Natural England Research Report NERR083

A Natural Capital Strategy for North Devon

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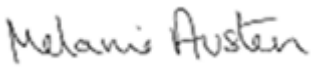
Foreword

As Chair of the North Devon Biosphere Partnership I am delighted that this Natural Capital Strategy has been produced as a result of the work that has been undertaken in the North Devon Biosphere as part of the North Devon Landscape Pioneer. The Biosphere Partnership has taken ownership of the Strategy and will develop a plan for implementing it that will include identifying and securing sustainable finance mechanisms to enable this, and engaging with wider key stakeholders and the public to deliver it. We are doing so because we strongly believe that this will be of benefit to the nature within the North Devon Biosphere, to the people who live and work in it, to those who visit it, and to the future generations that follow them.

The Government's 25 Year Environment Plan aims to leave the environment in a better state and the North Devon Landscape Pioneer was one of the initiatives to explore how the Plan can be delivered. The natural capital approach, promoted by the 25 YEP Plan and by this Strategy, at its best is a balanced approach that takes into account all of nature (which it terms the underlying natural capital assets) alongside the multiple benefits that nature provides for people.

A key role of the natural capital approach is to inform decision making and management by everyone involved and affected, so that people's use of natural resources is sustainable into the future, and future generations can also enjoy these resources. Where there are uncertainties in the underlying data, evidence and knowledge the natural capital approach supports precautionary management. The 25YEP highlights that institutional and cultural change will be necessary to deliver the ambition of the 25YEP.

This Natural Capital Strategy uses this approach to identify priority issues for the North Devon Biosphere (improving water quality, reducing flood risk, increasing carbon capture and storage, and dispersing tourism and recreation pressure). It then proposes strategic changes that can help address these issues and recommends four management principles to take them forward: institutional responsibility, adaptive management, localization and shared commitment. These principles are strongly in tune with the North Devon Biosphere Partnership which promotes sustainable development based on local community efforts and sound science on behalf of the constituent local authorities and stakeholders. The Partnership represents a breadth and diversity of many of the stakeholders who directly benefit from the natural resources of the Biosphere or have an interest in them. This Strategy will inform the 2050 Vision for the Local Plan and the Biosphere mid-term review. It will be crucially important that we identify and ensure linkages and integration with the Marine Natural Capital Plan and also join up with local and national priorities including making best use of funding to deliver improvements across the whole of North Devon.



Professor Melanie Austen, Chair of the North Devon Biosphere Partnership.

Executive summary

This Natural Capital Strategy is a product of the North Devon Landscape Pioneer. It will be of interest to those with responsibility for people and nature in North Devon, as well as a wider audience committed to protecting and enhancing the benefits people get from nature everywhere.

North Devon

This strategy covers the land area of the North Devon UNESCO Biosphere. The Biosphere is a rural area which is home to 166,000 people. Tourism, agriculture, food and health care are the largest economic sectors. It also has a smaller number of higher paid jobs in sectors such as advanced manufacturing, energy, marine and business services. The Biosphere is home to many protected areas on land and sea. These protect rare wildlife, significant geology and beautiful landscapes. At its core is Braunton Burrows, the largest sand dune system in England, which is internationally important for wildlife. The Biosphere also contains a large proportion of the UK's Culm grassland, a habitat valued for its rare plants and animals.

Environmental challenges

North Devon faces many environmental challenges. Our strategy identifies four priorities for urgent action. These are:

Protect and improve water quality

Many of the waterbodies in North Devon have poor water quality, including rivers, wetlands, the estuary and coastal bathing waters. This damages tourism, commercial shellfish production and wildlife. The problem is caused by industry, human waste treatment and agriculture. Because we are taking a natural capital approach we have focussed on changes to agricultural practice as a central part of resolving the problem. The most significant agricultural cause of water pollution is livestock. An additional cause is the poor management of nutrients and soil.

Minimise flood risk

Flooding is a significant and growing issue in North Devon, which impacts negatively on the health and prosperity of the local population. The area is prone to flooding because of steep gradients and impermeable rocks, but the problem is intensified by the way land is used and managed. Natural approaches to reduce flood risk can form part of a cost-efficient response to this problem. For example, farm management practices that reduce the rate of run off, as well as restoring peatland, Culm grassland and woodland.

Increase carbon capture and storage

To mitigate climate change we need to capture and store as much carbon as possible. Woodland and Culm grassland are effective in sequestering carbon. These habitats are present in North Devon but there is great potential for more. We need to increase their extent and manage them for maximum carbon storage, wildlife recovery and sustainable timber.

Manage tourism and recreation pressure

North Devon attracts nearly 6 million visitors a year, with the visitor economy supporting a business turnover of £0.56 billion and around 11,000 jobs. Tourism is highly seasonal and concentrates on the coastal strip. It's difficult to accommodate this many visitors without damaging the local environment. Negative impacts include littering, damage to fragile habitats, and overloading waste-water treatment facilities. These pressures can be addressed by careful management of the coastal strip area and developing alternative tourist destinations away from the coast.

Responding to the challenges

A strategic response

Rather than responding to individual issues in isolation we have identified strategic changes that, together, help address them all. We have only proposed changes which will:

- deliver a wide range of benefits; ***and***
- are good for wildlife; ***and***
- are affordable.

The heart of the change required is to the way land is used and managed. We turn first to land management.

Changes to land management

Farmland, woodland and the coastal strip are the priority areas for land management change, they cover a large area in North Devon so improvements will have a large impact overall. Our strategy identifies a suite of actions for each. These actions vary from mitigatory responses to more strategic changes.

For example, fencing rivers to keep cattle out reduces the amount of manure entering it. But this measure is not always adopted. Even with fencing in place, rain will wash slurry into rivers, unless there is an effective slurry management plan. This plan might include buffer strips, slurry storage and the carefully planned use of slurry as fertilizer. However, in some fields the stocking rate is too high for a management plan to prevent pollution run off. Meeting environmental targets would then require restructuring the business. The management of arable, sown grass and soil is another example. Careful management would prevent erosion, improve soil fertility, reduce water pollution and increase carbon storage.

Woodland has the potential to deliver significant benefits, including, sequestering carbon, providing timber, improving water quality, reducing flood risk, providing recreation opportunities and wildlife habitat. Bringing unmanaged woodlands into management and changing management in areas under an intensive forestry regime can support the provision of these benefits. Extensive management approaches that mimic natural processes or which integrate ecosystem service provision with timber goals will have the most positive impact on carbon storage, biodiversity, recreation, water quality and flood protection. Threats from pests and disease, including deer and grey squirrel, makes new planting less attractive due to its long term economic viability, therefore new planting needs to be integrated with strategies for pest and disease control.

A recent survey asked the top five reasons for visiting North Devon. These were beaches and coastline, coastal towns, scenery, tranquillity and walking opportunities. This highlights the importance of the coast, and protecting its tranquillity. It also points to the potential to diversify the tourism offer. For example, inland tourism opportunities could be built around walking, tranquillity and wildlife watching opportunities, as has been done on the Knepp Estate in Surrey.[1]

Changes to land use

We've also identified land use changes which are needed. These are new woodland, semi-natural grassland including Culm grassland, wetland and inter-tidal habitat. New habitats replace the habitat on which they are created, so there are losses as well as gains and therefore they need to be carefully planned. For some benefits the location of the new habitat is critical. For example, for woodland to reduce flood-risk it needs to intercept the flow of water from the upper catchment. New semi-natural grassland and Culm grassland also have a role to play. They can reduce flood risk, improve water quality, sequester carbon and provide wildlife habitat. New wetlands could also reduce flood risk, improve water quality and provide wildlife habitat as well as providing water

[1] https://www.kneppsafaris.co.uk/

availability in drought conditions. New inter-tidal habitat reduces flood risk from the sea, as well as storing carbon and providing nursery grounds for the fish stock.

Key stakeholders

The natural environment underpins wellbeing and economic prosperity therefore most people in North Devon are affected by the issues set out in this strategy. Local authorities, central government, businesses, charities and local communities all have an important stake in the outcomes.

Delivering the changes we have set out requires action by those who own and manage the land. We identified three groups of people critical to the success of this strategy. These are farmers, woodland managers and those involved in managing the coastal strip. Influencing these people will require three things: an appreciation of their motivations and goals, provision of the right skills and knowledge and changing the incentives they face through markets and regulation.

The wider group of stakeholders have important roles to play in influencing these factors. Taking farming as an example, customer demand for food products has an enormous influence on the landscape. Supply-chain accreditation schemes can therefore change land use in the directions we have highlighted. Regulation and incentives (such as agri-environment subsidies) from central government also have a significant impact. Farmer training, agricultural innovations and advice also impact how land is managed. The tourism industry has important differences, but is also driven by customer demand. Accreditation or quality schemes could direct demand beneficially. Shared management of congested or sensitive spaces by those with a stake in them could also help.

Management principles: clear responsibility and shared commitment

The changes we highlighted above are happening, but not yet comprehensively or consistently enough. To deliver change at the scale that is needed we need to transform the way we manage the environment. Specifically, we need an approach designed for engaging with a complex system. Successful experimental approaches, such as South West Water's Upstream Thinking, point us in the right direction. To progress this shift we recommend four management principles: These are:

A) Institutional responsibility:

Each environmental problem needs to be owned by an organisation (or formal partnership). This institution must be legitimate. It must have the expertise and levers (for example, regulation, incentives, influence) to change the outcome.

B) *Adaptive management:*

There are many uncertainties in the evidence base. This means that we cannot calculate exactly which, and how many interventions we need. Instead, we need an adaptive management cycle. This means declaring a target, tracking progress against it and adapting plans and investments as required.

C) *Localisation*:

Environmental management issues are inter-connected. This means that they need to be managed as part of a single planning system. This means devolving responsibility to a geographical level discrete enough for integrated planning.

D) *Shared commitment:*

The 'hard levers' of regulatory, incentive and certification schemes are not enough. These schemes are much more effective if co-developed rather than imposed. We need broadly shared understanding and commitment to addressing these priorities.

Next steps

This strategy highlights a range of workable and affordable interventions. The next steps are to get these interventions delivered in a consistent and organised way. This requires adoption and progression of the management principles highlighted above. How could these become a reality in North Devon? The Biosphere is keen to engage in this conversation with national and local partners. North Devon partners may wish to develop a natural capital spatial plan to ensure that the right investments go in the right places.

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1 Introduction

This strategy has been written by Natural England following a two year collaboration with the North Devon Biosphere Partnership. It is the result of an experiment in applying a natural capital approach to place-based decision-making. Four natural capital priority issues emerged from our evidence–based and deliberative process. We investigated these to understand the root causes of the problem, then identified possible solutions; this evidence base underpins this strategy.

1.1 Natural capital

The natural environment provides essential benefits to people. These benefits are normally ignored, or underrepresented, in decision-making. This failure to take account of the value of nature leads to missed benefits, unnecessary costs and sustainability risks. The exclusion of nature from our decision-making has its roots in economics. For most of the twentieth century nature was assumed to be robust and abundant, and therefore taken for granted in economic analysis. Natural capital is part of a movement, over the last few decades, to put nature back into economics. It treats nature as one of the capital stocks required to produce goods and services.

The logic chain below shows our approach to natural capital (Figure 1). We view the environment as asset or groups of assets. These assets deliver services (called ecosystem services), which provide benefits to people. The benefits have a value to society. To take a simple example a woodland is an asset, which could slow the flow of water through a valley (service), reducing flooding downstream. The reduced risk to human life, health and property is the final benefit which has value to society. The quantity, quality and location of the asset affect the services it provides, and therefore the benefits which people receive.

Figure 1: Natural England Natural Capital Logic Chain (From NECR285, Wigley et al., 2020)

Ecosystem, or natural capital, assets are interactions between non-living components, such as geology, and living species. Biodiversity is short-hand for the diversity in living species, and is an important indicator of the robustness of the ecosystem. We therefore depend on biodiversity for the services we need to survive.

The relationship between biodiversity and ecosystem services is complex and context dependent. Environmental management which focuses on maximising a small number of ecosystem services over the short-term will not necessarily be good for biodiversity.

Therefore to ensure the sustainable delivery of ecosystem services in the long-term biodiversity should be explicitly protected.

The sustainability of ecosystem systems services is only one of several important reasons to protect biodiversity. Another is people's direct enjoyment of it, particularly charismatic biodiversity such as wild animals and birds. Finally biodiversity has intrinsic value – value in its own right – and this is recognised in government policy (HM Government, 2018, p. 6).

1.2 Pioneers

In 2018 the UK Government published the 25 Year Environment Plan (HM Government, 2018). The plan's vision was to 'improve the environment within a generation' and this was supported by a goal of 'better decision-making that protects and improves the environment'. This better decision-making was framed around a natural capital approach. As part of delivery the 25 Year Environment Plan the Natural Capital Pioneers were set up to experiment with using a natural capital approach in a specific place, in order to inform wider roll out across the country. Specifically the Pioneers were asked to:

a) Test new tools and methods as part of applying a natural capital approach in practice;
b) Demonstrate a joined-up, integrated approach to planning and delivery;
c) Pioneer and 'scale-up' the use of new funding opportunities; and
d) Grow our understanding of 'what works', sharing lessons and best practice.

There are four Pioneers in England. These are:

- Landscape Pioneer (North Devon)
- Marine Pioneer (North Devon Coast and Suffolk Coast)
- Urban Pioneer (Greater Manchester)
- Catchment Pioneer (Cumbria)

The Pioneers formerly concluded in March 2020, but we expect that the new approaches they have developed will continue.

1.3 North Devon Landscape Pioneer

The North Devon Biosphere is one of 668 Reserves in 122 countries designated by United Nations Educations, Scientific and Cultural Organisation's (UNESCO's) Man and the Biosphere Programme to safeguard significant ecosystems. It includes areas governed by the North Devon and Torridge district councils, as well as small sections of Mid and West Devon. Throughout this document we refer to the whole biosphere area as North Devon.

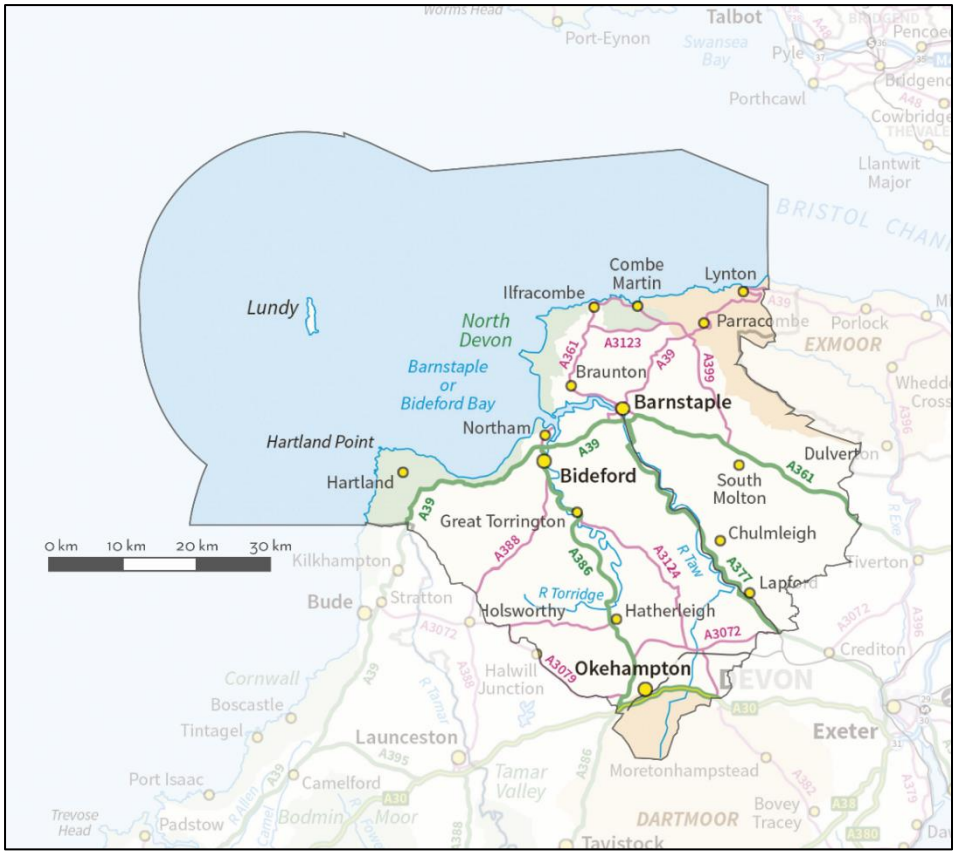


Figure 2: Map of the North Devon UNSECO Biosphere (Image created by Countryscape using © Ordnance Survey data and copyright 2019)

The UNESCO Biosphere is home to around 166,000 people and a variety of rare wildlife within a beautiful and highly valued landscape. These are recognised with the area (shown in figure 2) hosting 63 Sites Special of Scientific Interest, 671 County Wildlife sites, 3 Marine Conservation Zone's, covering 3,300 square kilometres and at its core is Braunton Burrows Special Area of Conservation, an internationally recognized sand dune system.

North Devon also encompasses one of the greatest concentrations of Culm grasslands in the UK. Culm is a low nutrient, species rich and often wet and boggy grassland. Culm forms over the Culm measures; an area of heavy clay soil, overlying carboniferous rocks. Due to the high water retention and low nutrient levels of the soil Culm grassland is naturally agriculturally poor. However, it supports a number of rare plants and animals as well as contributing to reducing flood risk and improving water quality.

The North Devon Biosphere has 12% woodland cover which includes Atlantic Oak Woodland, renowned for its rare plant communities. The dramatic and distinctive coastal landscapes of North Devon also sit within the Biosphere and are protected as Areas of Outstanding Natural Beauty.

1.4 Strategy

This document is a natural capital strategy for North Devon. This means that the North Devon Biosphere partners have come to a shared view on:

- **the current situation of natural capital assets in the biosphere;**
- **what is likely to happen under business-as-usual over the next twenty years;**

- **what priority issues need addressing;**
- **the physical changes required to address these issues; and**
- **changes to incentives and governance to deliver these.**

This provides the 'big picture' understanding required to put specific natural capital projects in perspective. It also provides the evidence to use a natural capital perspective to engage with other sectors.

Specific project planning is the next stage after strategy. Accordingly, this document does not make recommendations about specific places for physical land use changes, recommend how much of each change is required or undertake cost-benefit analysis.

In conjunction with this strategic approach we've also had a look at the potential for attracting in new funding streams using a natural capital approach in our linked investment cases document (Eunomia NECR 292, 2020).

2 Process

This section sets out a brief summary of the process that informed the development of the strategy. More detail can be found in Appendix A1.1.

2.1 We gathered all the relevant evidence to determine our Natural Capital Baseline

Our evidence process was based on the natural capital logic chain explained in the introduction. We wanted to gather all the relevant evidence across every stage of the logic chain. To do this we used the National Ecosystem Assessment Typology of habitats. We choose this one because it is well recognised, exhaustive and non-overlapping.

