Appendix 14.5

Report on Ecosystem Services Valuation

Background

The initial assessment for the project focused upon an appraisal of ecosystem service impacts of the main woodland measures to be implemented (Nisbet *et al*, 2011, Appendix 12.5). The assessment was updated in 2013, separating out impacts by catchment.

The purpose of this report is to provide a further update and fuller assessment of the ecosystem service impacts based upon new information on the measures implemented to date and refinements to some of the approaches adopted in earlier assessments. It incorporates: revised (lower) estimates of the new woodland created in the Pickering Beck catchment (19 ha of riparian woodland – down from the 50 ha assumed in 2011 and 25 ha in 2013); a different mix of woodland in the River Seven catchment (10 ha of riparian and 15 ha of farm woodland, compared to 25 ha of farm woodland assumed in 2013); an increase in the number of large woody debris dams created in the Pickering Beck catchment (from 100 to 129) and decrease in the River Seven catchment (from 50 to 38); and the contribution of the two timber bunds in the River Seven catchment.

This report extends the assessment to also consider the full range of land management interventions undertaken as part of the project. Individual results are provided for the two catchments (as well as combined estimates for both), with separate estimates given for the group of woodland, moorland and farm measures, and for these plus the large flood storage bund (i.e. for the entire project).

Of the measures implemented, five deal with woodland: new planting of riparian plus farm woodland, the construction of large woody debris dams (LWD) dams, amending forest design and management plans (small-scale felling and restoration of streamsides), and construction of timber bunds. There are also four non-woodland measures: constructing the large flood storage bund, installing farm measures (mainly yard works to reduce runoff - e.g. check dams), controlling moorland runoff (e.g. use of heather bale check dams and heather reseeding), and establishing no-burn buffer zones.

The same ecosystem service impacts are considered in this report as in the previous assessments (for a discussion of choice of impacts covered, see Nisbet *et al*, 2011).[1] These comprise seven categories:

1) Provision of habitat
2) Flood regulation
3) Climate Regulation

[1] Benefits and emissions associated with the large flood storage bund would not normally be classified as ecosystem services as they are not provided by nature. However, referring to similar types of benefits in other respects, for simplicity they are included in this study in considering ecosystem service impacts.

4) Erosion Regulation
5) Education and knowledge
6) Community engagement
7) Agricultural production

Each category of ecosystem service is discussed separately below. As the woodland is likely to be established in perpetuity, the impact on associated ecosystem service flows are expected to extend into the distant future. However, a 100-year time horizon is selected for the purposes of this study in order to facilitate comparison with other analyses of woodland projects over a similar time-frame.

Provision of Habitat

a) Woodland measures

All the woodland planted under the project is broadleaved. The previous land use in the areas where the riparian woodland was created was rough pasture – both within Pickering Beck catchment (19 ha distributed between 8 locations), and the River Seven catchment (10 ha as almost one continuous reach). For the planted farm woodland (15 ha in two blocks in the River Seven catchment), the previous land use was improved grassland.

Existing evidence on the marginal value of woodland habitat types created by the project appears very limited at present. Hanley *et al* (2002), for example, present willingness to pay (WTP) estimates per ha for different woodland types in the UK[2], but not specifically for riparian or farm woodland. The WTP estimate for 'Lowland New Broadleaved' of £0.84/ha/yr may be the closest category, but it is not entirely clear what the relevant population would be if this value were to be used to compute an aggregate value per hectare.

Based on a meta-analysis of data from the UK, the EU and Scandinavia, Eftec (2010a) hypothesise that the non-use value of woodland biodiversity together with the cultural services value of woodlands ranges from £30-£300/ha/yr, depending on the priority status of the woodland. Although riparian woodland is a priority habitat type and thus the value for this might be expected to lie at the high end of this spectrum, the range should be viewed as indicative given the little hard evidence on which it is based. Limited knowledge of how different generic woodland types affect biodiversity outcomes hampers distinguishing separate values for each (Eftec 2010a). While these are likely to depend upon specific spatial characteristics (e.g. the extent to which they enhance existing habitat networks), broadleaf farm woodlands in general might be expected to be associated with intermediate values in the spectrum.

The planted riparian woodland lies predominantly on adjacent slopes rather than on existing marshland. For the purpose of this valuation, a value of £300/ha/yr is assumed for the high estimate from the top end of the Eftec (2010a) range, with low and central estimates of £250/ha/yr and £275/ha/yr, respectively, at 2010 prices (these

[2] The woodland categories adopted by Hanley *et al* (2002) are: Upland Conifer (£0.35/ha/yr); Lowland Conifer (£0.33/ha/yr); Lowland Ancient Semi-Natural Broadleaved (£1.13/ha/yr); Lowland New Broadleaved (£0.84/ha/yr); Upland Native Broadleaved (£0.90/ha/yr); and Upland New Native Broadleaved (£0.61/ha/yr)

are then reflated to 2015 prices based upon the anticipated increase in the Treasury GDP deflator).[3] This approach is adopted in accounting for the impact on habitat provision of all the riparian woodland created (i.e. the 19 ha in the Pickering Beck catchment and the 10 ha in the Seven catchment).

For the farm woodland, an indicative value at 2010 prices of £165/ha/yr is assumed from the mid point of the Eftec (2010a) range for the central estimate, and £100/ha/yr and £230/ha/yr for low and high estimates, respectively (each is similarly reflated to 2015 prices based upon the expected change in the Treasury GDP deflator).

In each of the above cases the habitat values are assumed to increase linearly from zero on planting until they are fully realised, either once trees reach 55 years (low estimate), 20 years (central estimate), or 10 years old (high estimate). Thus for the 15 ha of riparian (non-floodplain) woodland planted in 2011 in the Pickering Beck catchment (and also the 15 ha of farm woodland planted that year in the River Seven catchment), the maximum aggregate value is reached either in 2066, 2031, or 2021 (i.e. year 55, 20 or 10) respectively, thereafter being assumed to remain constant[4] (the maximum aggregate habitat value in each case is reached two years later due to the last woodland planting assumed to occur in 2013). For the two catchments combined, the approach implies a maximum value of around £12,000/yr to £13,000/yr.

