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Northern Ireland Natural Capital Rural Study

A review of the wider economic value of selected farm systems in Northern Ireland

Interserve Consulting - Sustainable Business Advisory, March 2018

Contents

Summary

Natural Capital is the stock and flow of services from natural areas which include everything from clean air, water and food, to recreation, health & well-being and education.

By understanding the processes underpinning the flow of services, we are able to understand their wider value of natural stocks, which in turn can support better decision making, and make better decisions which recognise the wider benefit of the environment, society and the economy.

The Agricultural sector forms a significant part of the Northern Irish economy. The sector is made-up of 50,000 farmers, contributing to 3.25% of total GVA, which equates to £1.1 billion per year[1]. A good quality natural environment underpins the farming industry. Understanding and protecting the value of the services which underpin the agricultural environment in Northern Ireland is therefore essential.

This report presents the findings of an assessment undertaken to examine the ecosystem services provided by the agri-environment within a number of farming systems in Northern Ireland. From this assessment the baseline value of the goods and services of three farming systems is determined.

Three farms were assessed based on the stock and flow of services from the natural assets, upon which livestock are reared. Two are lowland farms, close to Antrim, one a dairy farm, the other a beef and sheep farm, and an upland hill farm, which is part of a special designated area.

The total combination of the value of the three farms assessed is £78 million per annum (non-discounted) based on 2016 data, this includes traditional farm outputs and educational impact.

- The Upper Hill Farm provides natural capital services value (including carbon stock) of £3.1 million per annum (excluding provisioning services, and the educational value of the farm).
- The Dairy farm provides ecosystem services to a value of £961k per annum (excluding provisioning services, and the educational value of the farm).
- The Beef and Sheep farm provides ecosystem services with a value of £324k per annum (excluding provisioning services and the educational value of the farm).

The hill farm delivers a higher value due mainly to carbon and water services delivered through peat assets. The beef and sheep, and dairy farms deliver a lot of value through air pollution regulation, based on the assets within each farm boundary.

Each of the farms regulate nitrogen positively which reduces the overall environmental impacts of high nitrogen outputs. There are some negative values associated with Potassium and Phosphorus cycling. While these are immaterial compared with the overall figures (the value associated with these is low), they may require attention in future.

Despite intensive farming practices, the farming systems deliver net positive environmental gain? For example, on the Hill Farm there is a net positive impact of rearing animals. Potential

[1] Northern Ireland Assembly

negatives are off-set by the management practices undertaken which result in a high level of carbon storage and water cycling.

The overall farm monetary impact is detailed overleaf in Table 1.

This report outlines a number of recommendations for enhancing natural capital assets on farm systems and progressing natural capital policy. These include NI centric payments for ecosystem services, diversification of the animals reared on farms in order to enhance natural capital benefits; partnership working to provide better health and well-being outcomes, development of a wider natural capital account and a long-term environment plan for Northern Ireland.

Table 1; CAFRE Farm Natural Capital Baseline

		Stock Value		30 year period		Annual Aggregated Value	
		Profit	Loss	Profit	Loss	Profit	Loss
Provisioning	Total Farm Output	£0	£0	£939,859,918	-£21,652,379	£31,328,664	-£605,258
Air Quality	Woodland Impact	£0	£0	£12,206,028	£0	£568,155	£0
	Grassland Area	£0	£0	£41,520,218	-£849,915	£1,402,865	-£28,330
Climate	Carbon Sequestered	£1,047,751	£0	£40,699,178	-£2,373,871	£1,356,639	-£75,312
	Carbon emitted through animal rearing	£0	£0		-£5,196,864		-£254,167
Water	Water treated, runoff prevented, availability	£484,268	£0	£11,925,934	-£1,934,246	£393,403	-£65,418
Education	Number of individuals with access to the site for educational purposes	£0	£0	£1,155,528,473	-£165,559,265	£43,541,160	-£13,410,677
Health and Wellbeing	Number of households with direct health and well being impocts	£0	£0	£8,126,448	£0	£304,301	£0
Nutrient Cycling	Nitrogen (N)Total quantity of N cycled within the site area based on plant coverage, structure and soil properties.	£0	£0	£42,778,359	£0	£1,425,945	£0
	Phosphorus (P)Total quantity of P cycled within the site area based on plant coverage, structure and soil properties.	£1,047,751	£0	£472,190,920	-£65,491,424	£17,440,997	-£4,741,046
	Pottassium	£0	£0	£35	-£20,985	£1	-£699
	Total Net Value	**£2,579,770**		**£2,724,835,510**	**-£263,078,948**	**£97,762,131**	**-£19,180,908**
	Total Gross Value				**£2,461,756,562**		**£78,581,223**

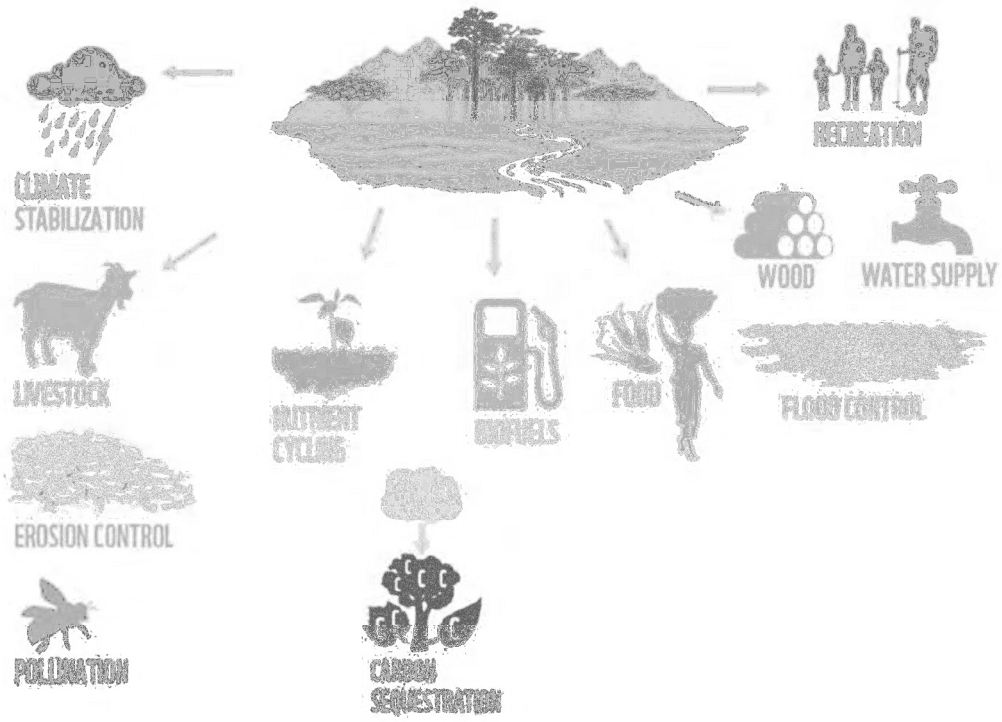
Introduction

Natural Capital is the stock of natural assets, which includes geology, soil, air, water and all living things. From this, humans derive wider natural capital flows in the form of ecosystem services, such as food, clean air, drinking water etc. It is these services which make human life possible.

The most obvious ecosystem services that we benefit from are food and water, as well as materials used for energy and building, and plants used for medicines.

However, there are less visible services provided by natural environments from which we benefit, such as flood protection, climate regulation and pollination. These services are underpinned by stocks of biodiversity. Figure 1 demonstrates some of the services which nature provides.

Figure 1; Ecosystem Services[2]



When we draw upon the natural environment for these services, this stock of natural assets can become degraded, which undermines the sustainability of populations and economies.

Whilst the natural environment is considered priceless, it is possible to understand the value of natural capital in monetary terms.

The Agricultural sector forms a significant part of the Northern Irish economy. The sector is made-up of 50,000 farmers,

[2] Ethical Corporation

contributing to 3.25% of total GVA, which equates to £1.1 billion per year[3]. A good quality natural environment underpins the farming industry without which the farming ecosystem cannot exist. Understanding and protecting the value of the services which underpin the agricultural environment in Northern Ireland is therefore important.

An economic assessment of the ecosystem services provided by agri-environment of some farming systems in Northern Ireland has been undertaken in order to determine the baseline value of the goods and services of three farming systems as outlined below;

- Dairy Farm;
- Sheep and Cow grazing with some crops;
- Upper hill farm.

The three farm systems are part of the wider CAFRE teaching estate. The operational and output costs for stock and goods have been apportioned to reflect that of a typical working farm system in line with advice from CAFRE staff members.

The following main ecosystem services have been measured and valued;

- Soil and nutrient cycling
- Water and flood protection
- Carbon storage and sequestration
- Air Pollution Regulation
- Education and recreation
- Food production

These have been assessed against key farm activities and natural assets as outlined in Figure 2 below.

Figure 2; Farm Assets

Site & Details	Habitat Assets	Asset Inputs
Dairy Farm	Improved Land Mixed Woodland Semi Improved Grassland Fen/ Swamp	Grassland Management Regime Habitat Soil testing results Productivity outputs – volume and cost Location maps, flood and insurance information Educational information i.e. students per year and education level Visitor numbers Productivity losses Details of ammonia abatement interventions All cost inputs

[3] Northern Ireland Assembly

Site & Details	Habitat Assets	Asset Inputs
Hill Farm Centre	Wet Heath Breeding Wader Site Rough Moorland Conifer Plantations Blanket Bog Semi Natural Grassland Semi Natural Low Input Semi Improved Grassland Species Rich Wet Grassland Improved Land	Grassland Management Regime Habitat and species details along with specific species where this exists plus area and any specific management plans Soil testing results Productivity outputs – volume and cost Built environment energy and water usage and any associated costs Location maps, flood and insurance information Recreational/ visitor information if relevant Productivity losses All cost inputs
Beef and Sheep Centre	Improved Land Parkland Mixed Woodland Semi Improved Grassland	Grassland management regime and stock grazing rotation Habitat details along with specific species where this exists plus area and specific management plans Soil testing results Productivity outputs – volume and cost Built environment, energy and water usage along with any associated cost Vet bills Location maps, flood and insurance information Educational details and outputs – i.e. number of students, levels of training etc Any recreational/ visitor information Ammonia abatement details Productivity losses

Methodology

In order to determine the wider economic impacts of natural capital, the Interserve valuation approach is based on a sub set of calculator tools. The tools assess the value of an outdoor space to produce a physical (i.e. tonnes of carbon, volume of water) and an economic value. Where it is not possible to deliver an economic value, wider qualitative values are included.