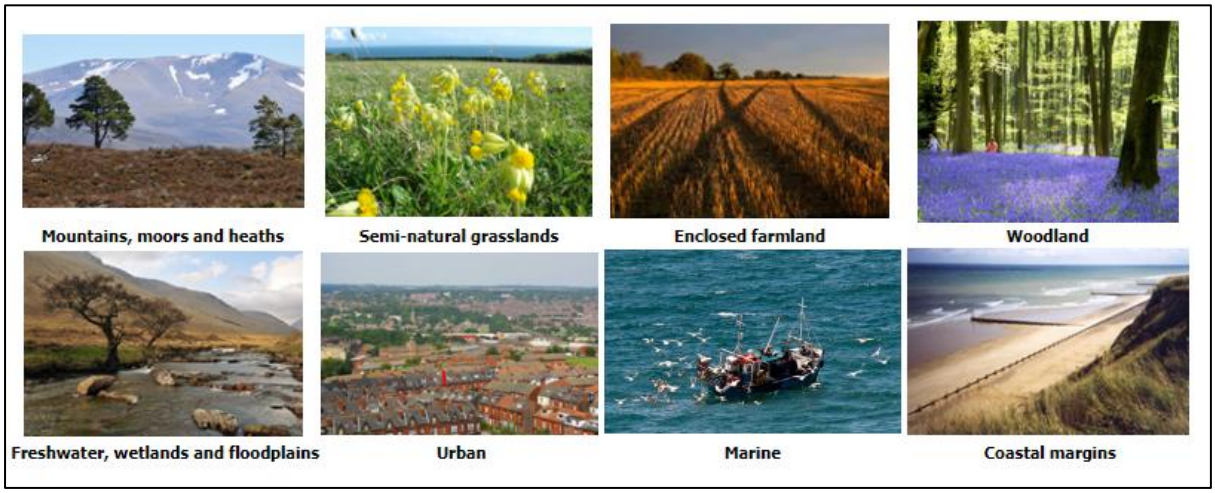


Figure 3: The National Ecosystem Assessments Habitats
Image from UK NEA (2011) (Photo Credits (left to right): Banner: © Steve; © Midlander1231; © Dave Kav; © Joe Edwards; © Keith1999; © Peter Mulligan; © David Mason. Main images: © Peter Mulligan; © D.Greves; © Steve Sawyer; © Angus Kirk; © Peter Mulligan; © Tasa M; © Simon Greig; ©)

We then built spreadsheets for each habitat addressing the questions provoked by the logic chain. We started to answer these questions based on the academic literature. This answered only a small proportion of the questions. We then expanded our evidence base to include grey literature and expert opinion, which we gathered through a local workshop. We then gave an objectivity rating to each answer, to guide users of the spreadsheet. The final spreadsheets are available in annex 1.

2.2 We prioritised four issues

We chose to prioritise pairs of habitats and ecosystem services. For example the carbon sequestration service from woodland. We did this through a multi-criteria prioritisation with three elements. These were:

- a scoping valuation of the economic value of that service on an annual natural capital accounting basis for the biosphere area
- the current condition of that habitat for delivering that ecosystem service
- the trend of that service over the last twenty years

We prioritised these based on value, then condition, then trend. This produced an interim list of priorities. This interim list of priorities was discussed at a workshop with Biosphere

partners and amended to a final list of priority pairs. These pairings were than simplified to give us our four priority problems:

- **Protect and improve water quality**
- **Minimise flood risk**
- **Increase carbon capture and storage**
- **Manage tourism and recreation pressure**

2.3 Root cause analysis of issues

The aim of the North Devon Landscape Pioneer is to address natural capital priorities in a manner which is effective, cost-efficient and sustainable over the long-term. To do this we needed to address issues at root cause, rather than just dealing with the problems as they arise. For this reason we decided to conduct a root cause analysis of the issues. Root cause analysis is an approach borrowed from engineering which tracks issues back to their root causes through asking a series of 'why?' questions. We worked with local partners and experts to build root cause analysis 'maps' (see appendix A 2.0). Using the root cause analysis 'maps' local partners then identified a large number of potential interventions which ranged from mitigatory and 'end-of-pipe' responses to those which would address the problem and root cause.

2.4 Strategic Responses

The next step was to bring this range of possible responses together into a coherent whole. To do this we ran a partners workshop which looked strategically at the situation. We looked at possible future scenarios for North Devon and significant drivers of change. . The Natural England team worked on these strategic interventions in consultation with local partners to identify a suite of interventions which would work as a group of interventions to address the problems we have identified.

3 Natural Capital Baseline

A series of workshops and reports were used to gather information on the ecosystem assets (further described in Appendix 1). In this section we show the headline information about the state of the ecosystem assets as well as current expenditure on them in North Devon.

3.1 Ecological state, past trajectories and anticipated trajectory

As described in the methodology section we produced eight spreadsheets, one for each broad habitat type. Table 1 below summarises the quantity and quality data for each of the broad habitats.

Table 1: Register of natural capital assets

Broad habitat *(UKNEA Classification)*	Quantity			Quality		
	Area (Ha) *	Trend (past 20 years)	Anticipated trajectory (next 20 years)	Current condition	Trend (past 20 years)	Anticipated trajectory (next 20 years)
Coastal Margins	3000	No data	Stable	Healthy	Stable	No data
Enclosed Farmland	176,000	Stable	Stable	Stressed	No data	No data
Freshwater	1000	No data	No data	Stressed	Increasing slowly	Increasing slowly
Mountains, Moorland and Heaths	10,000	No data	No data	Stressed	Decreasing slowly	Stable
Semi-Natural Grassland	4000	Decreasing slowly	Decreasing slowly	Stressed	Decreasing slowly	Decreasing slowly
Urban	4000	Increasing slowly	Increasing slowly	Stressed	Stable	No data
Woodland	35,000	Increasing slowly	Increasing slowly	Stressed	Stable	Increasing slowly
Marine	148,000	Stable	Stable	Healthy	Stable	No data

Notes:

* Rounded to nearest 1000 hectares.

Condition categories were choice of:

Healthy	Asset is delivering the ecosystem services which society expects from it and the capability to do this in future is stable or increasing
Stressed	Asset is delivering the ecosystem services which society expects from it but capability to do this in future is reducing.
Degraded	Asset is able to deliver the ecosystem services which society expects from it only partially, or at a reduced level, and the capability to deliver ecosystem services in future is reducing.
Damaged	Asset is able to deliver the ecosystem services which society expects from it only partially, or at a reduced level and the capability to deliver ecosystem services in the future is reducing, possibly to a state where the damage is irreversible.

Trajectory and Trend categories were choice of:

Increasing rapidly	Current figure greater than 20% of situation 20 years ago
Increasing slowly	Current figure between 10% and 20% greater than 20 years ago
Stable	Current figure within 10% of situation 20 years ago
Decreasing slowly	Current figure between 10% and 20% less than figures 20 years ago
Decreasing rapidly	Current figures more than 20% less that situation 20 years ago

3.2 Expenditure on natural capital in North Devon

The Pioneer worked with consultants and HM Treasury to map natural capital expenditure in North Devon. Figure 4 shows total spend by organisation in thousands, so total expenditure is £49.4 million. The Rural Payments Agency, disbursing single farm payment, is the largest (50%). This followed by South West Water (21%), Environment Agency (11.5%), then Natural England (10%). These figures exclude Non-Governmental Organisation spend, which would be approximately 3% of a total of £53 million if it were included (Eftec, Unpublished b).

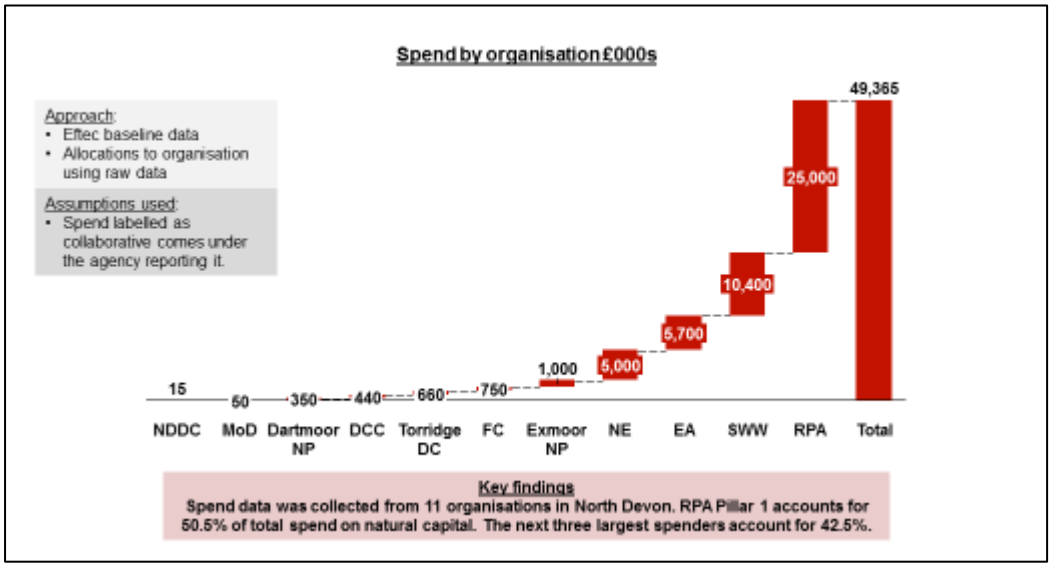


Figure 4: Which agencies are spending in North Devon? From (HM Treasury, 2017, p. 5)

Figure 5 (below) shows how spending is distributed across habitat types. It was not possible to assign a location to all the spending, so this graph is based on £ 19.2 million of spend (approximately 39% of the total). Much of what could not be mapped was either not spatially specific or spread fairly evenly. 83% is spent on enclosed farmland, with semi-natural grassland and woodland taking positions two and three.

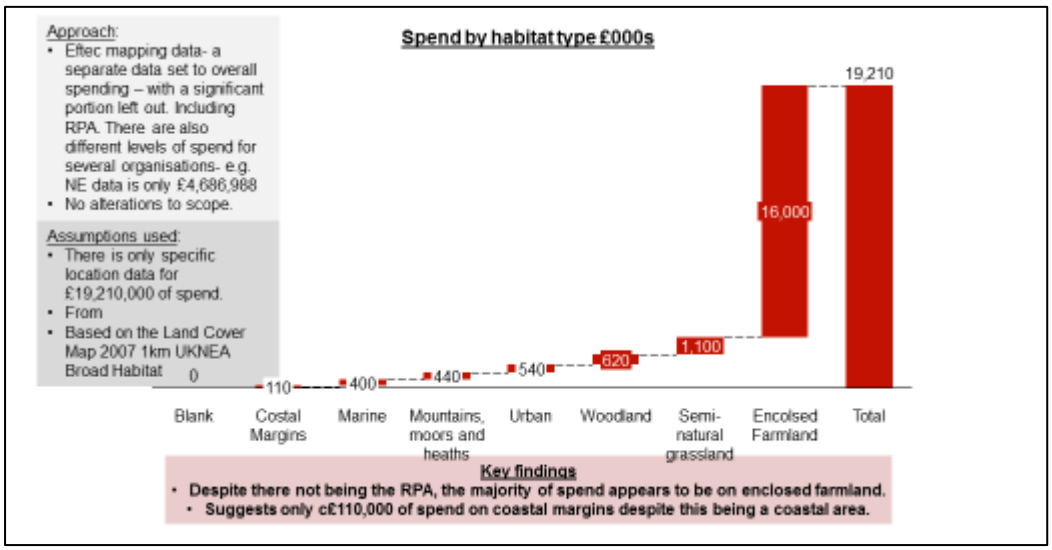


Figure 5: Who is spending on which habitats? From (HM Treasury, 2017, p. 10)

Figure 6 (below) shows where the money is being spatially targeted. It has the same limitations as described for the graph above, but does contain non-governmental organisational spend. There is a strong spatial pattern with approximately half the money being spent in one fourteenth of the area. Designated areas, such as Sites of Special Scientific Interest and Areas of Outstanding Natural Beauty, generally attract high levels of spend per hectare. However, as mentioned above, enclosed farmland receives the highest proportion of spend per habitat type, therefore from this analysis it is difficult to assess whether designations drive spending, or correlate with it due to other factors.

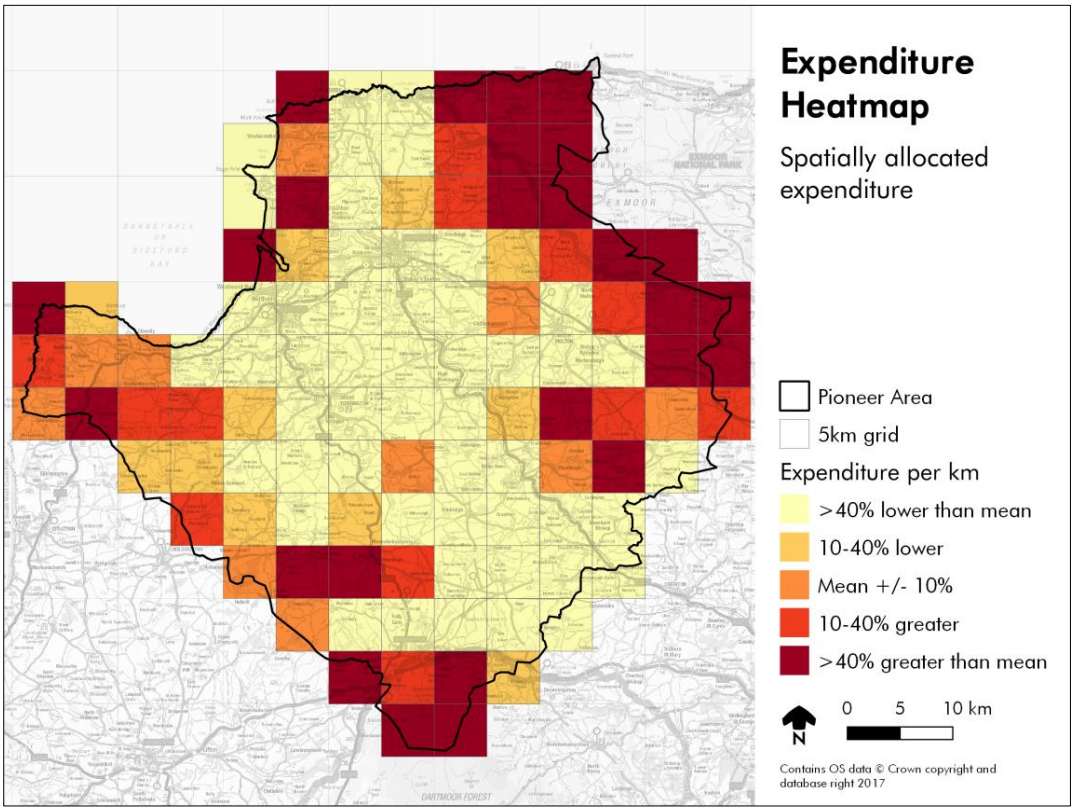


Figure 6: Expenditure Heatmap of North Devon From **(Eftec, Unpublished b, p. 22)**

Although total spending of £53 million per year sounds large, this is only about £3000 per person. This represents about 3% of government expenditure in the area, and compares to around £275 million per year on health, £630 million per year on social security services/payments and £92 million per year on education. These figures help to demonstrate that the environment receives comparatively little investment, yet provides a wide range of important public benefits.

4 Priorities

North Devon faces many environmental challenges. Our strategy identifies four priorities for urgent action; protect and improve water quality, minimise flood risk, increase carbon capture and storage and manage tourism and recreation pressure. In this section we describe and investigate the causes and impacts of the priority problems and outline any current initiatives trying to solve them.

4.1 Protect and improve water quality

North Devon supports ecologically important rivers, estuaries and bathing waters. The Taw and Torridge are the main rivers flowing through the Biosphere Reserve, with many smaller tributaries feeding into them before they reach the estuary mouth and sea (Bell et al, 2014). Achieving good water quality is important for wildlife and people; the quality of coastal waters in particular is important in maintaining cultural services for residents and visitors, and supporting the tourism industry (Bell et al, 2014). Poor river water quality is implicated in the decline of species such as the kingfisher and freshwater pearl mussel (Bell et al, 2014).

4.1.1 The problem

In North Devon very few of the water bodies in the Torridge and Taw catchments are in good ecological status with only 36% of water bodies reaching good status in 2009 and even less in 2013 (Environment Agency 2014). Water bodies can fail for a number of reasons including high nutrient levels, high levels of toxic pollutants (eg from mining and quarrying), too many physical modifications and a high number of invasive non-native species present. The main freshwater bodies in North Devon often fail due to the impacts of rural land management (North Devon Biosphere, 2014), however, other industries also contribute, including waste water treatment, mining and quarrying, urban and transport infrastructure and other industries and businesses (Environment Agency, 2014).

This strategy focuses on natural capital, therefore we investigated the water quality issues caused by rural land management and the solutions which could be provided by changing land management practices.

Rural land management can cause soil loss and the run off of problem pollutants; including phosphates, nitrates, faecal indicator organisms, sediment and pesticides (Natural England et al, 2016; UKNEA, 2011; Natural England, 2011; POST, 2014). This then impacts on water quality. High rainfall and the intensity of farming contribute to increasing pollution and soil run off, with much farmland being managed as part of intensive dairy farming systems.

Specific actions which exacerbate pollutant run-off are:

- Production of large volumes of slurry
- High levels and inappropriate timing of application to land of slurry and fertilisers.
- Soils affected by compaction and erosion.
- Direct contact between livestock and watercourses
- Pollutant run off from slurry stores and farmyards.

As well as the causes described above, improved pasture that is cultivated and reseeded may be subject to increased problems of soil erosion and run-off, especially from fields susceptible to erosion or through inappropriate operations (e.g. working up slopes) (Cranfield University, 2015). The timing of grass reseeds is also a factor affecting erosion risk, with spring reseeds in general reducing erosion risk compared to those undertaken in autumn (Defra, 2005).

Socio-economic factors are among the root causes of soil erosion and water pollution, encouraging the intensification of production and inappropriate use and management of land. For example, buyers may put pressure on growers to supply a given quantity and quality of crops on demand, so putting pressure on farmers/land managers to grow unsuitable crops and/or to access the land when conditions are less than ideal (Boardman, 2013; Cranfield University, 2015).

The management of enclosed farmland improved pasture and arable land, which are significant land uses in North Devon, are therefore critical in maintaining water quality.