In addition to woodland creation, there has also been a loss of conifer woodland from restoring the riparian zone in Cropton Forest, involving 3.2 ha in the Pickering Beck catchment and 2.6 ha in the River Seven catchment. The conifers have been felled and left for natural regeneration to convert the area to broadleaf woodland.[5] For the purposes of this assessment, indicative habitat benefits of conversion from conifer to broadleaf woodland of 60% of the habitat values per hectare assumed for woodland creation are taken for the central estimate, and ranged for sensitivity analysis from 40% (low estimate) to 80% (high estimate). The percentage for the central estimate draws upon the difference in the Hanley *et al* (2002) WTP estimates for lowland conifers (£0.33/ha/yr) and lowland broadleaves (£0.84/ha/yr), as a proportion of the latter.[6] The assumed per hectare values at 2010 prices (once the broadleaf woodland is fully established) range from £100/ha/yr to £240/ha/yr, with a central estimate of £165/ha/yr. In each case, one tenth of the area is assumed to naturally regenerate to broadleaves in each of the first ten years after felling the conifers. For the total of 5.8 ha of conifer woodland converted in both catchments, the approach implies a maximum of around £600/yr for the low estimate, £1,100/yr for the central estimate, and £1,500/yr for the high estimate.

b) Non-woodland measures

The large flood storage bund is considered to have no significant impact on habitat provision. The existing land use (pasture) continues after the construction of the bund.

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[3] See: http://www.hm-treasury.gov.uk/data_gdp_fig.htm (accessed 16/3/15).

[4] Note that the phased planting from 2011-13 affects when stabilisation occurs.

[5] The conversion of existing conifer woodlands to broadleaves is occurring more widely too (e.g. on 20.6 ha of the adjacent gullies), but as this does not form part of the Slowing the Flow project, associated impacts are not considered here.

[6] i.e. $0.6 \approx [(0.84 - 0.33)/0.84]$.

Furthermore, the area is expected only to be under water at most for between 12-18 hours every 10 years.

The farm and moorland measures are similarly not expected to have a significant impact on habitat provision. None of the measures involve creation of new habitat. The moorland check dams only act during high flows and then for a matter of a few hours at most, so their impact on habitat is expected to be minimal. Small areas of heather have been improved by reseeding – and generally also (except for grouse)[7] by controls on burning, but as the impact of this on overall habitat provision is considered relatively small and as no corresponding marginal value estimates are available, this was not included in the assessment.

Flood Regulation

Pickering has experienced significant flooding four times in the last 10-15 years (1999, 2000, 2002 & 2007). The 2007 floods were particularly severe, causing an estimated £7m in damage to homes and businesses.[8] Modelling suggests that to prevent flooding in the town for events similar to 2007 would require creating 570,000 m^3 of flood storage upstream in the Pickering Beck catchment, rather than the 650,000 m^3 of flood storage originally estimated (Odoni and Lane, 2010). For smaller events such as the 2000 flood, which affect around 50-60 properties on average about once every 25 years, around 120,000 m^3 of flood storage would be required. Although more recent estimates suggest a lesser volume may be needed,[9] this value is used as it provides a margin of additional protection from potential increases in flood risk associated with climate change over the 100-year time horizon considered.

Flood protection for a 1 in 25 year flood was estimated in 2013 by the Environment Agency (Dean Hamblin, pers. com.) to provide total cost savings of £4.2m over 100 years in present value terms.[10] This is equivalent at 2015 prices to an annual saving of around £147,000, or £1.23 per cubic metre of flood storage. The total estimated savings are derived from a high level cost-benefit analysis based upon the approach recommended in the Multi-coloured manual on economic appraisal of flood and coastal risk management.[11] The £4.2m estimate covers savings to both residential and business properties (92.4%), as well as to traffic (7.6%).

As noted above, an additional 450,000 m^3 of flood storage would be needed to prevent the town flooding for events similar to that in 2007. This would be expected to save around £7 million (at 2007 prices) in damage to homes and businesses once every 100 years, but also provide protection from intermediate (e.g. 1 in 50 year) flood events. Dividing the damage avoided by preventing flooding from such a 1 in 100 year event

[7] See: http://www.nargc.ie/habitat-conservation/heather-management-within-an-sac-by-burning---the-first-steps.aspx (accessed 17/3/15) for a perspective on the role of heather burning for providing grouse habitat.

[8] See: http://www.forestresearch.gov.uk/fr/INFD-7ZUCL6.

[9] Recent Environment Agency estimates suggest that only 80,000 m^3 of flood storage may be needed to prevent flooding by taking the top off the flood peak.

[10] i.e. discounted at Treasury Green Book rates.

[11] See: http://www.mdx.ac.uk/our-research/centres/flood-hazard/flood-hazard-research-centre-publications.

by the additional flood storage required, suggests the annual benefit of further flood storage is at least £0.19/m^3/yr at 2015 prices.

In the absence of evidence on the damage avoided by preventing flooding from intermediate events, or the shape of the relationship, for the purposes of this report, the value per cubic metre of additional flood storage above 120,000 m^3 at 2015 prices is ranged from £0.19/m^3/yr (low estimate) to £1.23/m^3/yr (high estimate). A central estimate of £1.20/m^3/yr based on assuming a linear decrease in the per cubic metre benefit with increasing flood storage and then rounding the flood benefit down is adopted.[12]

a) Non-woodland measures

The storage bund will have a storage capacity of 120,000 m^3 once completed. Thus, providing the flood storage required to prevent the town flooding for 1 in 25 year events similar to that in 2000, it is assumed to provide an annual flood risk reduction benefit of around £147,000 per year at 2015 prices. Since the bund will not become fully operational until July 2015, it is calculated to provide only half the full total annual flood benefit in the first year.

A total of 187 heather bale check dams have been constructed as part of the project – 130 small dams in February 2011 and 57 larger dams in January 2012. On average each of the small dams is thought to provide around one cubic metre flood storage, with the larger dams contributing two cubic metres per dam. Constructed within the Pickering Beck catchment, the dams provide some 244 m^3 of flood storage in total, implying a maximum annual benefit at 2015 prices from 2013 onwards ranging from £46 to £300, with a central estimate of £293 per year.[13]

Farm measures were implemented over the period 2012-2014. In the absence of detailed information, these are assumed to provide a nominal storage volume of 100 m^3, split 50:50 between the two catchments, with the proportion of additional flood storage added in each year based upon the number of measures implemented (two in 2012, one in 2013 and seven in 2014). This gives an estimated maximum annual value at 2015 prices from 2014 onwards ranging from £19 to £123 per year, with a central estimate of £120 per year at 2015 prices.

b) Woodland measures

The planting of 19 ha of riparian woodland and creation of 129 large woody debris dams in the Pickering Beck catchment is expected to contribute the equivalent of between 3,000 m^3 and 9,000 m^3 of flood storage (central estimate 6,000 m^3) in the

[12] Linear interpolation suggests a decline of £0.02/m^3/yr in the value per cubic metre associated with the additional flood storage. The high estimate for flood storage associated with the woodland measures, combined with the estimate for the non-woodland measures implies total additional flood storage of 9,294 m^3. The central estimate rounds down the estimated value associated with this additional level of flood storage from £1.21/m^3/yr.

