



Trial of the Natural Capital Protocol for land-based businesses

**Dryfesdalegate Farm
Natural Capital Assessment**

October 2019



Version	Date	Version Details	Prepared by	Reviewed by
1.0	30/07/2019	Draft Report	Paul Silcock	Charlie Russ
2.0	09/10/2019	Final Report	Paul Silcock	Charlie Russ





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EXECUTIVE SUMMARY

Dryfesdalegate Farm is one of four businesses participating in a Trial of the Natural Capital Protocol for land-based businesses. It is a lowland farm with two main enterprises, dairy and beef, with associated crop production for feed and forage. The farm is rented from Crown Estate Scotland.

The farm's enterprises are dependent on natural capital (NC) assets and a range of ecosystem services (ESS) (see **Appendix 1 and 2** for descriptions). Trends in the farm's key NC assets are shown in **Table 1** below. While most assets have a moderate status, **watercourses** have a poor status.

Table 1: Natural capital asset summary

Enterprise	Asset	Trend (2009 – 2019)		Current status
		Extent	Condition	
Dairy & beef enterprises	Temporary grassland (38 ha)	→	↗	
	Permanent grassland (60 ha)	→	↗	
	Hedgerows (0.2 km)	→	↗	
	Woodland (1 ha)	→	→	
Crop production	Arable land (30 ha)	→	↗	
Other	Water (rivers, streams, 3.6 km)	→	→	
Trend: "↗" = Improving/growing "→" = stable "↘" = deteriorating/shrinking				
Status: Good ; Moderate ; Poor				

Natural capital dependencies

Dryfesdalegate Farm is dependent on provisioning services (crop and livestock production) but also regulating and cultural services. It is these underpinning, but less obvious, services that are explored in more detail in this report, for example:

- **Local climate regulation** – cattle and sheep depend on woodland, trees and hedges for shelter and shade to maintain condition.
- **Soil quality regulation** – crop and livestock production depend on soil quality and health (organic matter, nutrients, soil microbes).
- **Disease and pest regulation** – crop and livestock enterprises depend on disease and pest regulation to maintain production.
- **Cultural heritage** – dairy/livestock farming relies on a body of knowledge that has built up over many generations.

Natural capital impacts

Over the past ten years, Dryfesdalegate Farm has had positive impacts in terms of crop and livestock production, recreation and cultural heritage services, but mixed/negative impacts on the following services:

- **Climate regulation services** – increased cattle numbers will have increased greenhouse gas emissions with negative impacts on global climate regulation. Local climate regulation may have improved as a result of hedgerow gapping up.
- **Soil quality regulation services** – farming practices such as careful grassland and crop management, better utilisation of manure and slurry, and spring/cover crops are likely to have improved soil quality.
- **Water quality regulation services** – while stock numbers have increased, negative impacts on water quality are likely to have

reduced with improvements in crop, stock and grassland management and investment in slurry storage etc.

- **Wild species diversity** - a negative impact associated with increased stock numbers will have been mitigated by an increase in the extent and diversity of habitats and reduced inputs/pollutants.

Risks and opportunities

Key farm-specific risks include:

- River bank erosion
- Water supply, quantity and quality of water
- Loss of wild species/biodiversity
- Disease, affecting animal health and welfare and productivity
- Climate change, leading to increased temperatures and more extreme weather events

Key farm-specific opportunities include:

- Soil testing
- Slurry and manure analysis
- Increasing soil organic matter
- Better utilisation of slurry and manure

These opportunities could generate an estimated increase in profit of at least £6,800 p.a. (see **Case Study 1**).

- Planting additional hedges and trees

This could generate an estimated increase in profit of at least £2,100 p.a. (see **Case Study 2**).

- Enhancing wildlife through habitat management
- Tackling river erosion and flooding with partners
- Being able to demonstrate the contribution the business is making to 'public goods'

- Developing a set of metrics for monitoring the natural assets of the farm over time.

In addition to the above, there are a number of high-level generic risks and opportunities for the dairy sector (see **Appendix 4**).

Actions for consideration

1. Test soil nutrients and soil organic matter, and analyse slurry and manure, on a regular basis
2. Improve soil quality (and achieve better resource utilisation) through a combination of measures including rotations, cropping, alternative cultivation techniques and targeted application of slurry and manure.
3. Discuss the River Annan erosion and flooding problem with Crown Estate Scotland and SEPA to investigate potential options/solutions.
4. Discuss tree and hedge planting and wildlife enhancement opportunities with Crown Estate Scotland and explore grant aid and other support for this.
5. Collate natural capital and ecosystem services data for the farm, and identify a few key indicators to monitor progress, in particular with regard to soils and biodiversity.
6. Explore ways to fill gaps in data through partnerships with Crown Estate Scotland, government bodies and voluntary organisations.
7. Engage with your milk purchaser, Arla, to demonstrate the farm's natural capital approach and identify opportunities for enhanced returns and support.
8. Keep a watching brief on future public schemes which will provide support for natural capital maintenance and enhancement.

P1. Field 27, test soils and improve soil quality



P2. Field 17, analyse slurry and target applications



P3. Field 15, hedgerow planting opportunity



P4. Field 1, river bank erosion issue





FRAME STAGE: Why?

1. Step 01: Get started

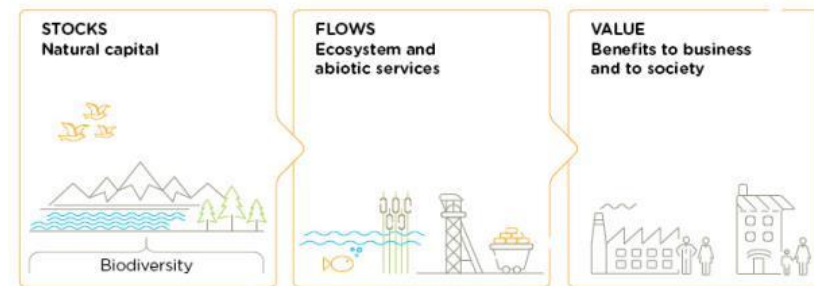
Crown Estate Scotland and its partners in a coalition of organisations with an interest in land management in Scotland are exploring the degree to which the Natural Capital Protocol (the Protocol) is applicable and useful to land-based businesses in Scotland. This report extends the trial of the Protocol to a dairy farm business.

Natural capital refers to the natural resources (or assets) that people use and from which they gain benefit. For Dryfesdalegate Farm, this includes its soils, water, arable land, grassland, hedges, woodland and other habitats, see **Table 3**. 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 Protocol², produced by the Natural Capital Coalition³, 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.

Dryfesdalegate Farm’s natural capital assets provide a range of ecosystem services, see **Table 4**. This framework has been adapted from the Millennium Ecosystem Assessment⁴ 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.

Dryfesdalegate Farm is dependent on the continued supply of ecosystem services such as soil quality regulation, pest and disease regulation 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 Dryfesdalegate Farm can help to identify, measure and value the impacts and dependencies of farm activities and outputs on natural capital.



SCOPE STAGE: What?

2. Step 02: Define the objective

2.1 Overall project objectives

The overall aim of the project is to trial the Natural Capital Protocol with a dairy farm business in order to test the value of the protocol for informing business decisions and help promote the approach.

This involves:

- Completing a natural capital assessment for Dryfesdalegate Farm, with specific recommendations for the business based on the assessment;
- Evaluating the application of the protocol to a dairy farm business and making recommendations for refining the guidance for use in the dairy sector.

This report sets out the key findings from the natural capital assessment of Dryfesdalegate Farm, whilst a separate update to the Overview Report and presentation presents the broader findings and lessons learnt from the project

2.2 Dryfesdalegate Farm objectives

The objectives relating specifically to the Dryfesdalegate 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.