The benefits and negative impacts are assessed as stocks and flows based on the ecosystem services provided by the defined area.

The information is based upon publically available studies and sources from Defra, Natural England, Met Office etc. and in some cases is supplemented by specific studies and site data.

The valuation is based upon the input of site specific data and provides a more in-depth review of the impact of changing environments and funded

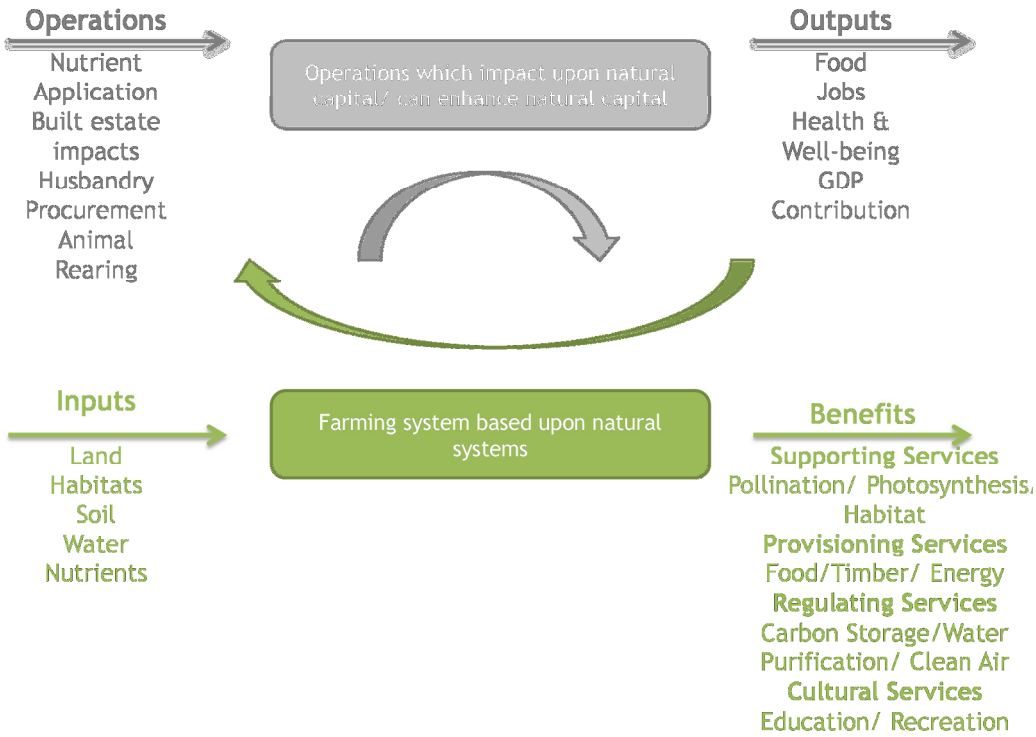
interventions which have created better quality green space, including the economic impacts on human health, education, and conservation. This methodological approach has previously been used to review development proposals, make cases for funding, and support planning and policy initiatives.

When utilising National Natural Capital Accounts methodology, the value of stock rearing has not typically been considered.

Therefore, the best approach is to understand and value the natural systems and the net impact of farming systems on natural assets and their ability to provide a flow of services. This will facilitate understanding of the wider impacts of stock rearing through the market value of the operations, plus the wider natural capital dependencies, such as energy and water use, along with waste production.

Additionally, educational and recreational services have been factored in to assess the wider value that these services bring to the local economy. Figure 3 demonstrates the interconnections between the natural system and the farm operations. As far as possible this study attempts to understand the connections between natural and farm systems to capture a true understanding of the natural capital dependencies and the impacts of improvements to farming operations. Furthermore, the study explores how changes in policy and markets, focussed in NI, may contribute to wider environmental, and economic well-being.

Figure 3; Natural Capital Dependencies and Impacts of a Farm System



In order to understand the impact of carbon, a standard set of sequestration and emission metrics have been applied to habitat types identified by CAFRE staff members. Once the habitat classification was determined, the appropriate carbon metric was applied as set out in the Natural England Paper "Carbon storage by habitat: Review of the evidence of the impacts of management
decisions and condition of carbon

stores and sources". In order to understand the value of carbon, a social price of carbon, as set out by the UK Government, has been utilised[4].

In order to calculate air pollution impacts, the Interserve Consulting air pollution regulation model was employed[5], utilising precipitation data provided by CAFRE, Northern Ireland Air Quality data, and price metrics set out by Government[6].

Water value has been calculated using precipitation data, habitat data, and assumptions made based upon site visits. The social price of water for the UK has been applied based upon work undertaken by WBCSB.

Nutrient cycling has been assessed based upon data provided by CAFRE and benchmarked against best practice[7], and the monetary value applied is based upon that of carbon relating to global warming potentials.

Educational services have been assessed based upon student number data, and monetary values have been derived from demographic and employment figures for Northern Ireland[8][9][10]. Where possible the potential impacts of a falling farm output and reduced employment as a result of Brexit have been calculated within the 30 year value.

Ecosystem Services

Ecosystem services are the goods and services provided by green areas and habitats that traditionally are not valued or are "hidden". These include carbon sequestration, pollution regulation and recreational services.

The ecosystem services valued within this assessment focus on the habitats at Wigan Flashes and the data available in order to determine their physical and monetary impacts. The services assessed for the purpose of this valuation include:

- Carbon Sequestration and Storage;
- Air Pollution;
- Climate Resilience;
- Water storage and retention;
- Flood Resilience;
- Soil and Nutrient Cycling;
- Education;
- Health and Well-being.

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[44] https://www.gov.uk/government/collections/carbon-valuation--2#social-cost-of-carbon
[5] http://www.forestry.gov.uk/pdf/airpollf.pdf/$file/airpollf.pdf

[6] https://www.gov.uk/guidance/air-quality-economic-analysis
[7] https://www.daera-ni.gov.uk/publications/nitrates-action-programme-2015-2018-and-phosphorus-regulations-workbook
[8] https://www.nisra.gov.uk/statistics/labour-market-and-social-welfare/annual-survey-hours-and-earnings

[9] https://www.nisra.gov.uk/sites/nisra.gov.uk/files/publications/Zx78P-labour-market-report-february-2018_1.PDF

[10]http://www.europarl.europa.eu/RegData/etudes/BRIE/2017/583116/IPOL_BRI(2017)583116_EN.pdf

The Cost of Carbon

A social cost of carbon has been applied for carbon sequestration and storage services. The social cost of carbon measures the full cost of an incremental unit of carbon emitted now, taking into account the full cost of the damage it imposes over the duration of time it is in the atmosphere. There are a number of methodologies to calculate the social cost of carbon, with a range of values as a result, the DICE model has been utilised within this study.

Net Present Value

Net present value (NPV) calculations have been used to take into account the value of the site over time. The time period used is 30 years, as is generally adopted[11], and a discount rate of 3.5% has been used in line with The Green Book recommendations.

Inflation

To account for currency inflation the nominal value of flows has been assumed to appreciate by 2% per year over the thirty year period.

Social Cost of Water

The social, or true cost of water, includes not only the supply costs, but also wider economic costs, and environmental and social externalities.
The social value of water used is the national value for the UK as a whole, based upon analysis carried out by TruCost[12]. Regionally specific data for the social value of water does not appear to be publically available. Therefore, the value used in this analysis is \$6.50 per m^3.

Hedonic Pricing of Cultural Services

High-level hedonic pricing analysis has been used in several places in this report, specifically for assessing house pricing impacts. This was carried out by applying the general analysis by Mourato[13] to Northern Ireland.

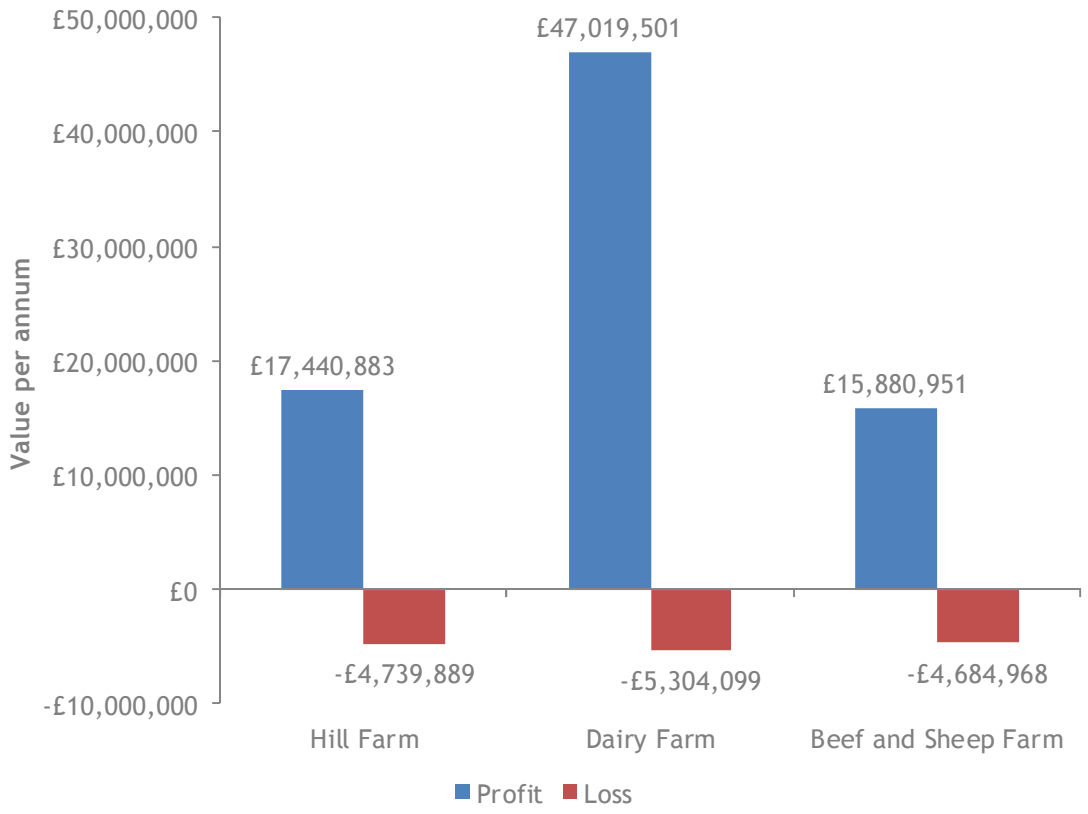
Baseline Natural Capital Account

Overall Value

The combined value of the three farms assessed is £78 million per annum (non-discounted) based on 2016 data. The split in value for each farm area, derived from ecosystem services, including provision services and education are detailed in Figure 4.