[13] The smaller dams are assumed to provide 10/12th of their full annual benefit in 2011 and the larger dams 11/12th of their full annual benefit in 2012 to reflect their construction in January that year in both cases.

upper catchment for a 1 in 25 year flood event,[14] This translates into an avoided damage saving over the 100-year period ranging from £55k to £1.1m, with a central estimate of £720k at 2015 prices (the corresponding mean annual benefit ranges from around £550 to £11,000, with a central estimate of £7,200). These estimates are net of the estimated 300 m^3 reduction in flood storage associated with conversion of 3.2 ha of existing riparian conifer woodland to broadleaves in the catchment. The flood risk reduction benefits are assumed to accrue fully from year 3 onwards (i.e. the year after all the woodland has been planted) and to increase linearly from 70% of this level in 2012 (i.e. year 1) up to the maximum in 2014.[15] It is recognised that these calculations only give a very rough guide to the nature of the potential contribution from the woodland measures, with benefits of the woodland measures contingent upon the total additional storage needed for a given level of flood risk reduction to be achieved.

In the Seven catchment, the 25 ha of woodland planting, 38 large woody debris dams, and two timber bunds are estimated to provide in total around 6,400 m^3 of flood storage.[16] The above discussion illustrated some of the difficulties in estimating the value of the woodland measures for flood risk mitigation in the Pickering Beck catchment. At present there is no flood damage cost data on which to base flood risk reduction value estimates for the measures implemented in the adjacent River Seven catchment. However, as a thought experiment, indicative estimates for the value of this flood storage have been derived based upon the range of values per cubic metre used for the Pickering Beck catchment. These suggest that the maximum annual values may range from about £1,000 (minimum) to £8,000 (high), with a central value around £7,700 per year, at 2015 prices.

Climate Regulation

a) Woodland measures

Carbon sequestration estimates covering standing biomass, soils and woody debris were obtained from Forest Research's C-SORT model along with estimates of carbon emissions from associated forestry operations. The carbon sequestration estimates are for a Sycamore-Ash-Birch mix (yield class 6) planted on gley soils and assuming 2.5 m initial spacing.[17] These species are considered to best represent the woodland most likely to be planted under the scheme. The estimates assume no thinning, no ploughing of the initial ground, no forest roads constructed or maintained, and no extraction or transportation of material from the site (or processing of material off site),[18] and, where used, fencing based on rectangular 2 ha blocks.

[14] The 3,000 m^3 figure comes from an assessment of the modelled flood storage of individual LWD dams (1200-1300 m^3) plus interception loss (190-380 m3) and soil moisture deficit (1900 m^3), minus ~300 m^3 reduction in interception due to conifer removal from around 2 ha. The 9,000 m^3 figure is based on previous interpolation of the OVERFLOW model results.

[15] By contrast, for the low estimates, they are assumed to increase from around 50% in year 0 to 70% in year 1, to 90% in year 2 (with the full benefits also assumed from year 3 onwards).

[16] The two timber minibunds are estimated to provide 3,600 m^3 of flood storage, the large woody debris dams 300 m^3, the 25 ha of woodland created about 2,840 m^3 and the 2.6 ha of conifers felled to reduce flood storage by around 240 m^3.

[17] 2.5 m spacing is the minimum density for native woodland planting under the English Woodland Creation Grant scheme. The estimates for this spacing are based upon interpolation (Tim Randle, pers. com.) The model used is assumed to apply to a wide range of broadleaved species.

[18] i.e. that any trees felled is to waste.

In estimating associated values, staged planting of riparian and farm woodland over 2011-2013 (with combined totals of 30 ha in 2011 and 14 ha in 2013) is accounted for, as is open space. Estimates are reduced by one fifth to account for an assumed 20% open ground, and for sensitivity analysis, the carbon estimates were ranged by +/-20%. While it is envisaged that the woodland planted will be maintained in perpetuity, non-permanence risks (e.g. associated with windthrow and fires) were then also accounted for by applying a buffer of 30% (low estimate), 20% (central estimate), or 15% (high estimate) to reduce the carbon estimates.[19] This is broadly in line with the 15%-30% buffer currently recommended under the Woodland Carbon Code.[20] The (low, central and high) social values of carbon currently recommended by the Department of Energy and Climate Change for sectors not covered by the EU Emissions Trading Scheme (ETS) are then applied.[21]

Both carbon sequestration rates and carbon values vary over time. The combined estimates for woodland creation in the Pickering Beck and River Seven catchments show net carbon emissions in the first year (year 0) as a consequence of factors including use of machinery for planting,[22] followed by increasing abatement rising to a maximum over 550 tCO_2/yr (central estimate) after twenty three years, thereafter generally declining. The mean over the 100 year period[23] is around 210 tCO_2/yr (central estimate). This is equivalent to an average annual carbon sequestration rate of about 4.8 tCO_2/ha/yr. As a consequence of assumed increasing social values of carbon over time, the associated total annual value of net carbon abatement (taking into account standing biomass, woody debris, soils and forest operations) valued at central DECC carbon values increases to a maximum approaching £88,000/yr (central estimate) after 45 years for both catchments combined. The mean for both catchments combined over the 100 year period is £42,000/yr (central estimate).

Impacts of converting 3.2 ha of existing riparian conifer woodland (assumed Sitka spruce yield class 12, 1.7 m spacing planted on gley) in the Pickering Beck catchment and 2.1 ha in the River Seven catchment to naturally regenerating broadleaved woodland were also estimated. Conversion to broadleaves (represented by a Sycamore-Ash-Birch mix yield class 4, 2.5 m initial spacing on gley) was estimated for both catchments combined to lead to a mean reduction in carbon savings of 36 tCO_2/yr (central estimate) over the 100 year time horizon. Equivalent to a reduction of

[19] These are assumed to apply to the positive sequestration estimates, but not to forestry operations emissions.
[20] See: http://www.forestry.gov.uk/carboncode.
[21] Values recommended for 2100 are assumed to apply also in subsequent years.
[22] The estimates from the latest version of the CSORT model use an updated soil carbon module that for mineral soils such as gley, start with an initially relatively low level of soil carbon that increases after planting (rather than the initial decline assumed previously).
[23] i.e. years 0-99 inclusive.

around 6 tCO_2/ha/yr (central estimate),[24] the associated mean value is around £8,000/yr at central DECC carbon values.[25]

b) Non-woodland measures

An assessment for the Environment Agency in 2014 estimated total emissions associated with construction of the storage bund of 1502.4 tCO_2 (see Table 1 below).