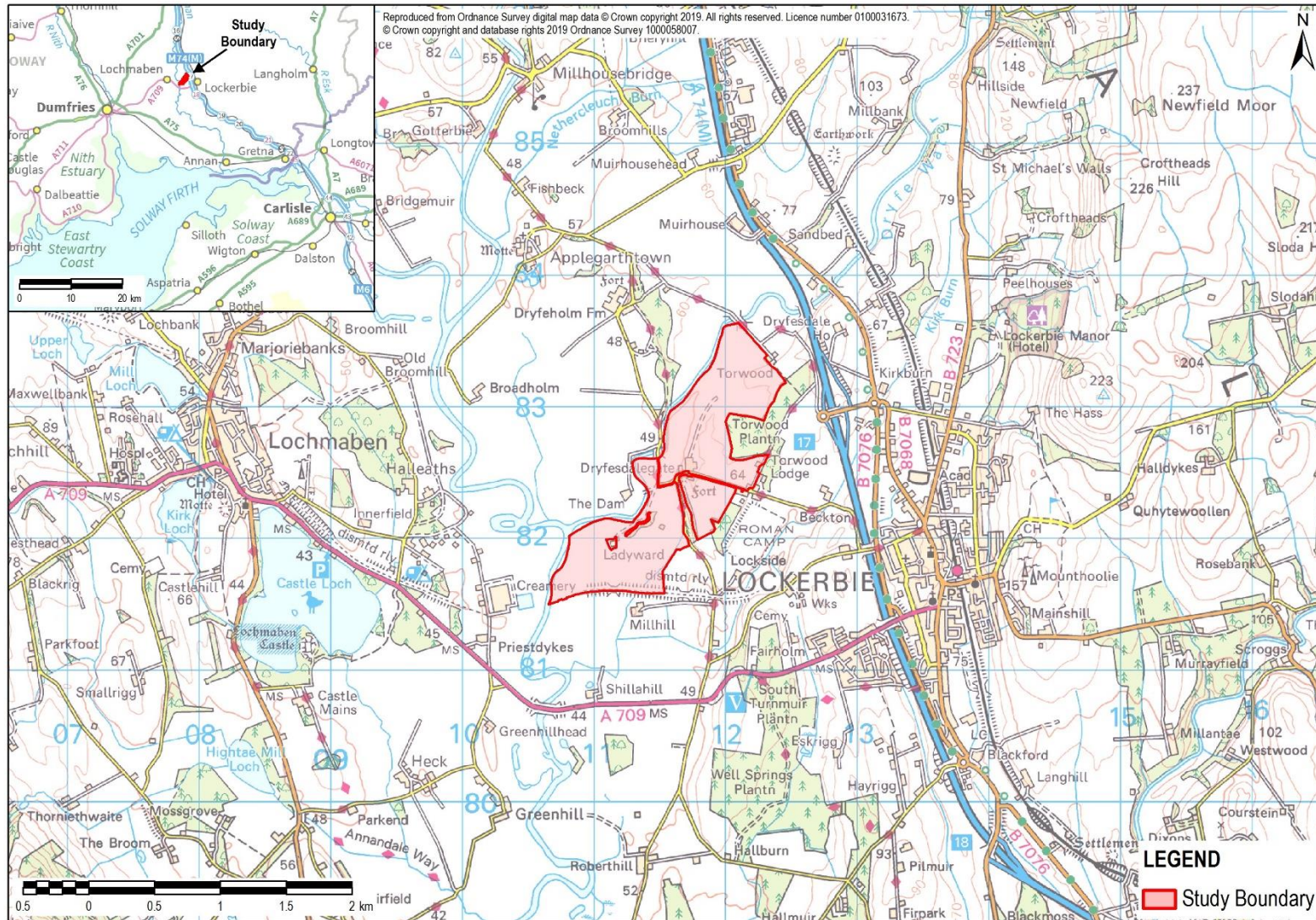
This has been done through a high level natural capital assessment of the whole farm, assessing the key natural capital impacts and dependencies of the farm's operations. In addition, a series of options have been developed for consideration which have the potential to enhance the farm's natural capital and benefit the farm business.

3. Step 03: Scope the assessment

3.1 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, risks and opportunities relating to the supply chain and elsewhere beyond the farm gate are taken into account 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 the impacts and dependencies of activities on Dryfesdalegate Farm as well the change in natural capital and ecosystem service flows over a 10 year period from 2009 to the present day (2019).

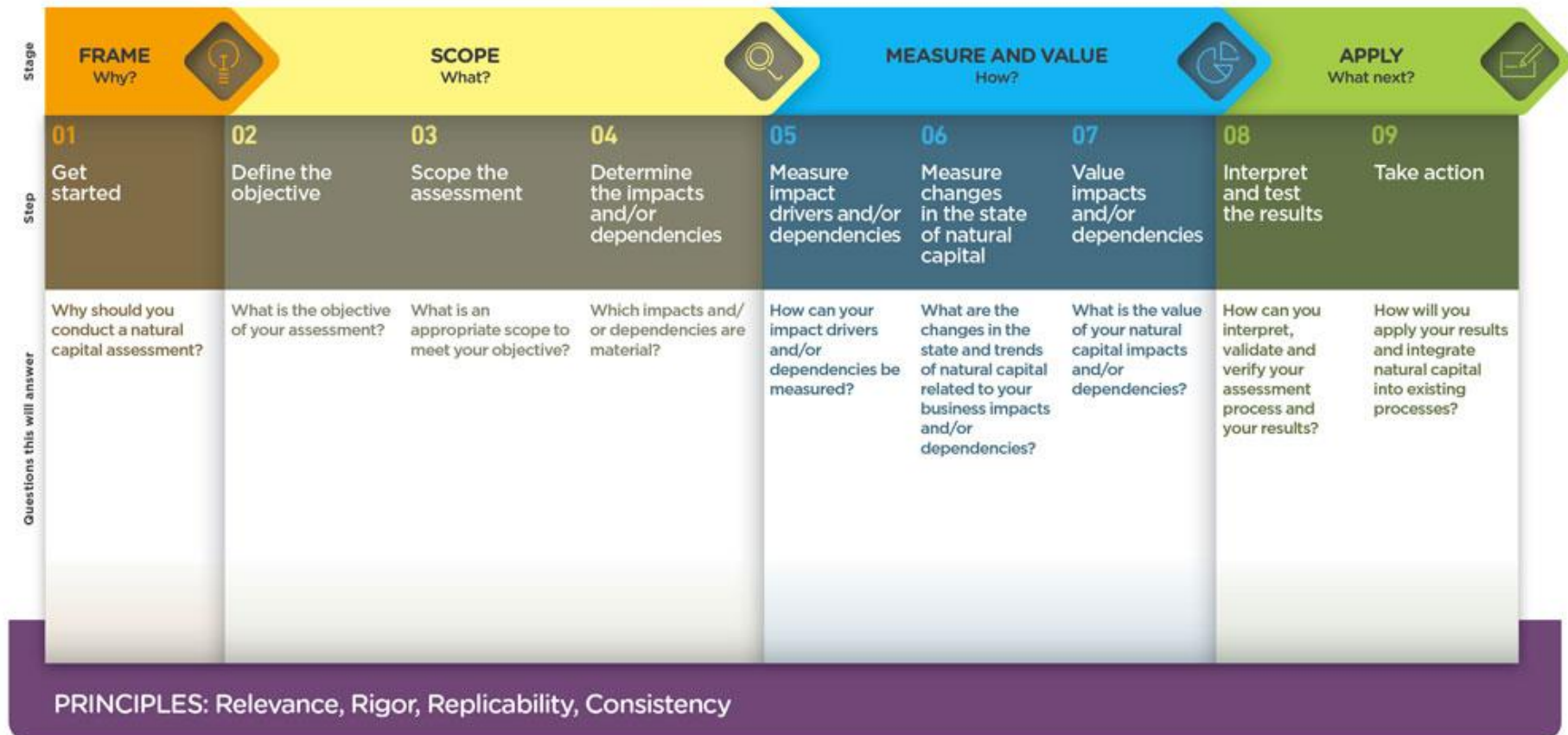
Figure 2: Map of Dryfesdalegate Farm (red line boundary shows main tenancy) and surrounding area



3.2 Approach

The work involved three meetings with the farmer over the period April to July 2019, 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



3.4 Dryfesdalegate Farm overview

Dryfesdalegate Farm is owned by the Crown, and Crown Estate Scotland lets out the farm to David Taylor. David's father took on the tenancy of the farm in 1966; in due course David became joint tenant with his father and is now sole tenant. Crown Estate Scotland works with its tenants to improve productivity while enhancing biodiversity.

Dryfesdalegate Farm is a lowland dairy farm covering approximately 134 ha. It is farmed in conjunction with 36ha of David's own land located 19 miles away, and 53 ha of land held under licence nearby. The farm is situated near Lockerbie on the Applegirth Estate in Dumfries & Galloway. The farm is well equipped with a mix of new and traditional buildings and good fencing. The land is generally flat and the climate is mild, being relatively close to the coast and in the South West of the country. Average annual rainfall for the area is around 1076 mm. There are small areas of woodland interspersed across the farm (see land cover map in **Appendix 3**). The farm lies outside the Less Favoured Area, although the owned land lies just within a Severely Disadvantaged Area.

Dryfesdalegate Farm runs a Holstein Friesian dairy herd, a beef enterprise and supporting forage and feed crops, as set out in **Table 2**. The farm is accredited under the Red Tractor Assurance standards. In addition, around 260 sheep are taken on tack for grazing during the winter.

Activities carried out by third parties on the farm (and adjoining land) include equestrian (one field is licenced out for horses), walking/biking (along paths and informal access routes) and sporting (pheasant/deer shooting and fishing carried out by sporting tenants/licensees of the Crown).

