Trial of the Natural Capital Protocol for land-based businesses

Ruthven Farm

Natural Capital Assessment

March 2018

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EXECUTIVE SUMMARY

Ruthven Farm is one of three-land based businesses participating in a trial to explore the degree to which the Natural Capital Protocol (the Protocol) is applicable and useful to land-based businesses in Scotland. Ruthven Farm is an upland farm with two main enterprises: sheep and suckler cows, with ancillary crop production for animal feed.

These enterprises are dependent on natural capital (NC) assets and a range of ecosystem services (ESS). An overview of the farm's key NC assets and trends over the current tenancy is given below:

Enterprise	Asset	Trend (2006 – 2017)	
		Extent	Condition
Livestock enterprise	Temporary and permanent pasture (137 ha)	↗	↗
	Hedgerows (4.5 km)	↗	↗
	Woodland (37 ha)	↗	➔*
Crop production	Arable land (8 ha)	↘	↗
Other	Mountains, moorlands and heaths (117 ha)	↗	➔
	Water (streams, 3.4 km)	➔	↘
"↗" = Improving/growing "➔" = stable "↘" = deteriorating/shrinking			

* Overall condition is stable due to degrading condition of old birch woodlands balanced by improved condition of newly planted woodland.

Natural capital dependencies

Ruthven Farm's key natural capital dependencies include provisioning services – crop and livestock production; regulating services – local climate regulation, soil quality and erosion regulation, disease and pest regulation; and cultural services – cultural heritage. The farm's dependency on regulatory and cultural services underpin the more obvious dependencies of crop and livestock production and therefore it is these services that are explored in more detail in the report:

Local climate regulation – livestock depend on shelterbelts to keep warm and lamb, decreasing the need for additional feed input.
Soil quality regulation – crop production and livestock pasture will depend on soil nutrient, pH and organic content levels to support the carrying capacity of the land.
Disease and pest control – both crop and livestock enterprises will depend on disease and pest management services to minimise production losses.
Cultural heritage - upland livestock farming particularly relies on a body of knowledge that has built up over many generations.

Natural capital impacts

This report looks at both the 'gross' natural capital impacts of Ruthven Farm's enterprises (i.e. the impact of farming activities compared to a benchmark of no farming/natural state); and the impact of the specific farming activities undertaken during the current tenancy (i.e. 2006 to present day).

Against a benchmark of the natural state of the land, farming often causes negative natural capital impacts, particularly on regulating services such as global climate, flood, water quality, disease and pest regulation. Whilst Ruthven Farm follows a minimal tillage approach, fertiliser application contributes nitrous oxide and

rumination of livestock generates methane (a potent greenhouse gas (GHG)) making GHG emissions a material impact of farming.

By contrast, the impacts on natural capital since Jim Simmons took occupation have largely been positive.

Local climate regulation services - significant hedgerow and woodland planting across the farm has increased the amount of shelter available to livestock from inclement weather.
Soil quality & erosion regulation **services** - farming practices such as using clover seed mix and reduced synthetic fertiliser have improved soil quality, as demonstrated by soil testing evidence.
Wild species diversity services - low-moderate intensity grazing and the development of habitat mosaics better supports diverse flora and fauna versus more intensive grazing.
Education services - Ruthven Farm is an environmentally friendly demonstration farm and hosts Scotland's Rural College and Aberdeen University students.

Risks and opportunities

Key risks include:

- Loss of woodland through prevented regeneration, which currently provides important livestock shelter.
- Loss of land and external pressure to take action on degrading/eroding river condition.
- Uncertainty over remaining tenancy period (renewal due within 4 years) means returns on any investments made are uncertain.
- Brexit, loss of Basic Payment Scheme, resulting in a reduction in income.

Key opportunities include:

- Tackling the degrading native woodland areas, perhaps with a pilot trial, to regenerate these shelterbelts.
- Establishing a plan of action to reduce river erosion, minimise land loss and cost of re-fencing, whilst also supporting water quality downstream.
- Being able to demonstrate the contribution the business is making to 'public goods', such as water quality and biodiversity, is likely to become increasingly important in the future, for building sustainable brands and for accessing public support payments available post-Brexit.
- Exploring the potential for longer term tenancies and moving away from seasonal lets that encourage short term approaches to farming
- There is an opportunity to develop a set of metrics for monitoring the natural assets of Ruthven Farm over time, including soil analysis.

Actions for consideration

- Liaise with Crown Estate Scotland and Glenlivet Estate regarding soil testing across all fields.
- Liaise with Crown Estate Scotland, Glenlivet Estate, Forestry Commission and Woodland Trust to establish a plan of action and support for efforts to protect the degrading native woodland and provide an alternative livestock shelter solution.
- Engage with Crown Estate Scotland, Glenlivet Estate and SEPA about the degrading condition of the Conglass Water to establish responsibilities and a plan of action to tackle erosion.
- Liaise with Crown Estate Scotland about the upcoming tenancy renewal. Certainty over the longer term future of the tenancy could enable further natural capital investment on the farm.

FRAME STAGE: Why?

Step 01: Get started

Crown Estate Scotland and its partners in a coalition of organisations with an interest in land management in Scotland would like to explore the degree to which the Natural Capital Protocol (the Protocol) is applicable and useful to land-based businesses in Scotland.

Natural capital refers to the natural resources (or assets) that people use and from which they gain benefit. For Ruthven Farm, this includes its soils, water, arable and pasture land, hedges, woodland and other habitats, see Table 2. More formally, natural capital can be defined as:

"…the stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits or 'services' to people"[1].

Figure 1 illustrates the relationship between natural capital and the flows of benefits (which can be ecosystem services or abiotic services) which provide value to people and businesses.

Figure 1: Natural capital stocks, flows and values

The Natural Capital Protocol[2], produced by the Natural Capital Coalition[3], is a standardised framework for businesses to identify, measure, and value their impacts and dependencies on natural capital. The framework is designed to help generate trusted, credible, and actionable information about how businesses interact with nature, or more specifically natural capital, that business managers need to inform decisions. This includes highlighting natural capital risks and opportunities for each business.

Ruthven Farm's natural capital assets provide a range of ecosystem services, see Table 3. This framework has been adapted from the Millennium Ecosystem Assessment[4] which identifies four broad categories of ecosystem services:

[1] Natural Capital Coalition (2016) Natural Capital Protocol [online] available at https://naturalcapitalcoalition.org/protocol/.

[2] http://naturalcapitalcoalition.org/wp-content/uploads/2016/07/Framework_Book_2016-07-01-2.pdf

[3] http://naturalcapitalcoalition.org/

[4] Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-being: Synthesis [online] available at https://www.millenniumassessment.org/documents/document.356.aspx.pdf

- Provisioning services; such as food supply, materials, energy, water supply, genetic resources.
- Regulating services; such as carbon sequestration and climate regulation, waste decomposition and detoxification, purification of water and air, pest and disease control.
- Cultural services; e.g. recreation, education and cultural heritage
- Supporting services; regarded as the basis for the services listed above (note: these are not separated out in the ecosystem services tables). These include services such as nutrient recycling, primary production and soil formation. These services make it possible for the ecosystems to provide services such as food supply, flood regulation, and water purification.

Ruthven Farm is dependent on the continued supply of ecosystem services such as soil quality regulation, pest and disease control and local climate regulation to support crop and livestock productivity. Activities on the farm also have impacts – both positive and negative - on natural capital stocks and ecosystem services flows. Conducting a natural capital assessment of Ruthven Farm can help to identify, measure and value the impacts and dependencies of farm activities and outputs on natural capital.

SCOPE STAGE: What?

Step 02: Define the objective

Overall project objectives

The overall aim of the project is to explore the degree to which the Natural Capital Protocol is applicable and useful to land-based businesses in Scotland through:

- completing pilot natural capital assessments for three land-based businesses, including Ruthven Farm;
- developing businesses' understanding of natural capital and the Protocol through this pilot; and
- producing case studies to help communicate the value to the businesses of reducing natural capital impacts and managing dependencies to share with the steering group and promote more broadly.

This report sets out the key findings from the natural capital assessment of Ruthven Farm, whilst a separate Overview Report presents the findings and lessons learnt from the wider project

Ruthven Farm objectives

The objectives relating specifically to the Ruthven Farm natural capital assessment are to:

- facilitate more informed decision-making in terms of land use and management, supporting enhanced environmental and economic performance and greater resilience in terms of primary production and other enterprises;
- systematically identify and assess natural capital risks and opportunities relating to the farm; and
- support the business to be better prepared and informed to secure future public payments and identify potential new revenue streams.