4.1.2 Current initiatives

There are a number of activities operating within the North Devon Biosphere area relating to land management that contribute to improvements in water quality. These include:

- The Biosphere's Catchment Management Plan, hosted by Westcountry Rivers Trust and Devon Wildlife Trust (North Devon Biosphere, 2014).
- The Northern Devon Nature Improvement Area delivered interventions on managing fields and river banks to minimise runoff of pollution and sediment (Northern Devon Nature Improvement Area, 2015).
- The Upstream Thinking programme, working on the River Yeo catchment around Barnstaple, is providing advice and capital grants to farmers to help prevent pesticides, nutrients and other pollutants from getting into waterways (Upstream Thinking, 2019).
- The Biosphere reserve's Woods4Water project supports landowners with advice and encouragement to plant woodland in selected areas (North Devon Biosphere, 2019).
- The North Devon Estuary Project offers small capital grants to install features such as culverts, stream protection, and sediment traps etc. in woodland (Craddock, 2018)

4.2 Minimise flood risk

The North Devon catchment includes areas drained by the Rivers Taw and Torridge and their tributaries and the North Devon Coastal Rivers that flow directly into the sea (Environment Agency, 2012a). Impermeable rocks and steep gradients in the upper catchments give the rivers a 'flashy' nature, which can cause rapid flooding downstream after heavy rainfall, particularly when this coincides with high tides in the estuaries (Natural England, 2015). Natural capital approaches that contribute to the management of flood risk focus on the goal of reducing and slowing run-off in peak events through land use and land management changes.

4.2.1 The problem

Flood risk in North Devon comes from river, surface water and tidal flooding. Several river and tidal floods have occurred in North Devon and the Environment Agency estimates that about 5% of all properties are at risk of flooding from a 1% Annual Exceedance Probability (AEP)[2]. The greatest concentration of properties at risk of river and tidal flooding is at Barnstaple, and this is set to increase due to rising sea levels (Environment Agency, 2012a). More frequently, surface water flooding causes floods across the catchment that can be deep and fast flowing (Environment Agency, 2012a) affecting property, communities and agricultural land in rural areas. Flooding not only has significant social and economic impacts but also environmental impacts, for example it exacerbates erosion and chemical and nutrient run-off from farms.

Flood risk is the combination of the likelihood of a flood event happening and the impact if it does occur, for example on housing and property. Flooding is generally being experienced with greater frequency and with more impact (Local Government Association, 2019). Flooding and the damage it causes can significantly impact people's mental and physical health. In North Devon future flood risk is likely to be significantly affected by two key factors (Environment Agency, 2012a).

- Climate change is predicted to be the main factor that influences future increases in flood risk, resulting in increased peak river flows from higher winter rainfall, more summer thunderstorms and rising sea levels.
- Land use and land management also affect how often flooding occurs and what impact it has. Intensive land management can increase the risk of flooding, for example soil compaction reduces the ground's ability to absorb water and increases runoff. Palmer & Smith (2013) surveyed soil structural degradation in southwest England under many cropping systems and confirmed a link between cropping, degraded structure and enhanced surface water runoff.

Urban development in the North Devon catchment is unlikely to have a large impact on flood risk (Environment Agency, 2012a) although the urban areas of Barnstaple and Bideford would see the most properties affected in the future. Whilst significant investment in targeted flood defence schemes can alleviate this risk, land use and land management changes within the wider catchment can improve the storage of floodwater and slow the flow to rivers, thus reducing the risk of flooding in vulnerable areas downstream.

[2] For a definition and explanation of AEP please see http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide/Chapter2.aspx?pagenum=4.

4.2.2 Current initiatives

There are a number of initiatives operating within the North Devon Biosphere area that improve the ability of the wider catchment to slow the flow of floodwater downstream. These include:

- As part of the Upstream Thinking Programme South West Water is working with Devon Wildlife Trust on the Working Wetlands Project, involving restoration of special mire and peat habitats on Exmoor and Dartmoor, and tree planting and restoration of Culm grassland to help the land to hold water naturally to reduce pollution and contribute to flood risk management (Upstream Thinking, 2019).
- The Culm Grassland Natural Flood Management Project – a major project from 2016-2020 to research and promote the benefits of Culm grassland in helping to manage flooding, enhancing current sites and creating new wet grassland (Devon Wildlife Trust, 2019).
- The Woods for Water project brings added flood attenuation benefits from its approach (North Devon Biosphere, 2019).
- The Boode Farm Natural Flood Management Pilot incorporates natural flood management measures such as log dams and hedgerow planting to increase the flood resilience of communities downstream (North Devon Biosphere, 2019).

4.3 Increase carbon capture and storage

To mitigate climate change we need the natural environment to capture and store as much carbon as possible. North Devon has a higher than average percentage of woodland and the majority of the UK's Culm grassland (Eftec, Unpublished a) two assets particularly effective in sequestering carbon (Alonso et al., 2012). The area of these habitats is, however, small compared to the area of farmland and over time land use change has reduced the extent of these assets. Management also affects capacity to store carbon and regulate climate change (Alonso et al., 2012).

4.3.1 The problem

Carbon storage is one of the most important services provided by broadleaved woodlands, but in North Devon the area of woodland is limited by low rates of new planting as well as historic losses. Low rates of woodland planting are believed to be a result of the limited attractiveness of woodlands compared to agriculture linked to a range of factors including agricultural subsidies and poor market returns from woodlands (Eftec, 2020). Additionally, the effectiveness of existing woodlands in capturing and storing carbon is reduced by factors such as under-management leading to poor structure, clear fell management and the impact of pests and disease (Alonso et al., 2012; Bressette and Beck, 2013).

The unimproved Culm grassland of North Devon has deeper and richer soils than other grasslands across the farmed landscape and the potential to store more carbon than grasslands that have been tilled or limed to improve productivity (Eftec, 2020). The area of Culm grassland in North Devon is decreasing, due to agricultural improvement. Remaining Culm grassland has been calculated to store 715,000 tonnes of carbon compared to a potential of over 5 million tonnes if the Culm was at 1900's extent and in good condition (Puttock & Brazier, 2014).

Improvement for agriculture has led to the development of intensively managed grassland capable of carrying more livestock or supporting forage production for longer periods (Devon Wildlife Trust, 2015). In some cases this has allowed milk production to take the place of beef rearing. In other areas the traditional grasslands have been under grazed or not grazed at all, allowing scrub to encroach (Devon Wildlife Trust, 2015). High stocking rates, particularly dairying which produces large volumes of slurry, also increase emissions of greenhouse gases, such as nitrogen oxides, methane, ammonia and carbon dioxide. Research indicates that intensively managed grassland can cause carbon release into the atmosphere if excessive levels of fertilizer are applied causing over stimulation of plant decomposition or if the soil is cultivated for reseeding (Ward et al., 2016).

4.3.2 Current initiatives

There are a number of current initiatives which aim to support carbon sequestration and forest management:

- North Devon Biosphere Reserve has set out policies to support a Woodland Enterprise Zone between 2017 and 2027. This sets out four priority areas to support economic growth around woodlands, coupled with increased support to better manage and extend woodlands for economic, climate regulation and biodiversity outcomes (North Devon Biosphere, 2014). Linked to this was a Devon County Council and Forestry Commission pilot, the Ward Forester Initiative.
- Devon County Council has declared a climate emergency and proposes that it will become carbon neutral by 2050 (Devon County Council, 2019) .

4.4 Manage tourism and recreation pressure

The North Devon coast with its varied landscapes and habitats is an attractive area for residents and visitors, contributing substantially to North Devon's economy through tourism and recreation. Tourism is a vital part of the local economy with visits to North Devon and Torridge estimated at 6 million per year, supporting over 11,000 jobs and was estimated to be worth more than £0.56 billion in 2016 (North Devon Council and Torridge Council, 2018).

4.4.1 The problem

While the value of North Devon's coast and the services it provides are widely recognised, they are subject to a wide range of threats and pressures, which, if not addressed, could have adverse implications on the economy, local communities and the environment over time. In North Devon, local partners identified a range of existing and potential pressures on the landscape, natural environment, tranquillity and character of the coast that are also documented nationally in the 2011 UK National Ecosystem Assessment (Eftec, 2020):

- Tourism can put pressure on resources, such as water or waste treatment facilities, increase land-claim for infrastructure development, damage sensitive ecosystems, cause pollution and littering, and have adverse social impacts, particularly when tourist numbers are strongly seasonal or greatly exceed the local population.
- Sea level rise, caused by climate change, resulting in inundation of low-lying coastal areas, accelerated erosion of beaches, dunes and soft cliffs exposed to significant wave action, more frequent coastal flooding and saline intrusion, and coastal squeeze (where natural habitats, such as dunes and saltmarshes, are constrained by steeply rising ground or coastal defences on their landward side, preventing natural landward translation).
- Coastal development, including recent growth in housing demand caused by strong net in-migration to coastal towns of people of working age and people choosing to retire by the sea.

4.4.2 Current initiatives

- Devon County Council have created a Public Rights of Way Improvement Plan (2012) developing and promoting long distance walking and cycling routes, such as the Two Moors Way and the Tarka Trail which have helped draw tourism inland and into rural parts of Devon (Devon County Council, 2012).
- The Tarka Trail Coastal Community Team, Economic Plan, March 2017 outlines a vision and priorities for action to develop the economic value of the Tarka Trail for the coastal communities along its length. The plan aims to use the Trail as a potential catalyst to generate opportunities and jobs within what are often very rural communities, working sensitively with the high-quality natural environment within which the Trail sits (Tarka Trail Coastal Community Team, 2017).
- The North Devon Biosphere is leading a brand-new EU Interreg funded project on "biocultural heritage tourism" which is seeks to improve spatial planning for sustainable tourism and developing visitor payback approaches as well as new tourism activities designed to work in harmony with the landscape and environment in the Biosphere (www.bcht.eu)

5 Responding Strategically

Our aim is to deal with these priorities strategically. A strategic response is one which understands the context, the systems and the relationships which give rise to the current problems. It makes recommendations for interventions which are desirable in-the-round, in contrast to reactions to problems that have unconsidered side effects. Our priority issues are interrelated. Any changes we make to address one of these issues will impact on all the others. Changes will also affect other ecosystem services, the farming industry and the wider economy.

In selecting our proposed interventions we have used the following criteria:

1) **Deliver for our priority ecosystem services**
2) **Deliver multiple benefits**
3) **Are good for biodiversity**
4) **Support the long-term health of the natural capital assets that the ecosystem services depend on**
5) **Do so at least cost, and at an acceptable cost** (including financial cost and ecosystem services trade-offs).

Our root cause analysis allowed us to build a shared understanding of the systems we want to influence. It gave us a range of potential interventions. Some of these were close to the root cause, i.e. they were systemic interventions. Others are further from the root cause and reduce or limit the problem once it has arisen. We have preferred systemic interventions, but have also included mitigatory interventions because some of these are helpful and low-cost.

The market rewards the delivery of products, such as food, but not non-market services such as the management of flood risk. This leads to the maximisation of short run economic activity that favours a narrow range of ecosystem services linked to the production of market goods. To maximise the wellbeing of the population we need to move towards a more balanced suite of ecosystem services that provide a wider range of benefits.

We have taken a systems perspective by examining the root causes of the priority issues and thinking about how the natural environment works in relation to these. For example, climate change has increased the intensity of rainfall events and intensive farming practices increase the rate that water runs off the landscape. Changes to the landscape can slow this flow, reducing the risk of flooding and making farms more resilient during drought conditions. To take another example, contemporary farming adds additional nutrients, at a cost to land managers. Currently, there is a significant problem with nutrients washing into water courses and into the sea. So nutrient management plans could reduce farmer costs and reduce water pollution.

We've thought about changes to the system in three steps:

1) physical changes to the landscape
2) the systems and incentives facing land managers, along with their motivations and capacities
3) governance changes

6 Physical changes to the landscape

A suite of land management and land use change interventions have been identified by stakeholders to address the natural capital problems outlined in section 6. Changes are needed both to the way land is used and managed. Applying these interventions to the whole North Devon landscape would be a step-change in the way we manage the natural environment. Landscape-scale change is needed to address the issues set out in this document to improve the state of the environment.

Land management changes are needed in areas such as farmland, woodland and the coastal strip, in order to improve the state of the ecosystem assets in North Devon, and their capacity to provide society with the benefits it relies on. Some land use changes are also required, such as planting more woodland in the right location so that water quality is protected and improved, and the well-sited creation or restoration of Culm grassland to contribute to reducing flood risk, improving water quality and supporting biodiversity.

The interventions and the expected benefits are shown in tables throughout this section. Each intervention was assessed as to whether it would improve key ecosystem services. Biodiversity has also been included explicitly to understand which interventions would be positive for biodiversity. A link is shown either with a ‘1’, which shows that it is supported by peer-reviewed evidence, or a 2 which shows that it is support by expert opinion from our process or evidence from Natural England’s Natural Capital Indicators Project (Lusardi et al, 2018).

6.1 Land management change

Farmland, woodland and the coastal strip are the priority areas for land management change, they cover a large area in North Devon therefore improvements to the management of these areas will have a large overall impact. Our strategy identifies a suite of actions for each. These actions vary from mitigatory responses to more strategic changes.

6.1.1 Farmland

Table 2 shows a range of land management interventions identified by stakeholders that serve to enhance a number of the key ecosystem services we have identified as priorities and also deliver a range of other benefits. A rating of 1 shows that there is peer reviewed evidence demonstrating an impact, a 2 shows that an impact is expected by expert opinion. Addressing issues within farmland such as pollution run off benefits not only the rivers and streams adjacent to the farm, but also improves water quality downstream in the estuary and sea. Clean water supports all forms of life including the rare Freshwater Pearl Mussel.

Table 2: Ecosystem service benefits of Farmland interventions

Farmland	Provisioning services				Regulating services								Cultural services			
Ecosystem services / **Interventions**	Food	Fibre	Fresh water	Air quality	Climate (global)	Water regulation	Erosion regulation	Water purification and waste treatment	Disease regulation	Pest regulation	Pollination	Natural hazard regulation	Cultural, spiritual and religious values	Aesthetic values	Recreation and eco-tourism	Biodiversity
Slurry management –slurry storage and treatment including anaerobic digestion					2			1							1	2
Limited stocking rates for reduced slurry inputs		1			1	1	1	1	1	1						1
Improved arable soil and agricultural practice – including decompaction; winter cover cropping, crop rotations, conservation tillage.	2				1	2	1	1			2	2				1
Nutrient input limits – organic and inorganic	2				1			1								2
Timing and management of grazing (e.g. not graze overwinter)						1	1	1								
Fencing watercourses							2	1								1

These interventions are measures that relate to soil and agricultural practice on farmland which form part of a suite of interventions identified within the Environment Agency's Working with Natural Processes to Reduce Flood Risk measures (Environment Agency , 2017) in relation to the management of arable and grassland systems. In this context, an evidence review (Environment Agency, 2018) found that although the suite of land management interventions identified as part of the *working with natural processes* measures can have flood risk management benefits locally for small events, there is limited evidence that demonstrates a significant impact at the catchment scale. However, despite the lack of flood risk evidence, such measures can also have a significant impact on diffuse pollution from agricultural land which leads to cleaner rivers, and thus estuaries, seas and bathing waters as well as increased carbon storage, supporting biodiversity and recreation and tourism. The principles of regenerative or holistic agriculture seek to improve farming productivity as well as the ecological health of farmland. Practices are encouraged which increase farms contribution to environmental quality (such as soil fertility and carbon capture) which in turn can improve crop yields (Pretty, 1995). A shift to this type of farming could be key for a more environmentally friendly farming landscape in future.

In the arable system conservation tillage (including non-ploughing techniques such as zero tillage or direct drilling) early sowing of winter crops, cover crops and carefully designed crop rotations can be used as interventions to help reduce soil compaction, encourage greater soil water retention capacity and slow water flow to help manage flood risk. These measures also reduce the amount of time soil is left bare and can improve soil structure and fertility, reduce soil erosion and can have a significant impact on the reduction of diffuse pollution. Crop rotation is common practice but has tended to be applied for agronomic rather than specifically water objectives, therefore new practices in North Devon need to be explored to ensure water and wider benefits can be achieved. The range of beneficial impacts will depend on the choice of crops, rotation scheme and the physical practices associated with the management of these.

Improved pasture is the dominant land use in North Devon. Eftec (Unpublished a) identifies an area of 97,000 hectares of improved pasture in the Pioneer area, as well as 58,000 hectares of permanent grassland (much of which has been agriculturally improved). Therefore, how this land is managed has a significant impact on the problems identified in section 6, particularly in terms of water quality improvement, flood risk management and carbon regulation. Livestock, particularly cattle, can have a damaging effect on soil in terms of compaction so a reduction in stocking density and/or movement from high risk areas at vulnerable times (e.g. winter) will limit compaction, enable infiltration and potentially reduce runoff and peak flows.

The emphasis on cattle farming in North Devon has led our stakeholders to identify improved slurry management as a key intervention to reduce diffuse pollution. Land use interventions that can contribute to a reduction in diffuse pollution from slurry are outlined in section 8.2.3 and good practice guidance exists for the spreading and management of slurry and other organic manures (Defra, 2018).

Anaerobic digestion of slurry is an additional mechanism that stakeholders identified for consideration. Using slurry for anaerobic digestion would reduce greenhouse gas emission, provide renewable energy, reduce fertilizer required, reduce diffuse pollution and reduce odour. This does, however, require significant capital investment and, where it has been examined in relation to Scottish livestock farming, the business case was found to be poor (Ford, Williams, & Morris, 2017). Greater subsidy and or mixing slurry and farm-yard manure with feedstocks with greater gas yield would make it viable. However its environmental credentials will depend on the feedstock. Purpose grown feedstocks, such as maize, will have significant impact on soil quality, water quality and biodiversity (North Devon Biosphere). In contrast using food waste as feedstock could be economically and

environmentally attractive (Banks, Salter, Heaven, & Riley, 2011), dependent on the renewable energy subsidy regieme. This is a developing technology so new options may be available in the future. The appropriateness of anaerobic digestion in the biosphere depends on a number of detailed issues about scale, planning, visual intrusion and the management of wastes (North Devon Biosphere).

6.1.2 Woodland

Woodland has the potential to contribute to the provision of key ecosystem services and address some or all of the priorities identified in section 6. The extent of woodland and where in the landscape it is located is discussed in section 8.2.1, this section relates to the impact management has on the ability of woodlands to provide the benefits identified in table 3. Our stakeholders identified interventions that enhance the diversity and structure of native broadleaved woodland (table 3).

Sing et al (2017) examined the intensity of woodland management in relation to the provision of key ecosystem services including climate mitigation, water quality, flood risk management, biodiversity and recreation. Generally speaking they found that less intensive management approaches that mimic natural processes or integrate ecosystem service provision with timber goals in an integrated way have the most positive impact on carbon storage, biodiversity, recreation, water quality and flood protection.

Such interventions would include stand restructuring with broadleaved species and low impact silvicultural systems such as thinning, pollarding or coppicing to improve structural diversity. These techniques maintain an open woodland canopy with occasional old, large trees and a cover of
ground vegetation for maximum structural diversity. Likewise, promoting natural regeneration reduces the need for site cultivation and soil disturbance. Woodland grazing by large herbivores, including domestic stock such as cattle, can help create structural and species diversity and guidance exists on species and stocking density to achieve specific aims (Mayle, 1999; Woodland Trust, 2012; Scottish Forestry, n.d.)