The farm labour includes 3 full-time, 2 part-time and 1 casual workers.

Table 2: Farm enterprises

Enterprise	Brief description
Dairy	<p>Herd of 238 Holstein Friesian dairy cows producing milk. Annual milk production is around 1.7 million litres or 7,457 kg per cow. The milk produced from the farm has a high butterfat.</p> <p>Milk is sold to Arla at the nearby Lockerbie Creamery at Priestdykes. There is relatively even production across the year, with every other day collection.</p> <p>There are around 130 dairy followers.</p> <p>Breeding comprises AI and beef bull.</p> <p>Grazing takes place from early/mid April to end of September, with cows housed during winter months. There is six months slurry storage across two tanks; wet slurry is spread using umbilical pipes and vacuum tanker. .</p>
Beef	<p>Two Limousin Cross suckler cows, and around 400 other beef cattle including Belgian Blue X, Aberdeen Angus X and Holstein Friesian (ranging in age from calves to over 24 months).</p> <p>Around 25% are sold as beef stores to neighbouring farms. The remainder are finished and sold direct to Stoddarts in Ayrshire which includes an abattoir and butchery for onward sale.</p>
Forage and feed crops	<p>101ha (249 ac) of permanent grassland and 38ha (94 ac) temporary grassland provide grazing and grass silage. Extra is provided by land licenced in.</p> <p>11ha (28 ac) of spring wheat is grown for whole crop silage.</p> <p>18ha (45 ac) of spring barley is grown for feed for beef cattle.</p> <p>Feed is also bought in for the dairy herd.</p>

4. Step 04: Determine the impacts and/or dependencies

4.1 Introduction

Every business impacts and depends on natural capital and the ecosystem services it provides and will experience risks and/or opportunities associated with these relationships. Impacts can be negative or positive.

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 (which includes livestock products such as milk and meat) 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 Dryfesdalegate Farm and the ecosystem services that flow from these; and secondly to determine which of the impacts and dependencies are most significant and worth more detailed investigation.

4.2 Natural capital assets and ecosystem services on Dryfesdalegate Farm

Dryfesdalegate Farm's **natural capital assets** can be viewed as a series of habitat types, set out in the Asset Register in **Table 3**. This shows the extent (e.g. hectares of land) and condition (e.g. good or degraded) of the assets, and highlights changes since 2009. Note, the same areas have been used in 2009 as 2019, due to lack of more specific data.

The land (tenanted area)⁵ comprises around 30ha of arable land, 38ha of temporary grassland (perennial ryegrass plus clover, Italian ryegrass), 60ha of permanent grassland, a small amount of rough grazing and around 1ha of woodland/trees (including 0.6ha of native woodland). There are also hedges which provide additional shelter/shade.

Soils on the farm are around 68% mineral alluvial soils with peaty alluvial soils, and 32% brown earth soils (Yarrow association), located on the east side of the farm. The farmland is also varied including around 43% Land Capability for Agriculture (LCA) Class 3.1 (capable of producing a moderate range of crops, with high yields of cereals and grass) and 57% Class 4.2 (primarily suited to grassland with some limited potential for other crops). The farm is relatively dry.

Watercourses include the River Annan, Dryfe Water and Caldons Burn. Where water quality is known, these watercourses are in **poor** status (100%). There is natural bank erosion with the river, thought to be caused/exacerbated by gravel bars no longer being dredged/removed on a periodic basis (in the past this has been used for tracks and drainage). Flooding occurs on low-lying land, up to 1m in depth, but not for long. The farm lies outside a Nitrate Vulnerable Zone.

Biodiversity on the farm includes a wide range of habitats and species (including oystercatcher and curlew, for example), although there are no species/population records. There are no SSSI or other designated sites on the farm.

⁵ Based on SAF and EUNIS data

The farm is not very wild, with an average score of 36 on the Relative Wildness index, with scores ranging from 19 to 68⁶.

There is good public access across the farm with a core path, the Annandale Way, and informal access. Access along the rivers is popular.

There are three scheduled monuments (a prehistoric fort, a Roman fort and an enclosure) on the farm, together with other historic features.

The farm does not presently participate in any agri-environment scheme (it was looked into but there were too many hoops to get through and restrictions). In the past, trees and hedges have been planted with the support from the landlord.

A series of maps illustrating some of the above elements are included in **Appendix 3** as a separate document.

The asset register shows an improvement in the condition of some of the farm's natural capital assets, and no change in other assets, although comparable historic and current data on extent and condition is limited (judgements have therefore been made based on available data and discussions with the farmer).

Dryfesdalegate Farm's natural capital assets provide a range of **ecosystem services**. An overview of the relative importance of different natural capital assets in delivering ecosystem service flows (shown by coloured cells) is shown in **Table 4**.

For example, cropland and temporary grassland are obviously important for crop and livestock provisioning services, but less so

for most regulating and cultural services. In contrast, permanent grassland, hedgerows, field margins, woodland and water are important for a wide range of regulating and cultural services, as well as some provisioning services such as livestock, wild food, timber and water supply.

The information in **Table 4** was compiled on the basis of information from the UK National Ecosystem Assessment⁷ as well as from observations and discussions with the farmer. Definitions for these services can be found in **Appendix 2**.

4.3 Key dependencies and impacts

The discussion and assessment outlined above helped us to identify what the key or 'material' dependencies and impacts are 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. The assessment of business dependencies and impacts is set out in **Sections 5.1 and 5.3**.

⁶ 'Relative Wildness' is a composite index based on four attributes: naturalness of land cover, ruggedness, remoteness and the lack of built modern artefacts. The scale is 1 to 256; the lower the score the less 'wild' the area.

⁷ 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 3: Farm natural capital asset register

Assets (habitat types)	Unit of measure	2009		Current status 2019		Data source	Trends
		Extent	Condition	Extent	Condition		
Enclosed farmland:							
Cropland (arable & horticultural):	ha	29.68	n.d.	29.68	Adequate/improving	SAF 2019 summary	Improving condition
Spring barley	ha	18.22	n.d.	18.22	Adequate/improving	SAF 2019 summary	Improving condition
Spring wheat	ha	11.46	n.d.	11.46	Adequate/improving	SAF 2019 summary	Improving condition
Temporary pasture (temporary improved grassland)	ha	38.04	n.d.	38.04	Adequate/improving	SAF 2019 summary	Improving condition
Permanent pasture (permanent improved grassland)	ha	59.97	n.d.	59.97	Adequate/improving	SAF 2019 summary	Improving condition
Permanent unimproved pasture (semi-natural grassland)	ha	0.14	n.d.	0.14	Adequate/improving	SAF 2019 summary	Improving condition
Field margins	ha of 3m field margins	n.d.	n.d.	n.d.	n.d.		
Hedgerows	length of hedges in meters	244.00	n.d.	244	n.d.	CS2007	Stable condition
Woodland:							
Coniferous (commercial)	ha	0.29	n.d.	0.29	n.d.	EUNIS/Google Earth	Stable condition
Broadleaved (amenity)	ha	0.72	n.d.	0.72	n.d.	EUNIS	Stable condition
Mountains, Moorlands and Heaths	ha						
Water (Openwaters, Wetlands & Floodplains)	length of streams in meters	3,588	n.d.	3,588	Poor	OS Open Rivers	Stable condition

n.d. no data

Table 4: Ecosystem services provided by the farm's natural capital assets

Current status 2019			ECOSYSTEM SERVICES																		
Assets (habitat types)	Current asset?	Trend	PROVISIONING SERVICES								REGULATING SERVICES							CULTURAL SERVICES			
			Crops	Livestock	Wild foods (game birds)	Wild foods (venison)	Wild foods (fish)	Water Supply	Timber	Fibre	Climate regulation	Flood regulation	Water quality regulation	Soil quality & erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage
Enclosed farmland:																					
Cropland (arable & horticultural):																					
Spring barley (feed for beef cattle)	Yes	Improving																			
Spring wheat (whole crop silage)	Yes	Improving																			
Temporary pasture (temporary improved grassland)	Yes	Improving																			
Permanent pasture (permanent improved grassland)	Yes	Improving																			
Permanent unimproved pasture (semi-natural grasslands)	Yes	Improving																			
Field margins	Yes																				
Hedgerows	Yes	Stable																			
Woodland:																					
Coniferous (commercial)	Yes	Stable																			
Broadleaved (amenity)	Yes	Stable																			
Water (Openwaters, Wetlands & Floodplains)	Yes	Stable																			

Relative importance:	
	high
	medium
	low
	not important

MEASURE AND VALUE STAGE: How?

