Natural Capital Assessment in Northern Ireland: Urban Study

Authors:
Dr Debbie Coldwell, Dr Jim Rouquette and Dr Alison Holt
Natural Capital Solutions Ltd

Contact details:
Dr J.R. Rouquette
Natural Capital Solutions Ltd
www.naturalcapitalsolutions.co.uk
jim.rouquette@naturalcapitalsolutions.co.uk

Report prepared for:
Northern Ireland Environment Link

Version: Final

April 2018

Executive summary

The breadth and the value of the benefits that natural capital delivers to people is increasingly being recognised in policy throughout the UK. The UK Government's recent *25 Year Plan to Improve the Environment* has shown a commitment to a more joined up approach to environmental management and it is hoped that these ideas will be taken up in Northern Ireland. In Northern Ireland, the concepts of natural capital, ecosystem services and the ecosystem approach are at the heart of conservation policy, and feature in planning policy for delivering sustainable development. However, the challenge is to demonstrate how natural capital approaches can work in practice so that they become an integral component of decision making.

This report presents a natural capital assessment of two urban sites in the Belfast area, Bog Meadows and Minnowburn, and was commissioned by Northern Ireland Environment Link. Using a natural capital accounting framework, the assessments aimed to identify and assess existing natural capital assets (asset register), the flow of services from them (physical flow account), and the monetary value of the resultant benefits (monetary flow account). The net ecosystem service benefits were then established, taking into account the costs of maintaining the natural capital assets (natural capital balance sheet).

Bog Meadows, a remnant of once extensive wetlands, is a 19 ha nature reserve situated 1.5 miles south-west of Belfast City Centre. It is a Local Nature Reserve and an important recreational resource with good public access and a wide variety of users, in an area of high social deprivation. The asset register shows a variety of habitats, predominantly grazed unimproved grassland, reedbeds and wet woodland. A qualitative assessment showed the broad range of services provided by this site, with water quality and water flow regulation services, and cultural services such as recreation, educational and aesthetic values being particularly important. The physical and monetary flow accounts show that the services of greatest value are physical health, and recreational value. These are estimated to provide annual benefits worth £459,000 and £372,000 respectively. The small area of woodland at the site meant that timber/woodfuel production, carbon sequestration and air pollution regulation rates were low. Agricultural production and associated greenhouse gas emissions were also small. Overall, the total cost associated with maintaining the natural capital assets of Bog Meadows was low (£19,400 per year), compared to the total ecosystem service benefits that it provides (£842,000 per year). The natural capital account showed that Bog Meadows is providing net benefits worth £26.3M over 50 years.

Minnowburn is a c.52 ha National Trust site less than 5 miles south-west of the centre of Belfast. It receives a considerable number of local visitors (145,000 visits recorded each year), and contains habitats of national importance for biodiversity. The asset register shows a significant area of the site is broadleaf woodland, with grazed improved grassland, and smaller areas of lowland meadow. As with Bog Meadows the qualitative assessment shows a broad range of ecosystem services are provided by this site, with moderate levels of food and fuel production. The site is moderately important for the delivery of regulating services such as carbon sequestration, air quality regulation and local climate regulation due

to the woodland area, and of high importance for cultural services like aesthetics and recreation. The physical and monetary flow accounts again show physical health and recreation to be the services of greatest value and are providing even greater benefits than at Bog Meadows, worth £1.8M and £0.9M respectively each year. The woodland at the site meant that timber/woodfuel production (£2,200 annual benefits), carbon sequestration (£9,500) and air pollution regulation (£32,400) were of higher value than at Bog Meadows, although still far lower than physical health and recreation. Agricultural production was in deficit and associated greenhouse gas emissions were a cost to society, but the site is a net sequester of carbon (more carbon is captured by woodland at the site than emitted by agricultural activities). Overall the total cost associated with maintaining the natural capital assets of Minnowburn was low (£40,900 per year), compared to the total ecosystem service benefits that it provides (£2.7M). The natural capital account showed that Minnowburn is delivering net benefits worth £89.1M over a 50-year period.