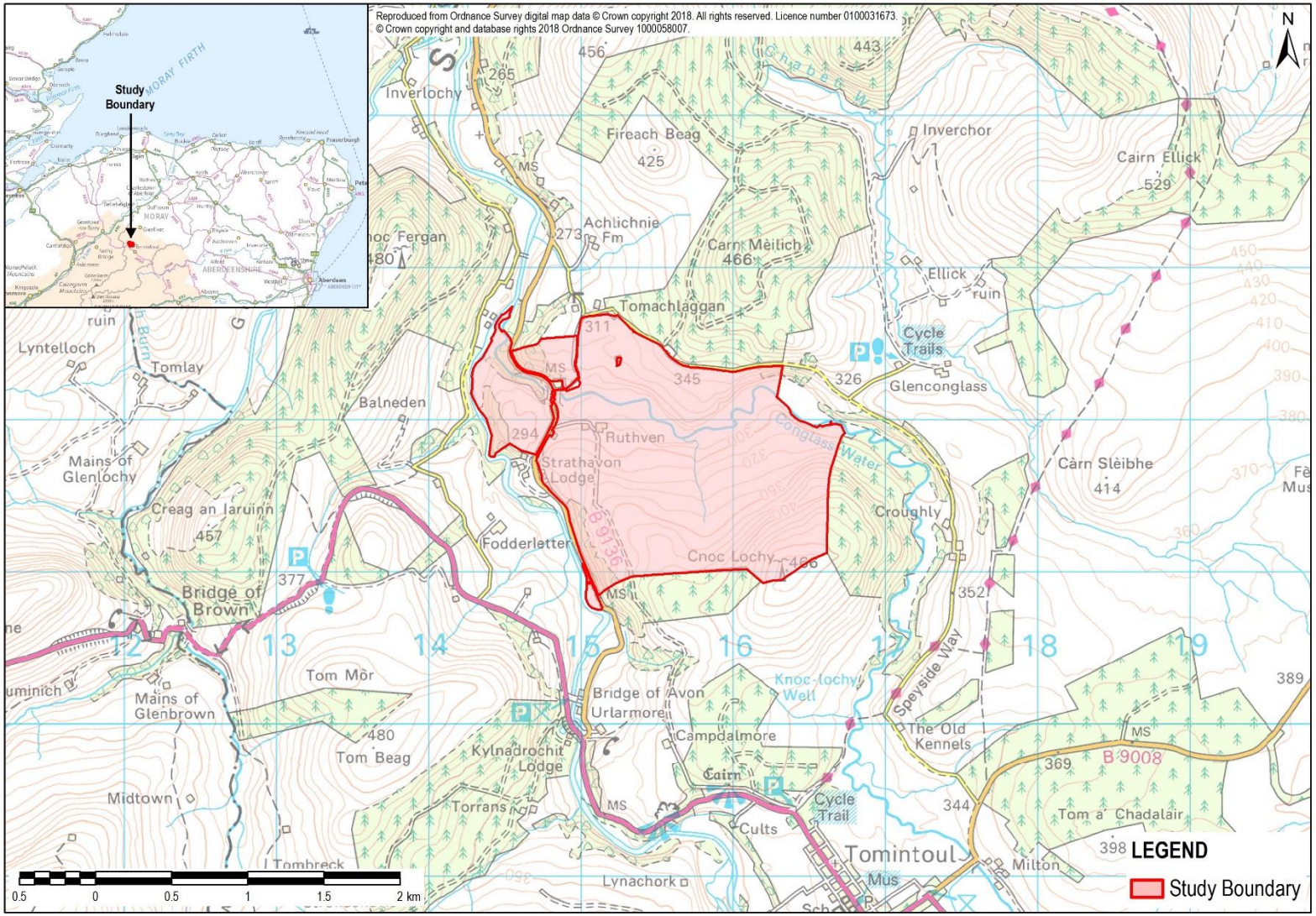
This has been done through a high level natural capital assessment of the whole farm, assessing the key natural capital impacts and dependencies of the farm's operations. In addition, a more detailed assessment of a recent woodland planting project was undertaken to demonstrate how quantification and valuation of natural capital costs and benefits may be a useful input to business decision-making.

Step 03: Scope the assessment

Scope of farm-wide assessment

- The assessment examines the **impacts and dependencies** of everyday **on-farm activities** on natural capital stocks and the benefits they provide.
- The assessment covers the impacts and dependencies of direct operations within the farm boundaries only (see Figure 2) and does not include consideration of supply chain impacts or dependencies. However, account is taken of risks and opportunities beyond the farm gate where these are relevant.
- We have assessed and valued impacts (positive and negative) from the perspectives of both the **business and society**.
- The assessment considers both impacts and dependencies of activities on Ruthven Farm in general (i.e. against a benchmark of a no farming/natural state) as well the change in natural capital and ecosystem service flows over an 11-year period from the start of the current tenancy in 2006 to the present day (2017).

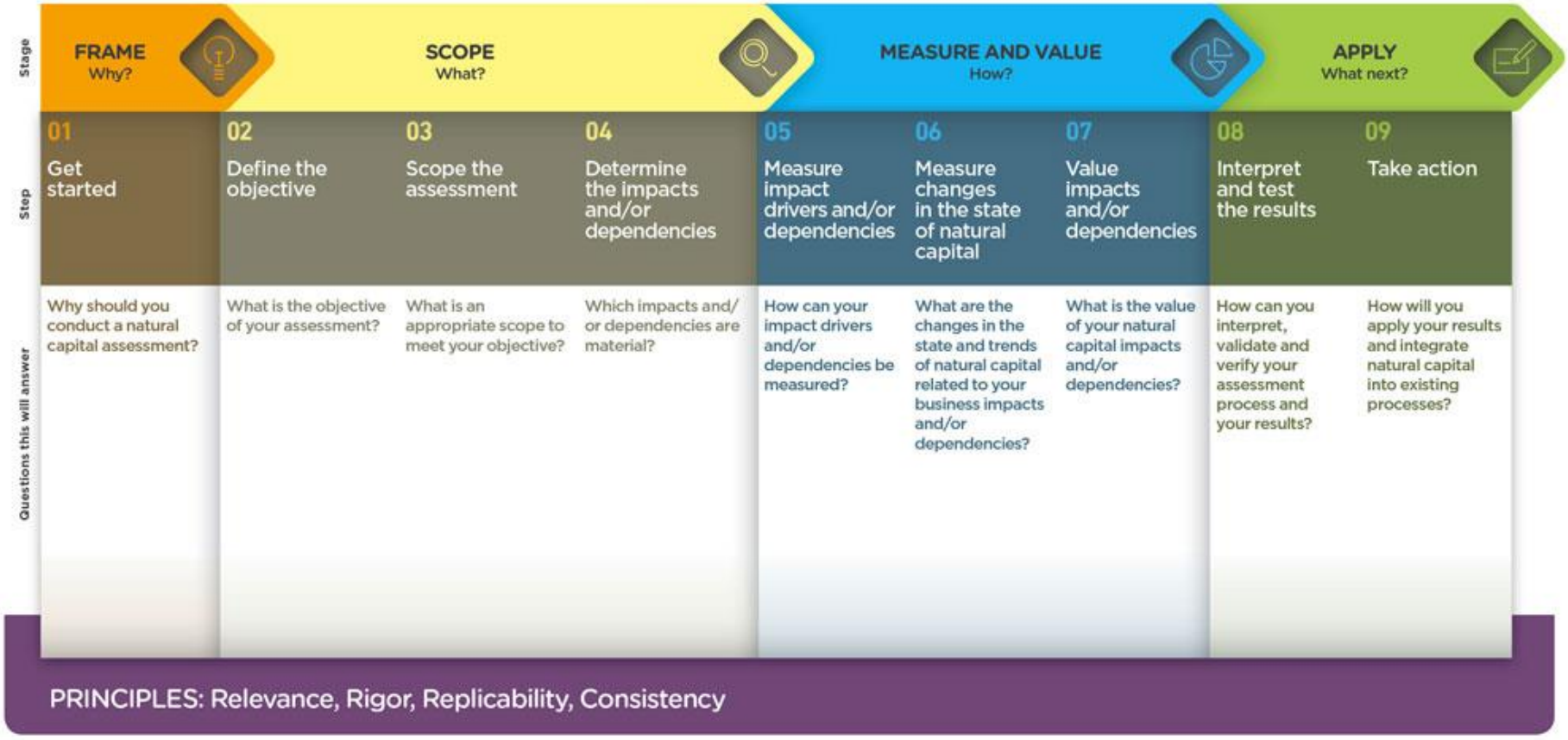
Figure 2: Map of Ruthven Farm (red line boundary shows original 2006 tenancy) and surrounding area



Approach

The work involved three meetings with the farmer over the period November 2017 to February 2018, a review of farm data, analysis and assessment. Our work follows the steps laid out by the Protocol and this report reflects that process, illustrated in Figure 3 below.

Figure 3: Natural Capital Protocol Framework



Ruthven Farm overview

Ruthven Farm is owned by the Crown, and Crown Estate Scotland lets out the farm to Jim Simmons, who took on the tenancy in November 2006. Crown Estate Scotland works with its tenants to improve productivity while enhancing biodiversity.

