to make such a bespoke assessment, which is anyhow contentious in that it rests upon many assumptions.

In the interests of proportionality, and reflecting that assessments made here and more generally are for decision support rather than decision making purposes, the standard ‘Green Book’ methods are employed in this study.

Specific methods, assumptions and transferred values applied to each ecosystem service are described in Annexes 1 and 2 for ‘current and ongoing’ restoration works and for the likely impacts of successfully bypassing of the Bayfield Hall obstructions respectively.

2 Summary of ecosystem services assessment from the River Glaven restoration

This section summarises the key findings of the detailed analyses respectively of 'current and ongoing' restoration works (Annex 1) and for likely impacts of successfully bypassing of the Bayfield Hall Lake impoundment (Annex 2).

2.1 Assessment of marginal benefits from 'current and ongoing' restoration activities

This section summarises the key findings of the detailed analyses of 'current and ongoing' restoration works in Annex 1.

Table 2.1. Summary of results for current initiatives on the River Glaven.

MA ecosystem service category	Annual benefit assessed	Notes
Provisioning services	**£20,000**	Largely related to payments for transition from ELS to HLS agri-environment payments
Regulatory services	**£66,550**	£53,810 in climate regulation, £11,400 in water regulation, and £1,140 in erosion regulation
Cultural services	**£167,159**	£123,459 from recreation and tourism (fishing, shooting and ecotourism), £36,500 as an addendum service of local amenity and informal enjoyment, and £7,200 for social relations (largely volunteer activities)
Supporting services	**£21,480**	Related to provision of habitat
Gross annual ecosystem services benefits	**£275,189**	

These benefits accrue from a modest initial gross investment of £7,140 charged costs under the WTT 'Cinderella Chalk Streams' project (RRC, 2006) and the same value again assumed for input by the Wild Trout Trust and the River Glaven Conservation Group, yielding a total financial investment (substantial uncharged input including volunteers) of £14,280.

When the cumulative annual ecosystem services benefits are assessed over 25 years with a discount rate of 3.5%, this equates to a gross scheme benefit of £4,635,937.

Whilst it is assumed that the costs are initially likely to be ongoing, if we nevertheless divide the gross lifetime scheme benefit (£4,635,937) by the initial gross investment (£14,280) the current and ongoing initiatives under the River Glaven sea trout restoration project yield a benefit-to-cost ratio of 325:1.

If we compare this to a gross 25 years, 3.5% discount rate for water regulation (flood risk management) benefits alone (an annual benefit of £11,400 yielding a lifetime value of £192,049), this still yields a substantial benefit-to-cost ratio of 13:1.

2.2 Assessment of marginal benefits from overcoming barriers to migration at Bayfield Hall Lake

This section summarises the key findings of the detailed analyses for likely impacts of successfully bypassing of the Bayfield Hall Lake impoundment in Annex 2.

Table 2.2. Summary of results for overcoming barriers to migration at Bayfield Hall Lake on the River Glaven.

Ecosystem service	Annual benefit assessed	Note/Research gap
Provisioning services	**£10,000**	Related to payments for transition from ELS to HLS agri-environment payments
Regulatory services	**£11,400**	Improved water regulation
Cultural services	**£11,823**	£6,723 from recreation and tourism (fishing, shooting and ecotourism), £4,380 as an addendum service of local amenity and informal enjoyment, and £720 for social relations
Supporting services	**£21,480**	Related to provision of habitat
Gross annual ecosystem services benefits	**£54,703**	

The sum of all annual ecosystem service benefits of overcoming barriers to migration at Bayfield Hall Lake on the River Glaven restoration is £54,703.

Assessed over 25 years with a discount rate of 3.5%, this equates to a gross benefit of £921,547.

This gross benefit value is indicative only, based on stated assumptions in Annex 2. However, it is a substantial sum and can be used to justify expenditure.

The annual benefit of £11,400 for water regulation (flood risk management) benefits alone, if aggregated over 25 years at a 3.5% discount rate, yields a lifetime value of £192,049, itself a substantial value which may alone justify the design and implementation of a sensitive bypass scheme for the Bayfield Estate lake and culvert.

