Expert-led natural capital assessment of the Lower Otter and Saâne Valley restoration projects

T.2.1.1: Lower Otter and and Saâne Valley Socio-economic Evaluations, Promoting Adaptation to Changing Coasts (PACCo) project

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1. Introduction

The Promoting Adaptation to Changing Coasts (PACCo) project is a joint initiative between England and France to demonstrate the restoration of two estuaries. The restoration projects aim to deliver a range of benefits for people and the environment while providing adaptation to climate change and working closely with a range of stakeholders. They also aim to demonstrate a model of how estuaries can be sustainably managed in the future in the face of climate change that can be applied elsewhere. The project is funded by EU's Interreg V A France (Channel) England programme.

The restoration sites are in the Lower Otter Valley in East Devon, England, and the Lower Saâne Valley in Normandy, France. Both are relatively small estuaries and share a number of similar characteristics and challenges. Restoration works are well underway at both sites. As well as the restoration works, the PACCo project wanted to carry out an assessment of the benefits that the works will provide, and a natural capital approach was deemed the most appropriate at capturing benefits to both people and the natural environment. A quick expert-led natural capital assessment was undertaken at both sites with a detailed assessment including a monetary valuation applied at the Lower Otter site. Natural Capital Solutions were commissioned to lead this assessment process. The primary aim was therefore to carry out an expert led natural capital assessment of the Lower Otter and Saâne Valley restoration projects and a do nothing alternative. A secondary aim was to demonstrate the assessment process and the advantages and disadvantages of different types of natural capital assessment. The results from the Lower Otter assessment can also be compared to the full detailed assessment carried out separately, although that is not reported here.

1.1 The natural capital and ecosystem services framework

Natural Capital is defined as:

> "*..elements of nature that directly or indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions"* (Natural Capital Committee 2014[1]).

These benefits (often referred to as ecosystem services) include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities. Different types of ecosystem services are shown in Figure 1.

The environment is being increasingly regarded as 'multi-functional', delivering a range of environmental, social and economic benefits to society. Coastal and estuarine habitats can sequester carbon, protect against coastal flooding and reduce water quality problems, as well as providing quality space for recreation and biodiversity, demonstrating how multi-functional benefits can be delivered. By changing the management of highly modified estuaries (and other sites) there is the potential to enhance a range of benefits, whilst also reducing environmental risk in the face of climate change.

[1] Natural Capital Committee 2014. Towards a Framework for Defining and Measuring Changes in Natural Capital. Working Paper 1, Natural Capital Committee.

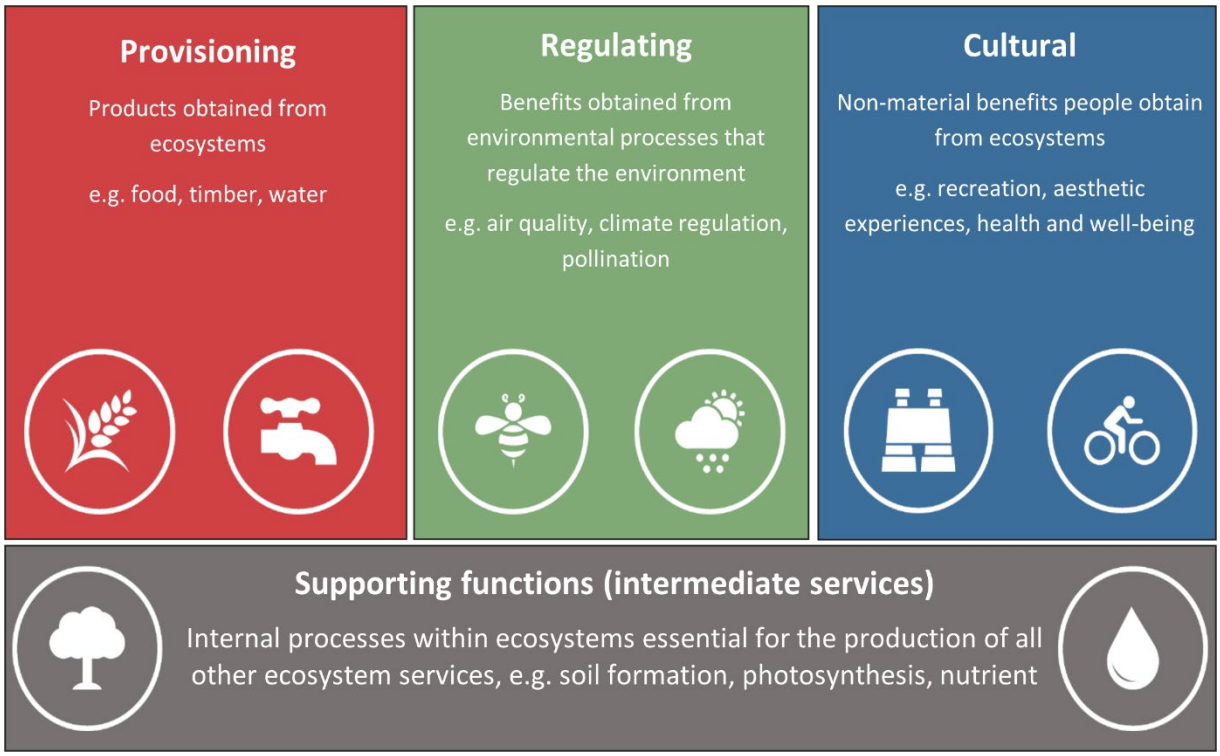

Figure 1: Key types of ecosystem services (based on MA 2005[2]). Note that supporting or intermediate services are now categorised as ecological functions (CICES[3]). They are the underpinning structures and processes that give rise to ecosystem services.

The concepts of natural capital and ecosystem services are widely supported; the challenge, however, is in implementing the approach and embedding it in working practices, so that it becomes an integral component of decision making. Progress is being made on how to deliver the approach on the ground and how to use it to inform and influence management and decision-making.

Methods for quantifying and valuing natural capital benefits are becoming increasingly robust and additional insight can be gained by taking a spatial perspective on the variation in natural capital assets and the benefits that they deliver across the study area using a Geographic Information System (GIS). However, even simple qualitative and expert-led approaches to assessment can be useful and have certain advantages over more detailed assessments (explored further in Section 2).

1.2 Report structure

Section 2 sets out approaches to natural capital assessment and outlines the methods used for this project. The next two sections then present the results of the assessment of the Saâne Valley (Section 3) and Lower Otter (Section 4) restoration projects. Brief conclusions are presented in Section 5.

[2] Millennium Ecosystem Assessment (2005) Ecosystems and human well-being: Synthesis. Island Press, Washington D.C. https://www.millenniumassessment.org/en/index.html

[3] Haines-Young, R. & Potschin, M. (2018) Common International Classification of Ecosystem Services (CICES) V5.1. Guidance on the application of the revised structure. Fabis Consulting.

2. Approaches to natural capital assessment

The natural capital assets (components of the natural environment) at each site deliver a range of ecosystem services, which provide benefits to people. The level of delivery of these ecosystem services will change depending on how the sites are managed over the coming years, and an assessment of natural capital is aiming to determine the level of delivery of ecosystem services under the baseline and alternative scenarios (and how this changes). Delivery of ecosystem services can be assessed in a number of ways, that vary greatly in their level of complexity.