Ruthven Farm is an upland farm covering approximately 300 ha. It is located on the Glenlivet Estate and within the Cairngorms National Park. It runs Blackface Sheep to breed mules, and pedigree Gascon cattle (see Table 1). Ruthven is fairly typical of upland livestock farms on the Estate, with a mix of open hill ground (150 ha) and enclosed in-bye land (150 ha).

Ruthven Farm is currently enrolled in an agri-environment climate scheme (June 2016), a Rural Development Contract (2014 and 2011), as well as the RSPB's Peesie wader monitoring project. It is also a member of Quality Meat Scotland Cattle & Sheep Assurance Scheme.

Jim and Lesley Simmons have won a number of awards for their commitment to wildlife on Ruthven Farm, including the Cairngorms Nature Farm Award and the 'Food and Farming' award in RSPB's Nature of Scotland Awards 2016. Over the past few years Jim has planted several hectares of mixed woodland, as well as 4,500 meters of new hedgerows to improve habitat connectivity and opportunities for nesting birds. The new riparian woodlands he planted will also help to improve woodland habitat connectivity and improve water quality for fish and freshwater pearl mussels. Several new ponds and wet scrapes will benefit a wide range of aquatic life, including wading birds such as snipe, lapwing, redshank, oystercatcher, and curlew.

Table 1: Farm enterprises

Enterprise	Brief description
Sheep	Flock of 500 Scottish Black Faces crossed with Blue Leicester rams for mule ewe lamb production. Flock of 150 mules producing cross-bred lambs (Suffolk ram) for fat lamb production. Hill flock of 80 Shetland and Shetland x Cheviots producing cross-bred lambs (Cheviot ram) for fat lamb production. Lambs are fattened off grass and stubble turnips. Forage-based, rotational grazing system.
Suckler cows	Suckler herd of 25 Gascon cows. Some heifer calves kept for replacement, some sold on for breeding; male calves sold as stores at 7 months. Forage-based system with cattle following sheep in grazing rotation. Cattle are mainly out-wintered.
Stubble turnips	Typically a catch crop, the stubble turnips are sown at Ruthven as a main crop and strip-grazed to provide autumn and winter feed for lambs weaned off grass. The area under cultivation varies from year to year, but is generally around 7 ha and follows a minimum tillage system since 2017.

Step 04: Determine the impacts and/or dependencies

Introduction

Every business impacts and depends on natural capital and the ecosystem services it provides to some degree and will experience risks and/or opportunities associated with these relationships. Impacts can be negative, e.g., pollution, or positive, e.g., improved water quality.

There are many ecosystem services that flow from the different types of natural capital, not all of which will be relevant for this assessment. For farm businesses, provisioning services such as crops and livestock are highly significant while others such as noise regulation may be less so.

This step in the process aims firstly to identify the natural capital stocks that are present on Ruthven Farm and the ecosystem services that flow from these and secondly to determine which of the impacts and dependencies upon these are most significant and worth more detailed investigation.

Natural capital assets and ecosystem services on Ruthven Farm

Ruthven Farm's **natural capital assets** can be viewed as a series of habitat types, set out in the Asset Register in Table 2. This shows the extent (e.g. hectares of land) and condition (e.g. good or degraded) of the assets, and highlights changes since the start of the tenancy (2006). For example, it shows an increase in woodland extent, but no improvement in condition. This is due to degradation occurring in a number of older native birch woodlands, whilst the condition of woodland planted during the current tenancy is improving, giving a net 'static condition' score.

The deteriorating condition of freshwater habitats may be explained by significant erosion occurring around Conglass Water. However, the register shows an overall improvement in the condition of Ruthven Farm's natural capital assets over the current tenancy, particularly in relation to hedgerows, woodlands and soils (cropland and pasture).

The natural capital assets on Ruthven Farm provide a range of **ecosystem services.** Table 3 provides an overview of the relative importance of different types of natural capital assets on the farm in delivering ecosystem service flows (shown by coloured cells). This shows, for example, that hedgerows on Ruthven Farm are important for local climate regulation (providing shelter to livestock), and how wetlands are important for disease and pest regulation as well as providing habitat for wild species. The information in Table 3 was compiled on the basis of information from the UK National Ecosystem Assessment[5] (in terms of the relative importance of different habitat types for different ecosystem services) as well as from observations and discussions with the farmer. Definitions for these services can be found in Appendix 2.

Key dependencies and impacts

The discussion and assessment outlined above helped us to identify where the key or 'material' dependencies and impacts are likely to lie and therefore which are likely to be most relevant to the farm business and its stakeholders. We reviewed the assessment with the farmer during a second site visit and agreed that all ecosystem services shown in Table 3 that have at least one green-coloured cell should be included in the more detailed assessment.

[5] McCracken et al (2011) Enclosed Farmland *In*: The UK National Ecosystem Assessment Technical Report. UK National Ecosystem Assessment, UNEP-WCMC, Cambridge [online] available at http://uknea.unep-wcmc.org/Resources/tabid/82/Default.aspx

Table 2: Natural capital asset register

Assets (habitat types)	Unit of measure	Start of tenancy 2006		Current status 2017		Data source	Trends (impact)
		Extent	Condition	Extent	Condition		
Enclosed farmland:							
Cropland (arable & horticultural)	ha	36.42	Degraded	7.75	Adequate/improving	Soil tests	Decreased extent, improving condition
Temporary pasture (temporary improved grassland)	ha	61.8	Degraded	23.88	Adequate/improving	Soil tests	Decreased extent, improving condition
Permanent pasture (permanent improved grassland)	ha	51.91	Degraded	113.55	Adequate/improving	Soil tests	Increased extent, improving condition
Permanent unimproved pasture (semi-natural Grasslands)	ha		-		Adequate/improving	Soil tests	Increased extent, improving condition
Hedgerows	metres	-	-	4,500	Species rich	Survey	Increased extent, improving condition
Woodland (includes farm woodlands)	ha	11.265	Degraded	37.19	Degraded/improving	Jim Simmons	Increased extent, static condition*
Mountains, Moorlands and Heaths	ha	102.95	-	117.1	Stable	Jim Simmons	Static extent, static condition
Water (Openwaters, Wetlands & Floodplains)	length of streams in meters	3,373	Unknown	3,373	Degraded	Jim Simmons	Degrading condition

* Condition is both degrading and improving - degradation of native birch woodland is offset by improving condition of newly planted woodland.

Table 3: Ecosystem services

Current status 2017		ECOSYSTEM SERVICES																		
		Provisioning								Regulating								Cultural			
Assets (habitat types)	Current asset?	Crops	Livestock	Wild foods (fish / game / venison / berries,etc)	Timber	Fibre	Genetic materials	Fuel	Water Supply	Global climate regulation	Local climate regulation	Flood regulation	Water quality regulation	Soil quality and erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage
Enclosed farmland:																					
Cropland (arable & horticultural)	yes																				
Temporary pasture (temporary improved grassland)	yes																				
Permanent pasture (permanent improved grassland)	yes																				
Permanent unimproved pasture (semi-natural Grasslands)	yes																				
Hedgerows	yes																				
Woodland (includes farm woodlands)	yes																				
Mountains, Moorlands and Heaths	yes																				
Water (Openwaters, Wetlands & Floodplains)	yes																				

Relative importance:
high
medium
low
not important

MEASURE AND VALUE STAGE: How?

Step 05: Measure impact drivers and dependencies,

Step 06: Measure changes in the state of natural capital,

Step 07: Value impacts and/or dependencies

This stage focused on assessing the dependencies and impacts of Ruthven Farm activities on natural capital and ecosystem services in more detail. It starts by identifying the specific activities that are dependent on, or give rise to impacts on ecosystem services before describing the nature of these relationships and their implications both for the business itself and for others that may also benefit from the services provided. Some of the broad approaches to monetary valuation of the costs and benefits are described and are demonstrated in more detail in the case study at the end of the report.

Natural capital and ecosystem service dependencies

Table 4 highlights the extent to which the core activities on Ruthven Farm are dependent on natural capital. This illustrates that, for example, livestock grazing is highly dependent on temporary and permanent pasture, whilst it is dependent to a slightly lesser extent on permanent unimproved pasture and only dependent to a low extent on mountains, moorlands and heath habitats. Hedgerows are an important asset, particularly for upland livestock farms where weather can be severe, as they provide shelterbelts for livestock.

Table 5 shows the dependency of activities on specific ecosystem services. Beyond the more obvious provisioning services of crops and livestock, this highlights that the farm depends on regulating services more than any other type of ecosystem service, including:

- local climate regulation;
- soil quality and erosion regulation; and
- disease and pest regulation.

Provisioning services

Crop production and livestock grazing are clearly highly dependent on the food provisioning services. This is due to the management of the land primarily for this purpose. These benefits are supported by a range of regulating services.