3 Lessons learned from the ecosystem services assessment from the River Glaven sea trout restoration

The River Glaven sea trout restoration scheme is not merely about sea trout in isolation. Rather, sea trout are an indicator species of a river reconnected laterally and longitudinally and restored to health and full function, yielding many associated benefits to society. It is then unsurprising that 'provisioning service' gains accounts for only 7% and 18% respectively of the gross benefits from 'current and ongoing' initiatives and for the anticipated benefits of bypassing obstructions on the Bayfield Estate.

The 'provision of habitat' service accounts for the full quantified 'supporting services', representing 8% and 39% respectively of the gross benefits from 'current and ongoing' initiatives and for the anticipated benefits of bypassing obstructions on the Bayfield Estate. However, this does not reflect all elements of ecological uplift as ascribing an economic value to other supporting services would require a linkage to a real or surrogate market; many of the supporting services are essential to maintain ecosystem integrity and functioning but are notoriously hard to monetise as 'final services'.

Significant elements of ecological gain are, in fact, expressed in their 'final service' form under the cultural service of 'recreation and tourism' (including recreational angling, shooting and ecotourism). Cultural services account respectively for 61% and 22% of the gross benefits from 'current and ongoing' initiatives and for the anticipated benefits of bypassing obstructions on the Bayfield Estate. Of these cultural services, the uplift to tourism in this attractive corner of England is particularly significant, accounting for virtually all (£123,456) of the total (£123,459) annual 'recreation and tourism' benefit from 'current and ongoing' restoration, the small remainder accounted for by combination of uplifts in angling and shooting values. Interestingly, with the focus on fish restoration, the modest annual contribution to cultural value by recreational angling benefit from 'current and ongoing' schemes (only £2,000) emphasises the role of sea trout as a focus for restoration rather than as a narrowly-framed primary objective.

The remainder of the gross benefits are accounted for by regulatory services, which account respectively for 24% and 21% of the gross benefits from 'current and ongoing' initiatives and for the anticipated benefits of bypassing obstructions on the Bayfield Estate.

What is striking is that the high cultural values associated with current and projected restoration include not only recreational angling and other direct exploitation of the target fish species, but also the building of significant social capital around the whole-river restoration initiative that has served to bring different constituencies together around common goals. In this way, the River Glaven scheme is akin to the constitution in 1986 of the Thames Salmon Trust as a registered charity (reconstituted in 2005 as the Thames Rivers Restoration Trust), with the ambitious aim of bringing about regeneration of the river such that salmon would again be able to run the river. The salmon was iconic of a river restored to full health, appealing to far wider constituencies than those interested in fishing for the (then non-existent) Thames salmon. The sea trout serves this same iconic role in the River Glaven, emblematic of a river restored to its natural vitality.

The economic values projected for further work to bypass the major obstructions on the Bayfield Estate not only provide a solid economic case for further progress with river restoration, but one that is arguably justified on flood risk management grounds alone. Together with the diverse values associated with current and ongoing restoration initiatives, they also demonstrate the many broader societal benefits flowing from a scheme with ecological restoration at its core.

Also significantly, although it was suggested that there might be some (not quantified) reduction in aesthetic value from draining pounds above mills by opening sluices to enhance fish passage, there was no measurable or significant loss entailed in the restoration scheme. It is usual to consider both benefits and losses from changes in habitat or its stewardship (for example in the Alkborough Flats ecosystem services case study quantified by Everard, 2009). However, ecosystem restoration (as also quantified by Everard, 2009, in the Tamar catchment) is generally found to result in net benefits or neutral impacts across all ecosystem service types.

Although there is always a risk of 'double counting' of ecosystem-derived benefits in complex socio-ecological systems, the methods deployed in this study sought to minimise the potential for this type of error. Given the magnitude of deduced benefits compared with the costs of the intervention, any error introduced by inadvertent double-counting would in fact have only a minimal effect on the resulting benefit-to-cost calculations, demonstrating that the overall conclusions of the study are robust.

Flowing on from this conclusion is a question as to whether monetisation is in any case required to justify continued investment in the sea trout restoration, given the unambiguous nature of the likely consequences of rehabilitation of habitat and overcoming barriers to fish migration in the River Glaven (using the Defra 2007 weighting system). It seems that habitat restoration of this nature has a uniformly positive effect on a wide range of ecosystem services and an associated substantial benefit-to-cost ratio across both intended and incidental ecosystem service outcomes, in common with that observed in the River Tamar (Everard, 2009) and, to a certain extent, the managed realignment of coastal defences used as a case study in the Defra (2007) valuation guide. In all of these cases, the likelihood of positive benefits is so significant, and indeed evident to a wide range of stakeholders, that monetisation may be superfluous.