This assessment has shown that the natural capital accounting approach can be successfully applied to urban sites in Northern Ireland. Both accounts show that the sites are providing significant goods and services to society, and these are 50-80 times higher than the costs of maintaining the sites. The benefits are, however, all in the form of external values (public goods) rather than private values that could be gained by the land owners, and income for these sites does not cover costs. Natural capital accounting is useful at highlighting the value of the natural environment, which may otherwise remain hidden. It is hoped that the application of Natural Capital accounts will be used to inform decision making and that the case studies described here can be used to demonstrate best practice, and to showcase the importance of natural capital in Northern Ireland.

There are a number of ways that this work can be built upon to inform decision-making and progress natural capital policy in Northern Ireland. It is recommended that a new policy framework is developed to encourage the wider use of natural capital approaches, including assessment and accounting, and that such approaches are required for all major development and investment decisions in Northern Ireland. Natural capital approaches should be integrated into Strategic Planning, Local Development Plans and Environmental Impact Assessments (EIAs) as an integral component of decision making.

In addition, natural capital accounts should be developed for a broader range of sites in Northern Ireland to highlight the benefits of this approach in different contexts. Mapping of ecosystem services and habitat opportunities would identify areas with high and low provision of, and demand for, services. It would reveal areas where natural capital could be improved through the creation and restoration of habitats, showing areas that should be protected, and areas that would be most suitable for development. This could lead to the development of investment strategies and plans for important locations, which would establish a compelling business case for natural capital investment.

Contents

1. Background

1.1 Aims

Natural Capital Solutions were commissioned by Northern Ireland Environment Link (NIEL) to undertake a natural capital assessment of two urban sites in the Belfast area, Bog Meadows and Minnowburn. The assessments identify and assess the existing natural capital stocks, the flow of services derived from this natural capital, and their value to society. These benefits are then compared to ongoing maintenance costs using a natural capital accounting framework. General principles regarding the role and approach to natural capital are provided, alongside recommendations on how to progress natural capital policy and develop the evidence base in Northern Ireland.

1.2 The natural capital approach

The natural environment underpins our well-being and economic prosperity, providing multiple benefits to society, and yet it is consistently undervalued in decision-making. Natural capital is defined as "*..elements of nature that directly or indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions"* (Natural Capital Committee 2014). These benefits (often referred to as ecosystem services) include food production, regulation of flooding and climate, pollination of crops, and cultural benefits such as aesthetic value and recreational opportunities (Figure 1).