Figure 2 provides an illustration of alternative approaches to natural capital assessment and some of the key differences. The bottom of the pyramid illustrates the full range of ecosystem services that are being delivered by a site and this may include some services that are not even recognised at present. There are then three levels of assessment illustrated: qualitative, quantitative and monetary. The diagram also illustrates that at each level of assessment, although more detail is obtained, less ecosystem services can be assessed (the breadth of the assessment reduces).

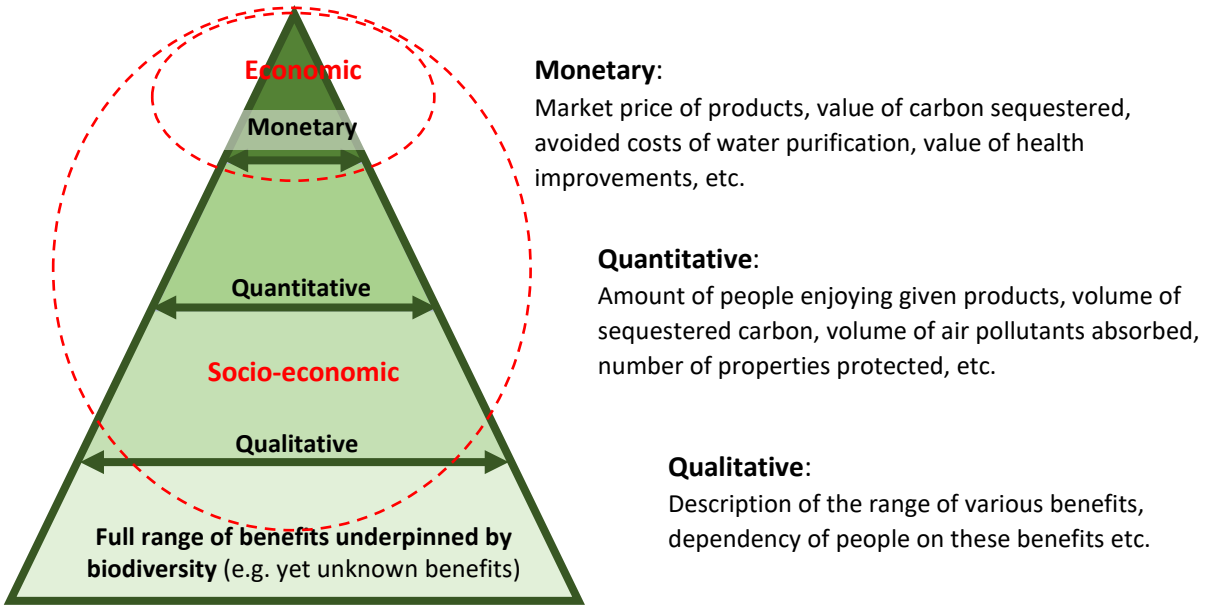

Figure 2: Approaches to natural capital assessment. Based on The Economics of Ecosystems and Biodiversity (TEEB 2011)[4].

Each approach to natural capital assessment has advantages and disadvantages and the most appropriate will differ in different situations. The key advantages and disadvantages of each approach are summarised in Box 1 (overleaf) and further details of each level of assessment are provided below.

[4] TEEB (2011) *The Economics of Ecosystems and Biodiversity in National and International Policy Making.* Edited by P. ten Brink. Earthscan, London and Washington.

Box 1: Principal advantages and disadvantages of alternative assessment approaches	
Simple expert assessment	
Advantages	Quick, cheap, easy, highlights key issues, useful for engaging stakeholders, a very wide range of ecosystem services can be assessed.
Disadvantages	Less precise, subjective, may be hard to justify making decisions based solely on this, exact score will vary depending upon the experts involved.
Quantitative modelling	
Advantages	May be seen as more trustworthy, easier to defend, reliable, accurate, can be standardised so results in different units can be compared.
Disadvantages	Less understandable, can be time-consuming, only as accurate as the models upon which they're based, can give false impression of accuracy, not all ecosystem services can be modelled accurately.
Monetary valuation	
Advantages	Provides a single unit for comparing options, can be used directly in cost-benefit analysis, benefits not put in monetary terms are often ignored, politicians and business people like it.
Disadvantages	Values may be treated with suspicion and scepticism, some ecosystem services remain very hard to value in this way.

Level 1 – Qualitative assessment

This step uses experts and/or stakeholders to perform a simple assessment based on their judgement. This is quick and easy to perform and the only requirement is for a facilitator/assessor who understands the process. It is useful both as a summary, and to provide a more comprehensive overview of the benefits provided by the natural environment in each area. It can be useful at drawing attention to key services and highlighting those that should be the focus of more detailed assessments. It can also be used as a means of engaging a wide range of people with an interest in the site, and as an initial screening of options. For small sites, or where the impacts of the proposals are minor, or where one management option is clearly preferable, this may well be the only assessment that is necessary. It should be noted that the assessment method is subjective and the overall scores will depend upon the experts involved. It can therefore be useful to include a range of experts or stakeholders with different backgrounds and representing different interest groups. However, despite this potential limitation, the results are fairly robust to individual bias and fairly close consensus is usually reached between experts with different backgrounds, which can be further enhanced through group discussion and reaching agreement on scores.

Level 2 – Quantitative modelling

This uses existing scientific literature or models to calculate quantitative amounts of ecosystem services being delivered and across the options being considered. It has the advantage of providing real data for inclusion in an options appraisal and is usually more accurate and unbiased. It can be used to provide further details on a few options taken forward following initial expert-based screening. This approach can cover a range of different levels of complexity as this depends on the models used for each ecosystem service and can vary from very simple average amounts up to detailed process-based mathematical modelling.

Level 3 – Monetary valuation

This is concerned with placing a monetary value on the benefits that are provided by natural capital. It usually requires quantitative modelling to have been carried out to determine quantities of benefits, and then a value is put on those quantities. This can be based on a variety of market, use and non-use valuation techniques, often based on transferring values from other studies. It is an essential part of natural capital accounting and is being increasing used in cost-benefit analyses and other decision-making processes. It is important at highlighting the values of the natural environment that are often hidden, or assumed to have zero value, and is an area that is rapidly advancing with new methods and values being developed. However, it can be time-consuming to undertake and there are a number of ecosystem services (especially many cultural services) that cannot be valued.

2.1 Approach used for this project

For this project we have used an expert-led qualitative natural capital assessment. This was chosen primarily due to time constraints, but as described earlier, it is also useful and effective at quickly providing a broad overview across many ecosystem services. For the Lower Otter site, outputs can also be compared to a full quantitative assessment and monetary valuation that was carried out there. Note that the facilitator (Jim Rouquette) did not see that report before the current assessment.