This was a very short study with no associated budget. We would ideally have liked to have undertaken more stakeholder engagement to ensure that all affected views were represented and that, therefore, no ecosystem services were overlooked or underrepresented. This approach would be consistent with evolving good practice in the mainstreaming of collaboration with communities and stakeholders in flood risk management and other environmental decision-making, as mandated by the UNECE Aarhus Convention of 1998 and supported by the report by Colbourne (2009).

Other issues yet to be more thoroughly researched include the geographical scale of the contribution of local initiatives of this nature, some of which may be diminished over relatively small distances (for example fall-out of sediment) but others of which may have considerably wider ramifications across the catchment (for example recruitment of fish, support for other wildlife and a contribution to river water quality) and more broadly (such as though enhancement of air quality or regulation of climate-change gases).

A final conclusion drawn from this work is that this study supports conclusions drawn elsewhere about the power of ecosystem services as a tool to help identify the breadth of issues and potential beneficiaries touched upon by environmental management schemes with, in this case, a broad range of 'collateral benefits' that may not have been part of the initial scheme design. By contrast, it also demonstrates the dangers of 'silo thinking', often enforced by siloed organisational structures, mandates and/or

budgets. Optimal societal value and sustainability of outcomes can occur only when a full range of impacts and benefits is considered simultaneously.

The benefits of both current and projected restoration initiatives on the River Glaven are clear and substantial, and the learning derived from this study is therefore relevant and transferable, with caution, to other environmental initiatives founded on restoration of river habitat, function and suitability for characteristic and iconic species.

Annex 1: Assessment of 'current and ongoing' restoration and access initiatives on the Glaven catchment

This Annex contains detailed considerations of ecosystem services impacts of 'current and ongoing' restoration and access initiatives on the Glaven catchment. Methods, assumptions and deduced transferred values are outlined in Tables A1.1–A1.4 below, respectively for provisioning, regulatory, cultural and supporting services.

Table A1.1. Provisioning service impacts of current initiatives on the River Glaven.

Weighting (++, +, 0, -, --, ?)	Quantification?	Monetisation?
Provisioning services		
Fresh water **0/+**	Improved habitat will enhance the supply of fresh water, both in terms of the stability and buffer of flows and of its quality, but the scale of interventions is small and the beneficiaries few, which thwarts meaningful quantification	There are various water abstraction points on the Glaven, largely for irrigation, which may benefit from water quantity and quality. Indeed, there is an argument that habitat restoration may provide some mitigation for abstraction. However, as a matter of policy, it would be dangerous to treat restoration as mitigation for intensified use. Therefore, this tangible benefit to the provision of 'fresh water' is valued as zero **Annual value = £0**
Food (e.g. crops, fruit, fish, etc.) **0/+**	An improvement in trout stocks can be expected, though the scale and intent of intervention is not to produce significant additional food production from the river. Likewise, marginal impacts from wildfowl and grazing from better connection between the river and its floodplain are likely to be net neutral. Enhanced fish and fowl stocks are captured as 'cultural' benefits below. No current intervention is likely to reduce farming costs (i.e. through disease control, reduced tillage, etc.)	There will be a boost in fish production in the river system, but most fishing is recreational 'catch and release' angling so this is assessed as zero benefit for 'food' (though values do accrue from 'recreation and tourism') Shooting is a popular activity on estates down the Glaven, but these benefits will also be captured under 'recreation and tourism'