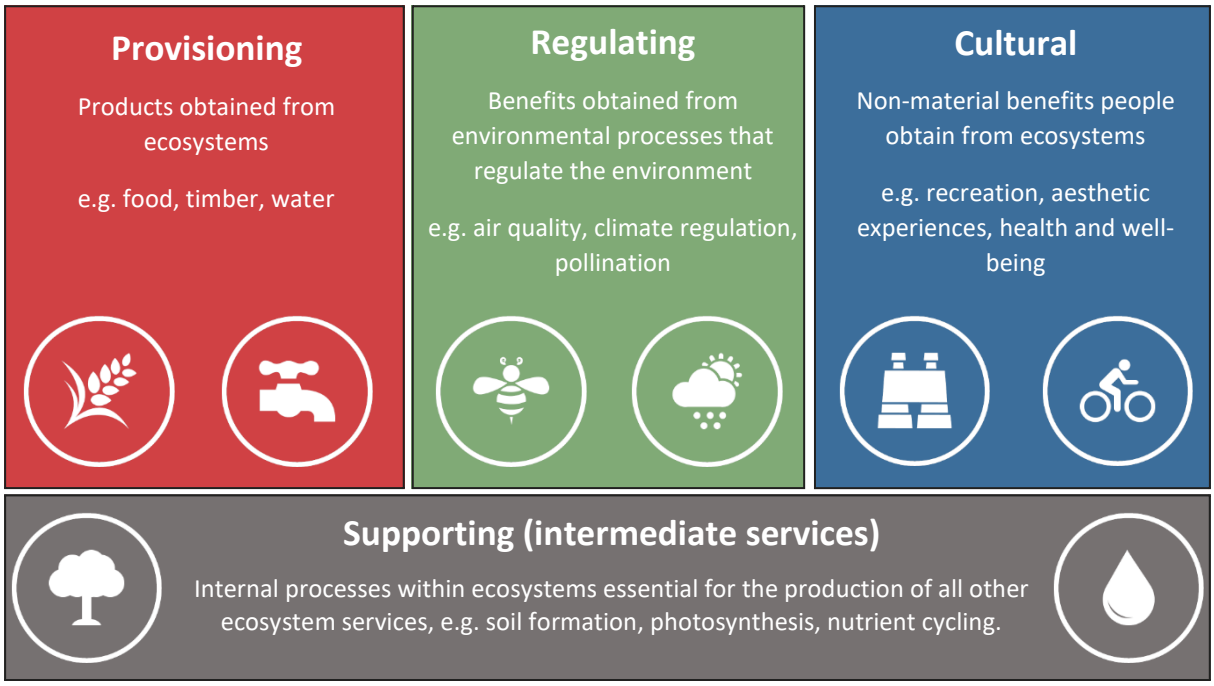

Figure 1: Key types of ecosystem services (based on MA 2005)

Another similar term that is commonly used is the *Ecosystem Approach*. This was defined by the Convention on Biological Diversity (CBD) as:

> *"…. a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way"*

The ecosystem approach is a broader framework than ecosystem services, although ecosystem services do form part of the approach. Its ethos is natural resource management that is sustainable, holistic and involves people. It shares similarities with the goals of sustainable development. Twelve key principles have been defined and can be viewed on the CBD website.

The concept of natural capital and its associated approaches can be used to understand the natural capital assets of an area or organisation. Through a natural capital assessment, it is possible to understand the extent and condition of those assets, so the number and the flow of ecosystem service benefits from those assets can be established. These benefits can then be valued. Information on the condition and benefits derived from an asset enables better informed land management decisions to be made because of the transparency gained by recognising an asset's full, long term value. It provides an understanding of the consequences of land management change (whether that be a change from one type of natural habitat to another, or from natural habitats to, for example, hard engineering or housing developments) on the range of benefits that can be provided by a landscape. It can also highlight how specific changes can be tailored to enhance certain services or values, and how environmental change (e.g. climate change) may affect natural capital assets, their benefits and values. It can reveal the value of both public and private benefits that come from managing landscapes, and it is key to identifying trade-offs and synergies between different ecosystem services.

By taking a natural capital approach, Northern Ireland Environment Link (NIEL), the Department of Agriculture, Environment and Rural Affairs (DAERA) and the Economics of Nature Working Group (EoNWG) will be able to more accurately demonstrate the value of the natural environment, highlight critical assets that require protection or restoration, enable natural capital to be taken in to account more fully in decision making, and start to monitor losses and gains over time.

1.3 Natural Capital Accounting

A natural capital account measures and values the natural capital assets of an area, based on the flow of ecosystem services and associated benefits from those assets. The benefits are then compared to the costs (capital and operational expenditure), in the form of a balance sheet. General principles and methodology have been developed, such as the Principles of Natural Capital Accounting background paper (ONS 2017) and Corporate Natural Capital Counting Guidelines (Eftec RSPB & PWC 2015). According to ONS (2017): "*natural capital accounts are a series of interconnected accounts that provide a structured set of information relating to the stocks of natural capital and flows of services supplied by them*". A natural capital account is comprised of a number of different components, outlined below and illustrated in Figure 2:

- An extent and condition account (asset register) – the area, type and condition of natural capital assets.

- Physical flow account – the biophysical annual flow of ecosystem services from the natural capital assets.
- Monetary flow account – the monetary value of these benefits calculated per annum, together with the overall value of the asset over its lifetime (usually calculated over 50 years)
- Maintenance cost account – the cost of current and future natural capital maintenance activities
- Natural capital balance sheet – the value of the benefits derived from the natural capital assets are compared to the costs of maintaining those assets. Valuations are referred to as 'asset values' and the maintenance requirements as 'liabilities', following standard accounting terminology. In addition, two components of asset value are recognised: private value (benefits to the landowner or organisation) and external value (wider benefits to society).