To carry out the assessment, an online workshop was held for each site in November 2022, attended by PACCo project staff with expert knowledge of the sites. At each workshop the facilitator introduced the concept of natural capital and outlined the assessment approach, and the project staff introduced the site and the restoration plans. The natural capital assessment was then performed through facilitated discussion. First the provision of ecosystem services under the **baseline** (pre-restoration or current site) was assessed, by simply scoring each ecosystem service on a scale from 0-3. Scores were discussed and agreed by consensus. Next, two scenarios were discussed, and the ecosystem services likely to be provided under each scenario were scored using the same approach. The scenarios were:

- **Restoration.** This is based on the PACCo plans and also includes any elements that are not being funded by PACCo, but are considered to be part of wider restoration efforts. This assumes that restoration works have been completed and any new habitats have established.
- **Do nothing.** This assumes that no restoration works are undertaken and that climate change will increase pressures on the sites and current structures. This is generally a continuation of current trends. It also assumes that no large-scale repair or enhancement of existing embankments is carried out.

List of ecosystem services

The list of ecosystem services to be assessed was pre-selected by the facilitator. The names and definitions of ecosystem services were derived from a combination of MA (2005), TEEB (2010) and CICES 5.1 (2018). We did not stick entirely with CICES nomenclature as a number of the names are not particularly useful to the non-expert and some names used previously are more intuitive, although we did update definitions to be in line with CICES. We also amalgamated certain categories (e.g. food production covering both plant and animal production) where it was not useful to keep separate. We also reduced the number of ecosystem services being considered, by removing those that are not relevant at the sites, based on scoping work carried out in Task 1 of the PACCo project and expert opinion. A full list of ecosystem services assessed and their definitions are given in the Annex.

3. The Saâne Valley restoration project

3.1 Site overview and restoration works

A detailed description of the Saâne Valley and restoration plans is beyond the scope of this report and is detailed in other PACCo reports[5,6]. In brief, however, it is a relatively small river that has been constrained behind a coast road on an embankment, with an estuarine culvert outlet / pipe providing outlet onto a shingle beach and the sea. The estuarine culvert outlet / pipe is too small during high water events, resulting in river water backing up and flooding. The river valley consists mostly of pasture land (with a little arable) and some freshwater wetlands, and is largely used for low intensity cattle grazing and for game shooting. A campsite sits next to the river, just behind the coastal embankment, but has been subject to flooding in recent years. The area is important for tourism. The Saâne Valley is subject to several risks, including coastal erosion, river flooding and coastal flooding, which are getting worse due to climate change impacts.

The restoration works to be undertaken as part of the PACCo project, and also more broadly, include:

- Removal of the estuarine culvert outlet / pipe and replacement with an open bridge, allowing free flow of water between the river and sea (work undertaken outside of PACCo project).
- Restructuring of the river channel to enable reconnection with the floodplain and the natural creation of saltmarsh habitats (work undertaken outside of PACCo project).
- Moving the campsite out of the floodplain (and improving facilities).
- Installation of a new wastewater treatment plant to remove direct discharges of wastewater into the river.
- Communications and facilitation programme.

The restoration works as a whole will restore the natural functioning of the estuary, which will also become saltwater influenced, as well as enhancing facilities for tourists and residents. Note that a natural capital assessment should really only consider direct changes to, and impacts of, natural capital on ecosystem services, but it is difficult to disentangle these from changes due to improvements in built facilities (like the wastewater treatment plant and improved camping facilities). Hence we have not attempted to differentiate between these, and the impact of all changes are included in the assessment.

3.2 Qualitative assessment of ecosystem service flows

The following experts took part in the assessment process:

- Camille SIMON, PACCo and Basse Saâne Project Manager, Conservatoire du Littoral ['Chargée de projet – Projet territorial Vallée de la Saâne / Projet PACCo'].
- Thomas DROUET, PACCo Project Officer, Conservatoire du Littoral ['Chargé de mission – Projet Territorial de la Basse Vallée de la Saâne / Projet PACCo'].
- Loïck LE LOUARGANT, Coastal Project Manager, Conseil Départemental de la Seine-Maritime. ['Chargé de mission littoral'].

[5] ABPmer, (2021). Promoting Adaptation to Changing Coasts (PACCo) Task 1 Methods Review.
[6] East Devon Pebblebed Heaths Conservation Trust (2022). Promoting Adaptation to Changing Coasts – Socioeconomic Framework.

Dr Lydia Burgess-Gamble, Senior Project Manager [Chef de Project Senior], PACCo, Environment Agency, also provided advice during the assessment process. The assessment was facilitated by Dr Jim Rouquette, Director, Natural Capital Solutions.

The qualitative assessment of ecosystem services currently provided by the Saâne Valley and under the two scenarios is presented in Table 1 and Figures 3 and 4.

Table 1: Estimated ecosystem service provision scores for the Saâne Valley. Scores: 0 = no delivery, 0.5 = some delivery but not significant, 1 = delivery, 2 = significant delivery, 3 = very significant delivery.

Ecosystem service category	Ecosystem service	Estimated provision		
		Baseline (current state)	Do nothing	Restoration
Provisioning	Food: crop and livestock production	1.5	1	1
	Wild produce (e.g. game, fish, berries etc.)	1	1	1.5
	Fibre and fuel (timber, woodfuel, wool etc.)	0.5	0.5	0.5
	Water (includes for drinking, agriculture & industry)	0.5	0.5	0.5
Regulating	Carbon sequestration and storage	1	1.5	2.5
	Water quality regulation (nutrients)	0.5	2	2
	Erosion control	1	0.5	1
	Water flow regulation (flood control & coastal protection)	0.5	1	2
	Pollination and gamete dispersal	1	1	1.5
	Pest and disease control	1	1	1
	Noise attenuation	0.5	0.5	0.5
	Air quality regulation	1	1	2
	Local climate (temperature) regulation	1	1	2
	Soil quality regulation	1	1.5	2
	Habitat and population maintenance (biodiversity)	2	2	3
Cultural	Recreation and tourism	2	1	3
	Health and well-being	2	1	3
	Aesthetic experiences	2	1	3
	Education, training and scientific investigation	2	1	3
	Spiritual and cultural experiences	2	1	3
	Characteristics and features of biodiversity that are valued (existence, option, bequest)	1	0.5	2
Mean score		**1.2**	**1.0**	**1.9**