		to avoid double-counting We can, however, expect economic income and savings from changed land stewardship. Large areas such as the Stody Estate at Hunworth in the upper catchment have made a transition in stewardship of low-intensity grassland stock management, allowing sites to wet up, whilst areas in the lower catchment (i.e. downstream of Glandford) have had flood banks breached to 'wet up' sites. Assuming 100 hectares of land transfers from Entry Level Scheme (ELS) payments of £30 per ha to a conservative Higher Level Scheme (HLS) payment of £200 per ha (HLS payments range from £40-700 per ha), this yields an annual benefit of £20,000. It is assumed that other farm savings (reduced fertilisers, pesticides and stock treatment costs, feed, etc.) are small enough to be lost within the uncertainty of this ELS➔HLS value **Annual value = £20,000**
Fibre and fuel (e.g. timber, wool, etc.) **0**	The net impact on wet woodland and reeds is likely to be neutral, there is no arable production that is likely to be displaced, and overall impact on fur-bearing stock is also likely to be neutral	**Annual value = £0**
Genetic resources (used for crop/stock breeding and biotechnology) **0/+**	It is likely that genetic diversity, potentially exploitable in future, will be protected or enhanced but the scale of this is likely to be small or neutral	**Annual value = £0**
Biochemicals, natural medicines, pharmaceuticals **0/+**	It is likely that biochemical diversity, potentially exploitable in future, will be protected or enhanced but the scale of this is likely to be small or neutral	**Annual value = £0**
Ornamental resources (e.g. shells, flowers, etc.) **0**	None known	**Annual value = £0**
Gross annual 'provisioning services' benefits =		**£20,000**

Table A1.2. Regulatory service impacts of current initiatives on the River Glaven.

Weighting (++, +, 0, -, --, ?)	Quantification?	Monetisation?
Regulatory services		
Air quality regulation **0/+**	Improved habitat is likely to enhance settlement of aerial particulates and metabolism of pollutants such as SOx, NOx and ozone. However, the scale of interventions is small and, owing to good existing air quality, the quantum of gains to beneficiaries are small	**Annual value = £0**
Climate regulation (local temperature/precipitation, GHG sequestration, etc.) **+**	Improved habitat (rewetted floodplains and development of carr) is likely to enhance sequestration of carbon and also provide positive benefits for local microclimate which may be locally significant, if hard to quantify. However, more sustainable catchments will also require less management interventions, which provides a basis for quantification	Rewetting of floodplains and development of carr are likely to sequester carbon. Assuming 200 ha of riparian habitats making a transition from permanent grassland to wetted, carbon-accreting soils or to wet woodland, and transferring values from the Everard (2009) study of the Tamar catchment (itself transferring in values from the a prior SWIMMER (2007) report) using a marginal cost of carbon of £27 per tonne, this yields an annual ecosystem service benefit value of £48,110 Savings on carbon emissions resulting from less management interventions in more resilient river systems are estimated as saving 10 man/machine days (@ £350 staff costs + £150 machine costs + £40 [round trip from home of 100 miles @ 40p per mile] travel to work) + £300 costs of machine haulage to/from site = £5,700 **Annual value = £53,810**
Water regulation (timing and scale of run-off, flooding, etc.) **+**	Improved habitat and opening of obstructions is likely to provide a more natural hydrology, which may have local benefits for natural flooding regimes of important habitat as well as offsetting some flood risk to property	Environment Agency databases reveal 57 properties at risk of flooding in the River Glaven catchment from Thornage to Cley. Assuming a conservative damage per household of £20,000, this yields a net potential flooding

		value of £1,140,000. Assuming a 1:10 risk of flooding, this produces an annual damage of £114,000. If the ongoing and current River Glaven restoration works, particularly the reconnection of channel with floodplain, makes a conservative 10% improvement in flood risk, this would yield an annual benefit of £11,400 **Annual value = £11,400**
Natural hazard regulation (i.e. storm protection) **+**	This benefit is likely to track that for hydrology, though quantification is more problematic	This is not valued in order to avoid double-counting; assumed to be rolled in with 'Water regulation' above **Annual value = £0**
Pest regulation **0/+**	Whilst enhanced habitat is likely to support populations of natural predators of crop and other pests, quantification of this benefit is complex	There are complexities in valuing this benefit, but we ascribe it a zero value to avoid any double-counting with agricultural/'food' benefits above **Annual value = £0**
Disease regulation **0/+**	Enhanced habitat is likely to improve natural microbial purification processes, through this will be confounded by cattle grazing in the river	The confounding factors – including breakdown of some pathogens but re-infection from agriculture of others – mean that no safe marginal value can be ascribed to this service **Annual value = £0**
Erosion regulation **0/+**	More natural hydrology and better connection with floodplain is likely to enhance erosion regulation, as indeed the trapping of silt from floodwater in the river. Loss of soil fertility is not addressed here as it may already be captured by agriculture/'food'	Reconnecting floodplain should arrest and accrete more silt, and this is monetised by assumptions about incremental savings in de-silting of the lower river between Wiveton and Cley (but not the tidal reach below as the source of this sediment may include coastal deposition). It is assumed that there is a 20% reduction in riverine siltation and therefore a 20% saving in de-silting which (if desilting works