Table 1: Carbon impacts of construction of the flood storage bund

	Emissions (tCO_2)	% of total
Concrete, Mortars & Cement	621.5	41%
Portable site accommodation	295.7	20%
Plant and equipment emissions	181.6	12%
Metals	175.7	12%
Quarried Material	163.7	11%
Personnel travel	39.1	3%
Material transport	12.2	1%
Plastics	10.9	1%
Timber	2.1	0%

Source: Environment Agency (Dean Hamblin, pers. com.)

The construction of the bund largely occurred during January to October 2014, with its completion postponed until suitable weather conditions in May/June 2015. Assuming 90% of construction-related emissions occurred during 2014, applying DECC social values of carbon implies a total carbon cost at 2015 prices for construction of the bund ranging from £47,000 (low estimate) to £140,000 (high estimate), with a central estimate of £93,000.

The farm and other measures implemented are not considered to have had significant climate impacts.

Erosion Regulation

a) Woodland measures

Planting woodland is expected to reduce the amount of sediment reaching watercourses. This would reduce any consequent need for downstream dredging, and potentially have other beneficial impacts too (e.g. in helping maintain soil fertility, improving water quality and preventing deterioration of habitats for fish and other

[24] Adopting a similar approach to that applying under the Woodland Carbon Code, the counterfactual for the existing conifer woodland assumes that once the long-run average net carbon sequestration is reached (estimated over 200 years at 203 tCO_2/ha based upon 60 year rotations), this level is then maintained. In addition, carbon in the harvested wood products pool is assumed to fall to zero at the end of the 100-year time horizon, rather than accounting for its subsequent release (this is equivalent to assuming that the social value per tCO_2 of the carbon remains constant in real terms at the end of the time horizon).

[25] Note both traded and non-traded values are used as a small proportion of the reduction in carbon savings is assumed to be associated with a reduction in use of woodfuel substitution for electricity.

aquatic species).[26] For the riparian woodland planting sites in the Pickering Beck catchment, estimates from the ADAS PSYCHIC model suggest the annual volume of sediment currently delivered by adjacent slopes to watercourses to be 12,365 kg.[27] Assuming 50% to 100% retention by woodland implies annual sediment removal following planting in the region of 6,000 to 12,000 kg per year. Based upon an assumed average density of 1.4 t per cubic metre, this gives a range for total sediment retention by the riparian woodland of 4.3 to 8.6 m^3 per year, with an equivalent range per hectare of 0.23 to 0.45 m^3/ha/yr.

For the riparian woodland planting sites in the River Seven catchment, estimates from the model suggest the annual volume of sediment delivered by adjacent slopes to watercourses to be 3,537 kg.[28] Assuming the same retention rates as before implies annual sediment removal by the new woodland in the region of 1,800 to 3,500 kg per year. This equates to 1.3 to 2.5 m^3 per year, with a range per hectare of 0.05 to 0.10 m^3/ha/yr retained by the planting.

The large woody debris dams are roughly estimated to each retain around 10-20 kg of sediment, which is assumed to be a one-off reduction in the year of their construction. For the Pickering Beck catchment, this gives a total of between 1,000 to 2,000 kg of sediment retained by all of the dams constructed, and equivalent figures of 400 to 800 kg for the River Seven catchment (in both cases assumed to occur in 2011).

Few studies exist that have estimated the benefits of controlling soil erosion in the UK (see Inman, 2006). In the absence of data to estimate the value of the retained sediment for water quality and biology, this valuation is limited to a consideration of the potential cost saving in terms of downstream dredging (assuming that the total downstream deposition of sediment (including that from the rest of the catchment) is sufficiently high for dredging to be considered necessary; and not ruled out on wider environmental grounds). A dredging cost at 2011 prices of £14/m^3 was used, taken from the mid-point estimate of unit dredging costs that are reported to have applied in the Norfolk Broads in 2005/6.[29] For the riparian woodland planting, the maximum reduction in sedimentation is assumed to occur 10 years after planting, with a linear increase from zero in year zero up to year 10 assumed. The approach implies maximum annual benefits in the Pickering Beck and River Seven catchments combined ranging from £84/yr (low estimate) to £166/yr (high estimate), with a central estimate of £125/yr at 2015 prices, that apply from 2023 (i.e. year 12) onwards.

b) Non-woodland measures

[26] There is fishing in the Pickering Beck primarily for trout, but also grayling (see: http://www.pickeringfishery.co.uk/index.html), but no estimates are available of the impact of sediment loads on species abundance or the value of this fishery.

[27] This estimate comprises 11,189 kg associated with the 15 ha of riparian woodland planted in 2011 and 1,176 kg with the woodland planted in 2013 (with differences per hectare related to differences in soil type and erodibility).

[28] This estimate comprises 1,334 kg associated with the 15 ha of farm woodland planted in 2011 and 1,176 kg with the 10 ha of riparian woodland planted in 2013 (with differences per hectare related also to differences in the proximity of woodland planted to the river).

[29] This is based upon the mid-point of the reported range of £13-£15/m^3 - see: http://www.broads-authority.gov.uk/broads/live/authority/meetings/navigation-committee/2005/09-08/%5Breport%5D%20Dredging%20programme%202005-06-Update.doc.

The 187 heather bale check dams constructed in the Pickering Beck catchment are estimated to retain 10 kg sediment per dam, giving a total of ~2,000 kg of sediment prevented from reaching local watercourses. This is assumed to be a one-off reduction and to occur in 2011, giving a benefit of around £22/yr at 2015 prices. The main flood storage bund is expected to have minimal effect on erosion control in view of its very infrequent use. The impact of the farm measures is expected to be small in view of their relatively limited extent.

Education & Knowledge

The Slowing the Flow project is expected to create opportunities for educational visits to find out about flood risk management using natural processes, such as woodland creation and improved moorland and farm management. There was an average of four education-related visits per year to the project by schools/colleges/universities and professional groups during the four years of Phase II of the project (2011 to 2014 inclusive). This number is thought likely to drop to three visits per year in 2015, two in 2016, one visit per year in the subsequent four years, and an average one visit every two years thereafter (depending on how many similar demonstration projects are initiated in the region in the future).