[11] H.M Treasury, *The Green Book*, 2016
[12] TruCost
[13] NEA Chapter 22, *Economic Values From Ecosystems*

Figure 4; Ecosystem Services Flow Value of CAFRE Farms



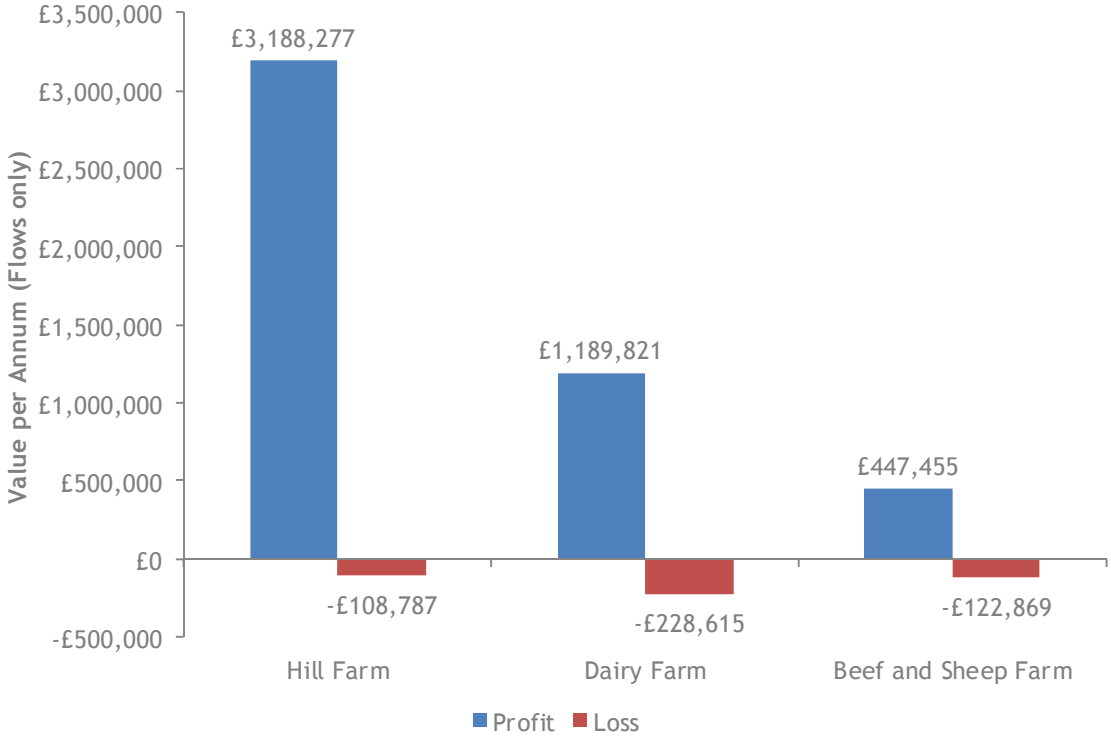
It is clear from Figure 3 that the Dairy farm generates the most value, but also incurs higher losses.

These losses, outlined above in monetary terms, are associated with the function of ecosystem services. For example, an increase in runoff and flood risk, or reduced ability to cycle certain nutrients, along with the costs of running each of the farms.

The values within Figure 4 include provisioning services, such as milk, wool etc. and the wider economic impacts of the educational activities on the farm. If these are discounted, and the "natural" ecosystem service values are reviewed, as demonstrated in Figure 5 overleaf, it is clear that the value provided by each of the farms is altered, with the Hill Farm providing the highest value in natural capital.

Figure 5 demonstrates that when the flow of value associated with the provision of college courses across CAFRE farms, and the value of provisioning farm products are discounted from the overall value, the Upper Hill Farm provides a much higher flow of services than either the Dairy or Beef and Sheep Farm. This is based upon both the assets within the farm but also through its specialist management practices for environmental stewardship.

Figure 5; "Nature" Based Ecosystem Services Flow Value of CAFRE Farms

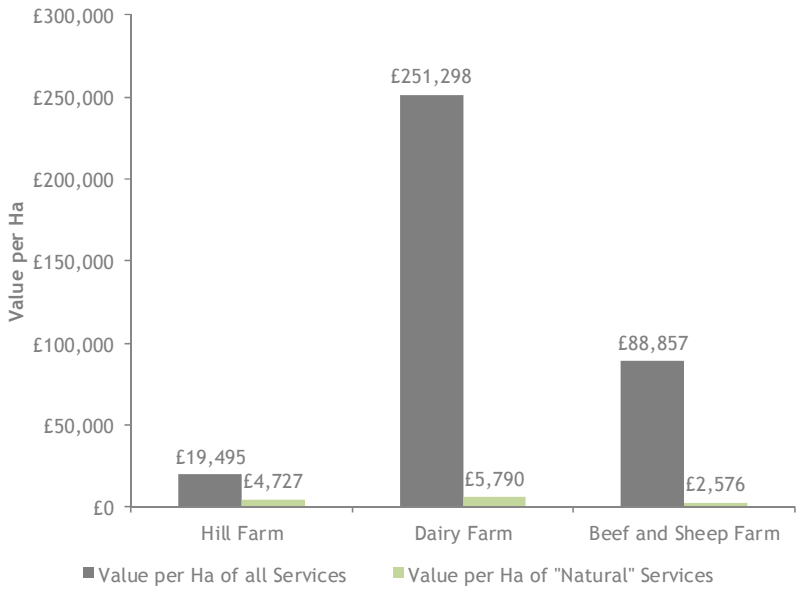


The Upper Hill Farm is larger than both the Dairy and Beef and Sheep Farm, and contains natural assets that the other farms do not. The Upper Hill Farm has particularly high quantities of peat, increasing the value of the ecosystem services provided.

When the value of the services are normalised against the area of the farm, as demonstrated in Figure 6, it is clear that the largest value per hectare is derived from the dairy farm. However, this is due to it being a smaller area than the Hill Farm. Despite the area assessed for the hill farm being four times greater than the assets at the dairy farm, there is only £1000 difference in the value of the natural capital derived from the farm.

Additionally, there is a smaller delta between the total value derived from the Hill Farm, and that derived from natural assets beyond food and educational provision.

Figure 6; Value of Natural Capital per Hectare per Farm System



Upper Hill Farm

Site Overview

Upper Hill Farm is situated in the Antrim Hills, and is partially situated within the Antrim Hills Special Protection Area for hen harrier and merlin; it covers 1040 ha, and is utilised for livestock grazing.

Grazing livestock is key to managing the land and the habitats on the farm, including delivering on environmental outcomes.

The farm is utilised extensively for educational and training purposes and to facilitate knowledge sharing in sustainable farming practices.

Much of the area is characterised by wet heath, with wider blanket bog and grassland areas and some conifer plantations (partial conifer removal is planned towards the end of 2018). The main habitat types are outlined in Figure 2; Farm Assets distribution is demonstrated in Figure 7. Figure 8 demonstrates the assets reviewed and assessed as part of this study.

Figure 7; Distribution of Habitat Assets at Upper Hill Farm

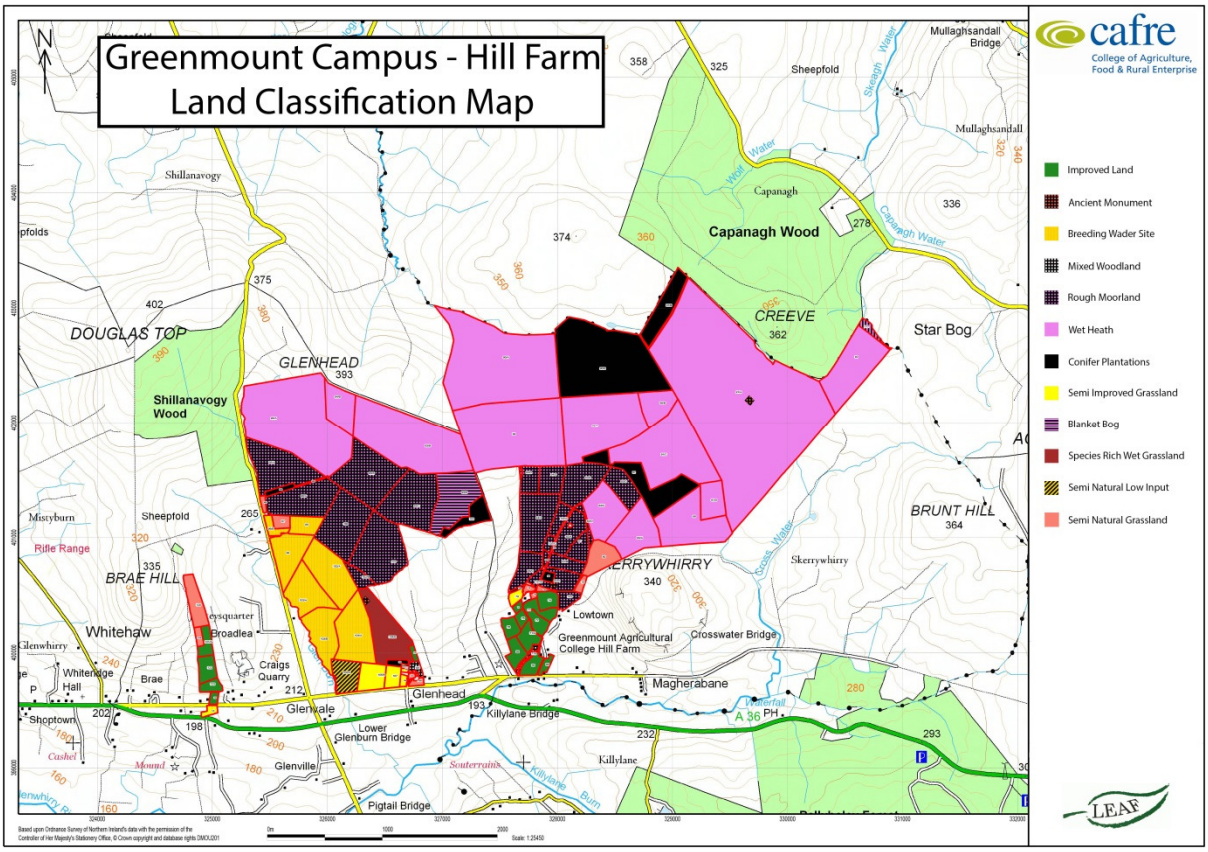


Figure 8; Upper Hill Farm Natural Capital Assets

Asset	Area (ha)	Condition	Distinctiveness	Biodiversity Value per Ha
Wet Heath	345	Moderate	High	8
Peat	345	Moderate	High	8
Breeding Wader Site	60	Moderate	High	8
Rough Moorland	125	Moderate	High	8
Conifer Plantations	45	Poor	Low	2
Blanket Bog	13.5	Moderate	High	8
Semi Natural Grassland	8.5	Moderate	Low	4
Semi Natural Low Input	4	Moderate	Low	4
Semi- Improved Grassland	9	Moderate	Low	4
Species Rich Grassland	16.5	Moderate	Medium	8

Qualitative Assessment of Ecosystem Services

Not all ecosystem services can be assessed based upon monetary valuation; however that is not to say that there is no value derived from such services. Furthermore, it is not possible to put a monetary value on some ecosystem services, such as albedo regulation and pollination.