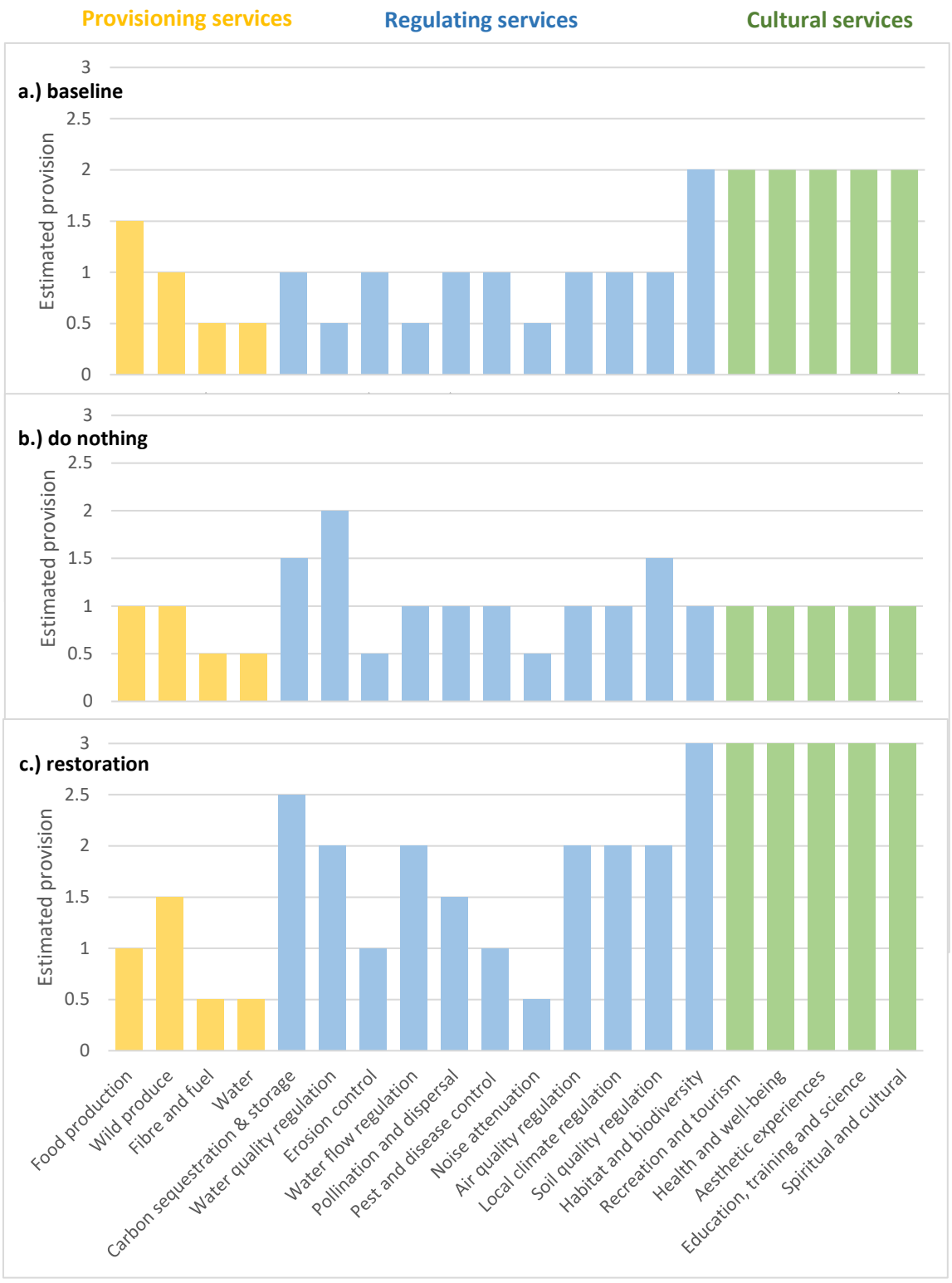

Figure 3: Estimated ecosystem service provision scores for the Saâne Valley for a.) the baseline (top panel), b.) the do nothing scenario (middle), and c.) the restoration scenario (bottom).

Under the **baseline** (pre-restoration situation) the valley is predominantly used for low intensity grazing, as well as some game shooting and a little fishing, resulting in a moderate food production score of 1.5 and a slightly lower wild produce score of 1. The only use of water is for cattle. Hence provisioning services are of some importance, but not particularly significant. Regulating services are nearly all delivered at a low level, with most scoring 1, and three services scoring 0.5. The wetland is not considered to be in good condition, hence carbon sequestration and storage is being delivered, but not to a high extent (score of 1), and invasive species are also present on site. Only habitat and population maintenance for biodiversity is considered to be significant as there is some good biodiversity present across the site. Cultural services are the most important group of services in the Saâne Valley pre-restoration, with significant delivery of most services (score of 2). The overall mean score for the site across all ecosystem services was 1.2, showing that a range of ecosystem services are being delivered by the site, but on average delivery is not particularly significant.

Under the **do nothing** scenario, food production is expected to fall a little due to more frequent uncontrolled flooding of the fields that will impact on grazing, but there are no other changes predicted for provisioning services. Impacts on regulating services are also relatively small, with a small decrease in erosion control (increase in erosion), but increases in carbon sequestration, water quality regulation, water flow regulation and soil quality regulation. Habitats for biodiversity are predicted to remain significant (score of 2), although there are likely to be changes dues to the effects of uncontrolled and prolonged flooding and consequent changes in habitats. The greatest impacts are expected to be on cultural services, with all services predicted to fall, with almost all declining from 2 to 1. The campsite and other tourism facilities would be severely impacted (and forced to close) due to more frequent uncontrolled and prolonged flooding. The fall in visitor numbers will also lead to a fall in health and wellbeing benefits, aesthetic experience, education opportunities, and spiritual and cultural experiences. The overall mean score across all ecosystem services is predicted to fall from 1.2 to 1.0.

Under the **restoration** scenario there are only small changes to provisioning services with a slight drop in food production, but offset by a similar slight rise in wild produce, as opportunities for game shooting and populations of suitable bird species will increase. The impact on regulating services is much more significant, with 8 of the 11 regulating services assessed expected to increase, with the remaining three unchanged. In particular, carbon sequestration and storage, water quality regulation and water flow regulation are all predicted to increase by 1.5 points as new wetland habitats in much better condition become established at the site. This is also expected to increase habitats and populations for biodiversity so that the area will provide very significant delivery (score of 3). All the cultural services assessed are also expected to increase after restoration and are predicted to be delivering very significant benefits (score of 3) in almost all cases. Of particular note, recreation and tourism is already significant and will increase to very significant, and the project is delivering very significant education, training and scientific investigation opportunities. The overall mean score across all ecosystem services will increase from 1.2 under the baseline to 1.9 under after restoration, showing that there will be significant (and a substantial increase in) delivery of ecosystem services on average after restoration.

Significant differences are apparent in Figure 3, between the scenarios, and also between cultural regulating and provisioning services. Cultural services are generally highest at the site under all scenarios, although decline a lot under the do-nothing scenario and increase under the restoration

scenario, whereas regulating services are relatively low under the baseline and the do nothing scenario, but increase a lot under the restoration scenario. Provisioning services are generally low and change little under any of the scenarios.

The **change in ecosystem service provision** is illustrated in Figure 4. In this figure, better outcomes are indicated by lines closer to the outside. Lines to the outside of the thick black line (the baseline) indicate an increase in ecosystem service provision, whereas lines to the inside indicate a decrease in provision. It is able to show the overall pattern of the response and highlights some of the key similarities and differences between the two scenarios. It is clear that the restoration scenario (red line in Figure 4) enhances most ecosystem services, with the exception of food production which suffers a small decline. On the other hand, under the do nothing scenario (blue line), some of the services stay the same, but there are significant declines for cultural services (e.g. recreation and tourism, health and wellbeing, aesthetic experiences), and habitat for biodiversity.