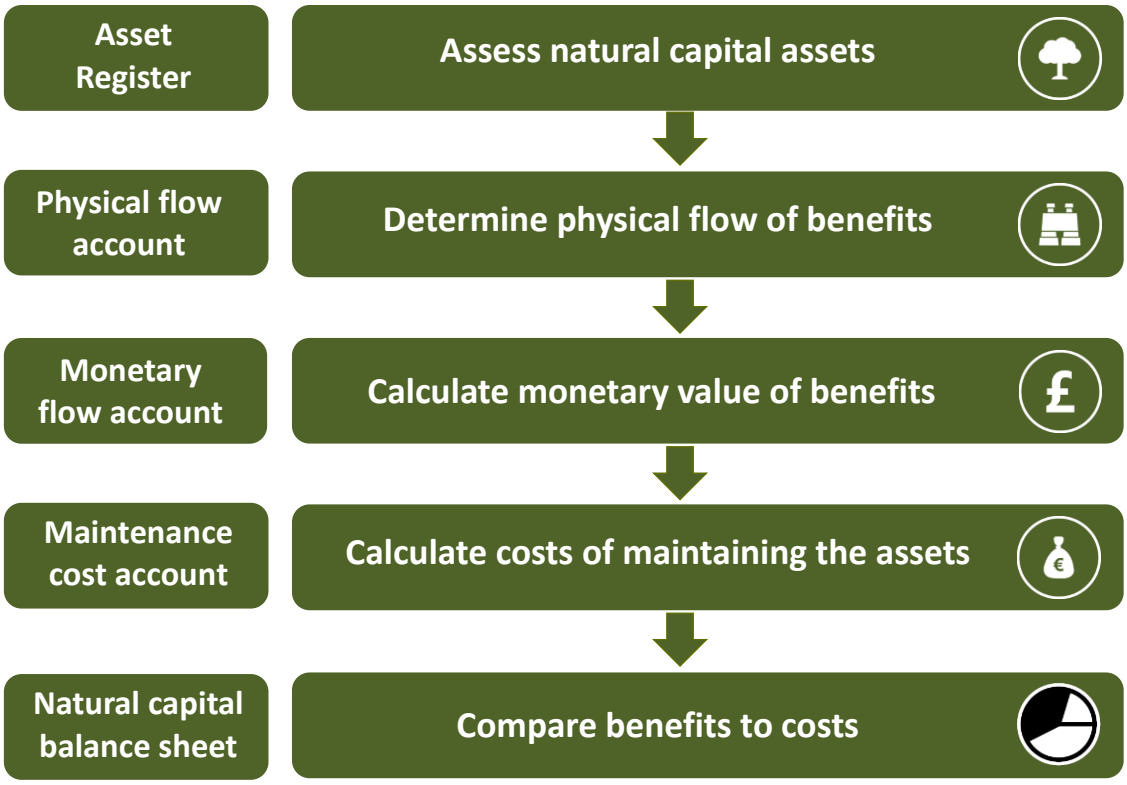

Figure 2: Outline of the assessment approach.

Natural capital accounts can be used to compare the benefits derived from existing natural capital assets with the costs required to maintain them (as demonstrated in this report). Once set up it can also be used to examine change over time from a baseline year, or can be used to determine the potential impact of a proposal or new investment.