The ecosystem services assessed and reviewed are outlined in Figure 9 and provide detail on how the farm system delivers these.

Figure 9; Qualitative Review of Ecosystem Services Provided by Upper Hill Farm

Type of Service	Ecosystem Service	Provision	Provisioning Assets
Provisioning	Food	High provision given the nature of the land use	All except conifer plantation
	Wool	High provision, lower than food, but provides income stream based upon the animal rearing which takes place	All except conifer plantation
Regulating	Carbon Sequestration and Storage	High given peatland Although the livestock grazing gives way to overall GHG emissions	All Assets Peat provides high level of both storage and sequestration. Conifer plantations provide decent carbon sequestration but this will be impacted by removal
	Climate Regulation (Albedo)	Medium.	The nature of the area provides a natural cooling based on habitat coverage, and transpiration; however there is no large immediate urban population from which there is a direct benefit, but the area will impact upon the local micro climate.
	Air quality regulation	Medium	The conifer plantation will provide some regulation of air quality (although this is being largely removed) along with some provision by grassland. However, due to the location of the farm, there are no large populations that will benefit directly, but there will be indirect benefits.
	Water Quality Regulation	High	Peat is present and will filtrate and cleanse water to a high level, although there may be some degree of nutrient residue at lower levels.

Type of Service	Ecosystem Service	Provision	Provisioning Assets
	Flood Regulation	High	Due to both peat, and presence of wider habitats, it's thought that there is extensive slowing of water flow through the hill farm habitat. Although there are no populations that will directly benefit from this, the slowing of water in higher catchment areas is known to aid in flood reduction downstream.
	Pollination	Medium	Due to the heather and the differing grassland, pollination provision is thought to be medium. Although the heather habitat is in moderate condition, it could be better connected as a whole, although heather attracts key pollinators such as bees.[14]
	Pest and Disease Regulation	Medium	Due to the varied habitat, it's thought that there will be some degree of pest and disease regulation offered by the genetic diversity of the habitats.
	Nutrient regulation	High	There are low stocking levels resulting in reduced trampling and nutrient loading, furthermore the presence of peat enhances denitrification.
	Biodiversity and habitat provision	High	The area is an SPA and supports areas of high distinctiveness, please see Figure 7 for more details.
Cultural	Education	High	The site exists to teach students and aid in knowledge share, especially with regard to sustainable land practices.
	Recreation	Medium	The site is closed off to the public, but offers some opportunity for bird watchers, and the Ulster Way runs through part of the area.
	Health and Well-being	Low	The farm is quite remote and not located close to any urban area, therefore due to lack of proximity this is thought to be low.

[14] The National Pollinator Strategy

Type of Service	Ecosystem Service	Provision	Provisioning Assets
	Aesthetic and Cultural	High	The uplands have been managed with sustainability and environmental stewardship in mind, therefore fit with the general aesthetic of the local area.

The assets across the Upper Hill farm which have been assessed, are thought to provide services across the range of provisioning and regulating services to varying degrees.

All assets are considered to provide cultural, aesthetic, pollination and educational services. It is thought that the peat and heath habitats and their underlying condition are responsible for the highest service provision; given both their biological and physical cycling abilities, and their ability to support biodiversity.

Due to the nature of the activities which take place on the Hill Farm, the highest provision of services is thought to come from the provision of food services and the educational services delivered by the farm.

Due to the use of resources within the farm system, such as water harvesting, and use of slurry/manure, there are wider positive impacts on natural capital through reduced resource and raw material impact.

Based upon the biodiversity value, as outlined in Figure 7, it is those assets with a higher biodiversity score which are qualitatively determined to have the higher provision of natural services.

Physical and Monetary Flow Accounts

The value of ecosystem services from the Hill Farm is based on 2016 data over a 30 year period. It includes the stock of carbon within peat which is £404,836,720, with the aggregated value of services for the annual period throughout 2016 estimated at £11,727,165, including losses.

This includes provisioning services of £100,000 per annum and educational benefit (due to teaching activities at the CAFRE site) of £10 million per annum.

Excluding provisioning services and the educational value of the farm, the natural capital services value is (including carbon stock) £3.1 million per annum. Should the farm area continue to be managed in the current way, without any significant changes to environmental stewardship, the value of the assets and the flow of services will remain at much the same level, but will appreciate in economic value over time (peat and heather ecosystems in particular, have the potential to increase over time).

Much of the value derived from the services comes from three main areas;

- Carbon Sequestration by peat;
- Water filtration by peat and;

- Air pollution regulation by the conifer plantations and grassland areas.

Proposals to remove some of the conifer plantation areas have been considered in both the carbon and air pollution calculations.

The largest loss of flow of services comes from carbon released by grazing animals, especially cows. However, this is offset by the sequestration properties of the peat.

Due to the peat development on the site and stocking densities, soil is in a good condition. Although there are negative impacts associated with the regulation of nitrogen in some areas, the overall impact is positive with nitrogen regulation valued at an average of £1.5 million per year (non-discounted). Due to the condition of the peat, and the expected improvement going forward, the value is thought to be much greater as a result of the denitrification processes which naturally occur through the formation and regulation of healthy peat ecosystems. This would compound any impact of nitrogen stocking as a result of animal rearing.

Although the Hill Farm is rural, the impacts of air pollution regulation are approximately £120,000 per annum based on the regulation of PM_{10}, SO_x and NO. This figure is the mitigated costs of healthcare as based on a UK average as outlined within the methodology.

Appendix A contains a copy of the Upper Hill Farm natural capital baseline account for 2016 and the 30-year value based upon no changes to the management of the farm.

Overall, the Hill farm was deemed to have a net positive impact on the environment, with its defined assets in a good to moderate condition, as a result of good management.

Figure 10 demonstrates the annual physical environmental benefits delivered by the Hill Farm.

Figure 10; Physical Benefits Delivered by the Flow of Ecosystem Services from the Upper Hill Farm

Ecosystem Service	Air Pollution	Carbon	Water	Nutrient Cycling
Physical Benefit	4 tonnes of PM10 3 tonnes of SOx 49 tonnes of NOx	13,000 tonnes CO2e per annum	51,000 m3/ annum	62 tonnes of nitrogen per annum

The conifer plantations are not in equivalent condition to the rest of the Hill Farm assets. However, plans are in place to remove the conifer plantations. which will impact upon the air quality regulation at the Hill Farm and reduce the ability of the conifer assets to regulate air pollution by 75%.

The carbon and water benefits are significant due to the good

condition of the peat. If the peat remains protected from disturbance, it will deliver increased benefits through enhanced carbon sequestration. The amount of carbon sequestered by the peat could reach up to 40,000 tonnes per annum. The peat will continue to act as a natural water filter, absorb rainfall, thus helping to re-charge water courses.

Due to the presence of the peat, nitrogen is cycled to reduce nutrient leaching, and reduce the global warming impact of inefficient nitrogen cycling. This is mitigated further by the sustainable stocking densities and grazing regime.

Dairy Farm

Site Overview

The Dairy Farm is part of the wider Greenmount Campus in close proximity to Antrim, and is made up of 170 ha of mixed lowland for grazing 180 dairy cows.

Much of the farm area is characterised by grassland for grazing, and there is some woodland which forms part of the wider Dairy Farm area.

The main habitat types have been outlined in Figure 2. Farm Assets distribution is demonstrated in Figure 11. Figure 12 demonstrates the assets reviewed and assessed as part of this study.

Figure 11; Distribution of Habitat Assets at the Dairy Farm

Figure 12; Dairy Farm Natural Capital Assets

Asset	Area (ha)	Condition	Distinctiveness	Biodiversity Value per Ha
Improved Land	116.2	Good	Medium	12
Mixed Woodland	33.2	Good	High	18
Semi Improved Grassland	8.3	Good	Medium	12
Fen / Swamp	8.3	Moderate	Low	4

Qualitative Assessment of Ecosystem Services

Not all ecosystem services can be assessed based upon monetary valuation; however that is not to say that there is no value derived from such services. Furthermore, it is not possible to put a monetary value on some ecosystem services, such as albedo regulation and pollination.

The ecosystem services assessed and reviewed are outlined in Figure 13 and provide detail on how the farm system delivers these.

Figure 13; Qualitative Review of Ecosystem Services Provided by the Dairy Farm

Type of Service	Ecosystem Service	Provision	Provisioning Assets
Provisioning	Food	High provision given the nature of the land use	Grassland and improved land areas
Regulating	Carbon Sequestration and Storage	Medium	Woodland and woodland soil will provide the bulk of sequestration and storage although grassland and grassland soil will to some extent
	Climate Regulation (Albedo)	Medium.	All assets will provide cooling at a microclimate level to Antrim in particular
	Air quality regulation	High	Woodland, with some contribution from grassland, given the area suffers from periods of high air pollution, and is close to Antrim

Type of Service	Ecosystem Service	Provision	Provisioning Assets
	Water Quality Regulation	Medium	There is no evidence of water logging or trampling, and grassland and woodland areas are in a good condition, therefore water filtration and cleansing is thought to be typical for these areas and contribute to wider availability of green water
	Flood Regulation	High	All assets demonstrated no trampling or water logging and are though to have a soil composition associated with the slowing of water to water courses and the local population
	Pollination	High	There is a good mix of woodland, grassland and pollinator strips in some areas, which are thought to provide adequate resource for the attraction of key pollinators
	Pest and Disease Regulation	Medium	Due to the varied habitat it's thought that there will be some degree of pest and disease regulation offered by the genetic diversity of the habitats across all assets.
	Nutrient regulation	High	All assets, there are no obvious signs of nutrient deficiencies, and woodland growth is good.
	Biodiversity and habitat provision	High	Whilst visiting site there were a number of species noted that are BAP priority areas for NI, and supported a range of birdlife and small mammals.
Cultural	Education	High	The farm is used for educational purposes
	Recreation	Medium	There are paths and walkways adjacent to the dairy farm land which are used by the general public
	Health and Well-being	Medium	In addition to access to parts of the estate, there are also views from parts of Antrim over the woodland assets in particular, which is known to have health and well-being benefits.
	Aesthetic and Cultural	Medium	All assets provide teaching experiences in line with the needs for NI farming.