Our stakeholders have also identified a number of interventions designed to address pest and invasive species as measures that need to be addressed in order to expand woodland cover in North Devon. For example, grey squirrels damage woodland by stripping bark from trees. This restricts the growth of trees and leaves them vulnerable to fungal infection. The Devon Invasive Species Initiative (2017) cites this, combined with deer browsing, as one of the primary reasons why new broadleaved woodland planting is limited in Devon. The reintroduction of pine martens is a possible mechanism for controlling grey squirrel populations and previous work has suggested that recovery of pine martens in Ireland and Scotland can be linked to suppression of grey squirrel populations (Tansey, 2018). This would need to be further explored in the local area to understand if pine martens could effectively suppress squirrel populations across the landscape, and to investigate any other benefits arising and potential conflicts before considering a re-introduction.

Table 3: Ecosystem service benefits of Woodland interventions

Woodland	Provisioning services				Regulating services								Cultural services			
Ecosystem services / **Interventions**	Food	Fibre	Fresh water	Air quality	Climate (global)	Water regulation	Erosion regulation	Water purification and waste treatment	Disease regulation	Pest regulation	Pollination	Natural hazard regulation	Cultural, spiritual and religious values	Aesthetic values	Recreation and eco-tourism	Biodiversity
Restructure with native broadleaved species		2	2	2	2	2	2	2					2			2
Low intensity woodland management for improved structure (e.g. age, height, species)		2			2				2					2		2
Thinning – increase ground flora with continuous cover (no clear fell)		1			1	2	2	2				2	2	2	2	2
Pest control (grey squirrel and deer)		2			2	2	2	2				2				2
Pine marten re-introduction		2			2	2	2	2				2	2	2		2
Remove invasive non-native species (Laurel and Rhododendron)										2						2

6.1.3 Coastal Strip

The interventions suggested by our stakeholders in table 4 are a selection of interventions that sit within the wider strategic framework of the Northern Devon Tourism Strategy 2018-2022 (North Devon Council and Torridge Council, 2018). This framework organises activity within three inter-linked themes with a commitment to sustainability i.e. not compromising the environmental and cultural assets upon which the future of tourism depends:

1. Develop the tourism product - the core assets, facilities and infrastructure upon which tourism depends to attract and retain visitors in the area.
2. Engaging and connecting with visitors – reaching out to potential visitor markets to raise awareness and impetus to visit, and to inform their experiences.
3. Developing capacity and capabilities of individual businesses and of the sector as a whole in northern Devon to take advantage of opportunities and potential for growth.

A key focus of our stakeholders was that of developing the tourism offer away from the coast to alleviate pressure. An online visitor survey in 2017 carried out by the North Devon Marketing Bureau showed the top five reasons for visiting the area were beaches and coastline, coastal towns and villages, countryside and scenery, peace and tranquillity and walking opportunities (North Devon Coast AONB, 2018). This does identify the significance of the coast but also highlights the potential to create more inland tourism offers, focused around walking and peaceful activities, reducing pressure on the coast at peak times.

Table 4: Ecosystem service benefits of coastal and tourism interventions

Coastal and tourism	Provisioning services				Regulating services								Cultural services			
Ecosystem services / **Interventions**	Food	Fibre	Fresh water	Air quality	Climate (global)	Water regulation	Erosion regulation	Water purification and waste	Disease regulation	Pest regulation	Pollination	Natural hazard regulation	Cultural, spiritual and religious	Aesthetic values	Recreation and eco-tourism	Biodiversity
Increase inland tourism offer including marketing and branding Culm													2		2	2
Traffic management				2									2		2	
Dune and marginal land grazing management (to prevent scrub encroachment)	2					2	2					2	1	1	1	1
Improve sewage infrastructure (to support bathing water quality)								2	2						2	2
Direct and manage recreational use of coastal places to protect sensitive areas							2									2
Manage diffuse pollution from inland agriculture	2							2	2						2	2
Code of conduct for jet skis and powered craft															2	2

6.2 Land use change

As well as land management changes, land use changes will also be needed to achieve improvements in the state of the environment, and the benefits it is able to provide. These are new woodland, semi-natural grassland and Culm grassland, wetland and inter-tidal habitat. New habitats replace the habitat on which they are created, so there are losses as well as gains and therefore they need to be carefully planned. For some benefits the location of the new habitat is critical. For example, for woodland to reduce flood-risk it needs to intercept the flow of water from the upper catchment. New semi-natural grassland and Culm grassland also have a role to play.

We assess the different benefits provided by interventions which increase the amount of woodland, semi-natural and Culm grassland, inter-tidal habitats and wetlands. Table 5 shows how interventions may affect the flow of ecosystem services. A score of 1 depicts that there is some peer-reviewed evidence for this impact, a score of 2 shows that this impact is expected by expert opinion and the Natural Capital Indicators report (Lusardi et al., 2018).

Table 5: Ecosystem service benefits of land use changes

Land use change	Provisioning services				Regulating services								Cultural services			
Ecosystem services / **Interventions**	Food	Fibre	Fresh water	Air quality	Climate (global)	Water regulation	Erosion regulation	Water purification and waste treatment	Disease regulation	Pest regulation	Pollination	Natural hazard regulation	Cultural, spiritual and religious values	Aesthetic values	Recreation and eco-tourism	Biodiversity
Plant more native woodland in the right places		1	2	1	1	1	1	2				1	1	2	2	1
Rural sustainable drainage systems (Rural SuDs) including swales, retention ponds, in-field buffer strips, riparian buffer strips, wetland creation / restoration			1		2	2	1	1	1	1	1			2		1
Increase extent and connectivity of Culm grassland					1	2	2	2			2		2	2	2	1
Increase amount of permanent semi-natural grassland on farms					1	2	2	2			2		2	2	2	1
Increase intertidal habitats - such as saltmarsh for example through managed realignment	2				2	1	2	1				2		2	2	2

6.2.1 Woodland

It is generally accepted that planting more woodland is a useful strategy to contribute to the management of biodiversity loss, water quality, climate change and flood risk (Burton, Moseley, Brown, Metzger, & Bellamy, 2018). The ability of woodlands to realise these and wider benefits though is dependent on both the type of woodland and where woodland is created in the landscape. For example, Burton et al (2018) identify there is growing evidence that planting slower growing, broadleaved woodlands could be more beneficial to long term change in the carbon stock. Our approach has identified planting deciduous, native woodland in the North Devon Landscape Pioneer is an intervention that will specifically help address our priorities of flood risk management and carbon storage but as shown in Table 5 woodland planting in the right places can also contribute towards enhancing other ecosystem services including water quality (both freshwater and marine) and recreation.

Planting woodland can contribute to the alleviation of flooding in three main ways (Burton, Moseley, Brown, Metzger, & Bellamy, 2018):

- Slowing the flow of water over the landscape
- Absorbing water
- Storing water

The Environment Agency (2017) have identified that catchment woodland can help reduce flood peaks, flood flows and flood frequency and riparian woodlands, planted immediately adjacent to a watercourse, can also slow flows. Along with cross-slope and floodplain woodland, planting is amongst the *working with natural process to reduce flood risk* measures (Environment Agency, 2017) and should be undertaken as part of a wider catchment-based approach to ensure that the best measures are adopted in the right places. For example, the extent of the flood risk benefits can depend on the size and characteristics of the catchment and where in the catchment the measures are located. Scale of planting is also an issue in terms of flood control (Nisbet & Thomas, 2006) (Nisbet, Silgram, Shah, Morrow, & Broadmeadow , 2011). Given current evidence, the smaller the area of woodland in a catchment, the less the effect it has on reducing flood peak (Burton, Moseley, Brown, Metzger, & Bellamy, 2018).

Woodland planted in the right places can also contribute towards improvements in water quality, another of our priorities in the North Devon Landscape Pioneer, particularly in terms of tackling diffuse pollution from farmland. Woodland can help reduce diffuse pollution by acting as a barrier and interceptor, whereby the presence of trees reduces the risk of direct contamination by agricultural activities on adjacent land and helps trap and retain nutrients and sediment in polluted run-off (Nisbet, Silgram, Shah, Morrow, & Broadmeadow, 2011).

An increase in the extent of woodland in the North Devon landscape Pioneer is therefore desirable at scale, but crucially in the right places to deliver the benefits identified above and in Table 5. Opportunity mapping is a technique that can identify the locations that have the most potential to deliver the benefits of woodland planting whilst also avoiding unintended losses such those areas that are already important for biodiversity and multiple ecosystem services and also ensuring that landscape character is maintained or enhanced.

6.2.2 Semi-natural grassland and Culm grassland

We have seen that agricultural practice is a source of diffuse pollution in the North Devon Landscape Pioneer and improving soil and land management practice can have a positive effect. Areas of set-aside and semi-natural grassland trap nutrients, preventing high loads of phosphates and nitrates from reaching watercourses. However, returning these areas to production can lead to a surge in released nutrients, so increasing the extent of *permanent* semi-natural grassland on intensively managed agricultural land is a land use change intervention proposed by our stakeholders.

Improved pasture is the dominant land use in North Devon, and therefore potentially plays a valuable role in contributing to climate regulation services. The restoration and increase in extent of semi-natural grassland from intensive agriculture is subject to a number of technical constraints most notably nutrient enrichment and impoverishment of the species pool (Walker, 2004). However, even with these constraints, reducing the intensity at which grassland is managed could deliver on flooding, water-quality and carbon storage aims. The converted land could still form part of an adapted farm system.

Research led by Devon Wildlife Trust and Exeter University has focussed on restoration of Culm grassland. Puttock and Brazier (2014) have established that, relative to intensively managed grassland, Culm grassland soils hold more water and store more carbon. Water leaving a Culm dominated catchment was of a higher quality than intensively managed, agriculturally dominated catchments (Puttock and Brazier, 2014). It is suggested that the restoration and reconnection of Culm grasslands to their previous spatial extent (or more) would enhance the provision of key ecosystem services on top of their already recognised importance for biodiversity. Recreation of Culm grassland where it would be most effective at the catchment scale could therefore be a beneficial land use change from intensively managed grassland or invasive scrub to help address the priorities identified in our process.

6.2.3 Rural Sustainable Drainage Systems

In addition to woodland planting there are a number of other land use interventions that can contribute to flood risk management and improve water quality and these are often brigaded under the banner of rural sustainable drainage Systems or Rural SuDS.

Rural SuDS are physical measures that are primarily designed to reduce the impacts of agricultural diffuse pollution by intercepting run-off or drainage pathways and trapping sediment before it leaves a field, thus breaking the pathway between the source of pollution and the receiving water course (Environment Agency, 2012b). In this way they help to maintain and manage water quality. A further benefit of such measures is that they also slow down flow and can contribute to the reduction of localised flooding as well as potentially creating aquatic habitats on farmland for wildlife.

Rural SuDS are a varied group of measures that are designed to be low cost and used with a minimum loss of agricultural production. To be effective and deliver the wider benefits highlighted in table 5 they need to be used as part of a systematic approach to managing farm runoff and catchment management.

Examples of Rural SuDS that have been identified as potentially providing the wider benefits shown in table 5 include the following (Environment Agency, 2012b):

- **Swales** – broad and shallow vegetated open channels designed to intercept and carry run-off, reducing its volume, slowing it down and removing pollutants.
- **Barriers or traps within ditches and swales** – these cause water to pond and increases sedimentation and filtration. In low flow conditions the water ponds and seeps slowly through the barrier or evaporates, but in high flow conditions flows over or through the structure.
- **Retention ponds** – wet ponds that are designed to permanently retain water, pollutant removal occurs through the settling of solids and biological activity.
- **Dry grass buffer strips** – broad, gently sloping areas of grass or other dense vegetation that can be sited on slopes around the farm to intercept runoff.
- **Riparian buffer strips** – bands of naturalised vegetation, dry or wetland, located alongside waterbodies. They ensure that machinery and farm animals are kept away from the waterbody thereby reducing the risk of direct pollution, but also encourage sedimentation by slowing the flow of run-off and trapping suspended solids.

- **Wetland creation / restoration** – this could be the restoration of areas to a previously permanently or semi-permanently flooded state, or the creation of constructed wetlands (engineered systems designed to use natural processes for water quality improvements). Restoring wetlands in the floodplain and encouraging more regular floodplain inundation and flood water storage is also identified as a specific land use change that can contribute to flood risk management (Environment Agency, 2017).

6.2.4 Increase intertidal habitat

The North Devon Catchment Flood Management Plan (Environment Agency, 2012a) identifies managed realignment of the coast along the Taw-Torridge estuary as potentially contributing to the management of flood risk upstream in Barnstaple and Bideford. Within estuaries, managed realignment has become a well-established approach to coastal management whereby existing coastal structures are removed or breached to allow the re-introduction of tidal regimes to coastal low-lying land. If there is no naturally occurring high ground, new 'hard' sea defences are created to set back the line of protection. This creates space for new inter-tidal habitat, such as saltmarsh or mudflats, to develop and move naturally.

Ashley *et al* (2018) identify the wide range of benefits saltmarsh provides in North Devon including acting as important nursery areas for commercial fish species and providing tourism and recreation opportunities. It is also an important habitat in its own right and the estuary is designated as the Taw-Torridge Site of Special Scientific Interest. This land use change can therefore deliver a wide range of benefits and addresses a number of the priorities of the North Devon Landscape Pioneer including:

- **Minimise flood risk** – both saltmarsh and mudflats contribute to the management of flood risk, largely by their ability to reduce wave energy in front of flood defences and thereby extending their design life. Because of the presence of vegetation saltmarshes are more effective at reducing wave energy and also the vegetation helps trap sediment and resist erosion (Environment Agency, 2017).
- **Protect and improve water quality** – the physical, chemical and biological processing that occurs in saltmarsh removes nutrients from seawater and land derived flows, sediment accumulation traps pollutants (Environment Agency, 2017).
- **Increase carbon capture and storage** – saltmarshes are significant sinks for atmospheric carbon due to rapid sediment accumulation and the potential for long-term storage of carbon (UK National Ecosystem Assessment, 2011). This is, however, dependent on the condition of the saltmarsh (Rees, Ashley, & Cameron, 2019).

7 Incentives, motivations and capacities

Our process identified three groups of people and organisations essential to the success of this natural capital strategy. These are farmers, woodland managers and those involved in managing the coastal strip. We take each in turn.

7.1 Farmers

Farmer's decision-making is complex and driven by a range of factors. This include market-based incentives, motivation, identity, skills and knowledge. Government intervention in decision-making comes through regulation, payments for more environmentally friendly farming practices and advice. The 25 Year Environment Plan seeks a clear understanding of which benefits the public is buying from farmers through agri-environment payments.

7.1.1 Incentives

The primary incentives faced by farm managers come from markets. Farmers face a competitive market for food. Their product is perishable, meaning they can't stockpile. This makes them 'price-takers' and leads to pressure to maximise financial return, which often means maximising food production.

Food production has a wider impact on the natural environment. These can be positive, such as maintaining culturally valued landscapes, or negative, such as chemical run-off. For the most part, these side-effects are not captured in markets. This means the market provides no incentive to maximise the benefits and minimise the costs. Partial exceptions include organic certification and industry and supermarket accreditation.

Some of the physical changes identified are straightforward to assess and could be enforced through regulation. These include fencing cattle away from the river, buffer strips and slurry storage. The polluter pays principle would suggest the costs should be borne by farms and passed through the supply chain to the consumer. But in reality, meeting capital costs would be financially difficult for many farms. Public subsidy or support from the supermarket supply chain are alternative ways to finance changes.

Increased taxes on inorganic fertilizer and pesticides could include part of their environmental cost into the purchase price. This would encourage careful use and reduce environmental impacts. At higher levels it would encourage a greater focus on nutrient management in farms. This would have an impact on food production, although in the medium-term losses would be lowered by adaptation.

Most of the changes that we've identified are too context specific to address through regulation or fiscal policy. Take cropping as an example, the appropriateness of the crop, the field and timing of harvesting. These issues need a scheme which incentivises relevant land managers to take the actions needed. This would involve agreeing plans and payment with relevant land managers, or ideally with groups of land managers who were relevant to the issue. For example, levels of sediment in the water courses can be measured and plans and payments adjusted to address them. This could be achieved through a Payment for Ecosystem Services approach, through a modified agri-environment scheme or through a mixture.

7.1.2 Motivations

Understanding the economic incentives facing farmers is necessary, but insufficient, to effectively address our priorities. It is also necessary to understand human and social factors, including farmer

motivations. Research identifies three dominant sets of farmer motivations, which in turn lead to different potential relationships to pro-environmental changes. These are:

- **Food producers**: Some farmers identify primarily as food producers, with an obligation to produce food to feed the world. This makes them reluctant to move land out of production for environmental benefits (Mills, Gaskell, Jones, & Boatman, 2013), (Schmitzberger, et al., 2005).
- **Profit maximisers**: Some farmers identify as profit maximisers, whose self-image is focused on running a profitable enterprise (Mills, Gaskell, Jones, & Boatman, 2013). This could lead to maximising food production and make environmental concerns seem a distraction. Alternatively profit maximisers could be more open to innovation and diversification in environmentally friendly ways.
- **Custodians:** Some farmers identify themselves as custodians of the land with an obligation to pass it on to future generations in a better condition. These are more likely to engage in environmental activities (Mills, Gaskell, Jones, & Boatman, 2013), (Page & Bellotti, 2015). Self-identity can also have an effect on whether farmers undertake unsubsidised environmental activities (Lokhorst, Staats, van Dijk, van Dijk, & de Snoo, 2011), (De Snoo, et al., 2013)

7.1.3 Capacities

Choosing the best action to improve the natural environment is complex and context-specific. Therefore the skills and knowledge of farmers are critical to achieving environmental goals. A key factor is whether farmers believe that the changes that they are being asked to make are beneficial. If they do not believe in an intervention they will not be able to deliver it enthusiastically (Stupak, Sanders, & Heinrich, 2019). This problem can be avoided through a deliberative approach in which actions are discussed and agreed between a farmer and someone who understands the wider evidence base.

Agricultural education in training colleges, is primarily oriented towards production and profitability. Broadening this perspective further would support environmentally sensitive farming. For farmers who are already working, extension and advice services are important and require a trusted relationship with an expert who understands both farm businesses and how farm operations relate to environmental outcomes. Support of this kind is currently available through catchment sensitive farming and agri-environment schemes.

7.2 Woodland

There are many similarities between woodland and farmland, but also some important differences.

7.2.1 Incentives

Woodland does not have the problem of producing a perishable product, but has significant commercial challenges, particularly for small and broadleaved woods. It takes much longer for woodland to yield a return on investment than farming, normally twenty to thirty years. This means that only fastest growing species (vigorous conifers) are profitable when compared to other potential uses of investment money. Many of these woodlands are also difficult to access, particularly with vehicles, which also affects profitability (Lawrence & Molteno, 2013, p. 32).

The recent growth in the woodfuel market has provided a new market incentive to small-scale woodlands, because woodfuel is only profitable at short transport distances and uses low quality wood (Lawrence & Molteno, 2013, p. 24).

Woodland is also not supported through state subsidy in the same way as farming, although some specific grants and support are available (Lawrence & Molteno, 2013).