5. Steps 05-07: Measure impact drivers and dependencies etc.

[Step 06: Measure changes in the state of natural capital; Step 07: Value impacts and/or dependencies]

This stage focuses on the **farm business's dependencies and impacts on natural capital and ecosystem services**. 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 demonstrated in the **case studies** at the end of the report.

5.1 Natural capital and ecosystem service dependencies

Table 5 highlights the extent to which the core activities on Dryfesdalegate Farm are dependent on natural capital. This illustrates that, for example, dairying and beef production is highly dependent on temporary and permanent pasture, and cropland. These enterprises are dependent to a lesser extent on hedges, woodlands and water however these are nonetheless important in terms of shelter, shade and water supply.

Table 6 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, dairy and beef production are clearly highly dependent on the food provisioning services. The farm is also dependent on water supply from groundwater. Hot water for the farm is provided by a biomass boiler, although the wood pellets are brought from elsewhere. In the past, stone has been taken from the river for tracks and drains. The third-party sporting activities are dependent on wild foods. 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 and erosion, pest and diseases (facilitated by, for example, the farm's rotation), water quality, flooding etc. Farming outputs are directly dependent on these, often 'hidden', services.

Cultural services

Cultural heritage was also identified as a 'high' dependency for the farm. Dairy and beef production on the farm relies on a body of knowledge, and cultural and intellectual capital, that has been built up over generations.

We have developed 'dependency pathways' for high dependency regulating and cultural services (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. See **Section 5.2**.

Table 5: Natural capital dependencies

Enterprises	Assets (habitat types)								
	Enclosed farmland:						Woodland (includes farm woodlands)	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)	Field margins	Hedgerows			
Dryfesdalegate Farm Enterprises								N/A	
Crop production (whole crop silage, beef cattle feed)									
Dairy (milk production)									
Beef (rearing and finishing)									
Recreation - equestrian									
Other Enterprises									
Recreation - walking/biking									
Shooting									
Fishing									

Table 6: Ecosystem service dependencies

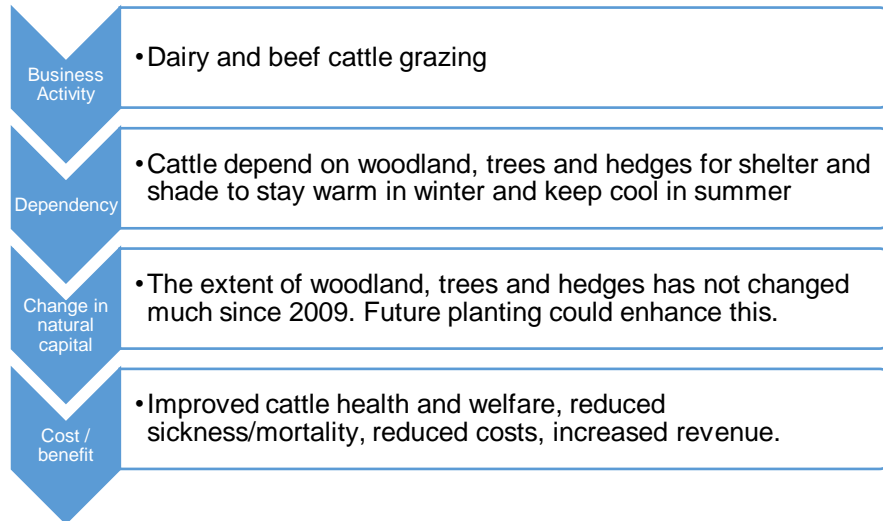
		ECOSYSTEM SERVICES																		
Enterprises	% area of land of enterprise	PROVISIONING SERVICES								REGULATING SERVICES							CULTURAL SERVICES			
		Crops	Livestock	Wild foods (game)	Wild foods (venison)	Wild foods (fish)	Water Supply	Timber	Fibre	Climate regulation	Flood regulation	Water quality regulation	Soil quality & erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage
Dryfesdalegate Farm Enterprises																				
Crop production (whole crop silage, beef cattle feed)	23																			
Dairy (milk production)	77																			
Beef (rearing and finishing)																				
Recreation - equestrian	1																			
Other Enterprises																				
Recreation - walking/biking	100																			
Shooting	100																			
Fishing	3																			

Dependency:	
	High
	Medium
	Low
	No dependency

5.2 What does your business depends on?

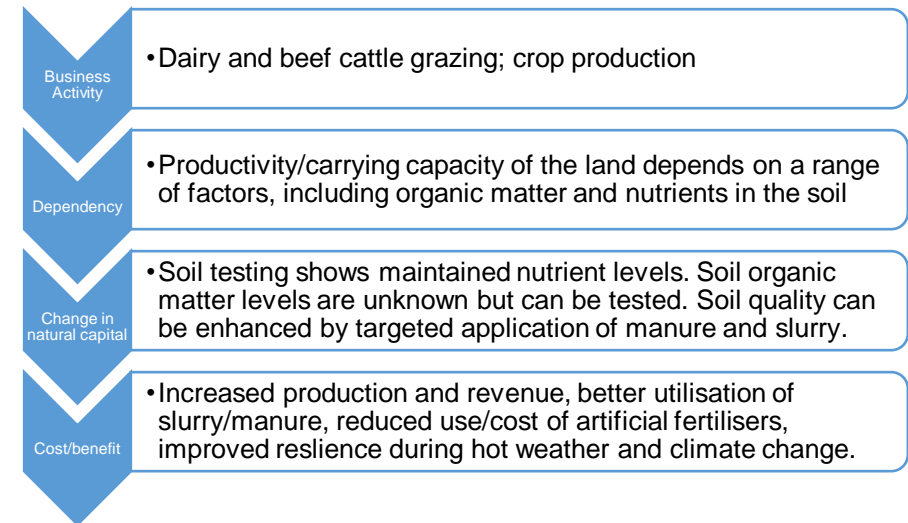
[Dependency Pathways]

Local climate regulation



The climate at Dryfesdalegate Farm is generally mild, but strong winds and rain during winter and hot spells during summer can affect the condition of the cattle. Cattle are likely to feed, gain weight/condition and produce milk if they have shelter and shade, therefore trees and hedges are key for providing local climate regulation services.

Soil quality regulation

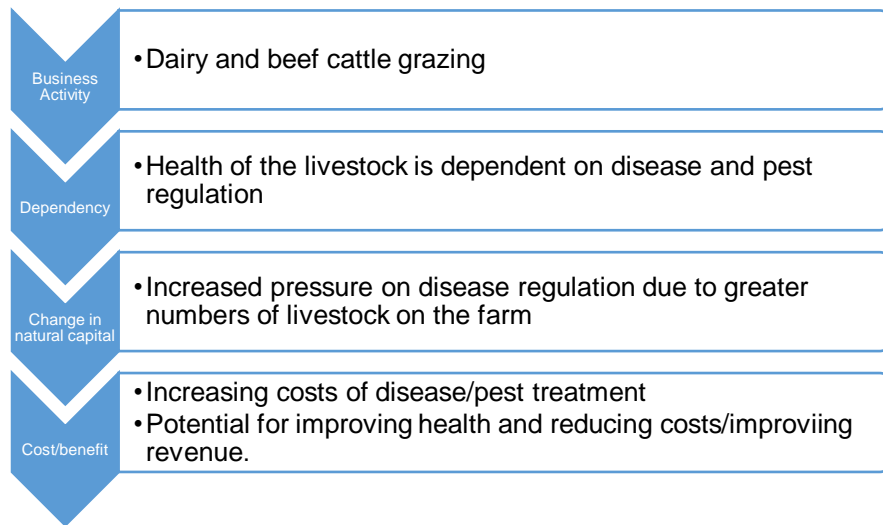


Crop and livestock production is directly dependent on soil health as organic matter and nutrients supports quality grassland for grazing and grass silage, and forage/feed crop production.

Soil testing has shown that nutrient levels have been maintained/improved and it is expected that other farming practices (e.g. rotational grazing, improved utilisation of manures and slurries) will have supported the provision of soil quality regulation services. Productivity gains have also been achieved through use of improved grass species and forage analysis.