The assets across the Dairy farm which have been assessed are

thought to provide services across the range of provisioning and regulating services to varying degrees, with the exception of the fen/swampland, which is man-made, and regulates run off from the yard area for the wider campus.

Due to the nature of the activities which take place on the Dairy Farm and the relatively high cost associated with these, the highest provision of services is thought to come from the provisional food services and the educational services delivered by the farm.

Although all assets are considered to provide cultural, aesthetic, pollination and educational services, it is thought that the woodland habitat and its underlying condition is responsible for the highest service provision; given both their biological and physical cycling abilities, and their ability to support biodiversity.

Based upon the biodiversity value, as outlined in Figure 11, it is those assets with a higher biodiversity score (i.e. woodland) which are qualitatively determined to have the higher provision of natural services.

Physical and Monetary Flow Accounts

The value of ecosystem services from the Dairy Farm (based on 2016 data over a 30-year period) is £1,274,552,223. The aggregated value of services for 2016 is estimated at £41,715,402 (including losses).

This includes provisioning services of £30 million per annum and educational benefit of teaching activities at the CAFRE site of £10 million per annum.

Excluding provisioning services and the educational value of the farm, the natural capital services value is £961k per annum (including carbon stock). Should the farm area continue to be managed in the current way, without significant changes to environmental stewardship, the value of the assets and the flow of services will remain at much the same level, but will appreciate in economic value over time (peat and heather ecosystems in particular, have the potential to increase in value over time).

Much of the value derived from the services provided comes from:

- Air Pollution Regulation;
- Health and well-being;
- Nitrogen cycling;
- Water treatment and capture;
- Carbon sequestration.

Although the value of carbon sequestration across the Dairy farm is approximately £1.2 million per year, this is offset by the largest loss, which is a -£4.2 million from cattle rearing and production.

There is a £600k per annum benefit to the local community through air pollution regulation, and the provision of cleaner air, and a further £300k a year benefit through health and well-being benefits based on the proximity to Antrim. This value is only based on the access and view across the woodland areas of the dairy farm boundary and has the potential to be higher.

The provision of green water availability by the site through treatment by the woodland and grassland areas is estimated at £30k per annum based upon the social value of water. The value of good nitrogen regulation within the farming system adds further value of £230k per annum.

There are some losses associated with phosphorus and potassium levels and availability. However, the impact of these over an annual period is -£0.00004 and -£666 respectively.

Appendix A contains a copy of the Dairy Farm natural capital baseline account for 2016 and the 30-year value (based on the assumption that there are no future changes to the management of the farm).

The dairy farm was deemed to have a net positive impact on the environment, with its defined assets in a good to moderate condition, as a result of ongoing management in line with the cores of LEAF and effective environmental stewardship.

Figure 14 demonstrates the annual physical environmental benefits delivered by the Dairy Farm.

Figure 14; Physical Benefits Delivered by the Flow of Ecosystem Services from the Dairy Farm

Ecosystem Service	Air Pollution	Carbon	Water	Nutrient Cycling
Physical Benefit	2.5 tonnes of PM10 1.7 tonnes of SOx 25 tonnes of NOx	1991 tonnes CO2e per annum	6621 m3/ annum	-0.16 tonnes P -2.8 tonnes of K 14 tonnes of nitrogen per annum

The woodland is in excellent condition, supporting a wide range of birdlife which indicates good biodiversity.

While carbon and water provide the largest physical benefit, the removal of key air pollutants by the woodland areas is important for air quality.

It is not anticipated that there will be any significant increase in farm carbon sequestration unless the area of woodland is increased.

Although the woodland area is small in scale compared with the other assets, it is the most valuable given its role in pollution, carbon, water and nutrient regulation.

Given the good condition of the soil, it is able to both treat and filter water in order to recharge green water supplies.

Beef and Sheep Farm

Site Overview

The Beef and Sheep Farm is also part of the wider Greenmount

Campus in close proximity to Antrim, and is made up of 130 ha of mixed lowland for grazing of 50 suckler cows and 200 finishing cattle, along with 75 ewes.

Much of the farm area is characterised by grassland for grazing, and there is some woodland which forms part of the wider Beef and Sheep Farm area, and part of this is being developed further. There was previously an organic farm system within the Beef and Sheep farm but this no longer exists.

In addition to grazing, as with the other farm sites, the site is extensively used for educational purposes.

The main habitat types have been outlined in Figure 2; Farm Assets distribution is demonstrated in Figure 15. Figure 16 demonstrates the assets reviewed and assessed as part of this study.

Figure 15; Distribution of Habitat Assets at the Beef and Sheep

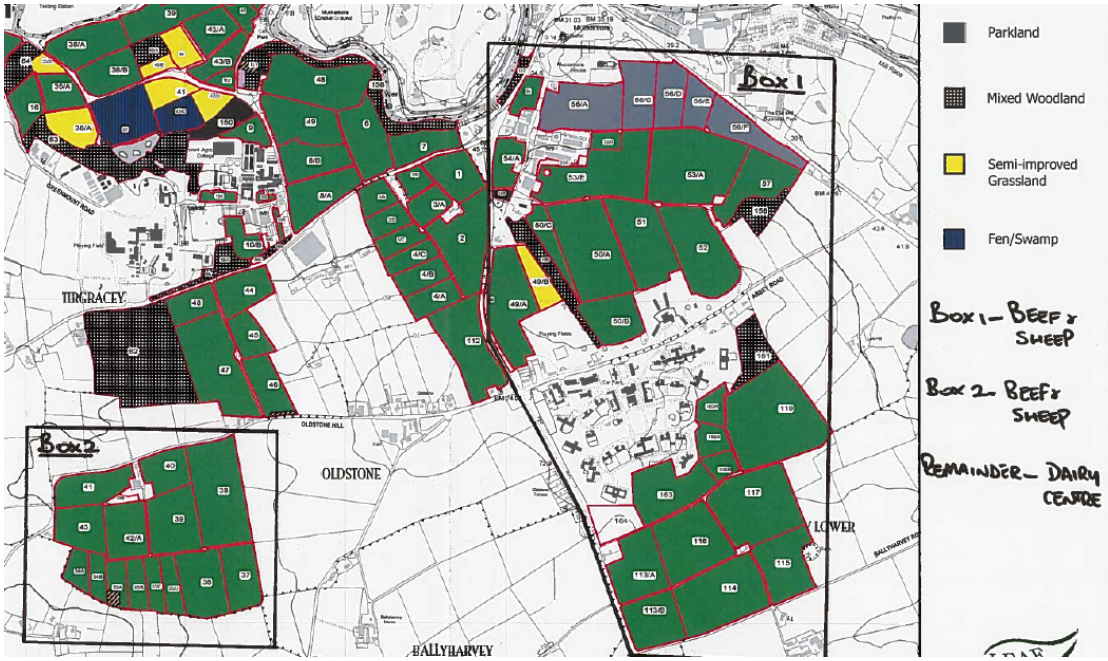


Figure 16; Beef and Sheep Farm Natural Capital Assets

Asset	Area (ha)	Condition	Distinctiveness	Biodiversity Value per Ha
Improved Land	100.8	Good	Medium	12
Parkland	12.6	Good	High	18
Mixed Woodland	8.8	Moderate	High	12
Semi Improved Grassland	3.8	Moderate	Low	4

Qualitative Assessment of Ecosystem Services

Not all ecosystem services can be assessed based upon monetary valuation; however that is not to say that there is no value derived from such services.

Furthermore, it is not possible to put a monetary value on some ecosystem services, such as albedo regulation and pollination.

The ecosystem services assessed and reviewed are outlined in Figure 17 and provide detail on how the Beef and sheep farm system delivers these.

Figure 17; Qualitative Review of Ecosystem Services Provided by the Beef and Sheep

Type of Service	Ecosystem Service	Provision	Provisioning Assets
Provisioning	Food	High provision given the nature of the land use	Grassland and improved land areas
Regulating	Carbon Sequestration and Storage	Medium/Low	Woodland and woodland soil will provide the bulk of sequestration and storage although grassland and grassland soil will to some extent. However, not all woodland areas are well developed, or are being developed, therefore the extent of the carbon storage and sequestration is reduced.
	Climate Regulation (Albedo)	Medium.	All assets will provide cooling at a microclimate level to Antrim in particular
	Air quality regulation	High/ Medium	Woodland, with some contribution from grassland, given the area suffers from periods of high air pollution, and is close to Antrim, although the development of some woodland areas will reduce the impact.
	Water Quality Regulation	Medium	There is no evidence of water logging or trampling, and grassland and woodland areas are in a good to moderate condition, therefore water filtration and cleansing is thought to be typical for these areas and contribute to wider availability of green water
	Flood Regulation	High	All assets demonstrated no trampling or water logging and are thought to have a soil composition associated with the slowing of water to water courses and the local population

Type of Service	Ecosystem Service	Provision	Provisioning Assets
	Pollination	High	There is a good mix of woodland and grassland, which are thought to provide adequate resource for the attraction of key pollinators
	Pest and Disease Regulation	Medium	Due to the varied habitat it's thought that there will be some degree of pest and disease regulation offered by the genetic diversity of the habitats across all assets.
	Nutrient regulation	High/ Medium	All assets, there are no obvious signs of nutrient deficiencies.
	Biodiversity and habitat provision	High	Whilst visiting site there were a number of species noted that are BAP priority areas for NI, and supported a range of birdlife and small mammals.
Cultural	Education	High	The farm is used for educational purposes
	Recreation	Medium	There are paths and walkways adjacent to the farm land which are used by the general public
	Health and Well-being	Medium/Low	There is some access, and offers some view from residential areas, which add to health and well-being benefits.
	Aesthetic and Cultural	Medium	All assets provide teaching experiences in line with the needs for NI farming.

The assets across the Beef and Sheep farm which have been assessed are thought to provide services across the range of provisioning and regulating services to varying degrees. However, there is reduced public access to parts of the woodland, which reduces both recreational and health and well-being benefits. However, the woodland being developed adjacent to the hospital will, in due course, offer a higher level of provision, from a health and well-being perspective and in terms of wider carbon and air pollution regulation.