		occupy 1 man + machine for 10 working days on a five-yearly cycle using costs elaborated above under 'climate regulation') = £1,140 per annum **Annual value = £1,140**
Water purification and waste treatment **0/+**	More natural hydrology and better connection with floodplain is likely to enhance water purification and waste treatment	'Fresh water' benefits are not valued here as this final service is already assessed as a provisioning service Whilst the Glaven is wholly covered by a Nitrate Vulnerable Zone (NVZ) designation, and rewetting of floodplain is likely to promote nitrogen metabolism (as well as phosphorus sequestration), the net contribution is considered to be marginal in the light of the already eutrophic state of the catchment **Annual value = £0**
Pollination **0/+**	Enhanced habitat is likely to support stronger populations of natural pollinators, though quantification of this benefit is complex	In this rural catchment, natural pollinators are not believed to be limiting so the marginal impact would be negligible **Annual value = £0**
Gross annual 'regulatory services' benefits =		**£66,550**

Table A1.3. Cultural service impacts of current initiatives on the River Glaven.

Weighting (++, +, 0, -, --, ?)	Quantification?	Monetisation?
Cultural services		
Cultural heritage **0**	Heritage infrastructure, including mill sluices and valued meadows, are mainly changing in stewardship rather than structure, so this value is not quantified. Arguably, dropping the formerly high water level forming pounds above mills could have negative consequences for cultural value, though not readily determined	Not quantified as related to stewardship rather than change in cultural capital **Annual value = £0**
Recreation and tourism **++**	Enhanced fish stocks will have some impact on recreational angling (which is not double-counted with the service of 'food' as 'catch-and-release' fishing is assumed). Further benefits accrue from improved wader and wildfowl stocks promoting shooting, enhanced wildlife promoting bird-watching,	Angling benefits include an assumed 20% uplift in game fish stocks and game angling, relative to £10,000 per annum of current angling (a syndicate of 50 rods @ £100 below Glandford

	photography and informal recreation, and regional tourism enhanced by the improved environment	and an additional assumed 50 informal rods enjoying fishing of equivalent value upstream), yielding an annual marginal benefit of £2,000 Shooting estates, attracting both local and visiting sportsmen, will be enhanced by improved river habitat and particularly connectivity between floodplains and the river channel. Assuming 1,000 people/days of shooting @ £500 daily yields a gross value of £500,000. However, only an assumed 10% of this will be for wildfowl and waders (the rest for pheasant on dry land), representing £50,000. Assuming a modest 2% uplift in both birds and shooting, this yields an annual benefit to shooting of £1,000 Wildlife-related recreation and eco-tourism is likely to be high as various parts of the Glaven are covered by SAC (EU Habitats Directive) SPA (EU Birds Directive) + AONB designations. (Most designations are in downstream reaches, but restoration upstream will improve the whole river ecosystem.) The Countryside Agency (1998) estimated that rural tourism in the English countryside is worth nearly £14 billion a year and supports 380,000 jobs. Dividing the area of the Glaven catchment (115 km^2) by that of England (130,410 km^2) multiplied by that value yields a value of £12,345,679. Overlooking the fact that the Glaven is a desirable area worth more than