7.2.2 Motivations

Because small woodlands are not normally profitable without subsidy, land managers need other motivations to move them into management. These are many and varied as tested by this quote from a woodland support officer, '*in order to engage with owners you need to be able to talk a multitude of languages, from biodiversity, to archaeology to woodland landscape'* (Lawrence & Molteno, 2013, p. 45). Land managers may hesitate to invest in woodlands due to real or perceived conflicts with other farm objectives (Burton, Mosely, Metzger, & Bellamy, 2018).

7.2.3 Capacities

Managing woodland requires a different set of skills, experience and equipment to farming. But many small plots of woodland are part of farms and are managed by farmers (DG Education and Lifelong Learning, p. 14). This is particularly true for ancient and broadleaved woodlands which often have the higher biodiversity (DG Education and Lifelong Learning, p. 14). This makes it difficult to manage them effectively, particularly as farmers are increasingly specialised. An expert is quoted in (Lawrence & Molteno, 2013, p. 30) saying, "*Farmers are getting more and more specialized, gone are the days of mixed farmers, now they are pig farmers or dairy farmers so to expect them to specialize and then to expect them to go off an manage their woodlands is in most cases not going to happen".*

7.3 Coastal Strip

Tourism is of great importance to the economy of Northern Devon (across the Districts of North Devon and Torridge, roughly the area of the biosphere), with a particular focus of activity on the coastal strip.

According to the South West Research Company in 2016:

- Northern Devon attracted an estimated 6.3 million visitors (1.3 million staying trips and 5 million day trips), who spent £480 million.
- Overnight visitors stayed a total of 5.6 million nights
- The visitor economy supported more than 11,100 jobs (19% of employment in North Devon, 10% of employment in Torridge) and supported business turnover in excess of £0.56 billion[3].

As well as locals and businesses, other key stakeholders which have impacts on the condition of the coastal strip include the local authorities, utilities companies, Visit Devon and the North Devon Marketing Bureau. Local authorities have a series of roles influencing development, rights of way and travel strategies. They act to conserve environmentally designated land in the coastal area. . Visit Devon and the North Devon Marketing Bureau lead on marketing to attract visitors as well as supporting local businesses.

7.3.1 Incentives

The tourism business in North Devon is highly seasonal. Therefore, businesses need to make the most of the short season by seeking to attract higher spending visitors. They also seek to extend the season through creating festivals and events and diversifying the offer (Northern Devon Tourism Strategy, 2018). There are currently no structured funding incentives aimed at tourism businesses but some are supported by local initiatives as well as Local Enterprise Partnership led programmes.

Ideally tourism would have a positive impact on the local natural environment. One way to promote a shift in this direction would be a local eco-tourism accreditation scheme. Eco-tourism aims to expose visitors to a nature-based experience while simultaneously sustaining or improving the ecology of an area, as well as enhancing the quality of life for local communities. The creation of an

[3] including as a result of tourism business spending locally and employee spending

ecotourism standard which is awarded at different levels (for instance, bronze, silver and gold) in accordance with the level of action to improve habitats, provides an incentive for action. A similar scheme, called *Nature's Best* is operating successfully in Sweden. It could be funded via a tourism tax or voluntary scheme. More information on this is detailed in the linked investment cases document (Eunomia, in press).

7.3.2 Motivations

Business owners are motivated by a wide range of factors which may include the ability to make a profit (there are limited employment options outside tourism in many coastal villages/towns), a strong sense of place (and thus wanting to look after the natural environment that draws their visitors) and enjoying the lifestyle of a local business owner (by being involved in the local community). Thus with the right support, encouragement and incentives it may be possible to increase the sustainability and reduce the environmental impact of tourism in the local area by encouraging sustainable tourism actions.

7.3.3 Capacities

The capacity of businesses to provide a sustainable tourism offer is likely to be mixed. The Northern Devon Tourism Strategy (2018) identifies the need to support the capacity of business owners in sustainable tourism, sharing knowledge and good practice. To make their businesses more sustainable owners need to consider a wide range of issues including impact on protected areas, carbon emissions, waste (including sewerage) and congestion. Businesses with access to beautiful and wildlife rich landscapes may be able to make these experiences part of their business model. There is potential to do on farms which are less intensively managed for food production, like that has been done by the Knepp Castle Estate in Surrey (https://knepp.co.uk/home). Both advice and funding may be needed to support these shifts.

North Devon needs to handle large visitor numbers in a way which protects both the natural environment and the visitor experience. This presents a number of management challenges not focussed on natural capital. Firstly, road systems which reduce traffic and noise, such as one way systems. Secondly, sustainable transport options such as bus, rail, park and ride and cycle paths. Lastly, sewage and waste management systems better able to cope with seasonal influx of large numbers of people. These would need to be provided by the organisations with the statutory powers to do so in North Devon, for example, the local authorities and the water companies.

Having identified the physical changes we want to see, and the incentives, motivations and capacities of those we want to influence, we now need to think about how to make it happen.

8 Making it happen

Making the changes outlined in this strategy natural capital investment happen is all about *governance and decision making.* Governance is a short-hand word which includes formal government, but also includes less formal processes, such as markets, voluntary organisations and civil society. It covers all the ways which responsibility is taken, decision are made and resources are allocated. The 25 Year Environment Plan highlights the importance of comprehensive, reliable data; strong governance and accountability; a robust delivery framework, and everyone playing their role in making the vision of a healthier environment a reality. What follows are a set of proposals for changing the governance so that it aligns, and therefore allows a strategic response to our priorities.

Our evidence base shows a large number of changes to land use and land management which would address our priorities. And many of these are currently happening in parts of North Devon. But they are not yet happening at the volume, in the right places or with the consistency required to successfully address our priorities.

In recent years there have been a number of experimental Payment for Ecosystem Services approaches, notably upstream thinking by South West Water (Upstream Thinking, 2019). These pilots try to move towards a governance system which allows the problem to be addressed. To do this we need a declared environmental outcome, such as reducing the amount of phosphorous in the river. It needs to be an outcome than can be measured at a reasonable frequency. We then need an organisation which takes responsibility for that outcome. The organisation needs a clear mandate and needs sufficient power, influence and funding. It needs to use this to get the right changes to land use and land management to address the outcome, and do so in a cost-efficient manner. Finally it needs to alter its plans year-on-year according to what actually happens.

Although this looks obvious, it is actually very difficult to arrange in practice. This is due to the complex interrelationships in the environment/economy. There are a number of principles, which if adopted would move us towards this situation. They are *institutional responsibility*, *adaptive management*, *localisation* and *shared commitment*. These are described further below.

1. **Institutional responsibility**

Environmental problems need to be clearly owned by an institution or partnership. This institution needs to be politically legitimate, have the right expertise and, critically, sufficient 'levers' to change the outcome.

2. **Adaptive management**

If we were dealing with simple, well understood systems, we would be able to calculate exactly which package of interventions would solve the problem. But we are dealing with complex systems which are not fully understood. We therefore need to deal with them through adaptive management. This means that actions that make strategic sense are put in place, notwithstanding uncertainties. Results are then assessed and new action plans developed in an adaptive cycle. In systems terms this is then a 'closed loop', where feedback from outcomes influences planning iteratively.

3. **Localisation**

Additional complexity is added because the priorities we have selected (and other ecosystem service issues) are all inter-related. For this reason they need addressing as part of a single planning system, rather than separately. In practice this requires significant responsibility at sub-national or local scale. National governance has to split things up into issues to make them manageable, so it loses this interrelatedness and complexity. The principle of subsidiarity means that issues should be dealt at with at the most local level possible. This varies from issue to issue meaning there is no 'perfect fit' governance system, but some are much better than others.

4. Shared commitment

It's clear from our incentives, motivations and capacities section that a wide range of changes need to come together, in a mutually reinforcing way, to support the changes we are seeking. In particular, although regulations and economic incentives are important drivers of behaviour, they are not the only ones that need to be taken into account.

To take farmers, as an important example. They tend to show resistance to 'top down' policies affecting their private land and farm business (Blackstock et al., 2007; Defra, 2012; Mills et al., 2013; Hall, 2018). Developing skills and influencing behaviours amongst this group in ways other than through regulation and incentives is therefore, likely to be critical. At the heart of this is ensuring that farmers maintain a sense of control. This can be achieved through dialogue and deliberation. Farmers need to feel well informed, involved in decision making and in possession of the relevant tools to undertake environmental changes. The effectiveness of interventions is strongly influenced by 'buy-in' of famers. This is also true of land owners, and the wider food supply-chain.

How then can this shared commitment be developed? It requires a commitment to participatory approaches. Participation is critical to the quality, credibility and legitimacy in terms of process and also the results achieved (Morris, Tassone, De Groot, Camilleri, & Moncada, 2011). It's also important to producing results which are easily understood by stakeholders and seen as trustworthy (Cumming & Norwood, 2012). Finally, they can improve the relationships between partners, building 'social capital' which sustains partnerships beyond the life of a particular scheme or funding stream (Willis, Lusardi, Darlow, Waters, & Maxwell, 2018).

Running successful participatory processes, however is challenging. It requires a very significant resource commitment. Incorporating diverging and sometimes conflicting views is difficult. A particularly challenging area is the inter-face between participatory processes and bureaucratic systems, whose rules may have been set at a different scale.

Finally it's worth noting that many of the examples around innovative natural capital work are from the water industry. The water industry regulatory system is unusual in the environment sector in that is allows and requires private sector money to be spent on environmental improvement.

9 Conclusion

We have carried out an innovative evidence-based and deliberative process focussing on North Devon's Natural Capital issues. It identified four priority issues, each with millions of pounds worth of benefits at stake. These were:

1) Protect and improve water-quality
2) Minimise flood risk
3) Increase carbon capture and storage
4) Manage tourism and recreation pressure

They are not the only concerns about natural capital, and it's important that they are not addressed in a narrow way which causes other problems or has disproportionate costs. Accordingly we have proposed strategic responses which will maximise positive contributions to other ecosystem service issues and minimise trade-offs. Our criteria for including interventions were that they:

- deliver for our priority ecosystem services
- deliver multiple benefits
- are good for biodiversity
- support the long-term health of the natural capital assets that the ecosystem services depend on
- do so at least cost, and at an acceptable cost (including financial cost and ecosystem services trade-offs).

The positive impact of our proposed interventions on non-priority ecosystem services is highlighted in the tables in Section 8.

This report highlights a large number of changes to land management and land use which meet these criteria. These are desirable actions whose costs are justified by resulting benefits and/or reduced risk. Further work is required to work out the most beneficial locations and institutions for these interventions.

These things are already happening in North Devon, but not strategically, systematically and consistently enough to deliver the scale and ambition of the 25 Year Environment Plan. To properly address the issues that we have identified we need systematic change. We need the interventions identified to happen much more consistently, in the right places and with the active support and buy-in of land managers, owners and the food supply chain. We have therefore proposed the following strategic governance changes:

- clear institutional ownership
- adaptive management
- localisation and;
- shared commitment.

These are principles, rather than specific recommendations. It is for local partners, in consultation with national government to work out how they could apply in North Devon.

The issues we've identified are important to North Devon's future wellbeing and economic success. They are complex issues with no 'quick-fix' solution, but by no means impossible to address. The land use, land management and governance changes highlighted in this report point to a way forward.

10 Ownership of the Strategy and Next Steps

10.1 Context

Partners and stakeholders have put considerable effort into what a successful strategy needs to deliver to meet the ambition, scope and timeframe of the 25 Year Environment Plan.

10.2 Governance and place based ways of working

The 25 YEP highlights that institutional and cultural change will be necessary to deliver its ambition. There is a huge challenge in syncing systems that operate mostly independently and in some cases are in competition with each other for finite funds and resources. Lessons from the Pioneer include some that are practical and can be applied in the near future and some that are more ambitious for the medium and long term.

As short term initiatives, the Pioneers are limited in their ability to deliver change and are relying on compelling evidence based learning and lessons to influence colleagues and others. There is a balance between keeping what works and changing what doesn't that can be delicate though evaluation can be valuable to resolve this.

10.3 Next steps

There are a number of next steps to realise the ambition of the Strategy:

1) Sharing lessons learned with Defra, partners and stakeholders – led by Natural England and the Biosphere Partnership
2) Progress the governance workstream in the Pioneer during this current phase to March 2020 – led by the Biosphere Partnership
3) Detailed project planning by existing and new Biosphere partners to develop and integrate investments for shared priorities. Some investment cases have been developed by way of example and to demonstrate the art of the possible. These are illustrated in the accompanying document (Eunomia, in press) - Led by Local Authorities, the Biosphere Partnership and Foundation.

Appendices

A.1 More detail on the evidence and participatory process

A.1.1 Partners involved during the process

Andigestion

North Devon Chamber of Commerce

Clinton Devon Estate

Dartmoor and Exmoor National Park Authorities

Defra

Devon County Council

Devon Local Nature Partnership

Devon Wildlife Trust

Environment Agency

Forestry Commission

Frontier Agriculture/King Seeds

National Farmers Union

National Trust

Natural England

North Devon AONB

North Devon Biosphere

North Devon Biosphere Foundation

North Devon District Council

North Devon Councillors

North Devon Homes

North Devon Marine Pioneer

Rothamstead Research

RSPB

Savills

South West Water

Teignbridge District Council

Torridge District Council

University of Exeter

Visit Devon

Westcountry Rivers Trust

A.1.2 Building a shared evidence base

Our approach to building a shared evidence base was to

- Set out everything we would like to know to manage the system on a spreadsheet (annex 1)
- To fill in everything we could on these spreadsheets from available literature
- To hold an expert workshop to fill in the gaps (19th July 2017)
- To allow further additions to be make electronically post-workshop.

Turning first to setting out the information we need, in order to make effective decisions we need to know;

1) what natural capital assets we've got;
2) how much of them we have;
3) where they are;
4) what quality they are;
5) what ecosystem services they provide; and
6) what the value of these ecosystem services is.
7) to whom: and

8) What it costs to maintain them

We also need to understand how this has changed in the past, how this might change in the future, and what causes changes. The questions are theoretically driven and easy to set out. We therefore developed a spreadsheet designed to capture the available evidence on points 1-6 above. We judged points 7 & 8 to be too ambitious for this stage in the process. A simplified representation of this spreadsheet is offered below.

We used the National Ecosystem Assessment (NEA) habitat types (ref) as our natural capital assets. There are:

- Mountains, moors and heaths,
- Semi-natural grasslands,
- Enclosed farmland,
- Woodland,
- Freshwater, wetlands and flood plains,
- Urban,
- Marine; and
- Coastal margins.

We chose the NEA habitats for two reasons. Firstly it made it easier to relate the evidence we were gathering to a national knowledge base. Secondly the NEA habitats provide a clear and exhaustive categorisation of the habitats in the United Kingdom. So we produced one spreadsheet for each of the eight habitat types: Table A below shows a simplified representation of the asset part of the data organising spreadsheet.

Table A: A simplified representation of the asset part of data organising spreadsheet

NEA habitat	Quantity (Ha)	Where is it?	What is it?	Quality?
Current state or value (quant)				
Current state or value (descriptive)				
Management - investment				
Management – regulation				
Management – influence				
Trajectory over the last twenty years				
Anticipated trajectory over the next twenty years				

The questions across the top of the spreadsheet are taken from our Natural England natural capital logic chain. We want to know how much of a particular habitat we have within the North Devon Landscape Pioneer area. We then want to know where it is, because spatial configuration is critical to the delivery of some ecosystem services. NEA habitats are broad categories, so the ‘what is it?’

column allows us to capture information about sub-habitat: for example, areas of deciduous and coniferous woodland. Lastly we want to capture information about the quality of the habitat.

The headings down the right hand side of the spreadsheet were as follows. The first two boxes give separate places to record quantitative and qualitative information. The next three boxes are about the management of the asset. They capture any information we have about investment in that asset, regulation to protect that asset or more subtle forms of influence designed maintain or improve the asset. The bottom two boxes capture evidence and views about the trajectory of the asset of the last twenty years and its anticipated trajectory over the next twenty years. Capturing this 'time dimension' is critical to strategic planning around natural capital. In addition to the data highlighted on our logic chain it is important to know how they have changed, what change is anticipated in future and why this is. This moves from a static 'balance sheet' understanding to a strategic understanding of natural capital assets as part of a wider system. After the asset section of the spreadsheet was a section looking at ecosystem service provision, as shown on the simplified table below (Table B).

Table B: Simplified representation of the ecosystem services part of the data organising spreadsheet

Services	Provisioning	Regulating	Cultural
Ecosystem Service (description)			
Ecosystem Service (quantification)			
Ecosystem Service (value)			
Investment			
Management			
Influence			
Trajectory last 20 years			
Trajectory next 20 years			

Across the top of each spreadsheet we tabulated ecosystem services. We based these on the Millennium Ecosystem Assessment framework (UKNEA, 2011). The simplified table shows only the categories of ecosystem services, we used the ecosystem services identified in Table C.

Table C: Ecosystem service categories used in evidence gathering spreadsheets

Provisioning	Regulating	Cultural
Food	Air quality	Cultural, spiritual and religious values
Fibre	Climate (global)	Aesthetic values
Genetic Resources	Climate (local)	Recreation and eco-tourism
Biochemicals, natural medicines, pharmaceuticals	Water regulation	
Fresh water	Erosion regulation	

	Water purification and waste treatment	
	Disease regulation	
	Pest regulation	
	Pollination	
	Natural hazard regulation	

Returning now to the categories on the right hand side of table B: for each ecosystem service we had a box to describe it qualitatively, then quantify it (if possible) and then value it. We then had boxes to capture any specific investment, management or influence relevant to that ecosystem service. In practice, experts were unable to separate out management intervention this way. The last two boxes captured evidence or expert opinion about the trajectory of the ecosystem service over the last twenty years and the expected trajectory over the text twenty years.

Our approach aimed to make use of all available evidence and expert opinion. This was necessary, because there is not enough information available to do it based on just on published literature. This presents a challenge, however, because it means using evidence with varying qualities, provenances and levels of objectivity. It was important that these differences were not lost in the final presentation of the data. Instead they needed to be retained and clearly signalled. This allows decision-makers to ensure that the weight they are placing on them is appropriate.

Our approach is focussed on the objectivity with which a judgement is established, rather than confidence, in order not to imply low confidence in local expert opinion. The approach needed to be simple and pragmatic to apply in order to be practically applicable in a resource-constrained planning environment. For this reason we made simple judgement based on the pedigree of the result (Functowitz and Ravetz). Our rating system is shown in Table D below.

Table D: Objectivity rating system

Objectivity.	**Explanation**
High	Established to standards for normal government decision-making analysis
Medium	Results are published and the methodology is published
Low	Expert Opinion or the methodology is not published
Very Low	Anecdotal

The final spreadsheet are available as additional documents on the publication website.