Due to the nature of the activities which take place on the beef and sheep farm and the relatively high market cost associated with these, the highest provision of services is thought to come from the provision of food services and educational services delivered by the farm.

All assets are considered to provide cultural, aesthetic, pollination and educational services. It is thought that the woodland habitat and its underlying condition are responsible for the highest natural service provision, given both their biological and physical cycling abilities, and their ability to support biodiversity. However, this could be

improved through continued management and habitat maturation.

Based upon the biodiversity value, as outlined in Figure 16, it is those assets with a higher biodiversity score (i.e. woodland) which are qualitatively determined to have the higher provision of natural services.

Physical and Monetary Flow Accounts

The value of ecosystem services from the Beef and Sheep (based on 2016 data over a 30-year period) is £362,222,700. The aggregated value of services for 2016 is estimated at £11,195,983 (including losses).

This includes provisioning services of £827k per annum, and educational benefit due to teaching activities at the CAFRE site of £10 million per annum.

Excluding provisioning services and the educational value of the farm, the natural capital services value (including carbon stock) is £324k per annum. If the farm area continues to be managed in a similar way, without any significant changes to environmental stewardship, the value of the assets and the flow of services will remain at much the same rate, but will appreciate in economic value over time (peat and heather ecosystems in particular, have the potential to increase in value over time).

Much of the value derived from the services comes from:

- Air pollution regulation;
- Nitrogen cycling;
- Carbon sequestration and;
- Water Cycling.

The highest value from the flow of ecosystem services is £225k per annum from nitrogen regulation. Due to the management practices on the site, there is a positive impact upon how nitrogen is cycled, resulting in positive denitrification processes, and reduced pollution and climate change impacts.

There is a carbon sequestration benefit of £57k per annum, but this is counteracted by emissions through sheep and cattle rearing, with a value of -£110k per annum.

Air pollution regulation through both woodland and grassland regulation contributes a wider social value to the Northern Ireland economy of £155k per annum through reduced healthcare costs and productivity increase.

The management of the site includes biological water treatment, which increases green water availability in Northern Ireland to a value of £10k per annum.

Appendix A contains a copy of the Beef and Sheep Farm natural capital baseline account for 2016 and the 30-year value based upon no changes to the management of the farm.

As with both the hill and dairy farms, the beef and sheep farm was deemed to have a net positive overall impact on the environment, despite the impact of animal rearing, with its defined assets in a good to moderate condition, as a result of good management.

Figure 18 demonstrates the annual physical environmental benefits

delivered by the Beef and Sheep Farm.

Figure 18; Physical Benefits Delivered by the Flow of Ecosystem Services from the Beef and Sheep

Ecosystem Service	Air Pollution	Carbon	Water	Nutrient Cycling
Physical Benefit	0.8 tonnes of PM10 0.5 tonnes of SOx 9 tonnes of NOx	733 tonnes CO2e per annum	5873 m3/ annum	-0.13 tonnes P -2.8 tonnes of K 14 tonnes of nitrogen per annum

The woodland and parkland are in good condition in some areas. These areas displayed a wide range of birdlife which indicates good biodiversity.

While carbon and water offer the largest physical benefit, the removal of key air pollutants by the woodland areas is important for local air quality. However, the benefit to air quality is much less than the Hill and Dairy farms, given the smaller the area of woodland.

The proposed creation of new woodland will further enhance ecosystem services, but not until both the quality of this area has been improved upon, and the trees planted in this area are more mature. This will also increase the carbon and water benefits, in addition to wider societal benefits through hospital patients utilising this area.

It is not anticipated that there will be any significant increase in the farm areas ability to sequester carbon, without a much greater change in the area of woodland. Although there is some woodland creation taking place, the area being developed is small in relation to the rest of the farm. Improvements in the condition of the woodland area adjacent to the hospital are required to deliver increases in the services associated with woodland. It is thought that the existing management plan will deliver co-benefits once the area has had time to establish over the next five to ten years, delivering maximum benefit after approximately 15 years.

As with the dairy farm, although the woodland area is small compared with the other assets, this asset is the most valuable as it offers higher rates of pollution, carbon, water and nutrient regulation.

Due to the good condition of the soil, it is able to both treat and filter water in order to recharge green water supplies. The soil nutrient content is very similar to the Dairy farm, which demonstrates a consistent approach to soil management.

Conclusions & Recommendations

Air Pollution

Although the farms operate in a rural environment, the flow of services to the wider community and society through the regulation of air pollution is valued at £1.9 million per annum. This is based on the reduction of key pollutants with known detrimental health impacts, which are targeted for reduction.

The £1.9 million impact is the calculated benefit to healthcare cost savings and productivity as result of reduced hospital emissions and a healthier, more productive population.

Air pollution levels, in Belfast especially, are some of the worst in the UK, and there are moderately high levels demonstrated previously in the Ballymena area[15].

Periods of higher than average air pollution are associated with human health problems, especially those with heart or lung issues.

Woodland and grassland areas produce farm outputs while mitigating air pollution on the farm.

As there is a larger grassland area than woodland area, there is a greater flow of regulatory services from the grassland. Furthermore, as the conifer areas at the Upper Hill Farm will be removed this will reduce the capacity for air pollution regulation.

However, woodland areas better regulate air pollution than grassland areas. Therefore, improvement of conifer and deciduous assets, would increase the ability of the farm areas to regulate air pollution and add to wider health and social value. Reduction in air pollution can have further health benefits relating to dementia resulting in wider value creation[16], however this would need to be paired with an Eco therapy type approach, utilising the estate across the CAFRE farms.

Recommendation 1; Increase woodland and better quality grassland areas for the regulation of key air pollutants

By increasing the quality and to some extent the area of specific land assets which are effective in regulating pollution, and offering dual benefits of food provision, plus other ecosystem services, the overall productivity of the area can be increased.

This action must not be detrimental to other assets, and is more likely to have more impact at both the dairy, and beef and sheep farms.

In order to increase potential funding to incentivise woodland creation and enhance the capability of air pollution regulation across the farm areas, a partnership approach is recommended, potentially with the PHA.

Collaboration of resources could help both PHA and farms, and it may be worthwhile engaging with the wider public through a volunteer programme. This would provide

[15] Pollution Solutions
[16] A review of nature based interventions for mental health

added value through education and health and well-being benefits. In some instances, it could be beneficial to allow succession of current pasture areas, to wildflower and woodland habitat, whilst maintaining grazing. This would increase biodiversity, reduce trampling, increase nutrient cycling and water treatment, and enhance air pollution regulation. This would be most beneficial at the dairy and beef and sheep farms.

Ammonia has a significant impact on both air quality and in deposition across Northern Ireland and can impact upon the natural capital value of a farming system. However, it has not been fully assessed in this study due to resource and time constraints.

Recommendation 2; Undertake a wider natural capital/ ammonia focussed study to understand the impacts of ammonia on the agri-environment

Given the impacts and ongoing concern regarding ammonia[17] deposition on agricultural land in Northern Ireland, it would be worthwhile assessing how farm based interventions will impact upon this baseline, and if this creates an overall benefit to natural capital.

This may form part of a wider study looking at a natural capital account for wider habitat and natural assets across Northern Ireland.

When making decisions relating to the creation or succession of habitat to regulate air pollution, they should be in line with BAP habitat, and focus on mixed broadleaf species where woodland type habitat is to be created.

Carbon

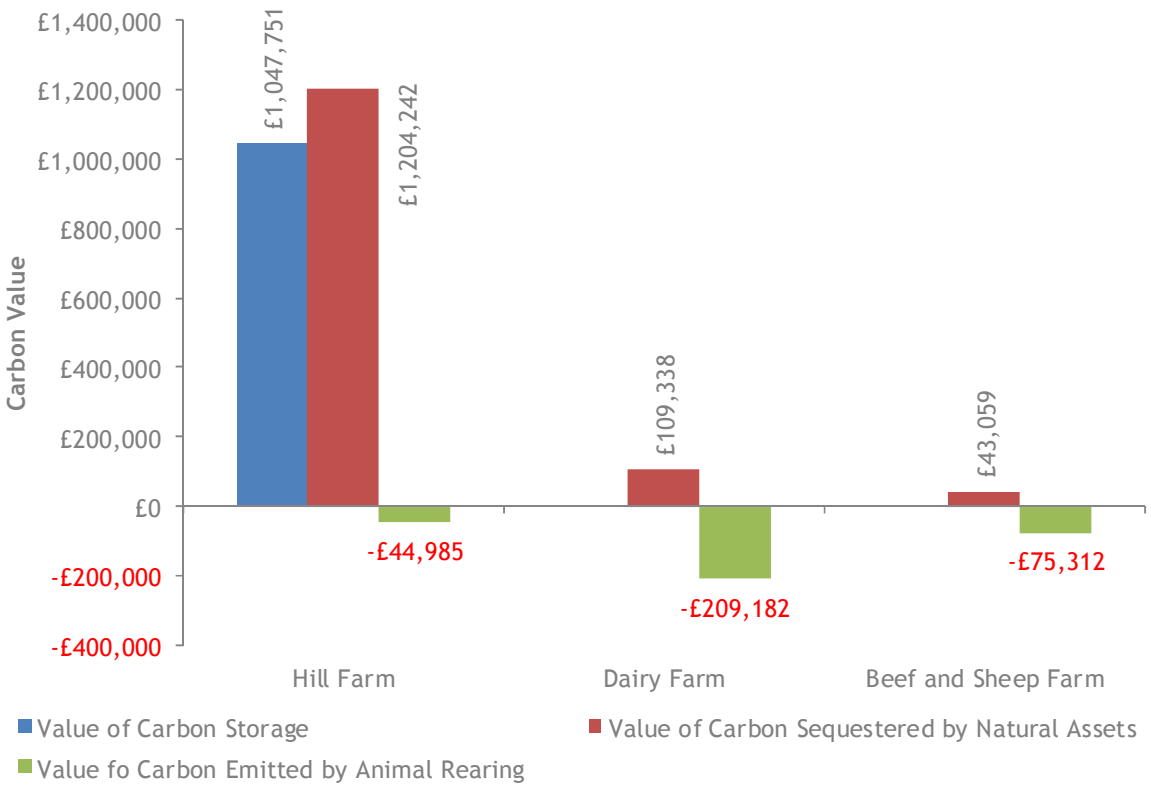
There is significant carbon (both positive and negative) impact as a result of farming practices across the three sites assessed.