Although there appears to be no well established methodology for estimating associated values at present, a simple approach used in some previous studies is to consider cost savings involved with visits to the new site compared to existing alternatives. While details are uncertain, potentially cost savings could be quite significant for some of the professional group visits (if one considers, for example, that the main alternatives where similar measures have been implemented to date are distant to the site).

For the purpose of providing tentative indicative estimates, it is assumed that the education and knowledge mean value per visit (in terms of avoided costs) at 2011 prices ranges between zero (minimum estimate) and £200 (maximum estimate), with a central estimate nearer the lower end (£40). The high estimates are comparable with the estimates for the ecological value of outdoor learning visits by schools derived in a study for the UK National Ecosystem Assessment (Mourato, et al 2010) which, focussing upon visits to RSPB reserves, suggested values of around £16 to £26 per pupil visit.[30] However, while arguing that 'investment' elements of such trips were likely to be predominant (given that the trips typically occur within school hours), the authors noted the difficulty of attributing costs entirely to increasing ecological knowledge (as opposed to 'consumption' elements associated with immediate enjoyment of visits). Furthermore, no estimates are made of the net value of the visits compared to visiting alternative sites (i.e. those not owned by the RSPB) – which could have been expected to be lower (and more relevant to the current study).

[30] Illustrative estimates in Mourato, et al (2010) are derived assuming a pupil to staff ratio of 10:1, an average staff salary of £35,000 for 195 8-hour working days per year, a cost to parents of £8 to £12 per pupil for each trip, 20-40 minutes travel time each way and a total of 30-45 minutes of 'excess time' (e.g. waiting) per trip and range from £851,000 to £1,324,000 for all recorded school visits to RSPB reserves in 2009/10 (Mourato, et al 2010, Table 8, p.42).

It is assumed from year 10 onwards for the high estimate that there is one visit a year and for the low estimate that there are no further visits. As they represent about half the land management interventions in the Slowing the Flow project, woodland measures are assumed to account for half the total education and knowledge benefits, with the other half associated with the moorland and farm measures. Reflating values to 2015 prices using the Treasury GDP deflator, this approach implies aggregate annual values associated with the woodland measures of £86 (central estimate) and £431 (high estimate) in years 0-3 years, declining in steps to £11 and £108 a year respectively from year 10 onwards. These benefits are considered to apply to the Pickering Beck catchment alone.

Community Engagement

Volunteers continue to make an important contribution to the Slowing the Flow project, including through participation in Programme Delivery Group meetings, community engagement events, liaising with partners, promoting the project via the media, tree planting and providing support for monitoring work. The level of support is estimated to average 190 person hours per year during Phase II and is assumed will be maintained at this level into the future. Increased social networking, social capital and community cohesion are viewed as important benefits of the participatory nature of the project. These have arisen partly as a result of greater understanding of the how land-use can contribute to flood risk management and provide additional ecosystem services, as well as greater community cooperation in the evolution of the project.

It is not immediately clear how best to value such benefits, nor to what extent they might have been realised through different activities had the project not gone ahead. However, Volunteer England (a charity and membership organisation concerned with volunteering in England) note that the simplest approach is to multiply the total number of volunteer hours by an average hourly wage.[31]

Volunteer time is then valued either at the main national minimum wage of £6.50/hr in 2014/5 (central estimate),[32] at the gross mean wage rate in 2013/4 in Ryedale Council District in North Yorkshire of £11.08/hr (high estimate),[33] or no monetary benefit is assumed (low estimate) as the time volunteered might have been put to an equally good use for the community in the absence of the project. All of the community development benefits were considered to flow from the woodland, moorland and farm measures, rather than from the large flood storage bund. Reflating values using the Treasury GDP deflator, this approach implies indicative maximum annual benefit estimates associated with the woodland measures ranging from zero (low estimate) to £2,053 (high estimate), with a central estimate of £1,080 at 2015

[31] http://www.volunteering.org.uk/resources/goodpracticebank/Core+Themes/Volunteer+Managers+and+Coordinators/Is+there+any+way+of+measuring+the+economic+value+of+the+work+our+volunteers+are+doing.htm.

[32] https://www.gov.uk/national-minimum-wage-rates (Note the minimum wage is lower for workers under 21).

[33] This is from Table 7.5a of the 2014 Annual Survey of Hours and Earnings (provisional version) published by the Office of National Statistics. See: http://www.ons.gov.uk/ons/publications/re-reference-tables.html?edition=tcm%3A77-337425. At 2015 prices, the hourly rate assumed is £11.31 (based upon the projected increase of 2.1% in the Treasury GDP deflator for 2014/15).

prices. These benefits are also assumed to apply to the Pickering Beck catchment alone.

Agricultural production

Current land uses expected to be converted into woodland comprise rough grassland used mainly for sheep grazing in the case of the riparian woodland, and a mix of arable crops and improved grassland for farm woodland. It is unclear to what extent agricultural production values will fall on local farms where areas are planted with woodland. However, for the purpose of providing rough indicative estimates, it is assumed that farm gross margins (low estimate), farm business income before accounting for the single farm payment (high estimate), or intermediate values closer to the former than the latter (central estimates)[34] based upon those in Craig (ed) (2014) apply. The low and high values for farm woodland (-£497/ha and -£37/ha) are taken from figures for lowland grazing livestock farms in England. As planting is likely to be on relatively steep ground with limited existing access, low and high estimates for riparian woodlands (-£129/ha and £4/ha)[35] are assumed to be half the figures for grazing livestock farms in less favoured areas (in each case these figures are assumed to be in 20012/13 prices and are reflated using the Treasury GDP deflator and then interpolating based upon the estimates for 2014/15 and 2015/16 to derive associated opportunity costs at 2015 prices). This approach implies that the central estimate at 2015 prices for the total value of lost agricultural production in both catchments combined is -£7,543 in 2011 and in 2012, then stabilising at -£8,950 from 2013 onwards.

Discussion

As noted above, the value of most of the ecosystem service impacts delivered can be expected to vary over time and to be sensitive to a range of underlying assumptions. Minima, maxima and means for each of the indicative central estimates for each of the impacts at 2015 prices are summarised in Tables 2a and 2b below for the woodland, moorland and farm measures, and for these plus the large flood storage bund (i.e. all project measures), respectively.

The large negative figures shown for the minimum climate regulation benefits relate to the effect of the clearance of conifer woodland from riparian zones and conversion to broadleaves (the carbon benefits of the harvested wood products and carbon substitution at the end of the first rotation under the baseline Sitka spruce option are not realised once the woodland is converted to broadleaves and left unharvested). The mean figures for climate regulation are higher in the River Seven catchment than the Pickering Beck catchment due to the greater woodland creation (25 ha compared to 19 ha) and lower area of conversion of existing conifer woodland to broadleaves (2.6 ha compared to 3.2 ha).