A.1.3 Choosing priorities

The shared evidence base provided an enormous wealth of information, but in order to build a natural capital strategy we needed to elicit some priorities for action. Because the Pioneer was asked to experiment with a natural capital approach we wanted to do this based on economic value. But information about the current economic value is not enough to support strategic decision-making. One also needs information about risks and opportunities. We would like to know which changes would give us the biggest improvement in the value of services. Unfortunately we have no direct evidence about the potential improvements. This means we need to infer this from the evidence we do have.

For this reason we chose priorities based on a multi-criteria analysis with three criteria. The criteria, in order of priority were:

1. **Value:** what is the annual value of this ecosystem service from this habitat?
2. **Condition:** how good is that habitat currently at delivering this service?
3. **Trend:** how has the condition changed over the last 20 years?

For the value we used a natural capital accounting approach based on annual flow of benefits. This approach is different from marginal valuation in that there is no counterfactual. We choose to present these values as order of magnitude to indicate the level of accuracy at which they should be understood.

We presented the methodology and the eight priority pairs to a workshop on 18th October 2017. Attendees then organised themselves into four small groups. We asked each group to recommend two ecosystem/habitat pairs which we should add to the list. We also asked for recommendations for pairs we should remove from the list. We asked for justifications for any changes. These justifications could be of two types. They could be based on disagreements about the evidence base or they could be based on a disagreement about the decision-rule. We did not insist that groups were consistent about decision-rules. They could suggest different priorities for different reasons.

In plenary we then asked groups to propose changes to the eight priorities, one at a time. We asked the wider group to accept or reject the proposals, and to justify their choices.

The table below (Table E) shows the results of the workshop. The 'Interim Pairs' column shows the pairs which our decision-rule selected. These are in priority order from top to bottom. The 'Final Pairs' column shows the agreed priority pairs at the end of the workshop. Their placement depends on the pair they replaced, and so is not in priority order. Those that we replaced are in italics. New ones that we added are in bold.

Table E: Interim and final ecosystem service-habitat pairs

Interim Pairs	**Final Pairs**
Improved pasture – water purification	Improved pasture – water purification
Arable – water purification	Arable – water purification
Arable – recreation & tourism	**Culm grassland – water regulation**
Permanent Grassland – recreation & tourism	**Coastal margins – tourism & recreation (and cultural)**

Deciduous Woodland – climate	**Woodland - climate**
Deciduous Woodland – water regulation	Deciduous Woodland – water regulation
Improved Pasture – climate	Improved Pasture - climate
Permanent Grassland – water purification	Permanent Grassland – water purification

Removed pairs

The reasons that we removed pairs were as follows:

1. *Arable / Recreation & Tourism.* The North Devon area as a whole has high value for recreation and tourism. There is no clear objective basis to distribute this value across habitats. For this reason the evidence base distributed this value broadly. Attendees knew that the highest recreation and tourism value was at the coast. Only a small proportion of arable fields are used or viewed from recreation sites. So we rejected this pair.

2. *Permanent Grassland / Recreation & Tourism.* The argument which applies to Arable applies equally to recreation and tourism.

3. *Deciduous Woodland / Climate.* Coniferous woodland is better than deciduous woodland for carbon sequestration. So someone suggested we should replace it with coniferous woodland. But deciduous woodland has higher value for recreation and biodiversity. So the group was concerned that just focussing on carbon was too narrow. Therefore we agreed to broaden the focus to woodland, recognising that a variety of woodland types would be required to achieve a range of ecosystem goals, including carbon sequestration.

Added pairs

The reasons that we added pairs are as follows:

1. *Woodland / Climate.* We have already given the rationale for this change above.

2. *Coastal Margins/ Tourism and recreation.* Coastal margins are not one of the largest habitats in area terms. This meant that they did not score highly for tourism and recreation, because this value was broadly spread across habitats. But attendees recognised that they were the most important for tourism and recreation.

3. *Culm Grassland/ Water regulation.* The decision-rule marked Culm low because there is less Culm than other habitats. Nevertheless, Culm is important for many ecosystem services and for biodiversity and so the group though it should be included. The group chose water regulation, because its one the easiest ecosystem services to demonstrate economically. Many felt cultural services were more important.

Retained pairs

The reasons that we retained pairs are as follows:

1. *Arable / Water Purification.* This pair was singled out because the evidence base suggested that arable made a big

contribution to water purification. Workshop participants disagreed. Participants chose to retain this pairing because arable farming is a significant problem for water quality. That is to say it has a high negative value. If the evidence base had had this right it would still have appeared in the ranking.

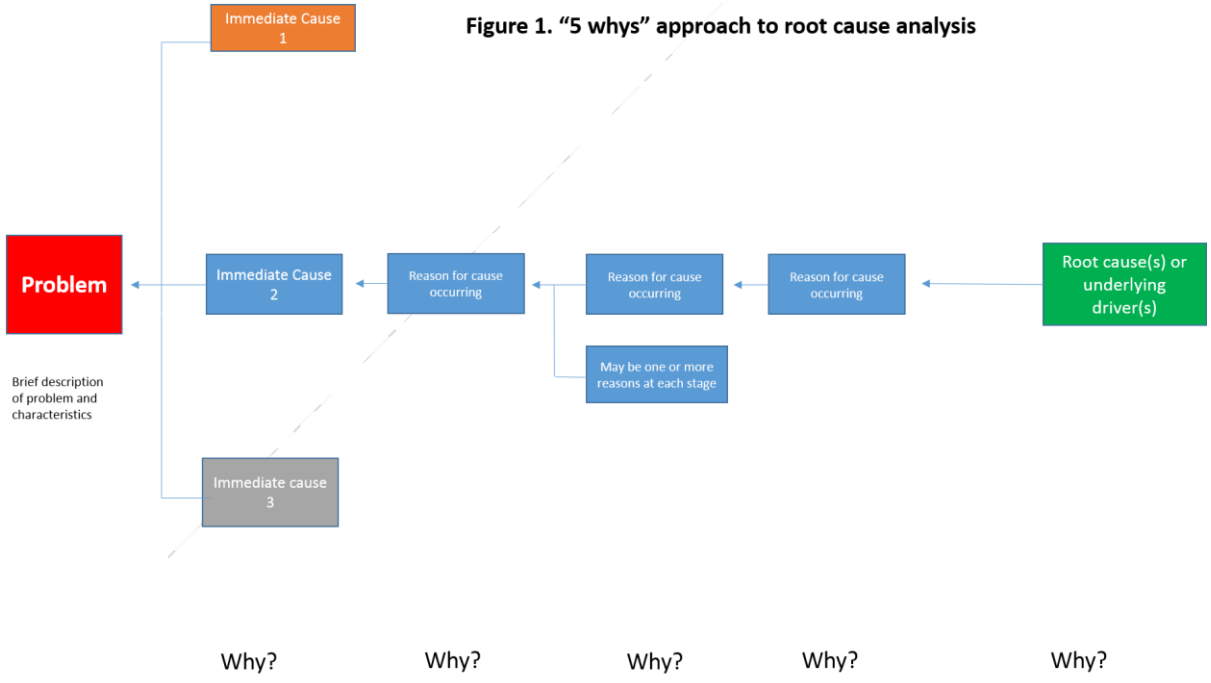
2. Other pairs were retained without feedback

Several participants struggled with this approach to prioritisation. For some this was a due to objections to using valuation is decision, for others it was a concern that this approach wasn't focussed on biodiversity and others felt it wasn't strategic enough or spatial enough.

A.1.4 Root cause analysis

Having identified some priority issues we wanted to move towards recommendations which would effectively address. To do this we borrowed Root Cause Analysis (RCA) from engineering. RCA is a collection of problem solving methods used to identify the real cause of a problem. It seeks to identify the point in the causal chain where an intervention would prevent the problem from occurring – this enables preventive action to be taken, rather than focusing efforts on dealing with the symptoms of the problem (Quality One, n.d.). RCA has been applied in a number of different fields, but it has rarely, if at all, been applied to environmental problems. It is hoped that understanding the root causes of problems affecting ecosystems and their services in North Devon should help to point to more effective interventions. The full root cause analysis report is published alongside this strategy (Eftec, Natural England Commissioned Report Number 291).

Figure A1: The 5 whys approach to root cause analysis



We applied RCA to each of the eight problems which emerged from the prioritisation workshop. This meant:

1) Reviewing the literature and evidence for each problem, drawing on national and local evidence;
2) Running eight teleconferences with local experts North Devon (one for each problem);

3) Drafting an RCA map for each problem
4) Running a workshop (20 February 2018 in Exeter), to discuss and refine these maps, and to begin to identify interventions to address each problem;
5) Further analysis of the RCAs and development of evidence-based narratives to support each one;
6) Running a second series of teleconferences to define interventions for each problem;
7) Analyzing the proposed interventions against a defined set of criteria, and examining in qualitative terms their costs and benefits;

The exercise highlighted a small number of potential interventions that would represent a significant change to current actions taken to improve the natural environment in North Devon, and many more that involve building on or upscaling current practice. The process helped partners to develop a shared understanding of the problems and potential solutions.

A.1.5 Writing the strategy

At this stage we had identified a range of possible interventions. Some of these were close the root cause, and would therefore lead a changes in the system, and others were more mitigatory. But each of these actions was built around addressing specific ecosystem service issues. To turn them into a strategy we needed to form the interventions into a coherent plan which would address our priority issues, but do so in a way which met our other criteria, where were:

- deliver for our priority ecosystem services
- deliver multiple benefits
- are good for biodiversity
- support the long-term health of the natural capital assets that the ecosystem services depend on
- do so at least cost, and at an acceptable cost (including financial cost and ecosystem services trade-offs).

To pull this together we ran a two day workshop on the 21st and 22nd June 2018, in North Devon. At the workshop we looked at:

- drivers of change
- 'heaven' and 'hell' scenarios; and
- Mapping local stakeholders.

The core the workshop was an attempt to group our interventions into bigger pieces of work which would deliver for multiple ecosystem services and our criteria above. We struggled to do this, largely because our interventions varied from the extremely specific (fence cows out of the river) to high-level ideas such as (resource mapping). We ran a further workshop in November 2018 looking for 'big ideas' which would address the issues raised in the strategy. The big ideas generated at this workshop also informed the linked investment cases document (Eunomia, in press).

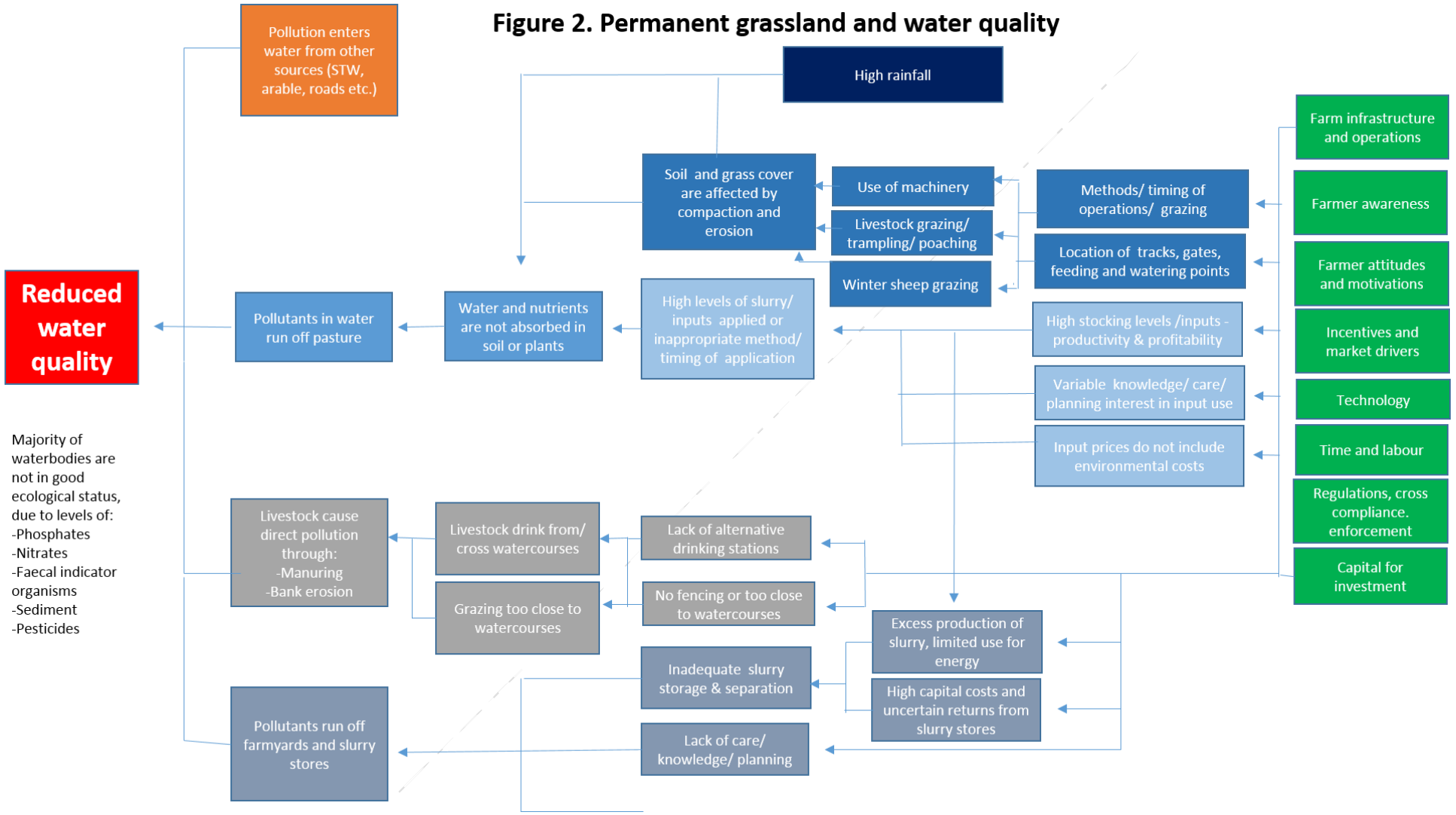
The final strategy has been produced by the Natural England team in consultation with biosphere partners, drawing on the evidence and the ideas from all stages of the evidence-based deliberative process.

A.2 Root cause analysis maps

A.1.6 Improve water quality

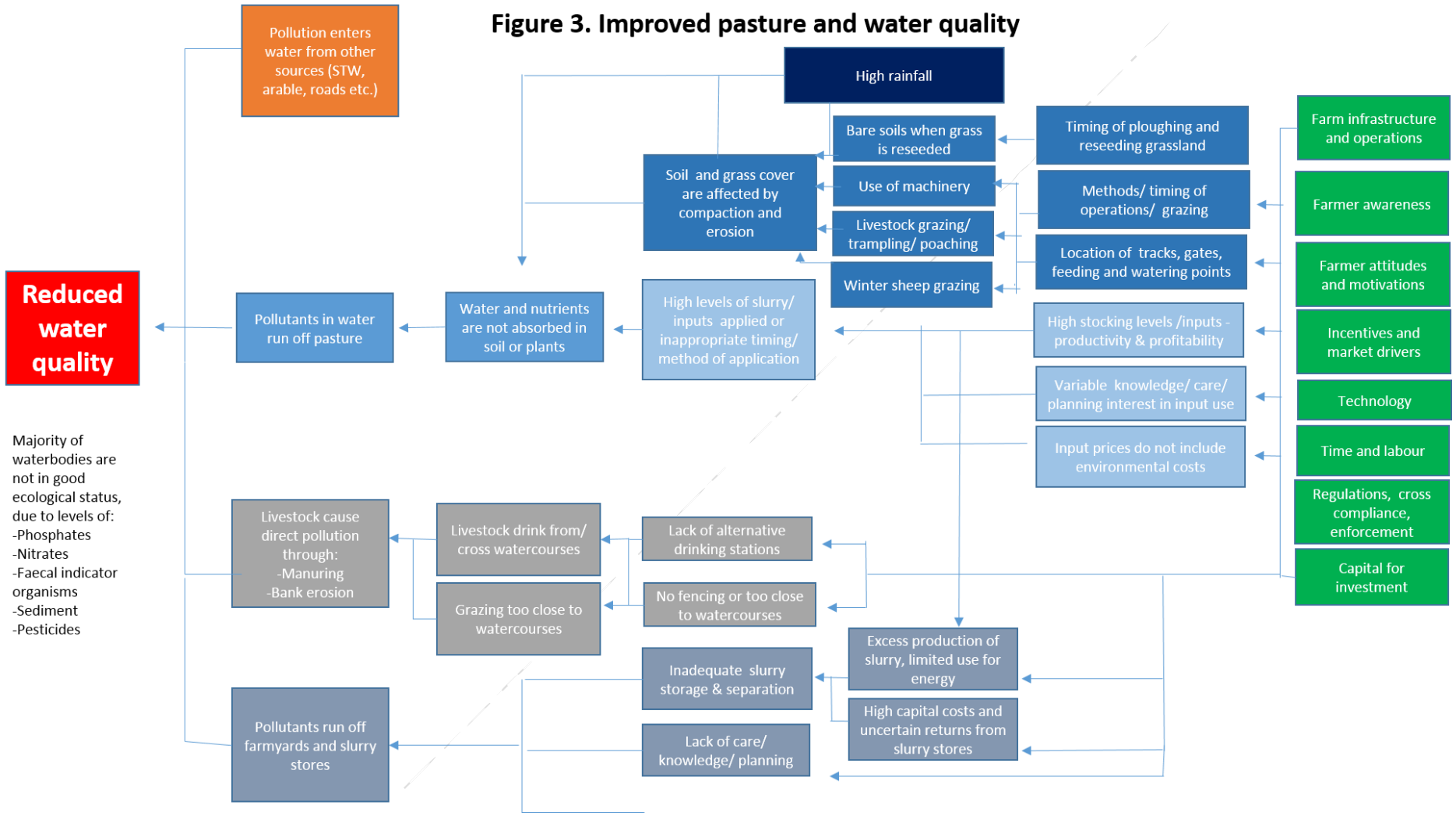
A.1.6.1 Permanent grassland and water quality;