Regulating services

It is no surprise that the majority of the farm's dependencies are classified as regulating services. These are the services that regulate climate, soil quality, pest and diseases, water supply and quality, flooding, erosion and so on. Farming outputs are directly dependent on many of these, and on an upland farm such as Ruthven Farm which operates close to the limits of viability, the dependencies are likely to be greater.

Cultural services

Cultural heritage was also identified as a 'high' dependency for Jim's livestock operations, as upland livestock farming particularly relies on a body of knowledge and cultural and intellectual capital that has built up over many generations.

We have developed and discussed dependency pathways for the high dependency regulating and cultural services identified in Tables 4 and 5 (the provisioning services of crops and livestock are self-evident). These pathways describe the ways in which business activities depend on natural capital and ecosystem services and how changes in these may impact positively or negatively on the business.

Table 4: Natural capital dependencies

	Assets (habitat types)								
	Enclosed farmland:								
Enterprises	Cropland (arable & horticultural)	Temporary pasture (temporary improved grassland)	Permanent pasture (permanent improved grassland)	Permanent unimproved pasture (semi-natural Grasslands)	Field margins	Hedgerows	Woodland (includes farm woodlands)	Mountains, Moorlands and Heaths	Water (Openwaters, Wetlands & Floodplains)
Crop production									
Livestock grazing									

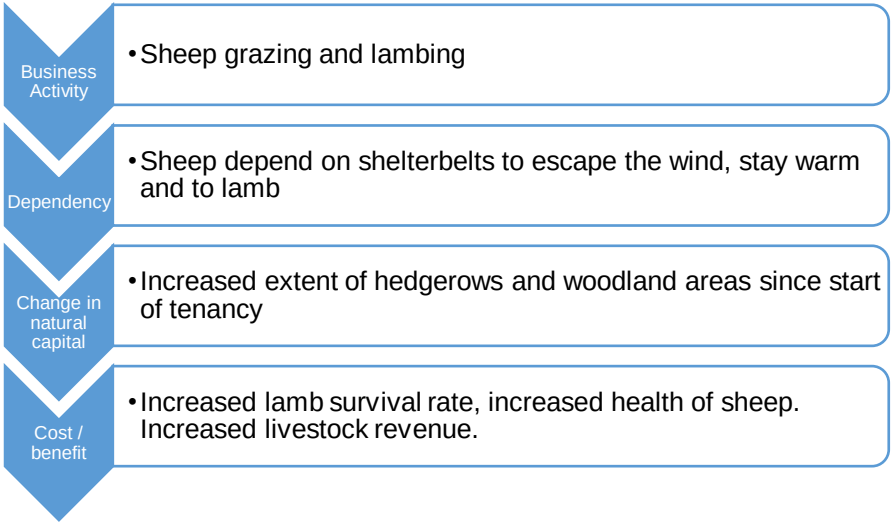
Table 5: Ecosystem service dependencies

		ECOSYSTEM SERVICES														
		Provisioning Services			Regulating Services								Cultural Services			
Ecosystem Services	% area of land of enterprise	Crops	Livestock	Water Supply	Global climate regulation	Local climate regulation	Flood regulation	Water quality regulation	Soil quality and erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage
Enterprises																
Crop production	3%															
Livestock grazing	97%															

Dependency:	
	High
	Medium
	Low
	No dependency

Dependency pathways:

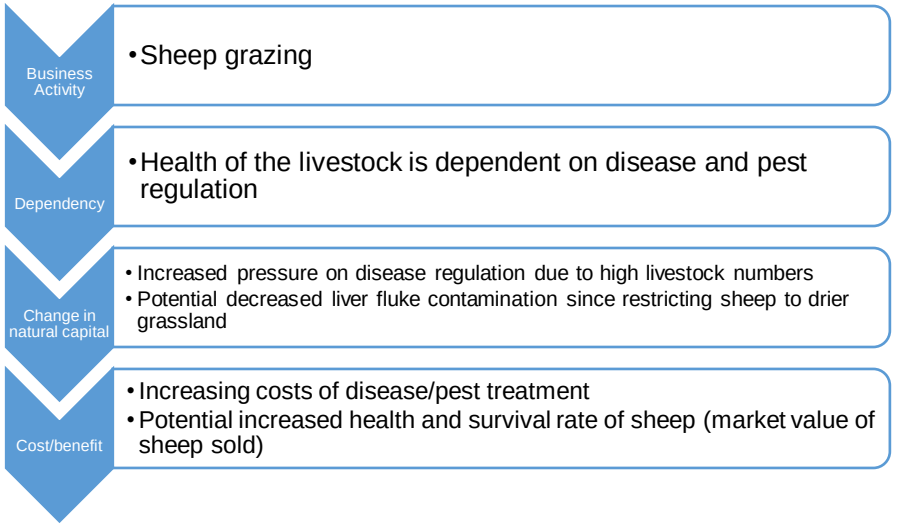
Local climate regulation



The weather on Ruthven Farm can be severe, with wind, rain and snow that affects the condition of the sheep. Sheep are more likely to feed and gain weight/condition if they have shelter and therefore shelterbelts are key for providing local climate regulation services.

There are four areas of 150-200 year old native birch woodland on the farm that provide important shelter to sheep, but are deteriorating. These woodlands have reached end succession stage and are not naturally regenerating (partly due to sheep browsing on saplings but also perhaps due to poor cultivating conditions). This presents a risk for local climate regulation services in the future. Jim has, however, planted over 4.5km of hedges and 26 ha of woodland during his tenancy to provide new shelterbelts for livestock.

Disease and pest regulation

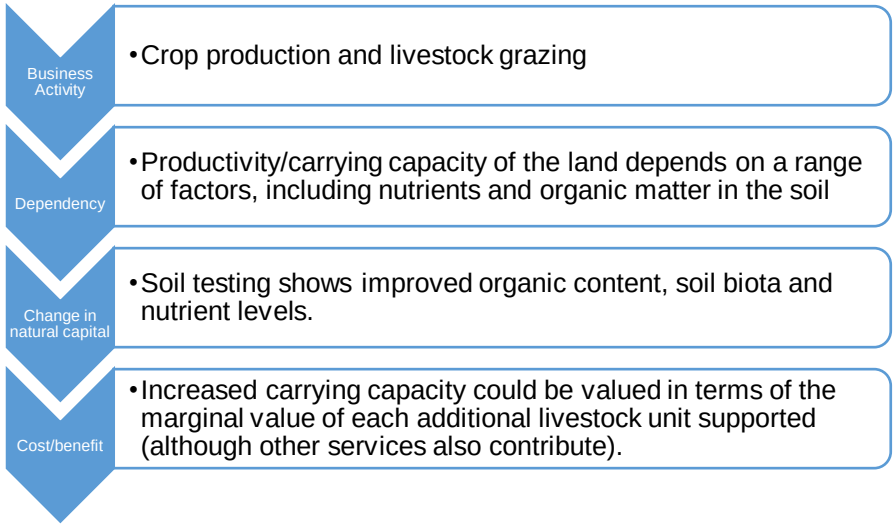


Incidents of pests and diseases (e.g. foot rot, worms) tend to increase over periods of intensive stocking as they spread amongst the animals and become embedded in the land. Ruthven Farm is no exception with this service increasingly under pressure (see Table 9) and a key dependency for livestock production.

In 2014, Jim fenced off a wetland area at the bottom of field 8 (see map in Appendix 3) that is home to snails carrying liverfluke larvae (a potentially fatal parasitic infection for sheep). By removing access to the wetland it is likely that liver fluke contamination will have significantly decreased. In practice this benefit is hard to value as sheep are also treated for liverfluke, however, as resistance to treatment is increasing natural disease management services are likely to become more important in the medium term.

See the Case Study on Page 23 for further details.

Soil quality regulation

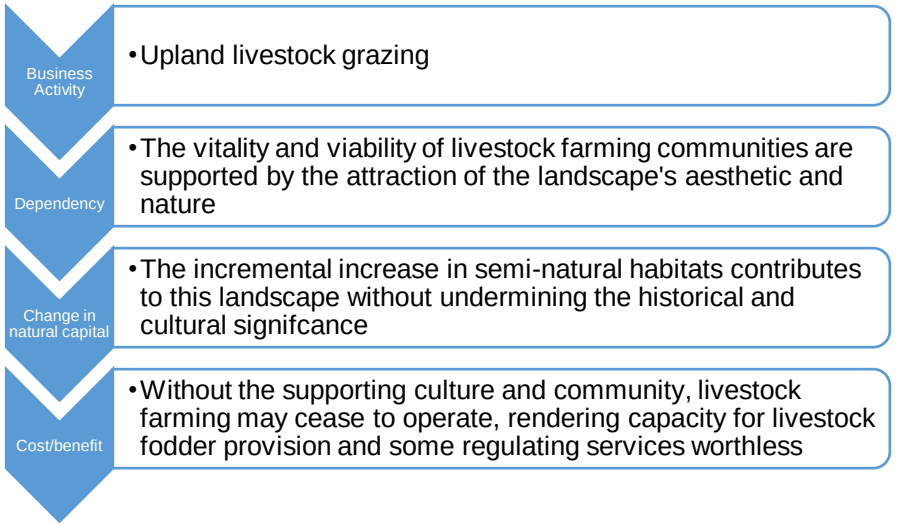


Crop and livestock production is directly dependent on soil health as nutrient and organic matter content supports quality grazing pasture and forage crop production.