[34] They include three-quarters of the difference between the gross margin and the net farm income (reflecting the idea that machinery and other costs may not be reduced much at the margin by farming a smaller area of the farm).

[35] A positive agricultural opportunity cost for the high estimate corresponds to cases where farms operate at a loss prior to subsidies being taken into account.

Table 2a: Indicative annual ecosystem service values based on central estimates for the woodland, moorland and farm measures

	Pickering Beck catchment			River Seven catchment		
	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)
Habitat creation	0	£6.3	£5.6	0	£6.2	£5.5
Flood regulation	£5.2	£7.6	£7.5	£6.0	£7.7	£7.7
Climate regulation	-£313.9	£66.7	£13.9	-£390.1	£53.0	£20.0
Erosion Regulation	£0.009	£0.097	£0.092	£0.001	£0.028	£0.026
Education and knowledge	£0.022	£0.173	£0.030	n.a.	n.a.	n.a.
Community development	£1.2	£2.4	£1.3	n.a.	n.a.	n.a.
Agricultural production	-£1.9	-£1.5	-£1.9	-£7.0	-£6.0	-£7.0

Note: n.a. = not available (not estimated)

Table 2b: Indicative annual ecosystem service values based on central estimates for all of the land management interventions (woodland, moorland and farm measures plus the main bund)

	Pickering Beck catchment			River Seven catchment		
	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)
Habitat creation	0	£6.3	£5.6	0	£6.2	£5.5
Flood regulation	£5.2	£154.7	£149.5	£6.0	£7.7	£7.7
Climate regulation	-£313.9	£66.7	£12.9	-£390.1	£53.0	£20.0
Erosion Regulation	£0.009	£0.097	£0.092	£0.001	£0.028	£0.026
Education and knowledge	£0.022	£0.17	£0.030	n.a.	n.a.	n.a.
Community development	£1.2	£2.4	£1.3	n.a.	n.a.	n.a.
Agricultural production	-£1.9	-£1.5	-£1.9	-£7.0	-£6.0	-£7.0

Note: n.a. = not available (not estimated)

Differences in the approaches used to quantify the different benefit estimates hampers direct comparisons. For example, the flood regulation, erosion regulation and knowledge and education benefits are based upon cost savings rather than consumer

values. Where a service is in demand, its value will generally be higher than the costs of production due to also reflecting elements of consumer and producer surplus, while where there is little demand, values may be lower than the costs. The costs of preventing losses, or the costs of alternatives, do not provide direct measures of value, but the Green Book considers such information can be useful in focusing discussion. Furthermore, supplementary guidance (Dunn, 2012, p.9) notes that the price paid by individuals to mitigate environmental effects may be used as a proxy for the value (given the example of using the costs of water filtration as a proxy in valuing water pollution damages). The Green Book also notes more generally the potential role for applying weighting and scoring to incorporate quantified data into the appraisal along with values (HM Treasury, 2003, p.58).[36]

For the woodland measures (whose contribution dominates most of the values in Table 2a), the results indicate that climate regulation is the largest benefit in both catchments, followed by flood regulation and then habitat creation (based on mean, or aggregate, values). Flood regulation is by far the largest benefit for all project measures in the Pickering Beck catchment, dominated by the contribution of the flood storage bund. Sensitivity analysis also tends to support this conclusion (low and high estimates are shown in the Annex at 2015 prices for the woodland, moorland and farm measures and all measures, respectively). However, the relative importance of the different impacts could conceivably change with further refinement of valuation approaches or estimates. For instance, were the flood risk reduction estimate based upon willingness to accept measures that included elements such as 'peace of mind' associated with reduced flood risk, this might increase its relative importance compared to the other impacts.

The ecosystem service benefits considered thus far are gross values not allowing for the costs of the measures implemented. Indicative costs of implementing the riparian and farm woodland creation measures at 2015 prices are shown in Table 3 below, with a minus sign simply used to denote a cost (as opposed to a benefit). The high estimates assume that many of the tasks are done by volunteers, while the low estimates do not take account of any reduction in costs arising from the use of volunteers.[37] The central estimates are mid-point estimates between the high and low ones. The cost estimates for the Pickering Beck catchment are lower than those for the River Seven catchment, reflecting no fencing or gates being used.[38]

The cost of building each of the smaller LWD dams is estimated at 2011 prices to range between -£110 and -£55, with a central estimate of -£80 (with the variations relating to the extent to which apprentices are used to construct the dams). This compares to a cost of -£500 and -£250 for the 12 largest dams, with a central estimate of -£375. Reflating to 2015 prices gives an estimated total cost for constructing all 167 LWD dams under the project in both catchments ranging from -£24,900 (low

[36] Related more to measures of producer surplus, the basis of the estimated agricultural impacts also differs from the other ecosystem service estimates (although their aggregation with the forestry costs is not considered problematic as this yields a useful estimate of direct costs plus opportunity costs).

[37] As of the beginning of April 2011, it is understood that volunteers had spent 70 person hours on such tasks to date.

[38] The estimates are also lower than for the standard 1.7 m spacing assumed previously, as far fewer trees are planted at the 2.5 m spacing (46% of these costs are assumed).

estimate) to -£12,400 (high estimate), with a central estimate of -£18,000.[39] In addition, the cost of building the two timber bunds in the Seven catchment in 2011 was £5,000 per bund.

Table 3: Indicative costs of woodland creation (£/ha at 2015 prices)

	Pickering Beck catchment			River Seven catchment		
Year	Low	Central	High	Low	Central	High
0	-£1,857	-£1,547	-£1,236	-£5,216	-£3,692	-£2,168
1	-£963	-£738	-£512	-£963	-£738	-£512
2	-£612	-£465	-£318	-£612	-£465	-£318
3	-£542	-£326	-£110	-£542	-£326	-£110
4	-£345	-£173		-£345	-£173	
5	-£86	-£43		-£86	-£43	
Total	-£4,406	-£3,291	-£2,176	-£7,765	-£5,437	-£3,109

The farm measures cost £145,000, assumed to be split 50:50 between the Pickering Beck and River Seven catchments. Reflecting the pattern of approvals, 20% of the costs are assumed to have been incurred in 2013, 10% in 2014 and the remainder in 2015. The heather bale check dams constructed in the Pickering Beck catchment are estimated to have cost £5,000, with 40% of the cost assumed in 2011 and the remainder in 2012, with the other moorland measures implemented in the catchment in 2013 estimated to have cost £2,000.