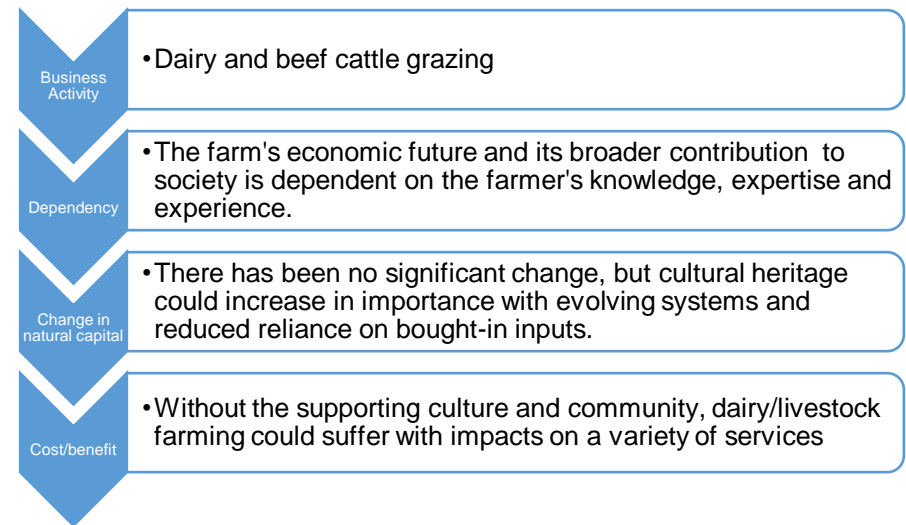
There is an opportunity to improve soils and achieve better utilisation of manures and slurries by extending soil testing to include soil organic matter, analysing manure and slurry, and applying them in a targeted manner. See also **Case Study 1**.

Disease and pest regulation



Incidents of pests and diseases (e.g. foul-in-the-foot, worms) tend to increase with more intensive stocking as they spread amongst the animals and become embedded in the land. Dryfesdalegate Farm is no exception; disease and pest regulation is a key dependency for livestock production.

Cultural heritage



Cultural heritage is identified as a 'high' dependency for the farm's dairy and beef enterprises, as these rely on a body of knowledge and cultural / intellectual capital built up over generations in the local area.

5.3 Natural capital and ecosystem service impacts

We have also assessed – as far as we are able given data available - the specific impacts of the farm on natural capital and ecosystem services over the past ten years of the tenancy (from 2009 to the present). These are shown in **Tables 7** and **8**.

In terms of natural capital assets, the assessment indicates that there have been improvements in hedgerows (gapping up) and mixed impacts on cropland and grassland; on the one hand improvement in terms of soil quality, nutrients and hence, productivity, but on the other hand greater pressure on natural capital due to higher stocking.

With ecosystem services, there have been medium positive impacts in terms of crop and livestock provisioning services (farm production has increased) and recreation and cultural heritage services (the farm has supported these basically free of charge). Negative impacts relate to several regulating services: climate regulation – including increased greenhouse gas emissions from an increased herd; and to a lesser extent water quality regulation and air quality regulation. David has made strides to fit nutrient application to need, thereby reducing any adverse impacts on water. There have

been mixed impacts in relation to wild foods, disease and pest regulation, and wild species diversity.

There are clear relationships between the dependencies and impacts, particularly around the crop and livestock provisioning services. These have increased in the past decade, but there have been some corresponding negative impacts in some regulating services.

Providing only one score for each service may hide some nuances. For example, while the overall impact on climate regulation is likely to have been negative due to increased stock numbers, there will have been some positive impacts arising from better resource utilisation, hedgerow gapping up etc.

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. See **Section 5.4**.

Table 7: Natural capital impacts – impacts over the period 2009-2019

Enterprises	Assets (habitat types)								
	Enclosed farmland:						Woodland (includes farm woodlands)	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)	Field margins	Hedgerows			
Dryfesdalegate Farm Enterprises								N/A	
Crop production (whole crop silage, beef cattle feed)	+/-								TBC
Dairy (milk production)	+/-	+/-	+/-						TBC
Beef (rearing and finishing)	+/-	+/-	+/-						TBC
Recreation - equestrian									
Other Enterprises									
Recreation - walking/biking									
Shooting									
Fishing									

Table 8: Ecosystem services impacts –impacts over the period 2009-2019

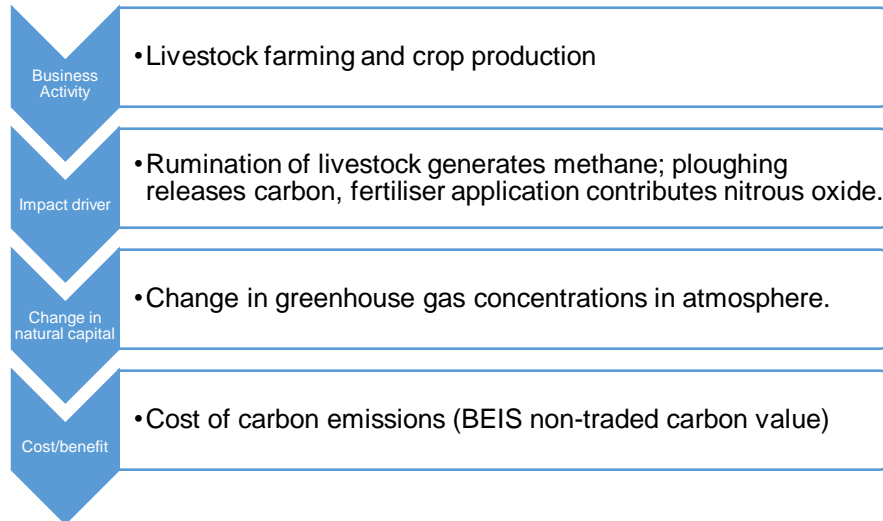
		ECOSYSTEM SERVICES																	
Enterprises	% area of land by enterprise	PROVISIONING SERVICES								REGULATING SERVICES							CULTURAL SERVICES		
		Crops	Livestock	Wild foods (game)	Wild foods (venison)	Wild foods (fish)	Water Supply	Timber	Fibre	Climate regulation	Flood regulation	Water quality regulation	Soil quality & erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education
Dryfesdalegate Farm Enterprises																			
Crop production (whole crop silage, beef cattle feed)	23																		
Dairy (milk production)	77																		
Beef (rearing and finishing)																			
Recreation - equestrian	1																		
Other Enterprises																			
Recreation - walking/biking	100																		
Shooting	100			+/-	+/-												+/-		
Fishing	3					+/-											+/-		

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

5.4 What are your business impacts?

[Impact Pathways]

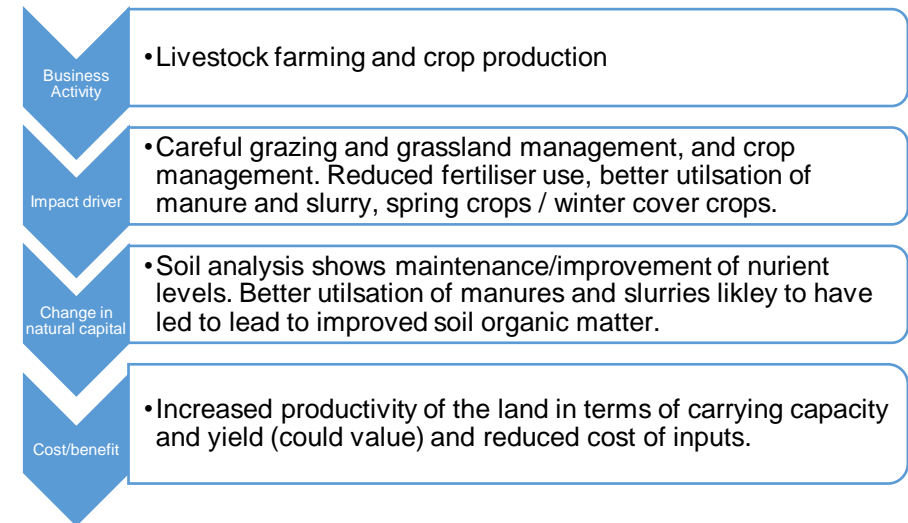
Climate regulation



The impact pathway above shows how crop and livestock production have a negative impact on global climate regulation. Livestock rumination releases methane (a very powerful greenhouse gas) to the atmosphere. Ploughing releases carbon dioxide and fertiliser application contributes nitrogen oxide. The increase in cattle numbers over the past ten years is likely to have increased overall greenhouse gas emissions from the farm.

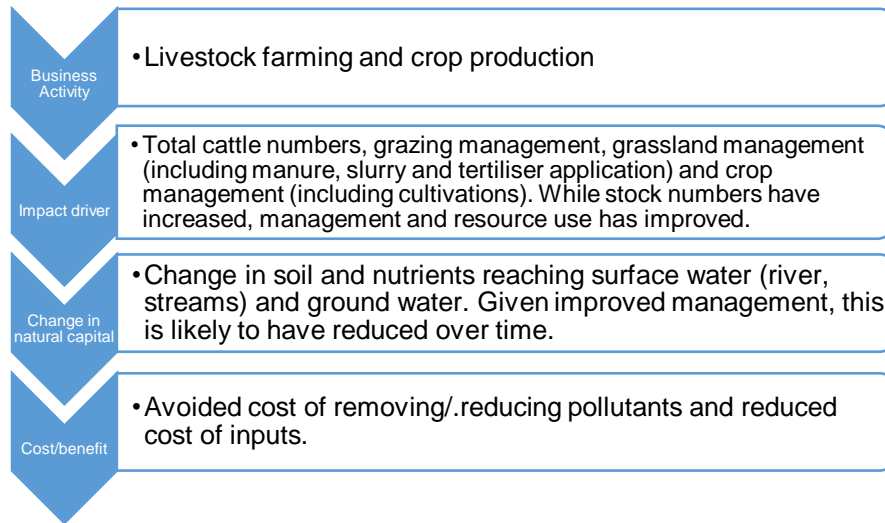
Local climate regulation may have improved as a result of tree planting and hedgerow gapping up, and this could be extended in future with a range of benefits.