Figure 2. Permanent grassland and water quality



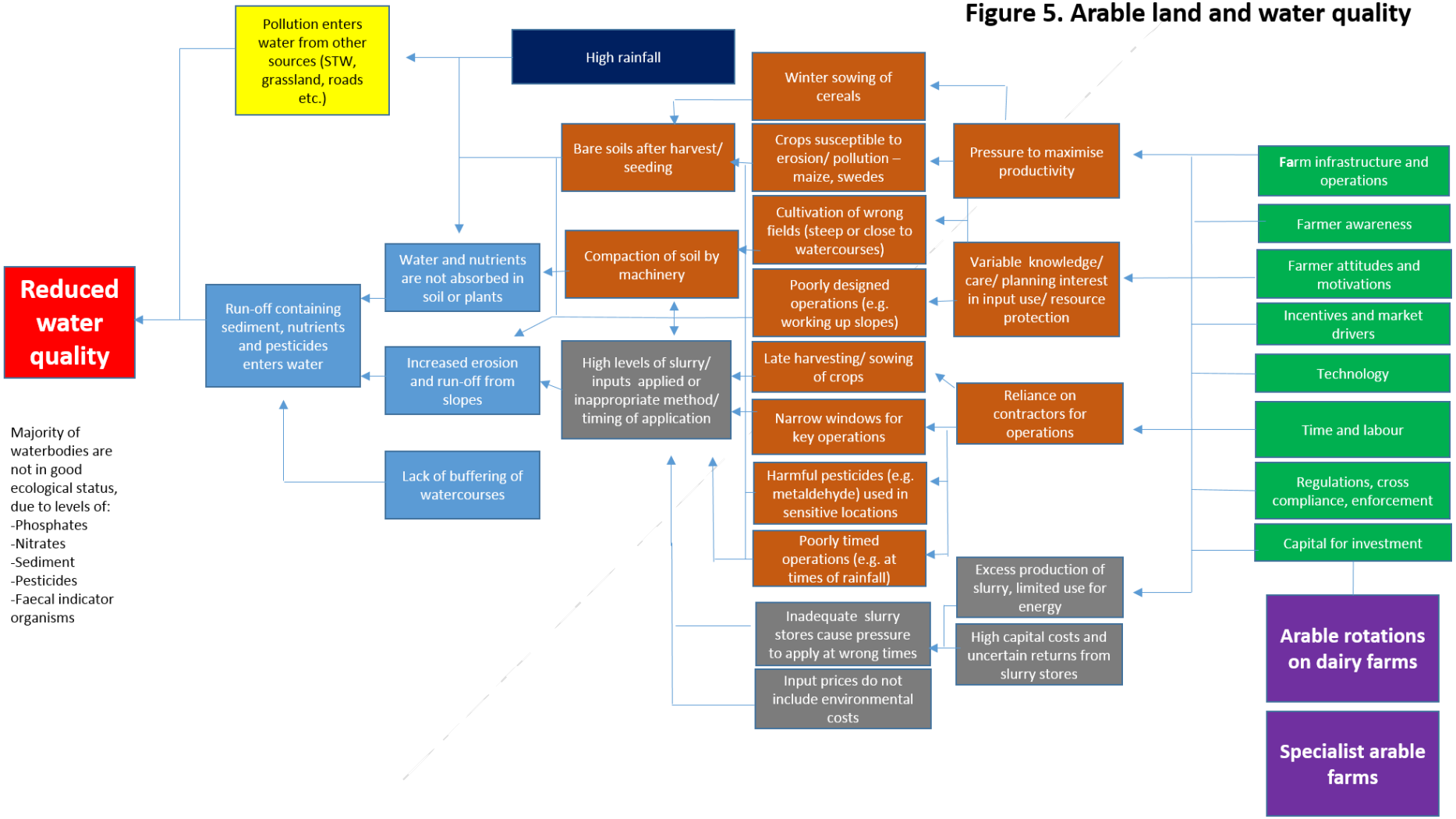
A.1.6.2 Improved pasture and water quality;

Figure 3. Improved pasture and water quality



A.1.6.3 Arable farmland and water quality;

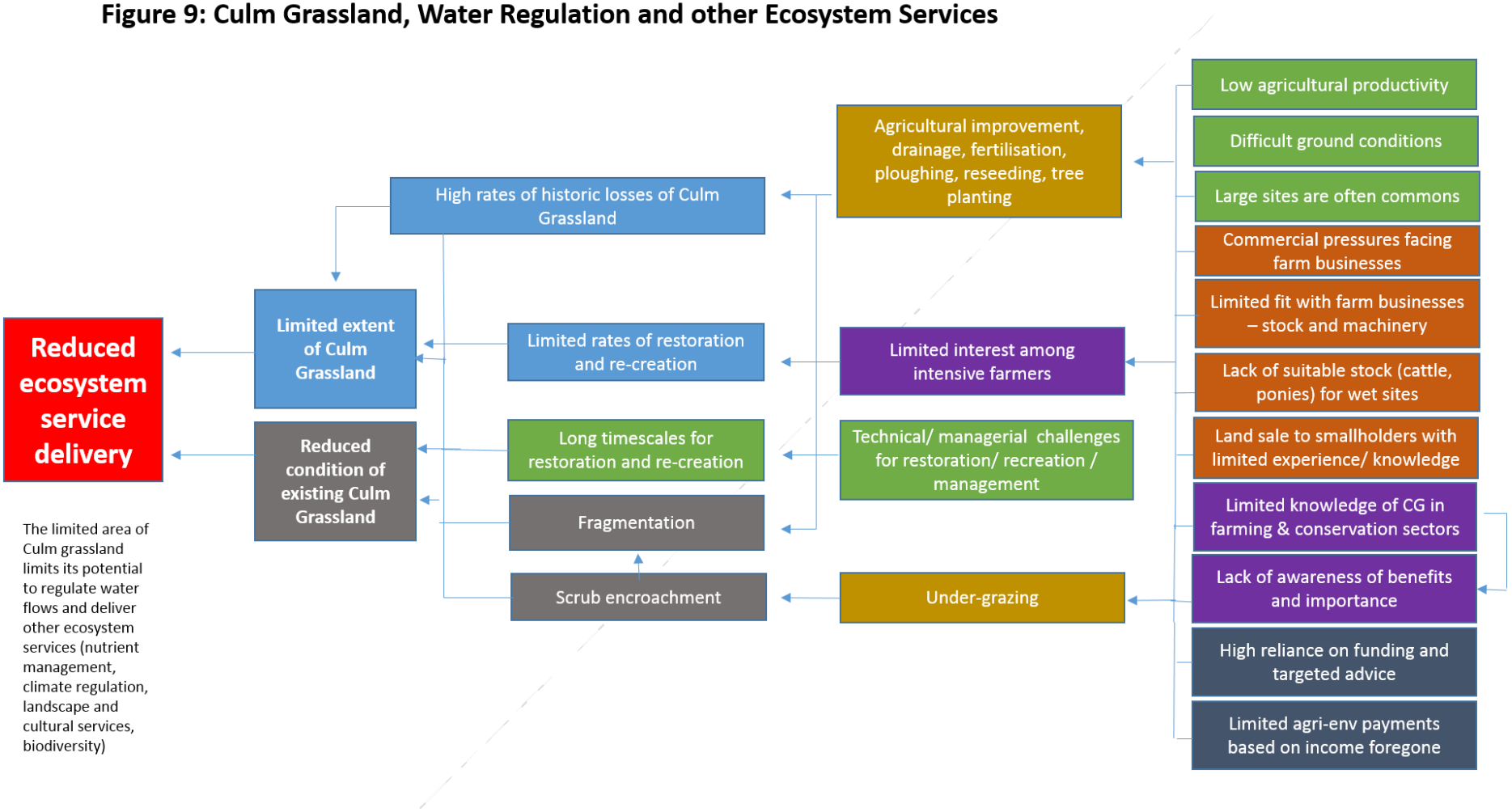
Figure 5. Arable land and water quality



A.1.7 Reduce flood risk

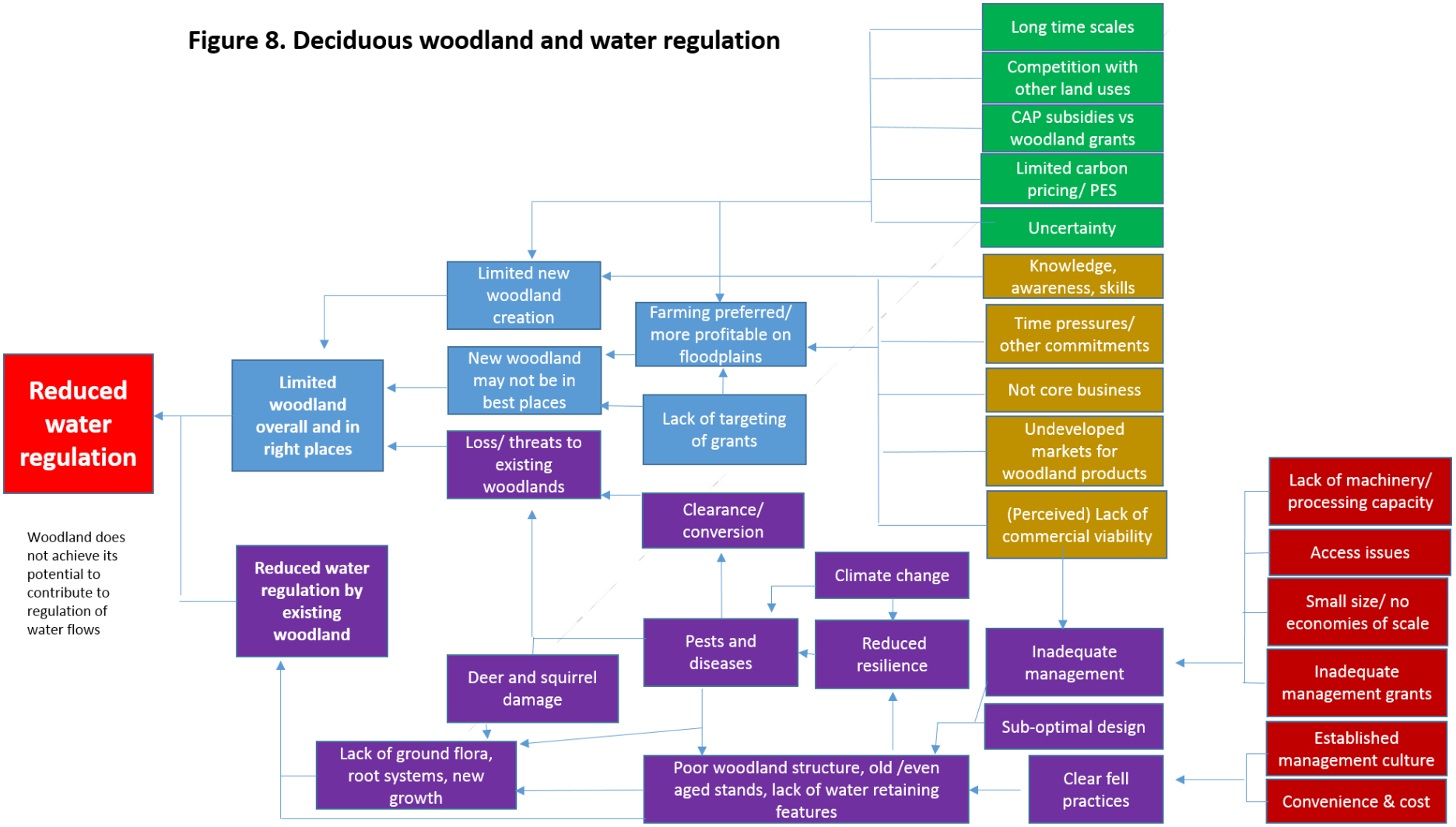
A.1.7.1 Culm grassland and water regulation/ other ecosystem services;

Figure 9: Culm Grassland, Water Regulation and other Ecosystem Services



A.1.7.2 Deciduous woodland and water regulation.

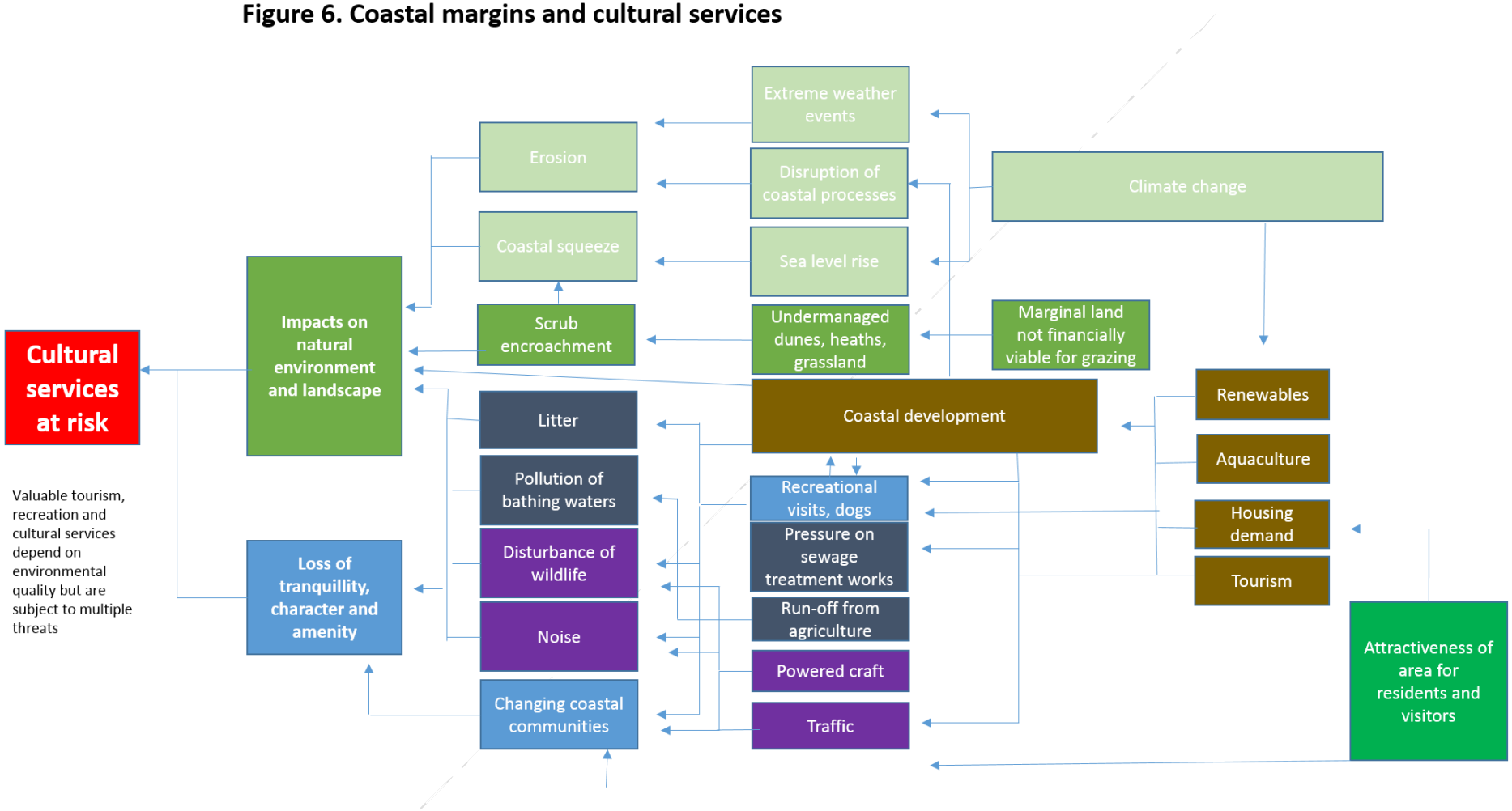
Figure 8. Deciduous woodland and water regulation



A.1.8 Mitigate tourism and recreation pressure

A.1.8.1 Coastal margins, tourism, recreation and cultural services;

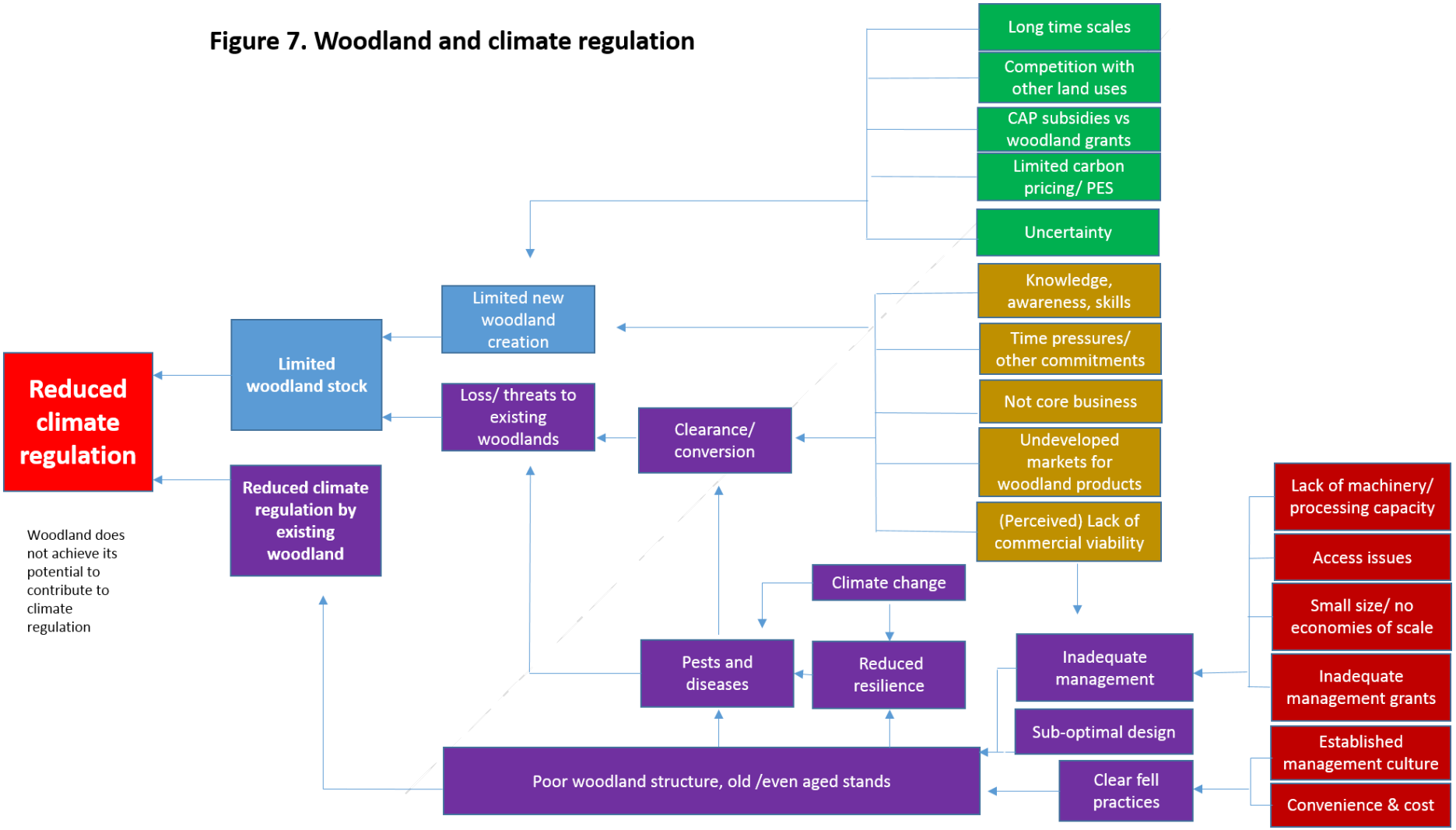
Figure 6. Coastal margins and cultural services