Since the start of the tenancy chemical fertiliser application has been reduced (NPK fertilizer use has reduced from 30 to 12 tonnes a year), and an increased quantity of clover is sown for nitrogen fixation. Soil testing has shown that nutrient levels have improved and it is expected that other farming practices (e.g. rotational grazing, increased use of hardstanding areas, fencing off wetland) will have supported the provision of soil quality regulation services.

Increased organic matter, and resultant improvements in soil water retention, may also help to make farm enterprises more resilient to extreme weather events in the longer term.

Cultural heritage



Cultural heritage was identified as a 'high' dependency for Jim's livestock operations, as upland livestock farming particularly relies on a body of knowledge and cultural / intellectual capital built up over many generations, particularly in the local area. These assets may become more valuable if future pressures on agriculture drive further diversification into agri-tourism.

Natural capital and ecosystem service impacts

The gross impacts (i.e. compared to a situation in which the land is not actively managed) of Ruthven Farm's enterprises on natural capital assets and ecosystem services are highlighted in Tables 6 and 7. These show that:

- There are clear relationships between the dependencies and impacts, indicating that Jim is managing and positively affecting the farm's core dependencies.
- There have been some negative trends in provisioning ecosystem services since the start of Jim's tenancy due to a less intensive approach to livestock rearing.
- The improvement in the cultural services of wild species diversity and opportunities for outdoor education will likely support plans for the farm to expand into agri-tourism.

Providing only one score for each service may hide some nuances. For example, woodland extent has increased, but we are aware that the birch forests in four separate areas are deteriorating, which can, at least to some extent, be attributed to the sheep grazing there.

We have also examined the specific impacts on natural capital and ecosystem services over the period of the current tenancy (from 2006 to the present). These are shown in Tables 8 and 9 and indicate that there have been improvements in local climate regulation (through hedgerow and tree planting), soil quality regulation (through changes to land management practices), wild species diversity (through creation and enhancement of habitat) and opportunities for farm-based research and education.

Similar to the dependency pathways, we have developed impact pathways showing the 'logic chain' from business activity to impacts on natural capital and the costs and benefits associated with these impacts.

Table 6: Natural capital impacts – gross impacts

Enterprises	Assets (habitat types)							
	Enclosed farmland:						Mountains, Moorlands and Heaths	Water (Openwaters, Wetlands & Floodplains)
	Cropland (arable & horticultural)	Temporary pasture (temporary improved grassland)	Permanent pasture (permanent improved grassland)	Permanent unimproved pasture (semi-natural Grasslands)	Hedgerows	Woodland (includes farm woodlands)		
Crop production								
Livestock grazing								

Table 7: Ecosystem service impacts – gross impacts

Enterprises	% area of land of enterprise	Ecosystem Services													
		Provisioning			Regulating								Cultural		
		Crops	Livestock	Water Supply	Global climate regulation	Local climate regulation	Flood regulation	Water quality regulation	Soil quality and erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage
Crop production	3%															
Livestock grazing	97%															

Impact:	Positive	Negative
High		
Medium		
Low		
Mixed	+/-	
None		

Table 8: Natural capital impacts – impacts over the period of the current tenancy (2006-2017)

	Assets (habitat types)							
	Enclosed farmland						Mountains, Moorlands and Heaths	Water (Openwaters, Wetlands & Floodplains)
Enterprises	Cropland (arable & horticultural)	Temporary pasture (temporary improved grassland)	Permanent pasture (permanent improved grassland)	Permanent unimproved pasture (semi-natural Grasslands)	Hedgerows	Woodland (includes farm woodlands)		
Crop production								
Livestock grazing								

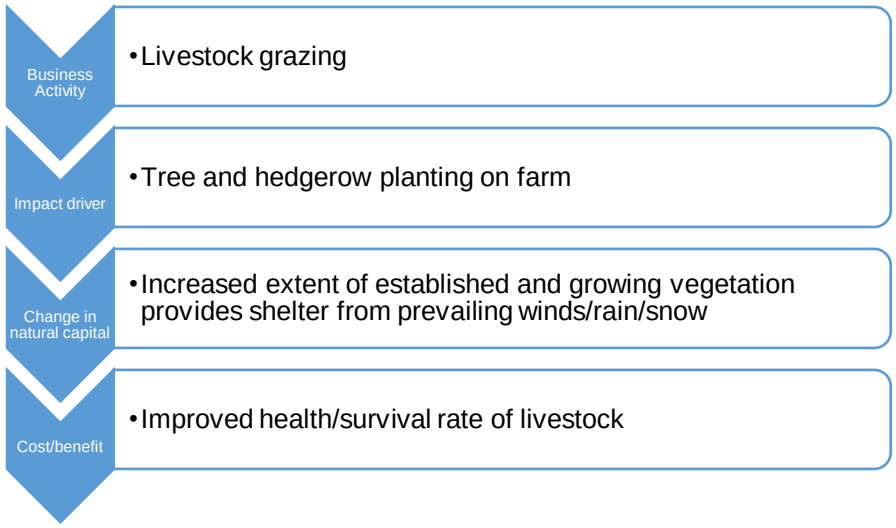
Table 9: Ecosystem services impacts – impacts over the period of the current tenancy (2006-2017)

Enterprises	% area of land of enterprise	Ecosystem Services														
		Provisioning			Regulating								Cultural			
		Crops	Livestock	Water Supply	Global climate regulation	Local climate regulation	Flood regulation	Water quality regulation	Soil quality and erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage
Crop production	3%															
Livestock grazing	97%															

Impact:	Positive	Negative
High		
Medium		
Low		
Mixed	+/-	
None		

Impact pathways:

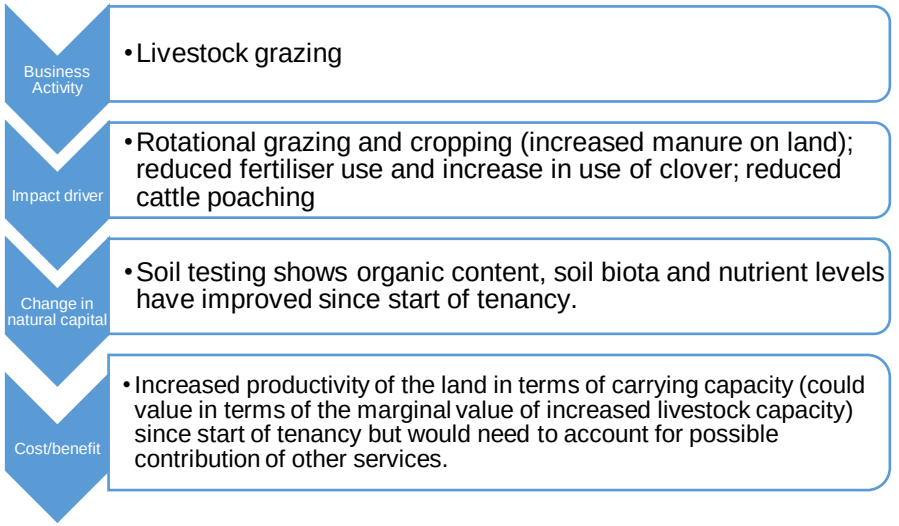
Local climate regulation



Jim and Lesley have planted over 4,500 metres of hedges since the start of their tenancy. This provides additional shelter for their sheep when the weather is poor. Sheep are more likely to feed, and thereby gain weight / condition, if they have shelter; when it gets very cold or snowy they tend to eat far less. The effectiveness of this windbreak in reducing wind-chill is demonstrated when ewes choose to position themselves against the hedges or trees to lamb. Jim has also noted a decreased requirement for concentrate feed over winter since planting the hedges.

However, there are four areas of old birch woodland on the farm that are in deteriorating condition. This poses a risk to the provision of local climate regulation services in these areas in the longer term, as they are not regenerating.