Soil quality regulation



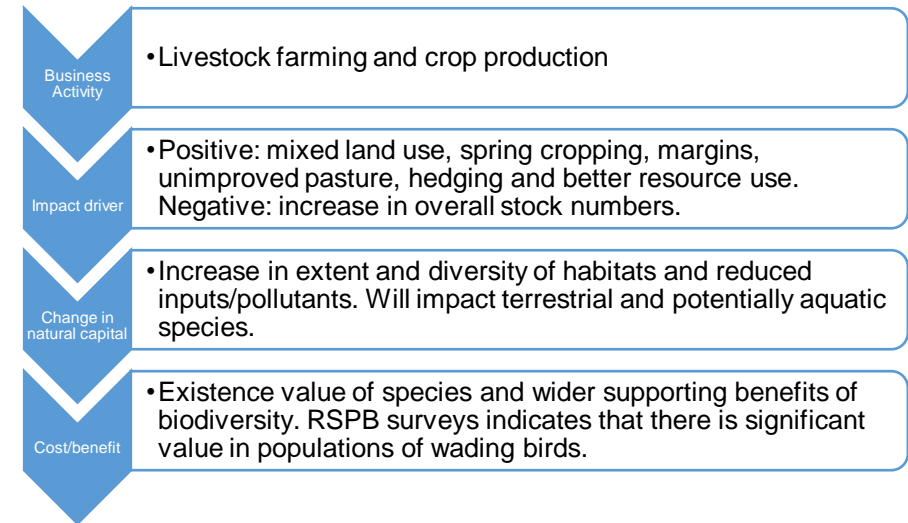
Over time, David has sought to improve storage and application of manure and slurry. There has been investment in a second slurry tank, and specialist equipment is hired in, which has enabled this valuable resource to be spread at the right time in the right way, thereby improving utilisation and, by addition of organic matter, enhancing soil quality. This has reduced the quantity of artificial fertiliser bought-in (currently around 100t p.a.). Additional soil testing and slurry/manure analysis could be undertaken to track improvement in soil organic matter and achieve better utilisation of slurry and manure. See also **Case Study 1**.

Water quality regulation



While the overall impact of the farming enterprises on water quality is likely to be negative, by virtue of a relatively intensive farming system, the impacts are likely to have reduced over the past ten years with improvement in crop, stock and grassland management and investment in slurry storage, resource use etc. Water quality regulation is closely linked to soil quality regulation.

Wild species diversity



Dryfesdalegate Farm is a very diverse farm, with different land uses and a network of hedges, trees, woodland and watercourses, and therefore generally good for wildlife. Over the past decade, there is likely to have been a mixed impact on wild species diversity. A negative impact associated with increased stock numbers will have been mitigated by an increase in the extent and diversity of habitats and reduced inputs/pollutants.



APPLY STAGE: So what?

6. Step 08: Interpret and use the results

This assessment has shown the natural capital dependencies and impacts for Dryfesdalegate Farm's dairy, beef and crop enterprises. In light of this, the following farm-specific risks and opportunities can be identified.

6.1 Risks:

Erosion – Bank erosion is occurring along the rivers Annan and Dryfe, resulting in land being lost and creating a risk for livestock and people. There is a need to discuss the causes with SEPA and scope potential solutions.

Water supply – The farm is dependent on water from a borehole for its main supply. Risks include reduction in quality and quantity, and regulatory non-compliance. These risks can be minimised by good land management.

Flooding – Flooding occurs alongside the rivers Annan and Dryfe; this has the potential to adversely affect grass/crop growth. Upstream solutions can help mitigate flooding.

Wild species/biodiversity – Wild species will be influenced by third party actions, meaning they are at risk from factors external to the farm. They are important for a variety of reasons not least because natural ecosystems underpin the farm.

Disease – Diseases have a direct impact on animal health and welfare, and productivity. Diseases such as foul-of-the-foot, gut worms and lung worms can be mitigated by good grazing management, with breaks/rotations, utilising natural pest and disease regulation.

Climate change may increase the likelihood of extreme weather events, such as excessive rain, storm events and drought. Ensuring resilience of the land and farm to withstand changes in weather patterns will be important. The risks mentioned above could all be exacerbated by climate change.

6.2 Opportunities:

Soil testing – Adding nutrients to the soil is expensive, and therefore soil nutrient testing is best done regularly so that applications can be targeted. Soil organic matter should also be measured to guide action to improve soil quality. New techniques are being developed to carry out soil analysis in a more cost-effective way, both high-tech and low tech.

Slurry and manure analysis – Analysing slurry and manure on a regular basis can guide better utilisation of this valuable resource.

Increasing soil organic matter – Higher levels of soil organic matter will make the land more resilient and mitigate against soils becoming water-logged or suffering from drought (important in the context of climate change). This can be achieved through continuing to add manure and slurry to the soil, using rotations and break crops (cover crops, green manure etc.), and using practices (e.g.no/min-till) which reduce disturbance of the soil to help protect carbon.

Better utilisation of slurry and manure – More targeted application of slurry and manure will enable the quantity of inorganic fertilisers purchased to be reduced, costs to be saved and risks (including exposure to volatile fertiliser prices) reduced. This would move the farm a step closer towards a circular system, i.e. the arable land and grassland are fertilised by livestock manure/slurry, which then deliver grass/forage for the dairy and beef herds.

Planting hedges and trees – Hedge and tree planting can deliver multiple benefits including shelter and shade for livestock, conservation of soil and water, carbon sequestration, habitat for wildlife, and amenity. David has gapped up hedges in the past, and the farm is blessed with a good mosaic of hedges, trees and woodland. More planting could be done, harnessing support from the landowner and/or grant schemes.

Enhancing wildlife – There are small areas of habitat, such as unimproved grassland, on the farm. Rather than spending money on trying to make unproductive areas more productive, it might better to focus on managing these for wildlife. Grants may be (come) available to accommodate this.

River erosion and flood management – There may be opportunity to work with SEPA/SGRIPD to tackle the bank erosion and flooding issues; support may be available from the Agri-Environment Climate Scheme (AECS) or similar.

Being able to **demonstrate the contribution** the business is making to ‘**public goods**’, such as biodiversity and water quality, is likely to become increasingly important in terms developing a sustainable reputation/brand, maintaining good supply chain relations and contracts, strengthening tenant-landlord relations and accessing public support payments.

There is an opportunity to **develop a set of metrics for monitoring the natural assets** of Dryfesdalegate 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, carbon and biodiversity. Capturing data from conservation organisations/volunteers (e.g. RSPB, BTO etc.) is recommended to help build up a picture of wildlife on the farm.