2. Natural capital and ecosystem services policy in Northern Ireland

The concepts and terminology of natural capital, ecosystem services and the Ecosystem Approach have been adopted by policy makers at international, UK and Northern Ireland Government levels. The primary challenge now is in applying these concepts, and this project is intended to inform adoption of the approach in practice. These ideas are very much at the heart of conservation policy in Northern Ireland, as evidenced by the document *Valuing Nature - Northern Ireland Biodiversity Strategy to 2020* (DOENI 2015a). The strategy highlights the importance of Northern Ireland's biodiversity, both in its own right and, in particular, for the delivery of goods and services on which people depend. The strategy recognises and outlines how the Ecosystems Approach will allow Northern Irelands' international obligations and local biodiversity targets to be met, at the same time as supporting society and the economy. The stated mission of the Northern Ireland Biodiversity Strategy is:

> *"To make progress towards halting overall biodiversity loss, establish an ecosystem approach and help business and society in general have a greater understanding of the benefits that nature can bring to everyday life in Northern Ireland."*

It is noted that the Strategy included an action to "*consider the outcome of the consultation on Biodiversity Offsetting carried out by Defra and decide on the way forward in Northern Ireland*". An assessment on the implementation of the Strategy (DAERA 2016) reported that DAERA officials are still (December 2016) considering the degree to which the concept might be applied in a Northern Ireland context.

In addition to the policies set out in the Biodiversity Strategy, the Wildlife and Natural Environment (Northern Ireland) Act 2011 introduced a statutory duty for all Government Departments and public-sector bodies to further the conservation of biodiversity.

Natural capital and ecosystem services concepts have also been inserted into planning policy. National planning policy in Northern Ireland is set out in the *Strategic Planning Policy Statement for Northern Ireland (SPPS): Planning for Sustainable Development* (DOENI 2015b). Sustainable development and improving well-being is at the heart of the SPPS and the importance of ecosystem services is specifically highlighted. Paragraphs 3.14-3.16 include the following statements:

> *".....The careful management, maintenance and enhancement of ecosystem services are therefore an integral part of sustainable development……Where appropriate, identifying the condition of ecosystems, the provision of services and their relationship to human well-being should be integrated into plan-making and decision-taking processes."*

The SPPS also contains a Core Planning Principle to design, manage, protect and provide strategic networks of greenspace in order to deliver a wide range of environmental and quality of life benefits.

Planning policy in NI is now being delivered by 11 new Local Authority Districts, who have a statutory duty to produce a Local Development Plan (LDP) for each area. These will include a

Plan Strategy and a Local Policies Plan, which provide an opportunity to apply the concept by adopting the Natural Capital approach to planning. Both Bog Meadows and Minnowburn fall within the Belfast Local Authority District, although the LDP is still at an early stage of development.

In January 2018 the UK Government published "*A Green Future: Our 25 Year Plan to Improve the Environment*". The proposals apply only to England, but it is hoped that many of the ideas will be taken forward by the devolved administrations. The principles of natural capital are further embedded in the 25 year plan, alongside the requirement for environmental net gain in development, and a more joined up approach across policy areas.

The documents described above illustrate that the concepts of natural capital and ecosystem services have now been embedded in UK and NI environmental and development policies. In addition, the NI Government specifically refers to natural capital in its draft Programme for Government. The key challenge now is in implementing the approach and embedding it in working practices, so that it becomes an integral component of decision making. At present a number of different methods have been applied and there is not yet a consensus on best practice. Here we demonstrate one of the key approaches that can be applied, that of natural capital accounting, and the insights that can be gained from taking this approach. We also outline in Section 6.3, some recommendations for taking the natural capital and ecosystem services approach forward in Northern Ireland.

3. Outline of methodological approach

Full details of the methodology are provided in Annex 1, with a brief outline of the approach described here. We use the framework for corporate natural capital accounting (CNCA) developed by Eftec et al. (2015) for the Natural Capital Committee, and the ONS (2017) Principles of Natural Capital Accounting. The approach used, therefore, draws on the concepts of natural capital and economic valuation[1]. It also follows the broad approach to natural capital assessment outlined in "*How to do it: a natural capital workbook"* published by the Natural Capital Committee (2017).

The natural capital assets of the sites were first described and mapped. The condition of the habitats was determined by the site managers for each site, although this is not a formal condition assessment as required for designated sites. Key risks that could result in the assets not being in acceptable condition were also identified.