A.1.9 Increase carbon capture and storage

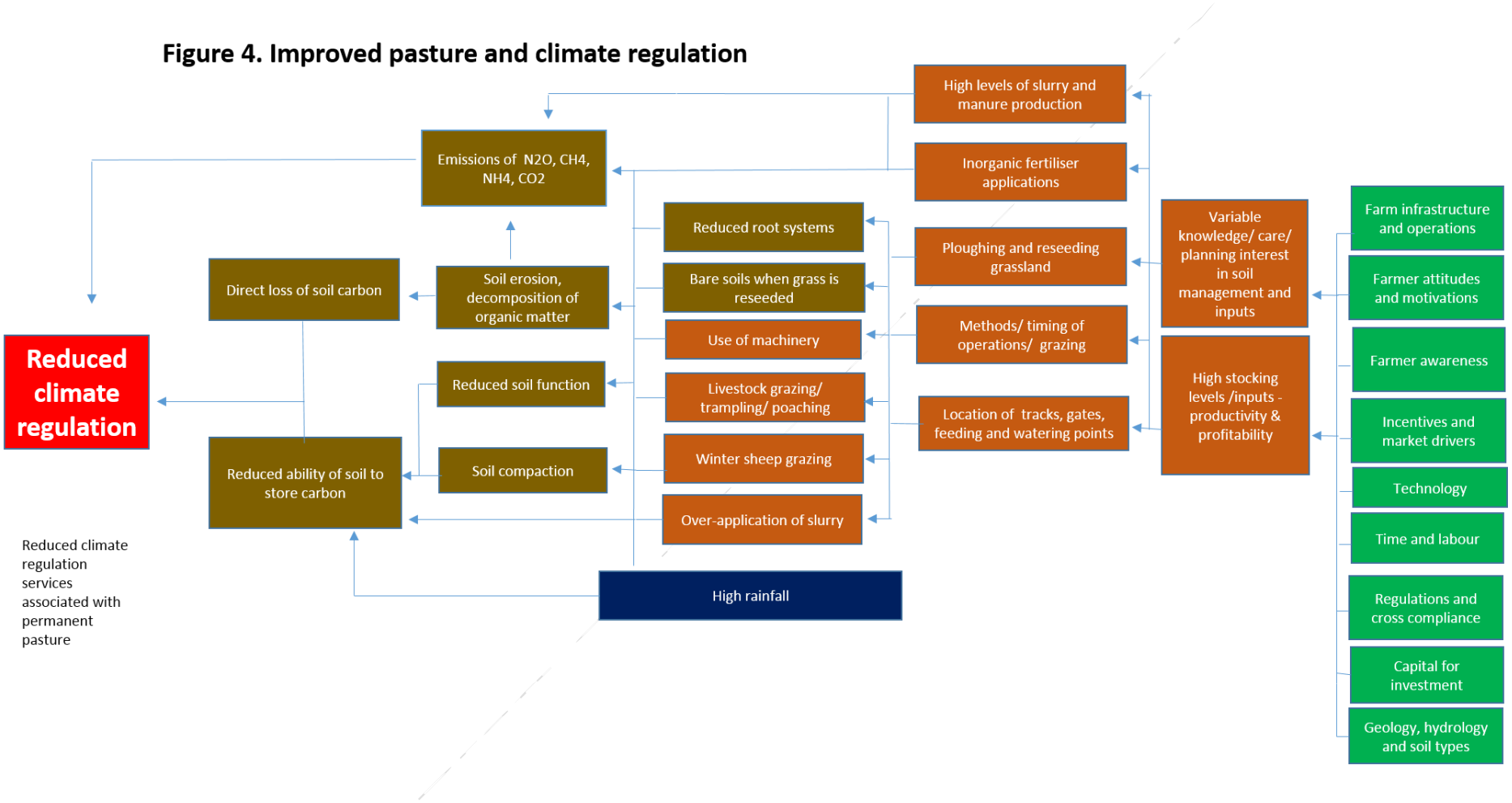
A.1.9.1 Woodland and climate regulation

Figure 7. Woodland and climate regulation



A.1.9.2 Improved pasture and climate regulation;

Figure 4. Improved pasture and climate regulation



References

Alonso, I., Weston, K., Gregg, R. & Morecroft, M. (2012). *Carbon storage by habitat - Review of the evidence of the impacts of management decisions and condition on carbon stores and sources.* Natural England Research Reports, Number NERR043.

Ashley, M., Rees, S., & Cameron, A. (2018). *North Devon Marine Pioneer Part 1: State of the art report of the links between ecosystem and ecosystem services in the North Devon Marine Pioneer. A report to WWF-UK by research staff at the Marine Institute at Plymouth.*

Avon Wildlife Trust, Eunomia, Natural England. (2019, July 9th). Retrieved from West of England Nature Partnership : http://www.wenp.org.uk/wp-content/uploads/2018/07/NCT-Final-Report.pdf

Banks, C., Salter, A., Heaven, S., & Riley, K. (2011). Energetic and environmental benefits of co-digestion of food waste and cattle. *Resources, Conservation and Recycling*, Resources, Conservation and Recycling 56 (71–79).

Bell, A., Le Helloco E., & Stainthorp R. (2014). The State of North Devon UNESCO World Biosphere Reserve. Retrieved from North Devon Biosphere: https://www.northdevonbiosphere.org.uk/uploads/1/5/4/4/15448192/state_of_the_biosphere_reserve_low_res.pdf

Blackstock, Kirsty L., Gail J. Kelly, and Bronwyn L. Horsey. "Developing and applying a framework to evaluate participatory research for sustainability." *Ecological economics* 60.4 (2007): 726-742.

Boardman, J. (2013). Soil Erosion in Britain: Updating the Record. *Agriculture 2013, 3(3),* 418-442.

Bressette, J. & Beck, H. (2013). The effects of high deer density on forest regeneration and carbon sequestration. *Environmental Research Journal. 7.*

Burton. (2018). *Reviewing the evidence base for the effects of woodland expansion on biodiversity and ecosystem services in the United Kingdom.*

Burton, V., Mosely, D. B., Metzger, M., & Bellamy, P. (2018). Reviewing the evidence base for the effects of woodland expansion on biodiversity and ecosystem services in the United Kingdom. *Forest Ecology and Management* , 366-379.

Craddock, S. (2018). *Estuary Project.* Retrieved from North Devon Biosphere: https://www.northdevonbiosphere.org.uk/uploads/1/5/4/4/15448192/north_devon_focus_area_estuary_pollution_project_report_2017.2018_-_edited_for_ndb_website.pdf

Cranfield University (2015) *Research to develop the evidence base on soil erosion and water use in agriculture.* Available at https://www.theccc.org.uk/publication/cranfield-university-2015-for-the-adaptation-sub-committee-research-to-develop-the-evidence-base-on-soil-erosion-and-water-use-in-agriculture/ Last accessed 09/12/2019.

Cumming, G., & Norwood, C. (2012). The Community Voice Method: Using participatory research and filmmaking to foster dialogue about changing landscapes. *Landscape and Urban Planning*, 105 p434-444.

De Snoo, G., Herzon, I., Staats, H., Burton, R., Schindler, S., van Dijk, J., & ... Schwarz, G. (2013). Toward effective nature conservation on farmland: making farmers matter. *Conservation Letters*, 6(1), 66-72.

Defra (2005). *Controlling soil erosion: A manual for the assessment and management of agricultural land at risk of water erosion in lowland England.* Available at http://adlib.everysite.co.uk/adlib/defra/content.aspx?id=000HK277ZX.0BEE022ZRNMNP6 Last Accessed 09/12/2019.

Defra. (2018). *Code of Good Agricultural Practice (COGAP) for Reducing Ammonia Emissions.* Available at https://www.gov.uk/government/publications/code-of-good-agricultural-practice-for-reducing-ammonia-emissions Last accessed 09/12/2019.

Devon County Council . (2018, November 8). *New Strategy Support Tourism Growth in North Devon*. Retrieved from Devon County Council : https://www.devon.gov.uk/northdevonnews/2018/11/08/new-strategy-supports-tourism-growth-in-northern-devon/

Devon County Council. (2012). *Public Rights of Way.* Retrieved from Devon County Council: https://www.devon.gov.uk/prow/rights-of-way-improvement-plan/

Devon County Council. (2019, 07 19). *Devon Climate Emergency.* Retrieved from Devon County Council: https://www.devon.gov.uk/energyandclimatechange/devon-climate-emergency

Devon County Council. (2019, July 9th). *Output by Industry*. Retrieved from Devonomics: https://www.devonomics.info/data/output/sector-composition/

Devon Invasive Species Initiative . (2017). *Devon Invasive Species initiative Fact Sheet .*

Devon Wildlife Trust (2015) *The economic value of ecosystem services provided by Culm grasslands.* Available at https://www.devonwildlifetrust.org/sites/default/files/files/About%20us/The-economic-value-of-Culm-grassland-April-15.pdf Last accessed 09/12/2019.

Devon Wildlife Trust. (2019, 07 19). *Culm Grassland Natural Flood Management Project*. Retrieved from Devon Wildlife Trust: https://www.devonwildlifetrust.org/what-we-do/our-projects/culm-grassland-natural-flood-management-project

DG Education and Lifelong Learning. (n.d.). *Advisory methodology and system possibilities to educate forest owners, professionals & consultants: Situation Book.* European Commission.

Eftec (Unpublished). *Assessment of natural capital in the Landscape Pioneer (North Devon).*

Eftec (2020). *Root Cause Analysis of problems affecting ecosystem services in the Landscape Pioneer (North Devon).* Natural England Commissioned Report number 291.

Eftec (Unpublished). *Financial Mapping in North Devon Final Report.*

Environment Agency. (2012a). North Devon Catchment Flood Management Plan: Summary Report. Available at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/294026/North_Devon_Catchment_Flood_Management_Plan.pdf Last accessed 09/12/2019.

Environment Agency. (2012b). *Rural Sustainable Drainage Systems*. Retrieved from https://www.gov.uk/government/publications/rural-sustainable-drainage-systems

Environment Agency (2014) The North Devon Management Catchment: A summary of information about the water environment in the North Devon management catchment. Available at www.gov.uk/government/consultations/update-to-thedraft-river-basin-management-plans. Last accessed 02/12/2019.

Environment Agency . (2017). *Working with Natural processes.*

Environment Agency. (2018). *Working with natural process – Evidence Directory.*

Eunomia (In Press) Natural Capital Investment Opportunities for North Devon.

Ford, S., Williams, M., & Morris, S. (2017). *Farmyard Manure and Slurry Management and Anaerobic Digestion in Scotland – Practical Application on Farm.* Ricardo Energy & Environment for ClimateXChange.

Funtowicz, Silvio O., and Jerome R. Ravetz. "The worth of a songbird: ecological economics as a post-normal science." *Ecological economics* 10.3 (1994): 197-207.

HM Government. (2018). *A Green Future: Our 25 Year Plan to Improve the Environment.* London.

HM Treasury. (2017). *Natural Capital Costing Project: North Devon Pioneer.*

Lawrence, A., & Molteno, S. (2013). *Increasing timber production from small private woodlands in England: effectiveness of initiatives.* Alice Holt: Forest Research.

Local Government Association (2019) Flood Risk and flood risk management. Retrieved from: https://www.local.gov.uk/topics/severe-weather/flooding/flood-and-coastal-erosion-risk-management/flood-risk-and-flood-risk

Lokhorst, A. M., Staats, H., van Dijk, J., van Dijk, E., & de Snoo, G. (2011). What's in it for Me? Motivational differences between farmers' subsidised and non-subsidised conservation practices. *Applied Psychology*, 60(3), 337-353.

Lusardi, J., Rice, P., Waters, R.D., & Craven J. (2018). *Natural Capital Indicators: for defining and measuring change in natural capital.* Natural England Research Report, Number 076. Available at http://publications.naturalengland.org.uk/publication/6742480364240896 Last accessed 09/12/2019.

Mayle, B. (1999) Domestic Stock Grazing to Enhance Woodland Biodiversity. *Forestry Commission Information Note*. Retrieved from: http://adlib.everysite.co.uk/resources/000/111/078/fcin28.pdf

Mills, J., Gaskell, P., Jones, N., & Boatman, N. (2013). Farmer attitudes and evaluation of outcomes to on-farm environmental management. . *Aspects of Applied Biology*, (118), 209-216.

Morris, J., Tassone, V., De Groot, R., Camilleri, M., & Moncada, S. (2011). A Framework for Participatory Impact Assessment: involving stakeholders in European policy making, a case study of land use change in Malta. *Ecology and Society*, 16 (1) 12.

Natural England (2011). Protecting water from agricultural run-off: an introduction. *Natural England Technical Information Note Number 098.* Available at http://adlib.everysite.co.uk/resources/000/266/464/TIN098.pdf Last accessed 09/12/2019.

Natural England (2015). NE389: National Character Area Profile: 149. The Culm. Retrieved from: http://publications.naturalengland.org.uk/publication/4292167

Natural England, Defra, Environment Agency (2016). Catchment Sensitive Farming - South West River Basin District Strategy 2016 to 2021. Available at http://publications.naturalengland.org.uk/publication/7539405?category=45002, Last Accessed 09/12/2019.

Nisbet, T., & Thomas, H. (2006). The role of woodland in flood control: a landscape perspective. In Eds B. Davies & S. Thompson, *Proceedings of the 14th annual IALE(UK) 2006 conference on Water and the Landscape,* (pp. p118-125. IALE(UK)). Oxford.

Nisbet, T., Silgram, M., Shah, N., Morrow, K., & Broadmeadow , S. (2011). *Woodland for water; Woodland measures for meeting Water Framework Directive objectives.*

North Devon Biosphere. (2014). *North Devon Biosphere Strategy.* Retrieved from North Devon Biosphere: https://www.northdevonbiosphere.org.uk/uploads/1/5/4/4/15448192/the_biosphere_reserve_strategy_2014_to_2024_final_version.pdf

North Devon Biosphere. (2014). *Catchment Management Plan*. Retrieved from North Devon Biosphere: https://www.northdevonbiosphere.org.uk/catchment-management.html

North Devon Biosphere. (2019, 07 19). *North Devon Biosphere*. Retrieved from Boode Farm: https://www.northdevonbiosphere.org.uk/uploads/1/5/4/4/15448192/working_with_natural_processes_poster_-_boode_farm.pdf

North Devon Biosphere. (2019, 07 19). *Wood4Water*. Retrieved from North Devon Biosphere: https://www.northdevonbiosphere.org.uk/woods4water.html

North Devon Biosphere. (n.d.). *Position statement on Anaerobic Digestion production in North Devon Biosphere.* Retrieved from https://www.northdevonbiosphere.org.uk/uploads/1/5/4/4/15448192/anaerobic_digestion_-_position_statement.pdf

North Devon Coast AONB. (2018). *North Devon Coast State of the AONB Report 2014-2018 .*

Northern Devon Nature Improvement Area. (2015). *Northern Devon Nature Improvement Area.* Retrieved from North Devon Biosphere: https://www.northdevonbiosphere.org.uk/uploads/1/5/4/4/15448192/nia_report_2015_-_final.pdf

North Devon Council and Torridge Council (2018). Northern Devon Tourism Strategy 2018-2022. Available at https://www.northdevon.gov.uk/media/379003/northern-devon-tourism-strategy-final.pdf. Last accessed 12/12/2019.

Page, G., & Bellotti, B. (2015). Farmers value on-farm ecosystem services as important, but what are the impediments to participation in PES schemes? *Science of the total environment*, 515, 12-19.

Palmer, R.C., & Smith, R.P. (2013) Soil structural degradation in SW England and its impact on surface-water runoff generation; *Soil Use and Management,* 29 (4); 567-575.

POST (2014) Houses of Parliament – Parliamentary Office of Science and Technology. Diffuse Pollution of Water by Agriculture. Postnote October 2014. Available at https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-478 Last accessed 09/12/2019.

Pretty, J.N. (1995). Regenerating Agriculture: Policies and Practice for Sustainability and Self-reliance. Earthscan Publications, 320 pp.

Puttock, A. & Brazier, R. (2014). *Culm Grasslands Proof of Concept Phase 1.* Available at https://www.devonwildlifetrust.org/sites/default/files/2018-12/Culm-Proof-of-Concept.pdf, Last Accessed 09/12/2019.

Quality One. (n.d.). Retrieved from https://quality-one.com/rca/

Rees, S., Ashley, M., & Cameron, A. (2019). *North Devon Marine Pioneer 2: A Natural Capital Asset and Risk Register. A SWEEP/WWF-UK report by research staff the Marine Institute at the University of Plymouth;.*

Schmitzberger, I., Wrbka, T., Steurer, B., Aschenbrenner, G., Peterseil, J., & & Zechmeister, H. G. (2005). How farming styles influence biodiversity maintenance in Austrian agricultural landscapes. *Agriculture, Ecosystems & Environment,* 108(3), 274-290.

Scottish Forestry (n.d.) Woodland Grazing Toolbox. Retrieved from: https://forestry.gov.scot/woodland-grazing-toolbox

Sing, L., Metzger, M., Paterson, J., & Ray, D. (2017). A review of the effects of forest management intensity on ecosystem services for northern European temperate forests with a focus on the UK. ,. *Forestry: An International Journal of Forest Research*, Volume 91, Issue 2, April 2018, Pages 151–164.

South West Research Company (2016). The Economic Impact of Devon's Visitor Economy 2016. Reported in https://www.northdevon.gov.uk/media/379003/northern-devon-tourism-strategy-final.pdf

Stupak, N., Sanders, J., & Heinrich, J. (2019) The role of farmers' understanding of nature in shaping their uptake of nature protection measures. *Ecological Economics,* 157, 301-311.

Tansey. (2018). *Woodland Trust research update – pine martens return to Wales, Wood Wise, Tree and woodland conservation, autumn 2018 pp 14-17. .*

Tarka Trail Coastal Community Team. (2017). *Tarka Trail Coastal Community Team.* Retrieved from North Devon Council: https://www.northdevon.gov.uk/media/377734/tarka-trail-coast-cct-economic-plan-v4.pdf

UK National Ecosystem Assessment. (2011). *Understanding nature's value to society. Synthesis of key findings.*

Upstream Thinking. (2019, 19 07). *Water Quality*. Retrieved from Upstream Thinking: http://upstreamthinking.org/index.cfm?articleid=8690

Walker. (2004). *The restoration and re-creation of species-rich lowland grassland.*

Ward S E, Smart S M, Quirk H, Tallowin J R B, Mortimer S R, Shiel R S, Wilby A and Bardgett R G (2016) *Legacy effects of grassland management on soil carbon to depth.* Available at http://eprints.lancs.ac.uk/78464/1/Ward_et_al_Accepted_author_manuscript.pdf Last accessed 09/12/2019.

Westcountry Rivers Trust (In Press) *National Natural Capital Atlas.* Natural England Commissioned Report.

Willis, C., Lusardi, J., Darlow, A., Waters, R., & Maxwell, S. (2018). *Evaluation of the Upland Ecosystem Service Pilots: Bassenthwaite NERR 077.* Natural England.

Woodland Trust (2012) Woodland grazing – introduction. *Woodland Wise – Woodland Conservation news*. Autumn 2012. Retrieved from: http://www.woodlandtrust.org.uk/mediafile/100263349/pg-wt-2014-woodwise-2012-autumn.pdf?cb=435a97b193f048419903e8a34c51ea8a

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