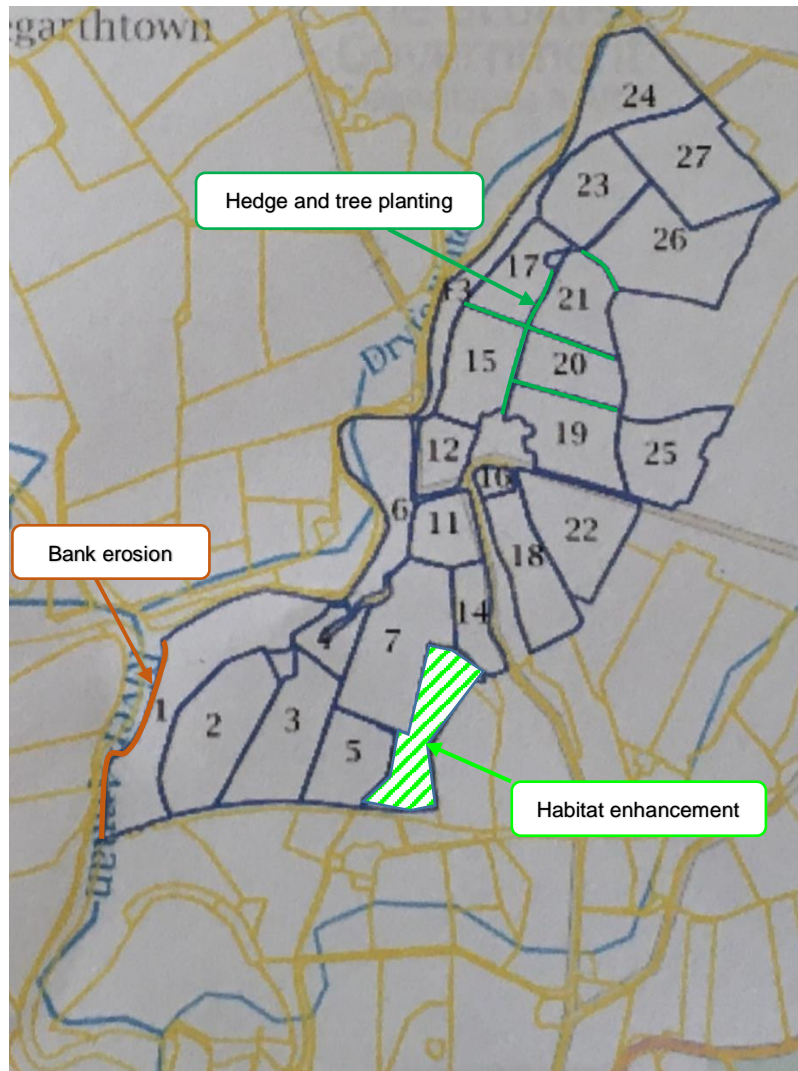
- Review these metrics on a regular basis and record the improvement in extent and condition (or deteriorations, if any) of the natural capital assets on the farm, and any investments made. This can help facilitate broader conversations between landlord and tenant about future developments of the farm to ensure its long term sustainability.

Case Studies 1 and 2 at the end of this report illustrate the benefits and costs associated several of the above opportunities including: improving soil and achieving better resource utilisation; and planting more hedges and trees.

Figure 4 shows the location of some of these on-farm issues and opportunities.

In addition to the above, there are a number of high-level generic risks and opportunities for the dairy sector to take into account. These are summarised in **Appendix 5**.

Figure 4: Specific issues and opportunities



7. Step 09: Take action

7.1 Actions for consideration:

1. Test soil nutrients and soil organic matter, and analyse slurry and manure, on a regular basis
2. Improve soil quality (and achieve better resource utilisation) through a combination of measures including rotations, cropping, alternative cultivation techniques and targeted application of slurry and manure.
3. Discuss the River Annan erosion and flooding problem with Crown Estate Scotland and SEPA to investigate potential options/solutions.
4. Discuss tree and hedge planting and wildlife enhancement opportunities with Crown Estate Scotland and explore grant aid and other support for this.
5. Collate natural capital and ecosystem services data for the farm, and identify a few key indicators to monitor progress, in particular with regard to soils and biodiversity. For example:
 - Soils: NPK; soil organic matter/carbon; pH.
 - Biodiversity: number of species present; abundance of specific species.
 - Habitats (farmland (by type), woodland, hedgerows, margins and watercourses): area/length and condition.
6. Explore ways to fill gaps in data through partnerships with Crown Estate Scotland, government bodies and voluntary organisations.

7. Engage with your milk purchaser, Arla, to demonstrate the farm's natural capital approach and identify opportunities for enhanced returns and support.
8. Keep a watching brief on future public schemes which will provide support for natural capital maintenance and enhancement.

Additional useful information

Regulations and guidance

<https://www.sepa.org.uk/regulations/land/agriculture/sector-specific-issues/>

<https://www.sepa.org.uk/regulations/land/agriculture/agricultural-regulation-and-guidance/>

<https://www.gov.scot/policies/agriculture-and-the-environment/pepfaa/>

Advice and video case studies

Slurry and Manures https://www.farmingandwaterscotland.org/wp-content/uploads/2018/08/Slurry_Manure.pdf

Cost effective slurry strategies <https://dairy.ahdb.org.uk/resources-library/technical-information/health-welfare/cost-effective-slurry-storage-strategies/#.XZ2tptLru71>

Alternative watering

<https://www.farmingandwaterscotland.org/livestock-arable/livestock-alternative-watering/>

Mind the gap – buffer strip minimum requirements


<https://www.farmingandwaterscotland.org/downloads/mind-the-gap-2-m-and-10-m-buffer-strip-near-watercourses-information-note/>

Dairy sector production plan

<https://sectors.sepa.org.uk/dairy-production-sector-plan/>


Please also see the weblinks included in the **Case Studies**.

CASE STUDY 1 – Opportunity to improve soil and achieve better resource utilisation


FRAME STAGE: Why?

Step 01: Get started

There is an opportunity to build on work carried out to date by farmer David Taylor to maintain and enhance soils and utilise slurry and manure.


SCOPE STAGE: What?

Step 02: Define the objective


To understand what impact better utilisation of slurry and manure might have on natural capital, specifically soil health, and provide a high level cost/benefit analysis.

Step 03: Scope the assessment

The assessment includes analysing soils and slurry and manure, and applying slurry and manure to increase soil organic matter and nutrients.

Step 04: Determine the impacts

Material impacts relate to soil health and quality, and the following ecosystem services: crop production; livestock production; soil quality regulation; water quality regulation; climate regulation; pest and disease regulation; and wild species diversity.


MEASURE AND VALUE STAGE: How?

Step 05: Measure impact drivers

Impact drivers include: enhanced analysis of soils and analysis of slurry and manure; targeted application of slurry and manure to fit crop/grass requirements; and reduced use of artificial fertilisers.

Step 06: Measure changes in the state of natural capital

Asset register:

		2019		Management interventions	Future status, 2020 onwards	
	Natural capital asset	Hectares	Data source	Activities undertaken	Hectares	Data source
Extent	Cropland (arable & horticultural):	29.68	SAF/DT	No change other than normal rotation	29.68	Estimate
	Temporary pasture (temporary improved grassland)	38.04	SAF/DT	No change other than normal rotation	38.04	Estimate
	Permanent pasture (permanent improved grassland)	59.97	SAF/DT	No change other than normal rotation	59.97	Estimate
Condition	Condition Indicators	Status / Score	Data source	Activities undertaken	Status / Score	Data source
	Soil organic matter	Not known	DT	Analysis, targeted application of slurry and manure	Improved	Estimate
	Extractable P, K, Mg and trace elements	TBC	DT		Maintained	Estimate
	Soil structure	TBC	DT		Improved	Estimate

	Natural capital and ecosystem service impacts:																				
	Assets (habitat types)																				
	Activity	Enclosed farmland:																			
		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)											
Improve soil and achieve better resource utilisation																					
	ECOSYSTEM SERVICES																				
	Activity	PROVISIONING SERVICES								REGULATING SERVICES							CULTURAL SERVICES				
		Crops	Livestock	Wild foods (game)	Wild foods (venison)	Wild foods (fish)	Water Supply	Timber	Fibre	Climate regulation	Flood regulation	Water quality regulation	Soil quality & erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage	
	Improve soil and achieve better resource utilisation																				

Step 07: Value impacts	Cost-benefit analysis:						
	Item	£	Notes				
	Cost						
	Analyse soil organic matter	60	£10/test over 4-5 year rotation. Say 6 sample per year. Cost is Loss on Ignition (LOI) test				
	Anayse manure and slurry	59	Slurry testing kit is £390 (eg Agros Nova) plus reagent costs of £20/yr, average annual cost when spread over 10 years = £59/yr. Alternative is laboratory test = £70+/year.				
	Total annual cost	119					
	Benefits						
	Nutrient value of dairy slurry (238 cows)	1,698	Financial value of dairy slurry, based on current NPK costs = £2.99/m³; and volume based on 25%, for fertiliser saving = 568m³. Calculations in framework spreadsheet.				
	Nutrient value of cattle farm yard manure (130 dairy followers + 400 beef cattle)	5,231	Financial value of cattle FYM, based on current NPK costs = £6.43/m³; and volume based on 25%, for purposes of fertiliser saving = 913m³. Calculations in framework spreadsheet.				
	Total annual benefit	6,930					
	Total annual profit	6,811					
	Other benefits such as improvements in crop and livestock yield/quality and carbon sequestration/storage could also be valued.						



APPLY STAGE: So what?

Step 08: Interpret and test results	This is an indicative assessment of the opportunity to improve soil health and achieve better utilisation of slurry and manure. In practice, the actual volumes/savings could be greater or less.
Step 09: Take action	Analysing soils and slurry/manure, and applying the latter in a targeted manner to meet crop/grass requirements, can improve soil, save costs and generate a range of other benefits. There is a range of other options for improving soils including cover/catch crops and changes in rotation/cultivation practice.
References:	https://www2.gov.scot/resource/doc/47121/0020243.pdf https://www.sruc.ac.uk/downloads/file/1276/tn650_optimising_the_application_of_bulky_organic_fertilisers https://www.soilassociation.org/media/15138/monitoring-soil-health.pdf https://www.theriverstrust.org/media/2017/04/Pinpoint-31.0-Nutrient-management-Manure-and-slurry-nutrient-testing.pdf

CASE STUDY 2 – Opportunity to plant more hedges and trees

FRAME STAGE: Why?