The natural capital assets identified at each site deliver a range of ecosystem services, which provide benefits to people. Those that can be quantified and valued were assessed in the physical and monetary flow accounts (below). However, there are still a number of ecosystem services that cannot be assessed in this way, hence a quantitative assessment (and a natural capital account) may not capture all the benefits provided by the site. A

[1] Economic valuation quantifies the benefits that people gain as a result of the consumption of goods and services. It is based on welfare or well-being concepts where policy aims to maximise the welfare of society. The economic value of ecosystem services can be measured within the framework of 'total economic value' (TEV) (Defra 2007).

qualitative assessment was, therefore, conducted and is useful both as a summary, and to provide a more comprehensive overview of the benefits provided by the natural resources in each area. It is also useful at drawing attention to key services and highlighting those that should be the focus of more detailed assessments. To do this, each ecosystem service was simply scored on a scale from 0-3, based on an expert assessment of the provision of each service at each site, determined using general principles and any data available. Note that these scores were separate to, and not used in, the calculation of the physical flows and monetised benefits of services used in the natural capital account.

Next, indicators were used to measure the physical flow and monetary value of a number of ecosystem services. The services assessed are summarised in Table 1 and discussed in more detail in Annex 1. Annual values were calculated for each service, as well as the present value (PV) of each service, which calculates the value of the flow of benefits over a 50 year period, using discount rates from the HM Treasury (2018), and the ONS (2014). All prices used are for 2018, or converted to 2018 prices using the latest HM Treasury GDP deflator series, to allow the comparison of annual flows. The estimated value of the benefits provided by the sites and the costs of maintaining them in present value terms were calculated and are summarised in a natural capital balance sheet giving the total net natural capital assets value.

Local data were used for the majority of indicators, with English or UK averages used when data were not available. A range of assumptions have been made in assessing the physical flows of ecosystem services, in the valuation of those flows as well as when using discounting and calculating present values. These assumptions are outlined when describing the methodology for the assessment and valuation of each ecosystem service.

Table 1. Units of measurement of the physical flow and monetary value of the ecosystem services.

Ecosystem service	Physical flow	Valuation
Carbon sequestration	Quantity of CO_2 sequestered	£/tonne of CO_2
Timber/woodfuel production	m^3/ha	£/m^3/year
Air quality regulation	Tonnes of PM_{10} and SO_2 absorbed	£/tonne of PM_{10} and SO_2/year
Agricultural production	Ha	£/ha/year
Greenhouse gas emissions from agriculture	GHG/ha	£/ha/year
Recreation	Number of visits	Recreational value/visit/year
Health & well-being (QALYs)	Active visits	£/QALY/year

4. Natural capital account for Bog Meadows

4.1 Site overview and natural capital asset register

Bog Meadows is a nature reserve situated 1.5 miles south-west of Belfast City Centre. The 19 ha site is all that remains of once extensive wetlands found on the outskirts of Belfast. The site was abandoned in the 1970s following a long history in agricultural use and has been managed for nature conservation, education and recreation by Ulster Wildlife, with help from the "Friends of Bog Meadows" community group since 1983. Ulster Wildlife bought the lease for the site in 1998 and it was designated as a Local Nature Reserve in 2000. It is an important recreational resource with good public access and a wide variety of visitors, in one of the most deprived areas of Belfast.

A breakdown of the main habitat types found at Bog Meadows is provided in the natural capital asset register (Table 2), including the condition and area of each habitat. The site map shows the location of these habitats (Figure 3). There are a variety of habitats at the site including, lowland meadows, reedbeds, wet woodland and hedgerows. It is home to several locally rare or uncommon species of plants and invertebrates, making it one of the most important sites for nature conservation in the Belfast area. The majority of the wooded areas developed naturally or were planted once Ulster Wildlife took over management of the site, with native broad-leaved species dominated by grey willow, as well as alder, ash, elder, holly, oak, birch, hawthorn and blackthorn. Bog Meadows includes areas of unimproved grassland that are grazed by beef cattle, including rare breeds such as Blue Grey and Irish Moiled cattle. Grazing activities are carried out by an external grazier under a grazing agreement at a low stocking density of 1 livestock unit per hectare.

Table 2. Natural capital asset register for Bog Meadows.