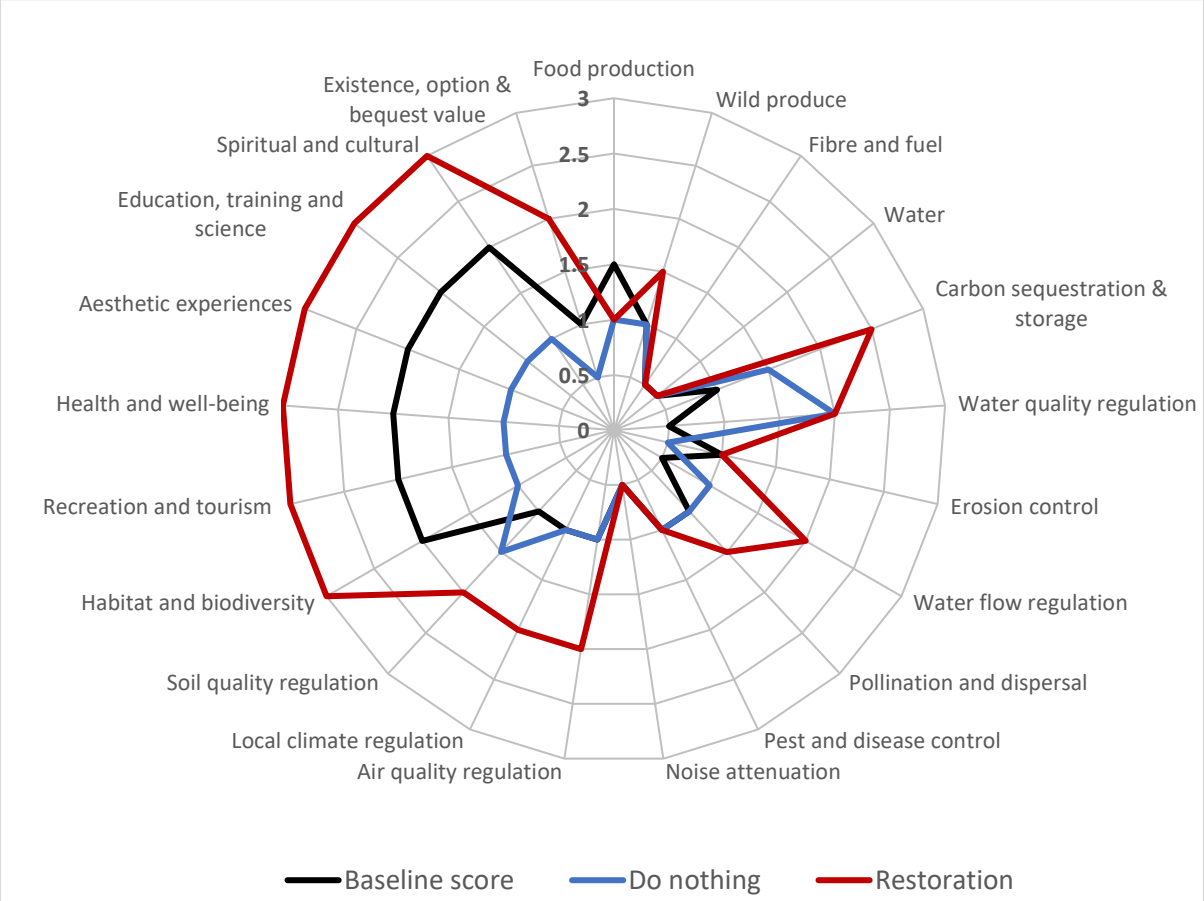

Figure 4: Estimated ecosystem service provision scores for the Saâne Valley for the baseline, the do nothing scenario, and the restoration scenario.

4. The Lower Otter restoration project

4.1 Site overview and restoration works

Like the Saâne Valley, the River Otter is also a relatively small river that has been constrained and straightened. The river drains freely into the sea by a bar, but the estuary has been restricted to a small part of the floodplain by the construction of two embankments in the early 19th century and straightening of the river channel. In addition, a small tributary was raised onto an aqueduct, and other features, including roads, a disused railway embankment, and multiple bridges, culverts and weirs are also present. The areas behind the embankments were reclaimed for grazing, a cricket pitch, and a disused landfill site is situated in a central part of the site. The area is important for tourism and contains a number of footpaths, including a section of the South West Coast Path, and a large car park for visitors. However, the area is subject to flooding from both the river and sea, with drainage impeded by the embankments, which are also proving costly to maintain.

The restoration works currently underway on the Lower Otter include:

- Creating three large breaches of the embankments, two to the north (upstream) to enable freshwater entry, and one to the south (downstream) to enable connection with the sea. A bridge will be constructed over the breach in the south to carry the South West Coast Path.
- Excavation of a drainage creek to control and distribute tidal waters across the site.
- Removal of the aqueduct and recreation of a meandering channel matching its historic location, where the tributary enters the Otter Valley.
- Raising of a local road, and raising and improvement of a footpath on the west of the site.
- Relocation of a combined sewage outflow which crosses the estuary mouth.
- Moving the cricket pitch out of the floodplain.
- The landfill site is to be protected and capped.
- Installation of viewing platforms, signage and landscaping measures to enhance visual and ecological value and clearance of encroaching scrub and pine.
- Large education programme with local schools.

The overall impact of the restoration programme will be to return the Lower Otter to a more natural state, with connectivity restored between the sea, the river and the floodplain. This will enhance the hydrological and ecological functioning of the system, enabling it to better cope with flooding and climate change impacts, and will also lead to the development of a range of estuarine habitats of benefit to biodiversity. Note that the Lower Otter restoration project has in part been developed as compensatory habitat for a project on the Exe estuary where habitat is being lost. A full assessment of impacts of the scheme may, therefore, wish to examine gains in the Otter compared to losses in the Exe, but that is beyond the scope of the current assessment.

Further details about the Lower Otter, its history and the restoration plans are provided in other PACCo reports[7] and Environment Agency (2020)[8].

[7] See ABPmer, (2021) and East Devon Pebblebed Heaths Conservation Trust (2022), referenced previously.
[8] Environment Agency (2020). Lower Otter Restoration Project Environmental Statement.

4.2 Qualitative assessment of ecosystem service flows

The following experts took part in the assessment process:

- Dr Sam Bridgewater, PACCo Project Lead for East Devon Pebblebed Heaths Conservation Trust
- Dr Carolyn Petersen, PACCo Project Manager, East Devon Pebblebed Heaths Conservation Trust

Dr Lydia Burgess-Gamble, Senior Project Manager, PACCo, Environment Agency, also provided advice during the assessment process, which was facilitated by Dr Jim Rouquette, Director, Natural Capital Solutions.

The qualitative assessment of ecosystem services currently provided by the Lower Otter Valley and under the two scenarios is presented in Table 3 and Figures 5 and 6.

Table 2: Estimated ecosystem service provision scores for the Lower Otter. Scores: 0 = no delivery, 0.5 = some delivery but not significant, 1 = delivery, 2 = significant delivery, 3 = very significant delivery.