		the mean, and assuming a modest 1% uplift, yields an annual benefit of £123,456 Implications for local property are currently excluded from this valuation to avoid double-counting **Annual value = £123,459**
Addendum service: Local amenity and informal enjoyment **++**	This 'addendum service' to the basic Millennium Ecosystem Assessment suite has been added to capture benefits for local people that might not be adequately captured under the category of 'tourism'. Permissive paths and picnic areas constructed near sites at which restoration had taken place (upstream from Glandford Mill and around Little Thornage) were, in our judgement, used overwhelmingly by local rather than visiting people	Various reviews (for example O'Gorman, Bann and Caldwell, 2009) describe community valuation as a research gap in terms of 'willingness to pay' and other methods. However, taking an 'averted costs' approach and assuming that 25 people in the catchment per day would drive ten miles (@ 40p per mile) for walking, dog-walking or picnicking in pleasant surroundings, this yields an annual benefit of £36,500 **Annual value = £36,500**
Aesthetic value **0**	It is assumed for the purposes of this study that these values are captured by 'recreation and tourism'	**Annual value = £0**
Spiritual and religious value **?**	None identified	**Annual value = £0**
Inspiration of art, folklore, architecture, etc. **?**	None identified; any enhancement assumed to be captured under 'recreation and tourism'	**Annual value = £0**
Social relations (e.g. fishing, grazing or cropping communities) **++**	The sea trout restoration project has served as a focal point for a number of statutory, local conservation, key estate and landowner, and other groups, enhancing local social capital around river integrity. To assess this benefit, we would need to undertake a full social audit, for which we lack resources. The value of building of social capital amongst often formerly fragmented stakeholders in the catchment can not be underestimated. However, its valuation is complex. The approach used here is to seek to value volunteer activity	A surrogate value for this service is building of social capital derived from the level of volunteer activity in the catchment. A review by O'Gorman, Bann and Caldwell (2009) of the *The Benefits of Inland Waterways* to UK Government provided valuation of volunteers of unskilled @ £50/day, skilled @ £150/day and professional @ £350/day. The RRC (2006) 'Cinderella Chalk Streams' report on work on the Glaven records

		50 man days (assumed here as 30 unskilled, 15 skilled and 5 professional) plus 10 project co-ordination days (assumed 2 unskilled, 6 skilled and 2 professional) yielding £7,200. Since this coordination has been maintained towards the restoration of the Glaven, it is assumed to represent an annual value. **Annual value = £7,200**
Gross annual 'cultural services' benefits =		**£167,159**

Table A1.4. Supporting service impacts of current initiatives on the River Glaven.

Weighting (++, +, 0, -, --, ?)	Quantification?	Monetisation?
Supporting services		
Soil formation **+**	Improved habitat is also likely to enhance soil formation, which may be locally significant	Soil-forming processes from the re-wetting of reconnected floodplains are of undoubted value, but this is not monetised here so as to avoid double-counting with soil erosion **Annual value = £0**
Primary production **+**	Improved habitat is likely to enhance primary production and photosynthesis, but quantifying this is complex	Assumed beneficial but at a level likely to be lost in uncertainties of assessment, and marginal benefits assumed small in an area already enjoying a healthy environment **Annual value = £0**
Nutrient cycling **+**	Improved habitat is likely to enhance nutrient cycling, but quantifying this is complex	Assumed beneficial but at a level likely to be lost in uncertainties of assessment, and already discussed above in the context of NVZs **Annual value = £0**
Water recycling **+**	Improved habitat is likely to enhance water recycling, but quantifying this is complex	Assumed beneficial but at a level likely to be lost in uncertainties of assessment, and also not valued as considered captured in the final service of water regulation **Annual value = £0**

Photosynthesis (production of atmospheric oxygen) **+**	Improved habitat is likely to enhance primary production and photosynthesis, but quantifying this is complex	Assumed beneficial but at a level likely to be lost in uncertainties of assessment, and marginal benefits assumed small in an area already enjoying a healthy environment **Annual value = £0**
Provision of habitat **++**	Sea trout restoration is just part of the benefit of habitat enhancement for wildlife, including also a number of EU Habitats Directive species in the river (bullhead, brook lamprey, water voles, otters, etc.) Furthermore, barn owl breeding occurs at the Little Thornage site, the flood meadow providing important feeding habitat. Improved river morphology, overcoming obstructions to migratory fishes and reconnection of river channels with their floodplains is assumed to contribute to WFD goals averting direct costs. In addition, these conservation actions are also considered to contribute to Biodiversity Action Plans (BAPs) for chalk river, water vole, white-clawed crayfish and otter	Resilience of trout stocks is a clear benefit, but values are captured under the 'final service' of recreational angling Bullheads are being lost from many Norfolk streams. This restoration work is assumed to avert the need for active management (man/digger days + haulage costs) to clean habitat or undertake bespoke projects also beneficial to brook lampreys Taking the contribution of current and ongoing restoration work into account as a contribution to river management for SAC, SSSI, SPA, WFD and BAP purposes, to which volunteer and voluntary sector contribution make a substantial contribution, this supporting service is valued as the sum of the service of 'social relations'/volunteer input (£7,200) + the charged costs of the RRC 'Cinderella Chalk Streams' project (£7,140) and the same value again for WTT/RGCG contribution (£7,140) = £21,480 which is considered an annual cost **Annual value = £21,480**
Gross annual 'supporting services' benefits =		**£21,480**