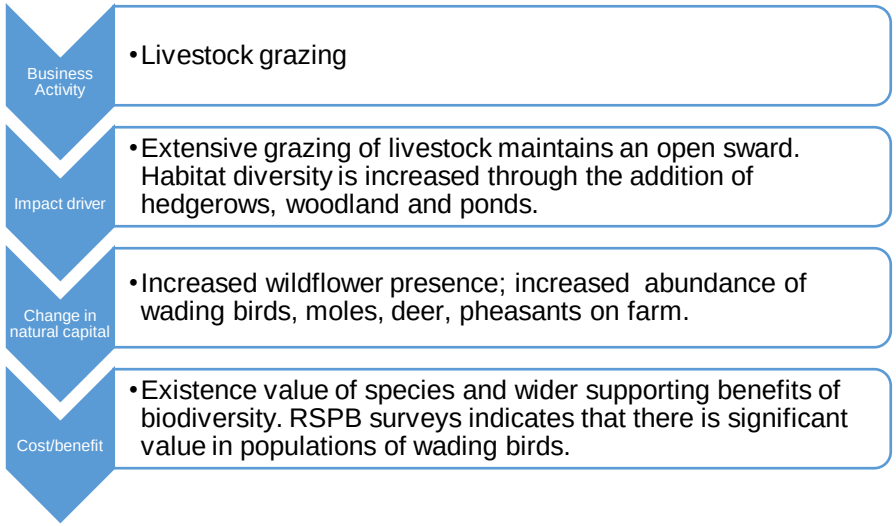
Soil quality regulation



Ruthven Farm previously operated under a fairly intensive silage-based system, with a series of short term tenancy agreements leading to low re-investment in the soil. Soil analysis showed a range of nutrients were ‘very low’ or ‘low’ in 2006.

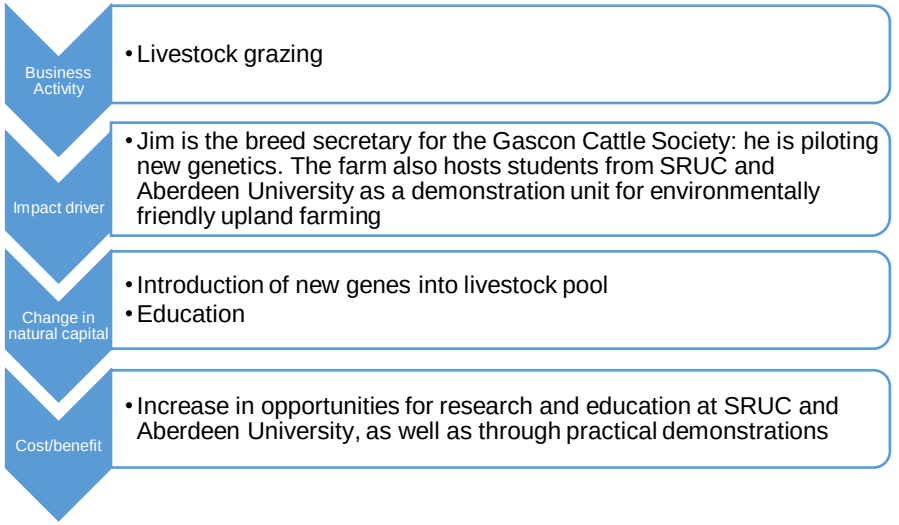
Jim has moved to a less-intensive grazing-based system, reversing some of the problems of soil compaction and low organic content. Rotational livestock grazing is practiced, allowing farmyard manure to provide organic content to the soil. Chemical fertiliser application has been reduced, and an increased quantity of clover is sown for nitrogen fixation (N:P:K use reduced from 30 to 12 tonnes per year). Cultivation on slopes is avoided to reduce the potential for erosion and pollutant run-off. Five-yearly soil testing is carried out for P, K and pH across a rotation of ten fields. Increased nutrient and organic matter content should help to meet grazing pressure and may improve resilience to extreme weather events in the longer term.

Wild species diversity



Jim and Lesley Simmons have won a number of awards for their commitment to wildlife on Ruthven Farm. Since taking on the tenancy they have planted several hectares of mixed woodland, as well as 4,500 meters of new hedgerows to improve habitat connectivity and opportunities for nesting birds. The new riparian woodlands should also improve water quality for fish and freshwater pearl mussels. Several new ponds and wet scrapes will benefit a wide range of aquatic life, including wading birds such as snipe, lapwing, redshank, oystercatcher, and curlew that are also seen to forage in the over-wintered stubble.

Education



Ruthven Farm contributes significantly to education through being a demonstration farm for environmentally friendly approaches to farming, as well as hosting students from Scotland's Rural College and Aberdeen University. Jim Simmons is also breed secretary for the Gascon Cattle Society and is piloting new genetics.

The value of the education component of this service is difficult to quantify but is likely to be significant and could be expected to increase with future expansion of the farm business into agri-tourism.

APPLY STAGE: So what?

Step 08: Interpret and use the results

This assessment has shown the natural capital dependencies and impacts for Ruthven Farm's livestock (and arable) enterprises. In light of this, the following risks and opportunities can be identified.

Risks

River erosion – Significant and increasing erosion is occurring at Conglass Water, resulting in land being lost and Jim needing to move fences to keep livestock away from the river. The neighbouring farm has agri-environment scheme funding to tackle this issue, however at this point in the tenancy there is not sufficient certainty to begin tackling such a big project without a guaranteed period of time over which to see the benefits on Ruthven Farm.

Woodland degradation - Four areas of birch woodland are used to shelter Black-faced Leicester sheep. However this habitat is 150 – 200 years old and degrading with no natural regeneration. While the ewes shelter here they will also browse on any saplings and this is one factor that may be preventing the woodland's regeneration. This poses a risk to future sheltered grazing land in these areas.

Increased disease rate - Resistance to liver fluke treatment is increasingly being seen on the farm, whilst infection rates of other diseases such as foot rot and worms are also increasing.

Tenancy length – towards the end of a tenancy, and with shorter term tenancies, the ability to long term plan and invest is hampered meaning there is a risk of reduced investment in the land, degrading its condition.

External impacts on wild species/biodiversity – Wild species will be greatly influenced by others' actions on the estate, meaning they are at risk from factors external to Ruthven Farm's actions.

Brexit poses risks (but also opportunities) for the business. Although the Government has committed to maintaining current levels of farm support until at least 2022, it is unlikely that such a generous area-based subsidy regime is sustainable in the long term, and the loss of subsidy income is a significant risk. The loss of Basic Payment Scheme will mean a reduction in income for farmers. It is also currently unclear whether the UK can negotiate a favourable trade agreement with the European Union. Without an EU trade agreement, WTO trade rules would apply, with tariffs on lamb exports making the sheep enterprise particularly vulnerable. A change in upland farming policy might result in a reduction in income and threaten the viability of extensive agricultural methods.

Climate change may increase the likelihood of extreme weather events, such as excessive rain and snowfall, storm events and drought. Ensuring resilience of the land to withstand changes in weather patterns will be important.

Input costs may rise due to a combination of supply limitations (e.g. Phosphorus), energy price rises and Brexit; continuing and potentially increasing price volatility can be expected.

Potential increase in regulation and legislation driven by consumer pressure for more sustainable products (potentially an opportunity for Ruthven Farm). The use of chemicals (e.g. glyphosate) is under constant review and may limit options available. Demonstration of best practice in animal health and welfare, but also environmental footprint of inputs (e.g. water use) and outputs (e.g. greenhouse gas emissions) is likely to be used for benchmarking suppliers.

Opportunities

Woodland regeneration – There is an opportunity to regenerate the old birch woodlands on the farm to ensure shelter is maintained for livestock, as well as habitat for wild species, carbon sequestration, erosion protection and other services. Both the Forestry Commission and Woodland Trust have visited the site, but no conclusions have been reached so far. There may be an opportunity to trial a regeneration site e.g. fencing off a small area to see if the soil can be cultivated to create an environment where the woodland will regenerate.

River erosion management – There may be opportunity to apply for an agri-environment scheme to tackle the river erosion problem. However, certainty over continued tenancy on the land is important for this to worth undertaking.

Soil analysis – more structured and regular soil testing encouraged/supported by Crown Estate Scotland (as well as explicit targets) could support more targeted soil improvement work such as liming and nutrient application to improve soil quality on tenanted farms. New techniques are being developed in a more cost-effective way, both high-tech (e.g. soil scanning services) and low tech (e.g. measuring the time period for a cotton rag to decompose in the soil).

Cultural heritage/education – incorporate natural capital into the cultural body of knowledge in Scottish farming by sharing lessons learned and the benefits of the case study valued here.

Being able to **demonstrate the contribution** the business is making to **'public goods'**, such as water quality and biodiversity, is likely to become increasingly important e.g. for sustainable brands and for accessing public support payments.

There is an opportunity to **develop a set of metrics for monitoring the natural assets** of Ruthven Farm over time, which would:

- Record the extent and the condition of the natural assets of the farm, such as soil health, water quality, hedges (shelter/mortality), carbon and biodiversity index.
- Review these metrics as part of the tenancy review, and record the improvement in extent and condition (or deteriorations, if any) of the natural capital assets on the farm, and any investments made. This can help facilitate broader conversations between landlord and tenant about future developments of the farm to ensure its long term sustainability.