Ecosystem service category	Ecosystem service	Estimated provision		
		Baseline (current state)	Do nothing	Restoration
Provisioning	Food: crop and livestock production	2	0	0
	Wild produce (e.g. game, fish, berries etc.)	0.5	1	1.5
	Fibre and fuel (timber, woodfuel, wool etc.)	0.5	0.5	0
	Water (includes for drinking, agriculture & industry)	3	3	3
Regulating	Carbon sequestration and storage	1	2	3
	Water quality regulation (nutrients)	1	2	2
	Erosion control	0.5	0	2
	Water flow regulation (flood control & coastal protection)	0.5	0.5	2
	Pollination and gamete dispersal	1	0.5	1
	Pest and disease control	0.5	1	2.5
	Noise attenuation	0.5	0.5	0.5
	Air quality regulation	0.5	0.5	0.5
	Local climate (temperature) regulation	1	2	2
	Soil quality regulation	1	1.5	2
	Habitat and population maintenance (biodiversity)	2	2.5	3
Cultural	Recreation and tourism	2.5	1	3
	Health and well-being	2.5	1	3
	Aesthetic experiences	3	1	3
	Education, training and scientific investigation	1	1	3
	Spiritual and cultural experiences	1	1	1.5
	Characteristics and features of biodiversity that are valued (existence, option, bequest)	2	1.5	3
Mean score		**1.3**	**1.1**	**2.0**

Under the **baseline** (pre restoration), the site is providing significant delivery of food production, as much of the floodplain is grazed for dairy. There are minor levels of fishing in the area. Water production is very significant (score of 3) as water is abstracted from the aquifer for public use, as well as a private borehole. Regulating services are generally low, with almost all given a score of 0.5 or 1. There is a small area of existing saltmarsh, but this is not thought to be accruing carbon. Erosion control is minimal (0.5) with lots of erosion occurring, partly due to the constraints caused by the embankments, which were almost breached in 2016. The only regulating service that is scored greater than 1 is habitat and population maintenance for biodiversity, which is considered to be significant (score of 2), with part of the site a SSSI and another part a Local Wildlife Site (LWS). Cultural services are generally higher at the site, with recreation and tourism, and health and wellbeing both considered important (given a score of 2.5), as the site attracts a lot of visitors, many of whom walk along the coast path and other footpaths. The site is considered to offer very significant aesthetic experiences (score of 3). The overall mean score across all ecosystem services is 1.3.

It is assumed that under the **do nothing** scenario there will be a catastrophic uncontrolled breach of the embankments and that there will be no funding to repair them. The participants noted that it is difficult to predict the impact on ecosystem services of this situation, as it will depend on the location and extent of the breach, although best guess scores were still provided. For provisioning services, the most significant impact will be on food production as the farmland will become inundated with saltwater, potentially for extended periods and with little ability to drain, and is likely therefore to become unusable. Wild produce may increase slightly (opportunities for fishing), but otherwise other provisioning services remain similar to the baseline. Some regulating services are predicted to increase, such as carbon sequestration and water quality, with both moving from some delivery to significant delivery (score of 2) as saltmarsh and other estuarine habitats are likely to expand, and cattle grazing and nutrient inputs will decrease. This will also lead to a slight increase in habitats for biodiversity (score of 2.5), soil quality regulation, and pest and disease control (as invasive species will be lost). On the other hand, erosion control will fall to zero, and pollination will decline a little as the Local Wildlife Site becomes inundated. Cultural services will be badly impacted with recreation and tourism, health and wellbeing, and aesthetic experiences all falling to a score of 1, as visitor number are predicted to fall strongly, and aesthetics will be impacted by long periods of standing water killing vegetation. The overall mean score of all ecosystem services is predicted to fall to 1.1, a decline of 0.2.

Under the **restoration** scenario food production will also fall to zero as the habitats behind the embankments will change to estuarine and saltwater influenced habitats. On the other hand, wild produce, primarily fishing, will increase to a score of 1.5. Water production will remain unchanged and highly significant. The delivery of many regulating services is expected to increase, with carbon sequestration and storage becoming highly significant at the site (score of 3), with the establishment of saltmarsh and other wetland habitats in good condition. This will also lead to the delivery of significant water quality regulation and erosion control benefits (score of 2). Water flow regulation is also expected to become significant (2), as well as soil quality regulation (2.5). Habitats and populations for biodiversity are expected to be enhanced, with very significant delivery of these benefits (3). Most remaining regulating services are less significant at the site. Meanwhile, cultural services are expected to be very significant (score of 3), almost across the board. The scheme is expected to be beneficial for visitor numbers, health and wellbeing, will maintain aesthetic experiences at a very high level, and offer very significant opportunities for education, training and scientific investigation. Characteristics and features of biodiversity that are valued will also be

delivered at very high levels (3), meaning that it is felt that people who do not visit the site will still find it valuable. The overall score across all ecosystem services is expected to rise to 2.0, meaning that on average the site is expected to deliver significant ecosystem services post restoration.