End of Annex 1

Annex 2: Illustrative assessment of overcoming obstruction at Bayfield Hall Lake in the Glaven Catchment

This Annex contains detailed considerations of ecosystem services impacts of overcoming obstruction at Bayfield Hall Lake on the Glaven catchment. Methods, assumptions and deduced transferred values are outlined in Tables A2.1–A2.4 below, respectively for provisioning, regulatory, cultural and supporting services.

The working assumption here is that, if the obstruction of the culvert and lake are bypassed, the upper river will be accessible for colonisation by trout for which the presence of redds below the confluence provides circumstantial evidence. Much of this illustrative assessment is based on incremental uplifts to ecosystem service benefits already identified for 'current and ongoing' restoration initiatives.

Table A2.1. Provisioning service impacts of overcoming Bayfield Hall Lake obstruction on the River Glaven.

Weighting (++, +, 0, -, --, ?)	Quantification?	Monetisation?
Provisioning services		
Fresh water **0/+**	Bypassing obstructions may naturalise hydrology and enhance water quality but, as the it was not assessed previously, abstraction value is also assumed to be zero here	**Annual value = £0**
Food (e.g. crops, fruit, fish, etc.) **0/+**	It is assumed that more naturalised hydrology will enhance the desirability of connectivity of channel and floodplains downstream	If an additional 50% catchment area is transferred from ELS to HLS, this would yield an annual benefit of £10,000 **Annual value = £10,000**
Fibre and fuel (e.g. timber, wool, etc.) **0**	None anticipated	**Annual value = £0**
Genetic resources (used for crop/stock breeding and biotechnology) **0/+**	None anticipated	**Annual value = £0**
Biochemicals, natural medicines, pharmaceuticals **0/+**	None anticipated	**Annual value = £0**
Ornamental resources (e.g. shells, flowers, etc.) **0**	None known	**Annual value = £0**
Gross annual 'provisioning services' benefits =		**£10,000**

Table A2.2. Regulatory service impacts of overcoming Bayfield Hall Lake obstruction on the River Glaven.

Weighting (++, +, 0, -, --, ?)	Quantification?	Monetisation?
Regulatory services		
Air quality regulation **0**	None anticipated	**Annual value = £0**
Climate regulation (local temperature/precipitation, GHG sequestration, etc.) **0**	The lake and also the floodplain of the lower river may be net carbon sinks. It is assumed that the loss of the lake sink will be offset by increased sequestration in floodplains flooding more naturally	Losses assumed to balance gains in carbon sequestration **Annual value = £0**
Water regulation (timing and scale of run-off, flooding, etc.) **+**	Improved habitat and opening of obstructions is likely to provide a more natural hydrology, which may have local benefits for natural flooding regimes of important habitat as well as offsetting some flood risk to property. In particular, river channels, especially those connected to their floodplains, have substantially more flow buffering capacity that open stillwaters which have virtually none	A further 10% improvement in flood risk would yield an additional annual benefit of £11,400 **Annual value = £11,400**
Natural hazard regulation (i.e. storm protection) **+**	This benefit is likely to track that for hydrology, though quantification is more problematic	This is not valued in order to avoid double-counting; assumed to be rolled in with 'Water regulation' above **Annual value = £0**
Pest regulation **0**	This marginal difference is assumed to be negligible	There are complexities in valuing this benefit, but we ascribe it a zero value to avoid double-counting with 'food' **Annual value = £0**
Disease regulation **0**	This marginal difference is assumed to be negligible	The confounding factors – including breakdown of some pathogens but re-infection from agriculture of others – mean that no safe marginal value can be ascribed to this service **Annual value = £0**
Erosion regulation **0/+**	More natural hydrology and better connection with floodplain is likely to enhance erosion regulation, but lakes can trap up to 100% of silt from though-flow. It is therefore assumed that losses from bypassing the lake are offset by gains from the river accreting silt in floodplains	**Annual value = £0**
Water purification and waste treatment **0/+**	More natural hydrology and better connection with floodplain are likely to combine to enhance water purification and waste treatment	'Fresh water' benefits are not valued here as this final service is already assessed as a provisioning service, and NVZ and phosphorus

		benefits are considered marginal **Annual value = £0**
Pollination **0**	This marginal difference is assumed to be negligible	In this rural catchment, natural pollinators are not believed to be limiting so the marginal impact would be negligible **Annual value = £0**
Gross annual 'regulatory services' benefits =		**£11,400**

Table A2.3. Cultural service impacts of overcoming Bayfield Hall Lake obstruction on the River Glaven.