Habitat	Condition	Area (ha)	% Area
Broadleaf woodland	moderate	2.40	13.9
Dense scrub	moderate	0.21	1.2
Hedgerow	moderate	0.71	4.1
Neutral unimproved grassland	moderate	6.61	38.2
Amenity grassland	good	0.14	0.8
Marshy grassland	moderate	0.62	3.6
Swamp	moderate	5.52	31.9
Open/standing water	moderate	1.11	6.4

Condition of almost all the habitats at the site is considered by the site managers (Ulster Wildlife) to be in moderate condition. The woodland and dense scrub is due to be reduced over time. The neutral unimproved grassland is recovering from a period of no-grazing and should recover naturally with time. The marshy grassland is in the process of succession, along with the swamp, and both habitats require works to halt succession e.g. creation of open water/ reedbed regeneration, and one area of marshy grassland next to the swamp should be scraped and flooded to revert to more natural habitat. Current works include the

removal of willow. Drain clearance is carried out on a rotational basis, although some drains are stagnant with very little water flow at present.

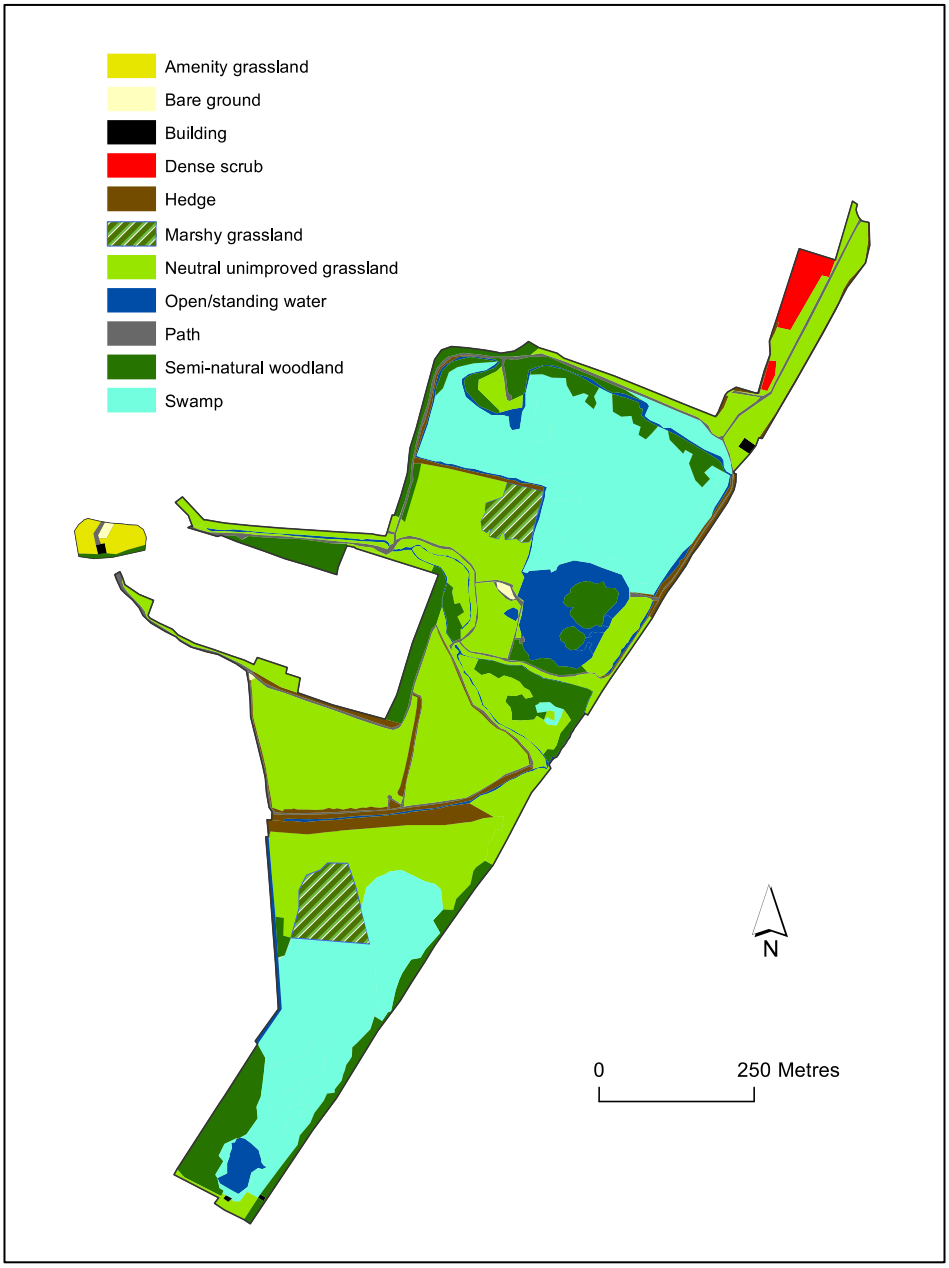

Figure 3. Key habitats present at Bog Meadows.

In terms of **risks**, the Ballymurphy Stream presents one of the greatest threats to the site. It passes straight through the site and under the motorway and is highly channelized and prone to flooding. At times of peak storm flow sewage is discharged into this watercourse and severe flooding results in sewage and detritus being spread over a wide area surrounding the path of the stream.

4.2 Qualitative assessment of ecosystem service flows

The qualitative assessment of ecosystem services currently provided by Bog Meadows is presented in Table 3. Provisioning services are currently limited, with only a low level of livestock production and very limited fuel and fibre production.

Provision of regulating services is much higher. In particular, there is estimated to be high provision of water quality and water flow regulation services. Wetland habitats are especially good at ameliorating poor water quality by trapping and retaining nutrients and sediment polluted runoff, and providing a natural filtering service. In addition, no agri-chemicals are applied to the grasslands, meaning that water flowing off the land will be of relatively high quality, and vegetation at the site will help to reduce soil erosion. Wetland habitats are also excellent at holding back water at times of flooding, and reducing surface water runoff, which will in turn reduce downstream flood risk. Carbon sequestration and air quality regulation services will both be delivered by the site, although at relatively low levels. Trees are the most effective at delivering these services but make up a relatively low proportion of the site.