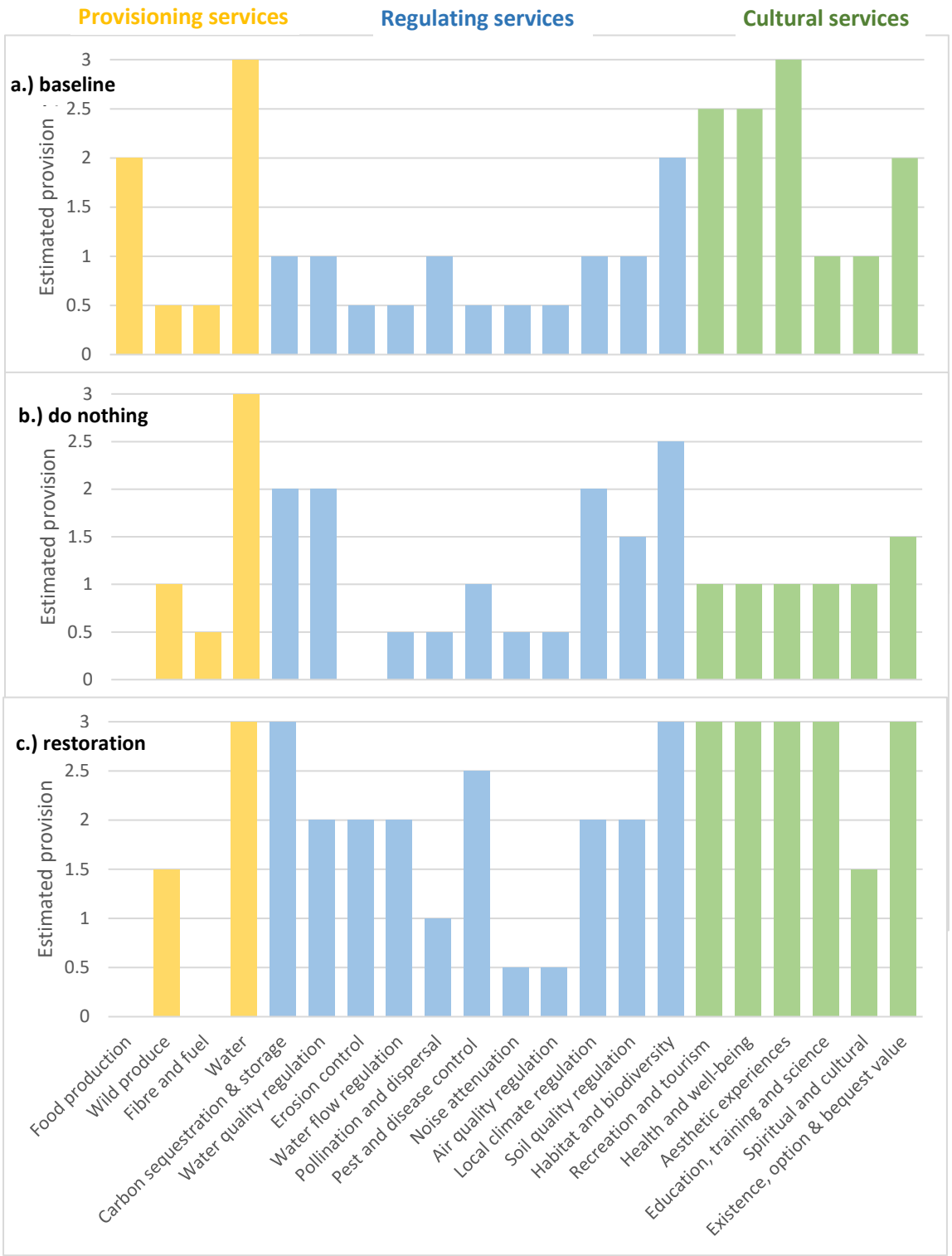

Figure 5: Estimated ecosystem service provision scores for the Lower Otter for a.) the baseline (top panel), b.) the do nothing scenario (middle), and c.) the restoration scenario (bottom).

Differences between the scenarios are apparent in Figure 5. It also shows that under the baseline the site is delivering cultural services and some provisioning services, but is generally low for regulating services. Under the do nothing scenario cultural services decline considerably, but regulating services generally increase. Under the restoration scenario, delivery of cultural services is very high, regulating services are more mixed, but some are now also very high, whereas production services are mixed, with water production very high, but other services delivering much less.

Figure 6 illustrates the **change in ecosystem services**. As before, the baseline is shown as the thick black line, with lines to the outside indicating an increase in ecosystem service provision and lines to the inside indicating a decrease in provision. The do nothing scenario (blue line) appears on both sides of the black line indicting a mixed response compared to the baseline, although the largest changes are declines in food production, aesthetic experiences, recreation and tourism, and health and wellbeing. The restoration scenario (red line) is almost entirely to the outside of the black line, indicting increases compared to the baseline, with the exception of food production, which shows significant decline. The largest increases are for carbon storage and sequestration, pest and disease control, and education, training and scientific investigation, which all increase by 2. Note that eight ecosystem services achieve maximum scores under the restoration scenario, indicating very significant delivery, compared to two under the baseline and one under the do nothing scenario. Some services, such as recreation and tourism, health and wellbeing, and biodiversity are very high, but the increase in score is less, as they already score quite well under the baseline.

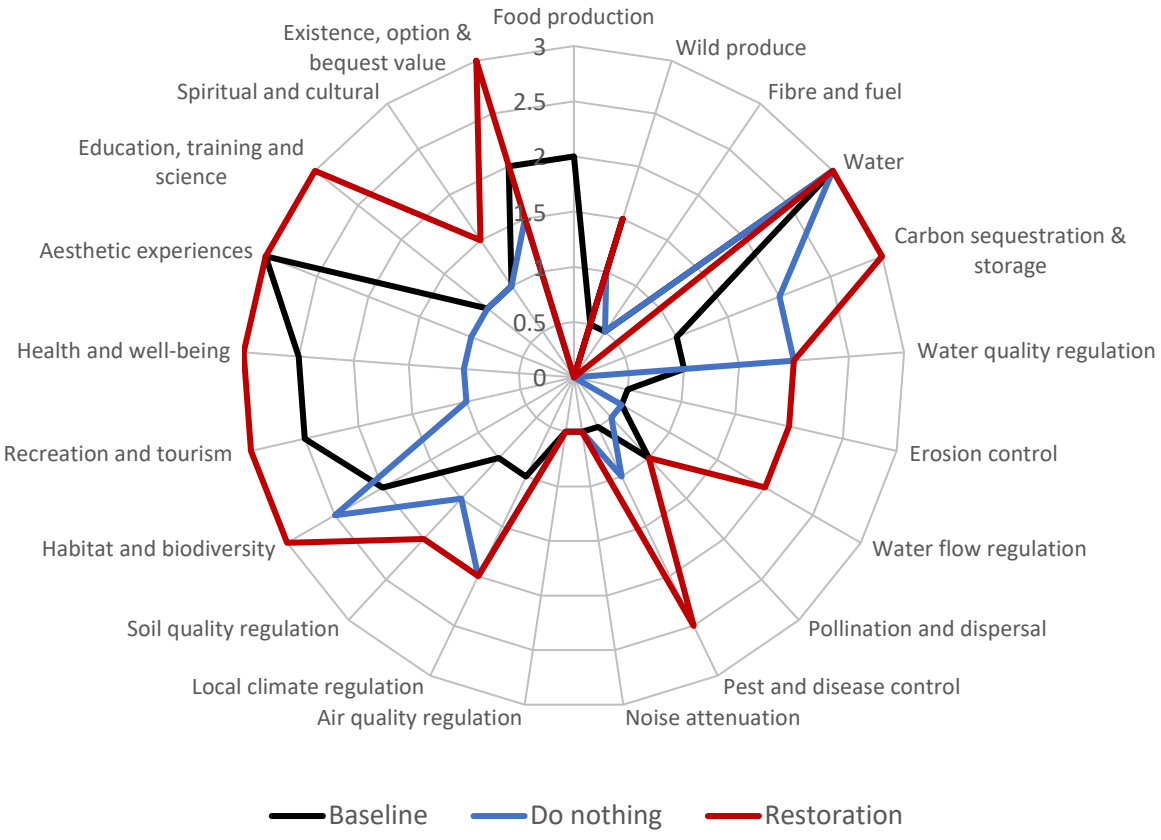

Figure 6: Estimated ecosystem service provision scores for the Lower Otter for the baseline, the do nothing scenario, and the restoration scenario.

5. Conclusions

A qualitative ecosystem services assessment has been carried out for two restoration projects on the Lower Otter in Devon, England and the Saâne Valley in Normandy, France. In both cases the ecosystem services being delivered by the baseline (pre-restoration situation) were first assessed, before assessing the predicted delivery of ecosystem services under both a do nothing scenario and a restoration scenario. In both cases, cultural services were important at the sites prior to restoration, as both sites already attract considerable numbers of visitors. Regulating services were generally of low importance, apart from habitats and populations for biodiversity which were considered to be of moderate importance. Production services varied between the sites, being low in the Saâne Valley, but more mixed in the Lower Otter, with food and water production being significant or very significant in the latter.

Cultural services were predicted to fall markedly at both sites under a do nothing scenario, primarily due to a forecasted major drop in visitor numbers caused by uncontrolled flooding impacting the visitor experience. On the other hand, regulating services showed some difference in response at the two sites. Many were unchanged in the Saâne Valley, with the exception of habitats for biodiversity which is predicted to fall significantly. In the Lower Otter, regulating services were predicted to show a much more mixed response, with a number increasing in delivery, along with several that stayed the same and a few that are expected to decline. Amongst the production services, a similar response was predicted at both sites, with food production expected to fall, but other services generally similar to the baseline.