Step 09: Take action

Actions for consideration:

- Keep a watching brief on future public schemes for natural capital maintenance and enhancements.
- Engage with supply chain partners/buyers to demonstrate Ruthven Farm's natural capital approach and identify win-wins from integrating natural capital into supply chain and marketing.
- Liaise with Crown Estate Scotland and Glenlivet Estate about the potential for conducting soil testing across all Ruthven Farm's fields.
- Engage with Crown Estate Scotland, Glenlivet Estate and the Forestry Commission and/or Woodland Trust about whether a pilot approach could be taken forward to regenerate the deteriorating birch woodland, and what solutions there might be for alternative livestock shelter.

- Discuss the Conglass Water erosion problem areas with Crown Estate Scotland and Glenlivet Estate to investigate options for action and responsibility.
- Liaise with Crown Estate Scotland about the upcoming tenancy renewal. Certainty over the longer term future of the tenancy could enable further natural capital investment on the farm.

CASE STUDY – Woodland planting / wetland restoration

This case study applies the Protocol to a practical example, providing a more in-depth assessment including quantification and valuation of impacts.

FRAME STAGE: Why?

Step 01: Get started

At the bottom of field 8 (see second map in Appendix 3) there was an area of unimproved grassland with an old infilled millpond and stream. This is a habitat for mud snails that carry the liver fluke parasite, which has infected and caused sheep loss on the farm.

In 2014 Jim undertook works to fence off this area, clear out the millpond and plant approximately 3 ha of woodland. This has reduced the foraging area for sheep, whilst also requiring investment in trees, fencing and pond clearing. However, benefits include: reduced poaching in the wetland; increased shelter from the woodland; reduced incidence of liver fluke amongst livestock; and increased habitat for wildlife.

The new woodland comprises a mix of broadleaves (60%) and conifers (40%) with 0.28ha kept open for the stream and mill pond.

SCOPE STAGE: What?

Step 02: Define the objective

The objective is to understand what impact Jim's activities have had on natural capital and ecosystem service provision and to estimate the net benefits (expressed in monetary terms) associated with these activities.

Step 03: Scope the assessment

This case study assesses the natural capital impacts of the woodland planting and wetland restoration, including:

- Planting of 2.49 ha of broadleaves and conifers
- Clearing of millpond
- Fencing off area around woodland and wetland

The assessment:

- Considers direct impacts within the farm boundary and looks at value from the perspectives of both the business and society.
- Quantifies and values impacts as far as possible.
- Considers impacts over a three-year period (2014 – 2017). The impacts are assessed in relation to the 'business as usual' scenario (i.e. the absence of the intervention). Costs and benefits are projected over a 15-year and a 50-year period to reflect the lag between implementation (i.e. tree planting) and realisation of the full benefits (i.e. when the trees are mature).

Step 04: Determine the impacts

The woodland planting and wetland restoration aimed to reduce liver fluke contamination amongst livestock, provide a shelterbelt for livestock and to provide habitats and wildlife corridors to support Local and National Biodiversity Action Plan (BAP) species.

The following ecosystem services were assessed as being significantly impacted and are included in the assessment:

- Global climate regulation
- Local climate regulation
- Disease and pest regulation

In addition there are likely to be some moderate positive impacts on water quality regulation and wild species diversity services.

The financial cost of the project as set out in the Rural Development Contract is approximately £15,000 over 15 years – this includes a capital outlay and 15 years of management.

MEASURE AND VALUE STAGE: How?

Step 05: Measure impact drivers,

Step 06: Measure changes in the state of natural capital, &

Step 07: Value impacts

Table A sets out the asset register for this case study, detailing the interventions taken and the resulting changes in the natural capital assets. For example, prior to the project livestock had access to the pond and stream, resulting in erosion of the banks and siltation of the millpond. The 'water' asset is therefore classified as in 'degraded' condition in 2014. After fencing off the area and clearing the pond the waterways are now in a good condition.

Table B sets out the impacts on natural capital assets. This reflects the information provided in the asset register, distilling it into a graded positive/negative (green or red scoring). For example, this project has had a negative impact on the extent of grassland habitat as it has converted grassland to woodland. This is reflected in the red score allocated to 'permanent unimproved pasture'.

Table C sets out the impact this project has had on ecosystem services. For example, the planting of woodland has greatly increased this area's provision of local climate regulation services, by providing shelter from the wind/rain/snow to livestock grazing in the adjacent field. This can be seen by the green scoring for this service.

Impact pathway maps showing the 'logic chain' from business activity to impacts on natural capital and the costs and benefits associated with these impact are shown below the tables.

Table A: Case study asset register

Natural capital asset (habitat types)	Unit of measure	Start of project 2014		Management interventions	Current status 2017		Data source	Trends (impact)
		Extent	Condition	Activities undertaken	Extent	Condition		
Enclosed farmland:								
Permanent unimproved pasture (degraded grassland)	ha	2.49	degraded	Grassland planted with trees	0	n/a	Rural Dev Contract/Jim Simmons	Decreased extent
Woodland (includes farm woodlands)	ha	0	n/a	Grassland planted with trees	2.49	good	Rural Dev Contract/Jim Simmons	Increased extent
Water (Openwaters, Wetlands & Floodplains)	ha	0.28	degraded	Millpond cleared of silt, stream and pond fenced off from livestock	0.28	good	Rural Dev Contract/Jim Simmons	No change in extent, improving condition

Table B: Natural capital asset impacts

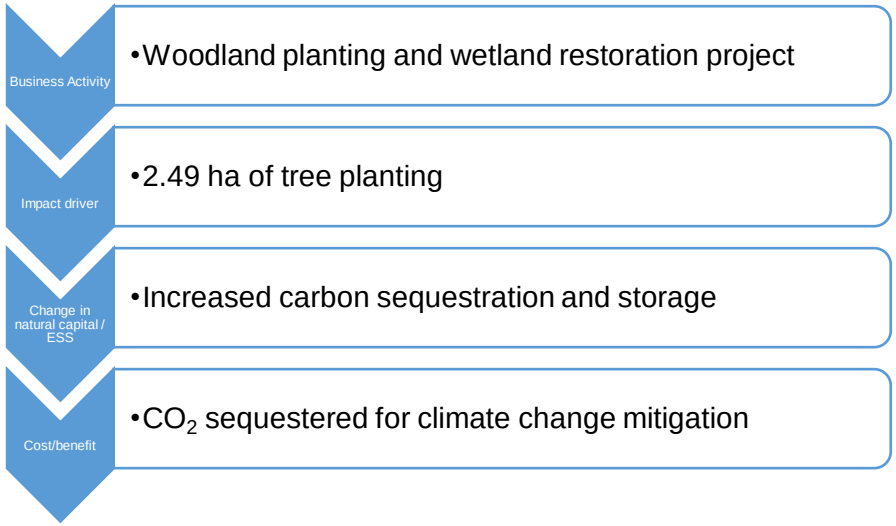
Activities	Assets (habitat types)							
	Enclosed farmland:						Mountains, Moorlands and Heaths	Water (Openwaters, Wetlands & Floodplains)
	Cropland (arable & horticultural)	Temporary pasture (temporary improved grassland)	Permanent pasture (permanent improved grassland)	Permanent unimproved pasture (semi-natural Grasslands)	Hedgerows	Woodland (includes farm woodlands)		
Woodland planting & wetland restoration								

Table C: Ecosystem service impacts

Activities	Ecosystem Services														
	Provisioning			Regulating								Cultural			
	Crops	Livestock	Water supply	Global climate regulation	Local climate regulation	Flood regulation	Water quality regulation	Soil quality and erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage
Woodland planting & wetland restoration															

Impact:	Positive	Negative
High		
Medium		
Low		
Mixed	+/-	
None		

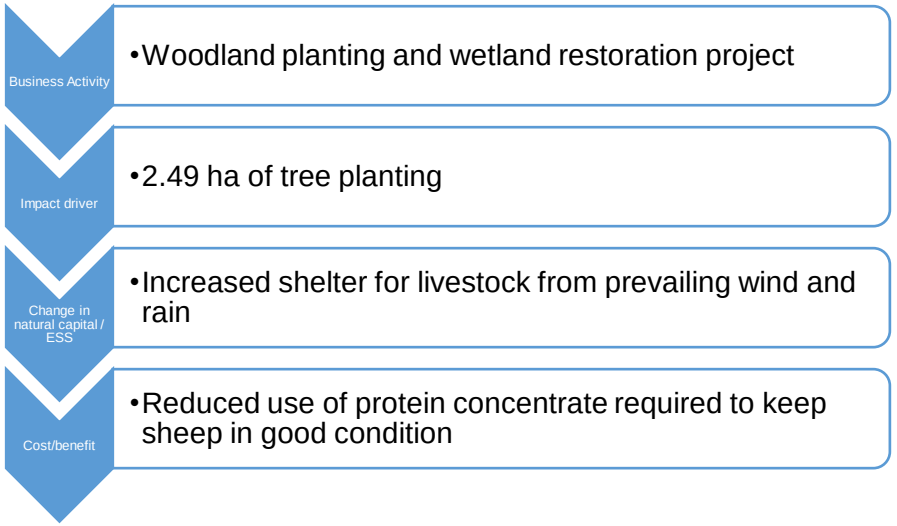
Global climate regulation



The carbon sequestration value associated with this mixed woodland is estimated to be approximately £16,500 over the 15-year appraisal period (lifespan of the Rural Development funding) and £64,800 over a 50-year period. This value relates to benefits delivered to broader society, rather than the farm business itself.