Step 01: Get started

There is an opportunity to plant more hedges and trees on the farm, building on the existing mosaic of hedges, trees and woodland and previous planting carried out by farmer David Taylor. This will have a range of farm business and environmental benefits.

SCOPE STAGE: What?

Step 02: Define the objective

To understand what impact more hedge and tree planting might have on natural capital / ecosystem services and to provide a high level cost/benefit analysis.

Step 03: Scope the assessment

The assessment covers the impacts of hedge and tree planting on the farm business and society more broadly.

Step 04: Determine the impacts

Material impacts relate to quantity and quality of hedgerows and the following ecosystem services: livestock production; climate regulation, soil quality regulation; water quality regulation; wild species diversity; and recreation/amenity.

MEASURE AND VALUE STAGE: How?

Step 05: Measure impact drivers

Impact drivers include the planting of additional lengths of hedgerow and/or gapping up of hedges; and the planting of more hedgerow trees.

Step 06: Measure changes in the state of natural capital

Asset register:

		2019		Management interventions	Future status, 2020 onwards	
	Natural capital asset	m/no.	Data source	Activities undertaken	m/no.	Data source
Extent	Hedges	244 (underestimate)	CS 2007	Plant and gap up 500m of hedgerow	744 (underestimate)	Estimate
	Trees	n.d.		Plant an additional 50 hedgerow trees	50 (underestimate)	Estimate
Condition	Condition Indicators	Status / Score	Data source	Activities undertaken	Status / Score	Data source
	Hedges	Part degraded, part good	DT	Gapping up	Good	Estimate
	Trees	Good	DT		Good	Estimate

	Natural capital and ecosystem service impacts:																																																																																												
	<table><tr><td></td><td colspan="17">Assets (habitat types)</td></tr><tr><td rowspan="2">Activity</td><td colspan="10">Enclosed farmland:</td><td colspan="7"></td></tr><tr><td>Cropland (arable & horticultural)</td><td>Temporary pasture (temporary improved grassland)</td><td>Permanent pasture (permanent improved grassland)</td><td>Permanent unimproved pasture (semi-natural Grasslands)</td><td>Field margins</td><td>Hedgerows</td><td>Woodland (includes farm woodlands)</td><td>Mountains, Moorlands and Heaths</td><td>Water (Openwaters, Wetlands & Floodplains)</td><td colspan="7"></td></tr><tr><td>Plant hedges and trees</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table>																			Assets (habitat types)																	Activity	Enclosed farmland:																	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)								Plant hedges and trees																						
	Assets (habitat types)																																																																																												
Activity	Enclosed farmland:																																																																																												
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	ECOSYSTEM SERVICES																																																																																												
Activity	PROVISIONING SERVICES								REGULATING SERVICES							CULTURAL SERVICES																																																																													
	Crops	Livestock	Wild foods (game)	Wild foods (venison)	Wild foods (fish)	Water Supply	Timber	Fibre	Climate regulation	Flood regulation	Water quality regulation	Soil quality & erosion regulation	Air quality regulation	Disease & pest regulation	Pollination	Wild Species Diversity	Recreation	Education	Cultural heritage																																																																										
Plant hedges and trees																																																																																													
Step 07: Value impacts	Cost-benefit analysis:																																																																																												
	Item	£	Notes																																																																																										
	Cost																																																																																												
	Plant 500m hedge plus protection	7000	£14/m for double row, native species, 6 plants per metre, plus spiral guards and canes, plus extra stockproof fence on one side, farm labour to plant. Follow-on maintenance excluded																																																																																										
	Plant 50 hedgerow trees	130	£2.60/tree for broadleaf species transplant, plus shelter, stake & tie, farm labour to plant. Follow-on maintenance excluded																																																																																										
	Total capital cost	7130																																																																																											
	Annual cost	713	Assume written down over 10 years. In practice, benefit could last 50 years plus.																																																																																										
	Benefits																																																																																												
	Increased milk yield resulting from enhanced access to shade	2,856	In trials in NZ, milk production was higher in cows that had access to shade compared to those without, but milk composition was not affected by shade treatment. Shelter is important for welfare and performance, including energy conservation. Lack of quantitative data. Consider just 1% increase in gross margin per cow at, say £1,200/cow (before forage costs) = £12/cow x 238 cows = £2,856																																																																																										
	Increased shelter to keep cows and other cattle warm in cold weather																																																																																												
Total annual benefit	2,856																																																																																												
Total annual profit	2,143																																																																																												
Other benefits such as carbon sequestration/storage could also be valued. Further benefits include reducing risk of pollution (including reducing nutrient run-off and sequestering ammonia), flood risk abatement, improving soils, providing wildlife habitats, enhancing landscape quality and providing raw materials (timber, logs, wood chip) and additional fodder.																																																																																													



APPLY STAGE: So what?

Step 08: Interpret and test results	This is an indicative assessment of the opportunity to plant hedges and trees. In practice, the actual volumes/savings could be greater or less.
Step 09: Take action	Consider which boundaries would benefit from gapping up and new hedgerow planting, and where it would be beneficial to plant new hedgerow trees. Prioritise and quantify lengths and numbers. Discuss planting project with Crown Estate Scotland and consider sources of grant aid including Scottish Government (AECS) and Woodland Trust (which provide subsidised tree and hedge packs); these could be shared with other tenants to meet minimum criteria, if required.
References:	<p>https://www.woodlandtrust.org.uk/mediafile/100263169/rr-wt-71014-benefits-of-trees-on-dairy-farms.pdf?cb=1b56268731f941ababd3c0f22db5d3ac</p> <p>https://www.sciencedirect.com/science/article/abs/pii/S1871141306000412</p> <p>https://www.sciencedirect.com/science/article/abs/pii/S1871141313004964?via%3Dihub</p> <p>https://www.fwi.co.uk/livestock/dairy/tree-planting-provided-big-benefits-one-dairy-farmer</p> <p>https://www.woodlandtrust.org.uk/plant-trees/large-scale/ - covers trees and hedges (up to 75% subsidy)</p>

Appendix 1: Glossary

Where available, definitions are taken directly from the Natural Capital Protocol⁸.

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.

⁸ 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

Appendix 4: Additional photographs

<p>P5. Field 1, River Annan, looking north</p>	<p>P6. Field 7, looking south east</p>
	
<p>P7. Field 6, River Dryfe, looking north</p>	<p>P8. Field 6, looking south</p>
	

<p>P9. Field 6, woodland belt</p>	<p>P10. Field 10, looking north</p>
	
<p>P11. Field 11, looking north east</p>	<p>P12. Farmstead, from River Dryfe</p>
	

<p>P13. Field 15/20, looking south</p>	<p>P14. Field 17/21, looking south</p>
	
<p>P15. Field 21, looking north east</p>	<p>P16. Field 23, looking north west</p>
	

Appendix 5: High level, generic risks and opportunities

Risks

Brexit poses risks for the business. It is likely that schemes similar to the current Basic Payment Scheme (BPS) will continue in Scotland until 2024, but thereafter loss of subsidy income is a significant risk. It is also currently unclear whether the UK can negotiate a favourable trade agreement with the EU. With 'no deal', WTO trade rules would apply, with tariffs on dairy products; this could create opportunities in terms of domestic dairy processing. Exchange rates would also be affected.

Changing consumption patterns. Markets for dairy products are subject to challenge with the rise of plant-based alternatives (soy, nuts), particularly among younger consumers. There is also the rise of alternative animal milk products (from cows, goats, sheep etc.)

Input price volatility and price rises could affect feed, fertilisers, and energy due to a combination of factors including global markets, supply limitations and Brexit.

Changes in regulation and legislation. The use of chemicals (e.g. glyphosate) is under constant review and may limit options available, and there is a proposed reduction in ammonia emissions. 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, linking to consumer pressure for more sustainable products.

Opportunities

Brexit provides an opportunity for dairy farms and the broader dairy sector to produce more for the domestic market. Added value can be obtained by strengthening supply chains and investment in processing infrastructure. Brexit opens up the possibility of a new subsidy regime that is better tailored to British agriculture, as well as more streamlined regulations. Future policy is likely to be focused on 'public payments for public goods', and strongly aligned to the concept of natural capital.

Alternative dairy systems such as Organic or Pasture for Life provide an opportunity to develop a more natural system with potential to improve profit, build a brand etc.