The rearing of cattle and sheep is an environmentally intensive practice. Farming cattle is more carbon intensive than farming sheep. Therefore, there is a higher carbon impact, and negative value, associated with cattle farming activities.

Overall, the sequestration of carbon negates the impact of carbon emitted by sheep and cattle. However, this is due to the impact of the peat at the Upper Hill Farm. Figure 19 demonstrates the net carbon benefit of each of the farms.

[17] Making Ammonia Visible

Figure 19; Value of Carbon Services within each Farm System



From Figure 18 it is clear that both the Dairy Farm and the Beef and Sheep Farm emit more carbon per year through animal rearing than that sequestered through natural assets, such has the grassland and woodland assets.

The Upper Hill Farm has much lower stocking densities than the other farming systems, resulting in wider habitat and peat development, especially at higher levels, where grazing does not take place. As a result, both heather and peat are developing, increasing both biodiversity, and carbon sequestration capability.

It is projected that as grazing of this nature continues, the peat will further develop, increasing the Hill Farms ability to sequester carbon and cycle water. This also supports biodiversity and increases the associated monetary value.

Recommendation 3; Increase the amount of habitat areas which sequester carbon

As discussed in Recommendation 1, in some instances it could be beneficial to allow succession of current pasture areas, to wildflower and woodland habitat, whilst maintaining grazing. This would increase biodiversity, reduce trampling, increase nutrient cycling and water treatment, enhance air pollution regulation, and increase carbon sequestration. This would be most beneficial at the dairy and beef and sheep farms.

For example, to negate the impact of the beef and sheep farm requires increased woodland coverage which is allowed to mature over time by 6.6 ha. Creating larger areas of mixed woodland within the boundary of the dairy and beef and

sheep farms as part of a wider offset scheme could be viable. Given changes to farm payments after Brexit, a "Farm Woodland Offset" scheme could be created. This would require the creation of an accredited offset scheme, tailored to Northern Ireland farms and potentially other businesses. Emissions offsets could be offered at a market price, and could form supplementary income. This would also offer wider ecosystem services. At present there is no formalised market for these, although carbon pricing structures and markets exist. It would be possible to maintain animal production, although tree protection would be required through the early stages of growth.

Depending on the price of carbon applied, there is an estimated value of £1600 to £3600 per ha of mixed woodland creation per annum.

Recommendation 4; Increase in Peat Eco-system utilising the Peatland Code

Peat within the Upper Hill Farm is well established; however the peatland code focusses on restoration of peatland areas. Through appropriate understanding of the wider peat area, it would be possible to increase this important habitat area, whilst receive funding for activities associated with the restoration of peat.

Much of the payments via the Peatland code will be aligned to payments received for environmental stewardship that NI farms may already receive, aligned to specific management activities. Therefore many farmers may already be familiar with the management practices, although the payments received may vary. It is not possible to understand changes to payments at present, but there may be dual benefits of carbon sequestration via a Peatland Code alignment, in addition to environmental stewardship payments via a revised CAP based system.

Given that carbon sequestration services provide some of the highest values (due to the social cost of carbon), it would be a good area to focus on, in terms of biodiversity and environmental improvements for the creation of new funding streams.

Brexit could impact upon both profitability and productivity of farming. Price increases could result in reduced stocking densities, and therefore lower productivity, and reduced emissions from grazing stock, which would have a further net positive impact upon the environment, but farm profitability would suffer.

Changing demands in consumer decisions around meat, and an increase in vegan diets, could impact upon the profitability of the farm outputs. Wider diversification based upon political and demographic changes should be considered when making decisions upon meat rearing. For example, there has been a decline in lamb sales in the UK[18], although exports to the EU remain strong. With the uncertainties of Brexit, it is not clear how this could impact Northern Ireland. The heightened promotion of vegetarian and plant based diets could further impact upon both price and UK market reduction. Therefore a review of how meat is reared, and the wider impacts of such, especially where positive i.e. LEAF assured etc. should be marketed upon in order to increase market accessibility and avoid any volatility in pricing changes. The promotion of environmental, and specially raised meat, would offer a market differentiation and potentially increase profitability.

[18] AHDB

Recommendation 5; Change in Grazing Practices

In order to increase carbon sequestration, improve the wider environment and potentially increase the value of Northern Irish lamb and beef, woodland grazing could be considered. This would have multiple benefits, as discussed in Recommendation 3, through increasing the habitat areas which sequester carbon, managing invasive species, increasing soil productivity and enhancing biodiversity.

It may be possible to alter the species which graze on these areas, in order to better manage the natural vegetation, increase farm payments and increase the value of farm products, with the sale of NI Woodland Reared Meat.

In order for this to be successful, a review would be required to look at the wider economic impacts of a switch in grazing practices, the impacts upon stocking densities and prices for such products at the point of sale, reviewed against current market prices to understand profitability. This could be trialled initially to determine the best course of action.

Given the carbon intensity of the farming practices, it may be worthwhile reviewing the use of renewables within the farm buildings at the Dairy and Beef and Sheep Farm. In particular, the integration of solar panels within farm buildings would reduce the overall production costs through energy cost reductions, and create a revenue stream at times when energy generated exceeds demand.

At present the renewable capability of Northern Ireland is less than the rest of the UK due to grid deficiencies and reduction in government incentives.

Recommendation 6; Review and embed renewable energy through integration with farm buildings

This would reduce farm running costs and offset the wider carbon impacts of animal rearing.

The buildings at the Dairy Farm may be most suitable for the installation of rooftop solar given that they are relatively new. This would need to be reviewed through a feasibility study.

Renewable energy subsidies have been scaled back, and solar capacity within Northern Ireland is relatively low compared with the rest of the UK. Therefore, a review would be required to ensure that both the costs and environmental benefits needed to support the wider economic viability of the farm are considered.

Anaerobic digestion could be considered. The Dairy Farm may be best placed to implement this, given the slurry management system in place. Although a full review of the total output would be required in order to determine scalability and output. The gas from an AD plant could be sold to add to the income stream of the farm. However, AD needs to be considered in the context of wider feedstock and nutrient management constraints.

Water

There are significant positive water impacts across each of the farming systems. The natural assets across each of the farms are thought to be able to cope with significant rainfall, as well as future increases in rainfall outlined in 2009 climate change forecasts.

When the farm sites were visited it was clear that grazing areas are not trampled and water logged, and therefore water filtration is deemed to be in line with what is expected for grass/crop covered areas.

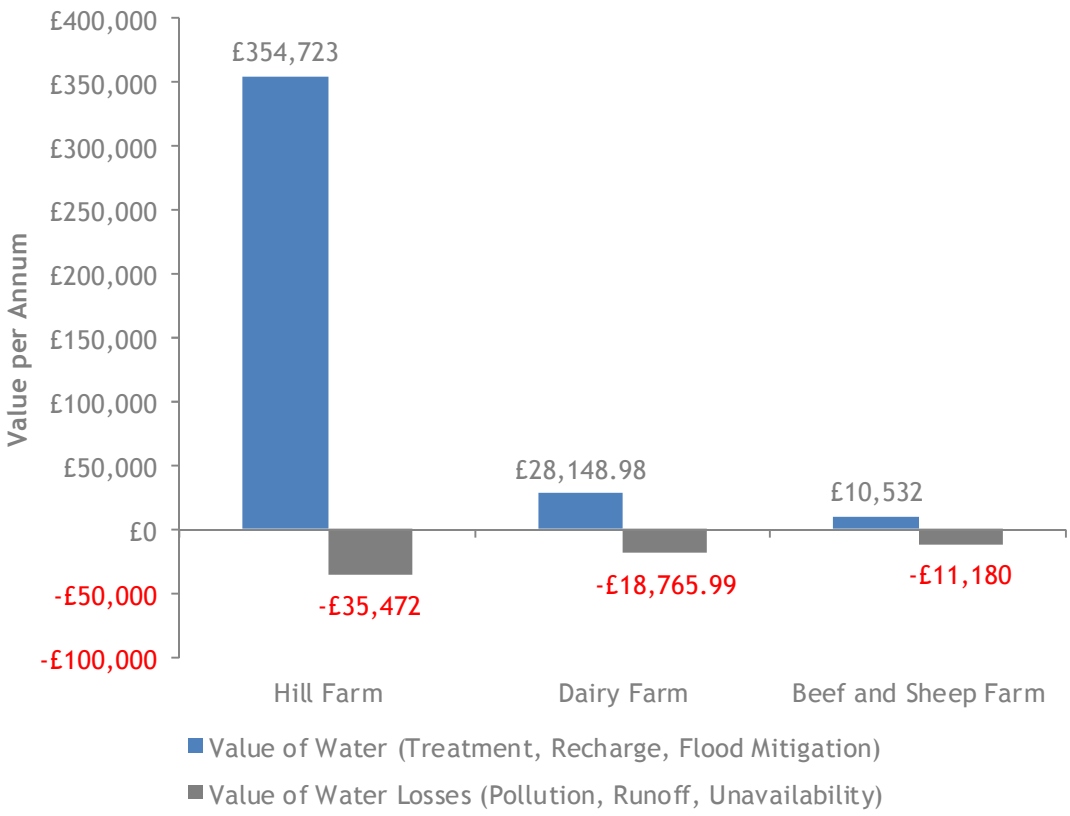
At the Upper Hill Farm, water filtration is good, and the peat is adding to wider water treatment, providing green water, which will require less mechanical and chemical treatment in order to provide drinking water.

As with carbon, the benefits of the peat system on water filtration at the Hill Farm enhances the overall value. Due to the nature and condition of the natural assets, there is a higher net positive impact due to the water filtration and treatment, and flood mitigation properties of the peat. This results in increased value, aligned to the social value of water at each of the upper hill farm.

Additionally, there is significant green water recharge from the grassland and woodland areas of the Dairy and Beef and Sheep Farms.

Overall the water value impacts of the farms are demonstrated in Figure 20.

Figure 20; Annual Water Value of the Farming Systems Assessed



There is added resilience through the ability of the assets to absorb and filtrate water associated with increased rainfall patterns. Over a 30-year period the value of water treated and released by the farming systems is expected to be £10.6 million from the Hill Farm, £316k at the Beef and Sheep Farm and £968k at the Dairy Farm.

In addition to adding to the overall environmental improvement of water quality, there are further benefits through reduced flood risk and increased biological availability of water to natural habitats, increased plant productivity, and carbon sequestration. At present the treatment of water by upland habitats in particular, is of interest to water companies, and how management of uplands can mitigate water treatment costs.