This value applies carbon sequestration rates reported in Christie et al. 2010[6] to the new mixed woodland and applies the UK Government non-traded central carbon prices[7]

Local climate regulation



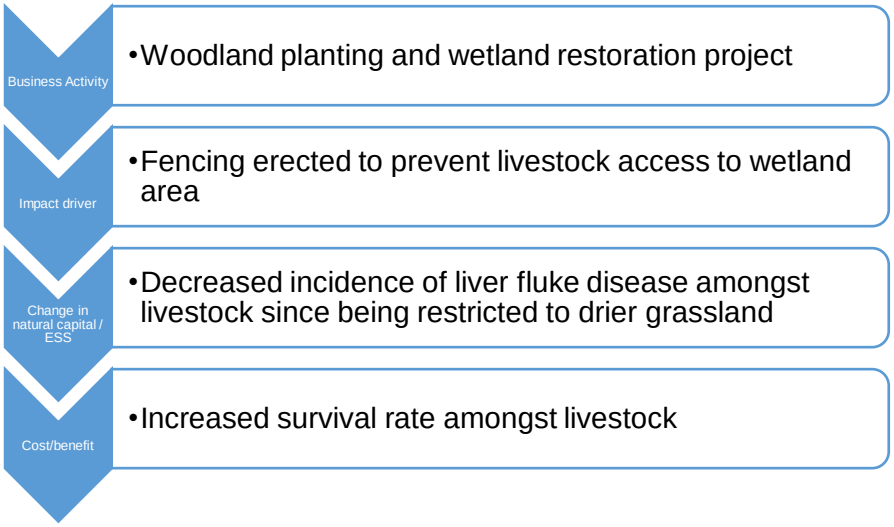
One of the main aims for planting this woodland was to provide shelter for livestock on the farm, particularly sheep, during the winter when driving wind and rain is common and can have a significant negative impact on sheep condition.

Based on an assumption that the shelterbelt improves the sheep condition by 1 condition score (say from score 2 to 3) this saves feed input that would otherwise be required to keep the sheep in good condition. Estimating the amount of protein concentrate saved gives a benefit value of approximately £88 per year. This is £1,051 based on a 15 year forecast, and £2,235 over a longer 50 year appraisal period. This longer 50 year time frame is provided for comparison against global climate regulation benefits – in practice it is very difficult to estimate benefits this far into the future as external factors may come into play. This value relates to benefits delivered to the farm business itself.

[6] Christie et al. 2010. Economic valuation of the benefits of ecosystem services delivered by the UK Biodiversity Action Plan

[7] DECC, 2015. Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal; Data tables 1-20

Disease and pest regulation



Reducing liver fluke contamination amongst livestock was a key driver for undertaking this project. While Jim routinely treats his livestock for the liver fluke parasite, it is becoming increasingly resistant to the treatments used. Preventing contamination is therefore an important way to regulate this pest and will likely become increasingly important in the immediate future, as resistance to treatment increases.

It is difficult, however, to measure and value the actual benefits delivered by this project as liver fluke treatment is still regularly used and there is no data to determine whether increased/maintained survival rates are due to veterinary treatment or reduced contamination.

Water quality regulation & wild species diversity

There are likely to be some positive impacts on wild species diversity and water quality regulation services.

Woodland planting and wetland restoration is expected to have a positive impact on biodiversity in the longer term. In particular, the actions could support UK BAP priority species and habitats[8] such as native woodlands, Northern Brown Argus (butterfly found only in the north of England and Scotland) and wood ants (which also feature on the IUCN red list – vulnerable and presumed declining). Other species such as hare and deer would also likely benefit.

Fencing off the wetland area has prevented livestock accessing the stream and breaking its banks, whilst clearing the millpond provides a natural silt trap, both of which should help to improve water quality downstream. As the rivers on and around Ruthven Farm are important spawning beds for salmon and habitat for freshwater pearl mussels there could be an increase in salmon and mussel numbers, however this is hard to gain data for and to attribute to a particular project, therefore it has not been possible to measure and value these benefits.

[8] These are those identified as being the most threatened and requiring conservation action under the UK Biodiversity Action Plan (UK BAP).

APPLY STAGE: So what?

Step 08: Interpret and test results

Based on a 15 year forecast, the present value of the financial cost is approximately £14,000 and will yield returns with present values of approximately £17,000 (£16,000 relating to global climate regulation and £1,000 relating to local climate regulation). This represents an approximate benefit-cost ratio of 1.2:1 over 15 years.

When looking at a 50 year forecast the same £14,000 financial cost (costs end after 15 years) will yield returns with present values of approximately £67,000 (£65,000 and £2,000 relating to global and local climate regulation respectively). This represents an approximate benefit-cost ratio of 4.7:1 over 50 years.

In addition the project will yield benefits relating to water quality downstream, as well as disease and pest management on the farm. There may also be benefits relating to improved soil quality in the adjacent downhill field, once the woodland matures and assists in drying out the soil. There is also the possibility that the Sitka spruce trees could be used to fuel the on-farm biomass boiler, making the farm energy self-sufficient. However, these impacts have not been measured or valued in this assessment.

Step 09: Take action

This assessment could be used for education and demonstration purposes, perhaps as part of the farm's expansion into agri-tourism, focusing on the benefits it has been possible to value to date.

There may be scope to consider whether this approach could be extended to manage less productive wetland areas on other livestock/arable farms in Scotland.

It should also be noted that the actions in this case study were made possible by external funding. At a time when the future of agricultural and environmental support is particularly uncertain, it would be worth considering the resilience of various funding opportunities and how this might be managed to ensure that organisations on the wider estate have the means to access similar forms of beneficial funding in the future.

Appendix 1: Glossary

Where available, definitions are taken directly from the Natural Capital Protocol[9].

Baseline	In the Protocol, the starting point or benchmark against which changes in natural capital attributed to your business' activities can be compared.
Biodiversity	The variability among living organisms from all sources including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (UN 1992).
Ecosystem services	The Millennium Ecosystem Assessment defines these as "benefits people obtain from ecosystems".
Natural capital	The stock of renewable and non-renewable natural resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people.
Natural capital dependency	A business reliance on or use of natural capital.
Natural capital impact	The negative or positive effect of business activity on natural capital.

[9] Natural Capital Coalition. 2016. "Natural Capital Protocol". (Online) Available at: www.naturalcapitalcoalition.org/protocol

Appendix 2: Ecosystem service descriptions

These are not intended to set definitive or exclusive interpretations of the listed ecosystem services, but can be used as an indication of the range of services to which this report refers, and the general meaning of those terms.

Air quality regulation	The regulation of air quality by ecosystems (e.g. the absorption of air pollutant particles by tree leaves)
Climate regulation	The capacity of ecosystems to influence the climate to improve local conditions (e.g. through a tree's shade) or mitigate global climate change (e.g. through the fixing of atmospheric carbon in woodlands)
Crops	The capacity of the ecosystem to support crop production
Cultural heritage	The value of cultural heritage arising from a community's historic relationship with its surrounding ecosystem
Disease & pest regulation	The capacity of ecosystems to regulate and control native or introduced pest and disease (e.g. slug predation by amphibians, or parasite exclusion through microclimatic conditions)
Education	The capacity of ecosystems to invoke interest and curiosity about the natural world
Fibre	The production of fibres and materials such as wood, skin, wax or flax for use as inputs for manufacturing or in their unprocessed forms
Flood regulation	The regulation, by upstream ecosystems, of water flows to prevent or mitigate flooding events downstream
Fuel	The provision of wood or other natural materials which are burnt or otherwise broken down to release energy, usually as heat.
Genetic materials	Genetic material (e.g. DNA), from all living organisms used, for example, in medicine, breeding programmes and research
Livestock	The capacity of the ecosystem to support livestock growth
Pollination	The service provided by wild pollinators in pollinating dependent crops and thereby enhancing yields
Recreation	The provision of views and experiences that promote and enhance recreation
Soil quality & erosion regulation	The capacity of ecosystems to stabilise, build and enhance soils
Timber	The provision of timber for use in construction and manufacturing
Water quality regulation	The regulation, through the filtering of sediment and the use of nutrients and pollutants, of ecosystems to improve water quality for human use
Water Supply	The provision of freshwater from ground or surface waters
Wild foods (fish)	The provision of wild freshwater and marine fish for food
Wild foods (game)	The provision of game animals for food
Wild foods (venison)	The provision of wild deer populations for food
Wild Species Diversity	The range of species which provide benefits to people through their aesthetic, natural history and existence. Biodiversity also contributes to the health and functions of ecosystems.

Appendix 3: Supplementary maps

See separate document