Weighting (++, +, 0, -, --, ?)	Quantification?	Monetisation?
Cultural services		
Cultural heritage **0**	Bayfield Hall Lake, the culvert and associated infrastructure has heritage value but it is assumed that this will be preserved in any modification, or at least any losses offset by the creation of attractive open flowing channel through which sea trout may migrate	**Annual value = £0**
Recreation and tourism **+**	Angling, shooting and ecotourism may be enhanced, though this is not the main purpose of the scheme	Assuming a modest 5% uplift on values derived from shooting and ecotourism under 'current and ongoing' restoration initiatives, but a 25% uplift of recreational angling, yields an annual value of £6,723 **Annual value = £6,723**
Addendum service: Local amenity and informal enjoyment **+**	This 'addendum service' to the basic Millennium Ecosystem Assessment suite has been added to capture benefits for local people that might not be adequately captured under the category of 'tourism'. Bayfield Estate is private but there is some permissive use for local people	3 people in the catchment per day would otherwise drive ten miles (@ 40p per mile) for walking/dog-walking in pleasant surroundings, yielding an annual benefit of £4,380 **Annual value = £4,380**
Aesthetic value **0**	It is assumed for the purposes of this study that these values are captured by 'recreation and tourism'	**Annual value = £0**
Spiritual and religious value **?**	None identified	**Annual value = £0**
Inspiration of art, folklore, architecture, etc. **?**	None identified; any enhancement assumed to be captured under 'tourism and recreation'	**Annual value = £0**
Social relations (e.g. fishing, grazing or cropping communities) **+**	The sea trout restoration project has served as a focal point for a number of statutory, local conservation and other groups, enhancing local social capital.	A 5% uplift is assumed relative to the value derived for 'current and ongoing' restoration

	This additional measure will enhance that, bringing the Bayfield Lake angling club and the Bayfield Hall estate more directly into the social capital network	initiatives, yielding an annual benefit of £360 **Annual value = £360**
Gross annual 'cultural services' benefits =		**£11,463**

Table A2.4. Supporting service impacts of overcoming Bayfield Hall Lake obstruction on the River Glaven.

Weighting (++, +, 0, -, --, ?)	Quantification?	Monetisation?
Supporting services		
Soil formation **0**	It is assumed that loss of soil formation from silting in the lake will be offset by increased soil formation in floodplains	**Annual value = £0**
Primary production **0**	Marginal difference relative to current initiatives is assumed to be negligible	**Annual value = £0**
Nutrient cycling **0**	It is assumed that loss of nutrient cycling from lake through-flow will be offset by increased nutrient cycling in floodplains	**Annual value = £0**
Water recycling **+**	Improved habitat is likely to enhance water recycling, but quantifying this is complex	Marginal benefits assumed small, and considered captured in the 'final service; of water regulation **Annual value = £0**
Photosynthesis (production of atmospheric oxygen) **+**	Marginal difference relative to current initiatives is assumed to be negligible	**Annual value = £0**
Provision of habitat **++**	The benefits of overcoming this major obstruction to migratory fish as well as fluxes of water and sediment are likely to be significant for bullheads, brook lampreys and other species of conservation concern as well as a major contribution to WFD 'good ecological status'	Resilience of trout stocks is a clear benefit, though values are captured under the 'final service. of recreational angling Benefits for protection of Habitats Directive species (particularly bullheads and brook lampreys) as well as the contribution to river management for SAC, SSSI, SPA and WFD purposes, is, conservatively, at least as great as the cumulative schemes already taking place (and in reality probably far more so dependent upon scheme design) **Annual value = £21,480**
Gross annual 'supporting services' benefits =		**£21,480**

End of Annex 2

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