Recommendation 7; Introduction of Payments for Ecosystem Services (PES) for Upland Water Treatment

In order to make PES work, there would need to be significant collaboration between Government and Water providers. A PES system would work based upon a water provider paying farmers for services relating to water treatment, which will include sustainable peat management.

There are a number of pilot schemes across England, and there is increasing interest from insurance and infrastructure organisations who have a vested interest in ensuring that water is managed sustainably, and invest in such schemes.

A Farmer-led PES schemes, with a water company, would require engagement with relevant landowners to propose and contract for naturally engineered assets on their land or changes in their farming practice.

There is no NI specific data available relating to revenue that would be gained through PES; however, the cost of treating water in England is £1096 million per annum. Therefore, implementing Government led metrics similar to the Defra PES Action Plan, could have significant positive economic impacts for upland farmers.

If farmers are able to demonstrate the benefits of water treatment in lowland pasture, they could benefit from such a system. Such a scheme could be rolled out across NI to maximise benefits. There would need to be significant review of catchment level interventions with funding made available to effectively trial such a system. It would be a worthwhile exercise to understand how a farm such as the Hill Farm could fit with the National Demonstration Test Catchments Network[19]. Additionally, there are already significant environmental stewardship incentives across Northern Ireland. Developing these into a market for ecosystem services could assist with wider farm payments across Northern Ireland, whilst enhancing the natural environment on which farming depends[20].

Nutrient Cycling

Each of the farms regulates nitrogen in a positive manner, reducing the overall environmental impacts of high nitrogen outputs. There are some negative values

[19] http://www.demonstratingcatchmentmanagement.net/
[20] DEFRA; Developing the potential for Payments for Ecosystem Services: An Action Plan

associated with P and K. These are immaterial compared with overall figures, but may be an area that requires attention.

As a result of the ongoing management of the soil systems across each of the farms, the soil assets are deemed to be in good condition, supporting healthy environments, particularly at the Upper Hill Farm.

Furthermore, the ecosystem assets across the Dairy Farm and Beef and Sheep Farm demonstrated good quality woodland, and the grassland areas were largely in good condition, with no sign of nutrient depletion or leaching. Although only a high level visual inspection of grassland and adjacent water bodies took place.

Soil testing analysis for each of the farms determined the value of the nutrient recycling.

At the Hill Farm, the existence of peat, and the low stocking densities result in further denitrification. As a result, the cycling of nitrogen is worth just under £1 million per annum. Whereas at the Beef and Sheep Farm the value of nutrient cycling is £223k per annum, with some losses from phosphorus and potassium as a result of higher or lower concentrations across the farm system. Whereas at the Dairy farm the benefit of nutrient cycling is £226k per annum, again with some losses from phosphorus and potassium.

Overall the net benefit is due to the best practice approach to land management across all three farms which has delivered good soil quality, reduced water pollution as a result of nitrate control, and a reduced climate impact as a result of reduced nitrogen losses.

Education

The overall value of education is £43,542,161 per annum as a result of the educational activities across the three farms, and has been split across each of the farms.

This has been calculated based upon the current youth unemployment rate in Northern Ireland, benefit claims, and the perceived impact of Brexit, taking into account the benefit and wider economic impact of a potentially reduced farming economy.

Although the educational flow value of the farm is not typical for commercial farming systems, the benefits of sharing sustainable farming practices should not be ignored.

It may not be possible for farmers to offer any specific service to enhance farm profits and incomes relating to educational programmes. However, it should be acknowledged that the value of a farming workforce which understands the importance of a strong environment underpinning agricultural practices, will be beneficial.

Given the proportion of Northern Ireland's GDP which relies upon farming, it will be increasingly important to have a workforce which understands the need for creating sustainable farming systems which will support the industry going forward.

This is especially important should changes in the current CAP based payments switch to more environmentally focussed outputs, rather than the size of land holdings.

Wider Considerations

Despite the intensive nature of agricultural practices in Northern Ireland, the overall net impact upon the environment is positive rather than negative. This is testament to the environmental stewardship and best practice approach towards farming across the CAFRE estate.

These practices may not however be typical across wider commercial farms within Northern Ireland. Without taking the best practice approach demonstrated across the three farms assessed, the productivity of the farm system, and the natural assets which support it would be impacted upon.

Recommendation 8; Wider assessment of natural capital value in commercial based farms

Although there may be constraints on the amount of data available to undertake such an assessment, it would be valuable to understand the differences in natural capital flows and values based upon different management styles, and to compare the impacts on productivity and the commercial output. This would enable a wider understanding of the natural capital benefits of the commercial productivity of farm systems, and hopefully act as a driver to promote more environmentally beneficial practices.

With changes in CAP payments imminent, and uncertainty around subsidy payments after Brexit, it is essential to gain a better understanding of the impacts and co-benefits.

Only some farm types have been assessed, and other farm systems, such as poultry and pig production will have differing impacts upon the flow and benefits of ecosystem services. There is not necessarily a one size fits all approach towards environmental stewardship within agri-business. It would be worth undertaking a wider Natural Capital Account for other farm types within Northern Ireland.

There has been much speculation regarding changes in payments post-Brexit, and as part of the wider 25 year Environment Plan. Given the reliance of the NI economy on the natural environment, and the overall need to increase resilience, reduce carbon emissions and improve declining biodiversity, it would be worth developing a similar 25 year Environment Plan for Northern Ireland.

Recommendation 9; Implement a Northern Ireland Specific Long Term Environment Plan

Given that the policies required to support the environment in Northern Ireland differ from that in England, a NI focussed long-term plan for the environment is required.

Such a Plan would go beyond farming systems, providing a strategic plan for enhancing and improving the environment of Northern Ireland to deliver future prosperity and well-being.

Enhancing the natural environment upon which Northern Ireland's food system depends has obvious environmental benefits, and would support cleaner air, water and reduced overall climate impacts.

However, improved environmental stewardship also offers farmers wider business diversification opportunities through, for example, reducing stocking densities to rarer breeds, resulting in improved environment, and higher prices per units, or energy generation, supporting wider energy policy in Northern Ireland, and a low carbon future.

In order for farms to benefit from improving the environment which results in beneficial eco-system services, there would need to be changes in policy to support incentive based payments. Education of land managers and farmers is required to aid such a transition to payments for ecosystem services.

Appendix A – Farm Accounts

Upper Hill Farm Baseline Account

		Stock		30 year period		Annual Aggregated Value	
		Profit	Loss	Profit	Loss	Profit	Loss
Provisioning	Total Farm Output			£7,029,877	-£3,718,212	£261,114	-£160,876
Air Quality	Conifer Impact			£2,456,892		£81,896	£0
	Grassland Area			£1,163,040		£38,768	£0
Climate	Carbon contained within Vegetation			£36,127,251	-£849,915	£1,204,242	-£28,330
	Carbon Released by grazing animals	£1,047,751		£0	-£919,784	£0	-£44,985
	Water treated, runoff prevented, availability			£10,641,686	-£1,064,169	£354,723	-£35,472
Education	Number of individuals with access to the site for educational purposes			£385,176,158	-£55,186,422	£14,513,720	-£4,470,226
Health and Wellbeing	Number of households with direct health and well being impocts					£0	£0
Nutrient Cycling	Nitrogen (N) Total quantity of N cycled within the site area based on plant coverage, structure and soil properties.			£29,211,448		£973,715	£0
		£1,047,751		**£472,187,494**	**-£65,456,714**	**£17,440,883**	**-£4,739,889**
					£407,778,531		**£12,700,994**

Dairy Farm Baseline Account

			30 year period		Annual Aggregated Value	
		Monetary Value	Value			
		Profit	Profit	Loss	Profit	Loss
Provisioning	Total Farm Output		£939,478,774	-£21,652,378.62	£31,315,959	-£605,258
	Woodland Impact		£9,233,267.62		£469,063.15	
Air Quality	Grassland Area		£2,771,045.89		£103,763.85	
	Carbon Sequestration		£3,280,150.67	-£114,514.37	£109,338.36	
Climate	Carbon emitted through animal rearing			-£4,277,080.14		-£209,182.28
Water	Water treated, runoff prevented, availability	£484,267.88	£968,301.76	-£534,677.99	£28,148.98	-£18,765.99
Education	Number of individuals with access to the site for educational purposes		£385,176,157.72	-£55,186,421.50	£14,513,720.00	-£4,470,225.76
Health and Wellbeing	Number of households with direct health and well being impocts		£8,126,447.87		£304,300.80	
	Nitrogen (N)					
	Total quantity of N cycled within the site area based on plant coverage, structure and soil properties.		£6,827,218.78	£0	£227,574	£0
	Phosphorus (P)					
	Total quantity of P cycled within the site area based on plant coverage, structure and soil properties.		£0.00236	-£0.59	£0.0001	-£0.0197
Nutrient Cycling	Pottassium		£34.96	-£20,011.47	£1.17	-£667.05
	Total Net	**£2,349,768**	**£1,355,861,400**	**-£81,785,085**	**£47,071,869**	**-£5,304,099**
	Total Gross			**£1,276,426,083**		**£41,767,771**

Beef and Sheep Farm

		Stock		Value			
		Profit	Loss	Profit	Loss	Profit	Loss
Provisioning	Total Farm Output			£27,593,280	-£2,756,180	£919,776	-£91,873
Air Quality	Woodland Impact			£1,809,720	£0	£60,324.02	£0
	Grassland Area			£2,621,921.34	£0	£94,859.68	£0
Climate	Carbon Emitted by Dairy Herd			£0	-£2,259,356.89	£0	-£75,311.90
	Carbon contained within Vegetation			£1,291,776.16	£0	£43,059.21	£0
	Water Treatment Ability or inability of the site to naturally process water due to the vegetation and habitat present on site	£307,069.14		£315,946.89	-£335,399	£10,532	-£11,180
Education	Number of individuals with access to the site for educational purposes			£385,176,157.72	-£55,186,421.50	£14,513,720.00	-£4,470,225.76
Nutrient Cycling	Nitrogen (N) Total quantity of N cycled within the site area based on plant coverage, structure and soil properties.			£6,739,691.86	£0	£224,656	£0
	Phosphorus (P) Total quantity of P cycled within the site area based on plant coverage, structure and soil properties.			£3,426.02	-£34,709.39	£114	-£1,157
	Pottassium			0	-£973.30	0	-£32.44
	Total Net	**£307,069**		**£425,551,920**	**-£63,329,220**	**£15,867,041**	**-£4,649,780**
	Total Gross				**£362,529,769**		**£11,217,261**