The combined cost for all the forestry measures is estimated to range between around -£0.3m and -£0.1m at 2015 prices, with woodland creation accounting for over 90% of the total.[40] The cost of the non-woodland measures is estimated at -£3.4m, with the bund accounting for 98% of this.[41]

The estimates considered so far have not accounted for the timing of the costs and benefits (i.e. their distribution over the 100 year period considered). Both cost and timing aspects are accounted for in Tables 4a and 4b below, where each 100 year flow of annual values has been converted into a present value by discounting based upon the Treasury Green Book protocol and then summing. The woodland measures account for over 95% of the total benefits but under 89% of the total costs given for the group of woodland, moorland and farm measures in Table 4a (based on the range of values).

Using the cost saving estimates as proxies for associated values – the approach also adopted in computing initial estimates (Nisbet *et al*, 2011), and aggregating across

[39] Construction costs in the Pickering Beck catchment are assumed to be divided between calendar years on the same basis as the volume of flood storage provided, with a slightly higher proportion in 2011 (54%) than in 2012 (46%).

[40] Cost savings could be expected to accrue where natural regeneration of broadleaves is used in place of replanting conifers. However, these savings are not accounted for here to allow for the possibility that natural regeneration proves unsuccessful and conventional planting is subsequently required.

[41] The total cost of the bund more than doubled from the early assessment to £3,128,000. This was due to the bund being designated a 'category A' reservoir that needs to withstand a 1 in 10,000 year event in order to minimise the risks of its failure causing potential storm surge damages.

benefit categories gives a net present value (NPV) for both catchments combined ranging from around -£0.3m (low estimate) to £2.4m (high estimate) for the woodland, moorland and farm measures, with a central estimate of £1.0m. This compares to a range of £0.6m to £3.2m and a central estimate of £1.9m for all of the project measures.

The positive NPV in each case for the Pickering Beck catchment in Table 4b shows that the sum of the present values of the ecosystem service impacts of all the measures under the project exceeds the present value of the costs of implementing them. This indicates that from a societal perspective the public benefits significantly outweigh the costs. A comparison of the benefit-cost ratios (based on the central estimate) for the different measures in the Pickering Beck catchment gives values of 5.6, 3.8 and 1.5 for the woodland measures, the combined set of woodland, moorland and farm measures, and for these plus the flood storage bund, respectively. The range of values reflects the significant climate regulation benefit for the woodland measures, the relatively limited impact assumed for the farm measures compared to their cost, and the relatively high cost of the large flood storage bund.

Although the climate benefit is the largest woodland service, the flood regulation benefit is also significant and notably exceeds (by 62%) the forestry costs plus the loss in agricultural production for the central estimate. However, for private landowners, the estimates (based upon Treasury Green book discount rates) for the Pickering Beck catchment suggest that the present values for woodland grant payments applying in 2011 (£3,800/ha)[42] only partly covered the costs of forestry establishment and lost agricultural production combined (central estimate - £7,400/ha).[43] The benefit-cost ratio (2.5) for the woodland measures in the River Seven catchment is less than half that in Pickering Beck, mainly due to planting on better quality farmland and the higher woodland establishment costs (use of fencing).

Over the 100-year time horizon, the 44 ha of woodland created in the project is projected to result in net carbon sequestration of between 15,000 tCO_2 and 27,000 tCO_2 (central estimate 21,000 tCO_2) - equivalent to 340 tCO_2 to 640 tCO_2 per hectare (central estimate 480 tCO_2/ha). Based upon government guidance on appraisal and evaluation (DECC, 2014),[44] the woodland creation is cost-effective from a climate

[42] The overall grant rate for planting the woodland in the River Seven catchment was higher. In addition to the £3,800/ha (comprising a grant of £1,800/ha for planting native broadleaves, plus an additional £2,000/ha made available under a new scheme to encourage woodland creation for water benefits in priority areas), a Farm Woodland Premium applied. The 15 ha of farm woodland planted in 2011 received £300/ha for 15 years, while the 10 ha of riparian woodland planted in 2013 received £60/ha a year for the first 15 years. The associated present values of grants paid in the River Seven catchment was £4,515 for the riparian woodland and £7,376/ha for the farm woodland.

[43] Furthermore, grants were only paid in the Pickering Beck catchment for creation of 8.1 ha of woodland, with none paid for the other 10.9 ha.

[44] This recommends deriving the cost-effectiveness (CE) of a measure by dividing its NPV (excluding the present value of the carbon benefits) by the total tonnes of carbon dioxide equivalent saved. The carbon benefits excluded are either those in the traded sector (i.e. covered by the EU ETS) or those in the non-traded sector (i.e. not covered by the EU ETS), depending whether the impact being investigated is in the traded or non-traded sector. Values for 2015 recommended for the non-traded sector range from £31-£93/tCO_2 at 2014 prices (being higher in subsequent years) – see: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal.

Table 4a: Indicative ecosystem service present values (£k at 2015 prices) for the woodland, moorland and farm measures

	Pickering Beck catchment			River Seven catchment		
	Low (£k)	Central (£k)	High (£k)	Low (£k)	Central (£k)	High (£k)
Habitat creation	£72	£131	£172	£59	£127	£186
Flood regulation	£18	£221	£334	£35	£226	£232
Climate regulation	£128	£366	£667	£181	£532	£1,000
Erosion Regulation	£2	£2	£3	£0	£1	£1
Education and knowledge	£0	£1	£9	-	-	-
Community development	£0	£39	£68	-	-	-
Agricultural production	-£76	-£56	£2	-£272	-£208	-£16
Forestry Costs	-£99	-£74	-£50	-£200	-£144	-£87
Non-forestry costs	-£69	-£69	-£69	-£64	-£64	-£64
Net Present Value	-£25	£562	£1,137	-£260	£470	£1,252

Table 4b: Indicative ecosystem service present values (£k at 2015 prices) for all of the project measures