Responses under the restoration scenario were generally similar at the two sites, with increases in cultural services, so that the sites are predicted to offer very significant delivery of most of these services, and increases in a number (but not all) of the regulating services. Habitat for biodiversity, carbon sequestration, water quality, water flow and soil quality regulation are amongst the services that are expected to be enhanced considerably by the restoration projects and will deliver significant or highly significant benefits at both sites. Food production is predicted to fall, whereas wild produce will increase slightly at both sites, with little change in other production services. It is common finding in studies of this type that increases in cultural and regulatory services can lead to trade offs in production services, primarily that of food production.

The assessment has also demonstrated alternative approaches to natural capital assessment and the advantages and disadvantages of qualitative, quantitative and monetary approaches. The qualitative approach used here has clear advantages of being extremely quick, relatively easy, and yet is able to give a good indication of likely results across a broad range of ecosystem services. It can also be useful as a screening exercise where multiple options are being considered, although that was not the case here. However, it should be borne in mind that it has a number of disadvantages as well, primarily that it is more likely to be inaccurate and it is prone to bias. In this case the assessment was undertaken by the people who were planning and delivering the restoration projects, so they may be prone to score the restoration scenario more favourably, although that risk has been reduced by the use of an expert facilitator who was not part of the project team and group discussion to arrive at consensus scores. In addition, qualitative approaches to assessment, results in scores that follow the expected pattern of response, and will not pick up unexpected results that would not be easily predicted, but may be captured by detailed modelling. Although note that modelling is also not always accurate. The

relative changes also should be used as a guide, rather than exact, as a change in score from (for example) 1 to 2 and from 2 to 3 are not necessarily the same in quantity.

It should also be noted that the assessments demonstrate the impact on natural capital and the ecosystem services that flow from them, but includes both natural and built project elements. Some changes in benefits are therefore produced by new facilities such as water treatment works, or new visitor facilities, rather than directly by natural capital. It would be difficult to disentangle the effects of the different components of the restoration works. But this is not considered to be a problem here, as the aim of the project was to examine the impact of the restoration works as a whole on ecosystem service provision.

Overall, the qualitative assessment used here should be seen as providing a good indication of the level of ecosystem service delivery at the two sites and the impact of the scenarios. It highlights key gains and losses under the proposals and across a wide range of ecosystem services and is useful at engaging stakeholders. The results should be seen as indicative, rather than exact, but if seen in that light can still be extremely useful. A full quantitative or monetary valuation should still be performed when time and resources allow, to build up a more accurate picture and to enable costs and benefits to be included in cost-benefit analyses to aid decision making. It is also recommended that the results of this qualitative assessment are compared to the results of the full assessment completed on the Lower Otter, to enable further conclusions to be drawn.

Annex: Definition of ecosystem services

Adapted from the Millennium Ecosystem Assessment, TEEB and CICES 5.1.

Provisioning services	The products obtained from ecosystems, including:
Food: crop and livestock production	Plants cultivated or animals reared for nutritional purposes, including cereals, vegetables, fruit, mushrooms, meat, dairy produce, animal feed.
Wild produce (e.g. game, fish, berries etc.)	Wild plants and animals used for nutritional purposes, including fish, honey, wild berries, wild fruits, wild mushrooms.
Fibre and fuel (e.g. timber, wool, wool etc.)	Fibres and other materials from cultivated plants or from reared animals for direct use or processing, such as wood, thatch, straw and fibres and compounds (latex, gums, oils, waxes, dyes, etc.), industrial materials, energy sources (wood, organic matter).
Water (for drinking, agriculture and industry)	The natural storage, retention and supply of freshwater. Fresh water extracted (or potential for extraction) for human uses.

Regulating services	The benefits obtained from the regulation of ecosystem processes, including:
Carbon sequestration and storage	Uptake and storage of carbon from the atmosphere, which regulates our global climate. Regulation of the concentrations of gases in the atmosphere that impact on global climate or oceans.
Water quality regulation	Vegetation and soil filters pollutants from water, controlling the chemical quality of water. Natural processes that break down and/or assimilate waste materials, including physico-chemical and microbial purification of water
Erosion control	Regulation of the erosion of soil (for example through vegetative cover). Roots stabilize the soil and foliage intercepts rainfall, preventing erosion and compaction of the soil.
Water flow regulation (e.g. flood control and coastal protection)	Hydrological cycle and water flow regulation (including flood control, and coastal protection). The capacity of vegetation to retain water and release it slowly. Buffering of the impacts of natural hazards and disruptions. Structure and storage capacity of vegetation can reduce the effects of storms, floods and droughts.
Pollination and gamete dispersal	Natural pollination (especially by insects) is crucial to plant reproduction, without which many wild plant species would go extinct and current levels of agricultural production would be impossible or very expensive. 'Gamete' (reproductive cells) dispersal in a marine context.
Pest and disease control	Natural regulation of potential pests and invasive species. Plants and animals that provide natural pest control function. Natural regulation of disease organisms. Could protect crops, human health, livestock, wildlife and domestic pets.
Noise attenuation	Natural features such as forests, woods, trees etc. reducing noise from industrial and building sites, roads, entertainment districts, airports etc.
Air quality regulation	Natural regulation of the quality of air. Moderating NO_x, O_2, SO_x, NH_3, and O_3. Vegetation mitigates effects of pollutants from particulate matter (e.g. PM_{10} and $PM_{2.5}$).
Local climate (temperature) regulation	Regulation of microclimate. Mediation of ambient atmospheric conditions by virtue of presence of plants Transpiration from leaves. Forests and other vegetation can provide shade, provide shelter from wind and moderate local heat island effects.
Soil quality regulation	Weathering processes and their effect on soil quality, ensuring soils form and develop. Decomposition and fixing processes and their effect on soil quality, ensuring the organic matter in our soils is maintained.
Habitat and population maintenance (biodiversity)	Providing habitats for wild plants and animals that can be useful to us. Supports ecosystems of conservation value. Habitats provide living space for plants and animals, allowing for biological and genetic diversity and providing a gene pool for potential future uses.

Cultural services	The non-material benefits people obtain from ecosystems, including:
Recreation and tourism	Human values derived from recreational uses of ecosystems, including their often substantial tourism potential. Natural ecosystems are often used as places for relaxation and recreation, including hiking, camping, fishing, and nature viewing.
Health and well-being	The role of natural landscapes and urban green space for maintaining mental and physical health is increasingly being recognized. Using nature to destress.
Aesthetic experiences	Most people enjoy natural scenery and landscapes; the beauty of nature. This is important not just for human enjoyment but can also have economic importance by influencing property prices.
Education, training and scientific investigation	Natural areas provide numerous opportunities for study, education, and research, as well as references for monitoring environmental change.
Spiritual and cultural experiences	The things in nature that help people identify with the history or culture of where they live or come from or that have spiritual importance for people. Nature is a common element of all major religions. Natural landscapes also form local identity and sense of belonging.
Characteristics and features of biodiversity that are valued (existence, option, bequest)	The things in nature that we think should be conserved because of their non-utilitarian qualities (existence value). The things in nature that we want future generations to enjoy or use for whatever reason (option or bequest value).