	Pickering Beck catchment			River Seven catchment		
	Low (£k)	Central (£k)	High (£k)	Low (£k)	Central (£k)	High (£k)
Habitat creation	£72	£131	£172	£59	£127	£186
Flood regulation	£3,911	£4,114	£4,227	£35	£226	£232
Climate regulation	£86	£283	£542	£181	£532	£1,000
Erosion Regulation	£2	£2	£3	£0	£1	£1
Education and knowledge	£0	£1	£9	-	-	-
Community development	£0	£39	£68	-	-	-
Agricultural production	-£76	-£56	£2	-£272	-£208	-£16
Forestry Costs	-£99	-£74	-£50	-£200	-£144	-£87
Non-forestry costs	-£3,020	-£3,020	-£3,020	-£64	-£64	-£64
Net Present Value	£876	£1,420	£1,954	-£260	£470	£1,252

change mitigation perspective.[45] Indicative costs[46] for delivering carbon savings range from £31/tCO_2 (low estimate) to -£20/tCO_2 (high estimate), with a central estimate of -£2/tCO_2 for both catchments combined (negative values indicate a net benefit,[47] while positive values indicate a net cost per tonne of carbon dioxide saved). In each case these estimates at 2015 prices are below the associated DECC benchmark cost-comparator of £51/tCO_2. As expected from the lower woodland establishment and agricultural opportunity costs, woodland creation is especially cost-effective in the Pickering Beck catchment, with indicative costs for delivering carbon savings of between £11/tCO_2 (low estimate) and -£31/tCO_2 (high estimate), with a central estimate of -£18/tCO_2.[48]

[45] This result is robust to the exclusion of the speculative flood regulation benefit estimates for the River Seven catchment. The positive NPVs across both catchments for all the measures implemented (robust to exclusion of the Seven catchment flood regulation estimates too) imply that the project as a whole can also be considered cost-effective from a climate change mitigation perspective - a result driven by the net carbon sequestration benefits of the woodland creation.

[46] In computing these estimates, it is assumed that woodland creation accounts for 70% of the education and community development benefits, and around 50% of the flood benefits associated with all the woodland measures implemented.

[47] also indicated by a positive NPV when the carbon benefits are excluded.

[48] Corresponding costs for the River Seven catchment range from £46/tCO_2 to -£11/tCO_2, with a central estimate of -£10/tCO_2.

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Annex: Sensitivity Analysis and initial Scoring of Potential Impacts

Table 5a: Ecosystem service impacts - Woodland, moorland and farm measures low estimates

	Pickering Beck catchment			River Seven catchment		
	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)
Habitat creation	0	£5.6	£4.0	0	£4.7	£3.3
Flood regulation	£0.3	£0.6	£0.6	£0.9	£1.2	£1.2
Climate regulation	-£57.0	£13.5	£4.7	-£69.9	16.3	£6.6
Erosion Regulation	£0.006	£0.065	£0.061	£0.001	£0.019	£0.018
Education and knowledge	£0	£0	£0	n.a.	n.a.	n.a.
Community development	£0	£0	£0	n.a.	n.a.	n.a.
Agricultural production	-£2.6	-£2.0	-£2.6	-£9.2	-£7.9	-£9.2

Note: n.a. = not available (not estimated)

Table 5b: Ecosystem service impacts - woodland, moorland and farm measures high estimates

	Pickering Beck catchment			River Seven catchment		
	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)
Habitat creation	0	£7.1	£6.7	0	£7.8	£7.3
Flood regulation	£7.9	£11.4	£11.4	£6.1	£7.9	£7.9
Climate regulation	-£840.4	£147.8	£24.3	-£1,048	£109.8	£36.9
Erosion Regulation	£0.012	£0.13	£0.12	£0.001	£0.037	£0.035
Education and knowledge	£0.22	£0. 86	£0.25	n.a.	n.a.	n.a.
Community development	£2.1	£4.1	£2.2	n.a.	n.a.	n.a.
Agricultural production	£0.062	£0.078	£0.078	-£0.58	-£0.54	-£0.54

Note: n.a. = not available (not estimated)

Table 6a: Ecosystem service impacts - all measures (low estimates)

	Pickering Beck catchment			River Seven catchment		
	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)
Habitat creation	0	£5.6	£4.0	0	£4.7	£3.3
Flood regulation	£0.3	£147.7	£142.6	£0.9	£1.2	£1.2
Climate regulation	-£57.0	£13.5	£4.3	-£69.9	16.3	£6.6
Erosion Regulation	£0.006	£0.065	£0.061	£0.001	£0.019	£0.018
Education and knowledge	£0	£0	£0	n.a.	n.a.	n.a.
Community development	£0	£0	£0	n.a.	n.a.	n.a.
Agricultural production	-£2.6	-£2.0	-£2.6	-£9.2	-£7.9	-£9.2

Note: n.a. = not available (not estimated)

Table 6b: Ecosystem service impacts - all measures (high estimates)

	Pickering Beck catchment			River Seven catchment		
	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)	Min (£k/yr)	Max (£k/yr)	Mean (£k/yr)
Habitat creation	0	£7.1	£6.7	0	£7.8	£7.3
Flood regulation	£7.9	£158.6	£153.3	£6.1	£7.9	£7.9
Climate regulation	-£840.4	£147.8	£22.9	-£1,048	£109.8	£36.9
Erosion Regulation	£0.012	£0.13	£0.12	£0.001	£0.037	£0.035
Education and knowledge	£0.21	£0.86	£0.25	n.a.	n.a.	n.a.
Community development	£2.1	£4.1	£2.2	n.a.	n.a.	n.a.
Agricultural production	£0.062	£0.078	£0.078	-£0.58	-£0.54	-£0.54

Note: n.a. = not available (not estimated)

Table 7: Scores assigned to likelihood of impact of project measures on ecosystem services (from Nisbet *et al*., 2011)

	Bunds	Woodland creation	Stream/drain restoration	Farm Measures	Combined
Provisioning					
Fresh water	0	0	0	+	+
Food	0	-	0	0	-
Fibre & Fuel	0	+	0	0	+
Genetic	0	0	0	0	0
Biochemicals	0	0	0	0	0
Ornamental	0	0	0	0	0
Regulatory					
Air quality	0	+	0	0	+
Climate	(-)	+(+)	+	0	+
Water/flood	++	++	++	++	++
Natural hazard	0	+	0	0	+
Pest	0	0	0	0	0
Disease	0	0	0	0	0
Erosion	++	++	++	++	++
Water quality	+	+	0	++	+
Pollination	0	0	0	0	0
Cultural					
Heritage	0	0	0	0	0
Recreation	++	+	+	+	++
Aesthetic	0	+	+	0	+
Spiritual	0	0	0	0	0
Art/folklore	0	0	0	0	0
Comm. engage.	++	++	+	+	++
Education	++	++	++	++	++
Supporting					
Soil	0	+	0	+	+
Primary prod.	0	+	0	0	+
Nutrient cycl.	0	0	0	0	0
Water recycl.	0	0	0	0	0
Photosynth.	0	0	0	0	0
Habitat	0	++	+	+	++