Table 3. Estimated ecosystem service provision scores for Bog Meadows: 0 - no delivery; 0.5 - some delivery but not significant, 1 - delivery, 2 -significant delivery, 3 - very significant delivery. List of ecosystem services adapted from CICES v5.1.

Ecosystem service category	Ecosystem service	Estimated provision
Provisioning	Food: crop and livestock production	1
	Fibre and fuel (e.g. timber, woodfuel, wool, peat etc.)	0.5
	Water (includes for drinking, agriculture and industry)	0.5
Regulating	Carbon sequestration and storage	1
	Local climate regulation	2
	Air quality regulation	1
	Water quality regulation and erosion control	2
	Water flow regulation	3
	Pollination	2
	Pest and disease control	2
	Noise attenuation	2
	Soil quality regulation	2
	Habitat and population maintenance (biodiversity)	3
Cultural	Aesthetic experiences	2
	Education, training and scientific investigation	3
	Recreation and tourism	2
	Health and well-being	2
	Characteristics and features of biodiversity that are valued (existence, option, bequest)	2
	Spiritual and cultural experiences	2

Noise attenuation is particularly relevant at the site (there is a high demand for this service) as it is adjacent to a motorway. The habitats of themselves only contribute a low level of

service (dense woodland and scrub would provide higher levels of service). However, the presence of an intervening physical space between the motorway and housing provides a very significant level of noise reduction. Other regulating services provided at moderately good levels include pollination services, pest and disease control and local climate regulation.

Bog Meadows is expected to provide relatively high levels of most cultural services. It is a publicly accessible area with an excellent footpath network, close to a large urban population, hence offering the opportunity for people to gain a range of non-material benefits from access to the natural environment. However, there are no facilities at the site, which will reduce the number of visitors who could potentially visit. The value of recreation and physical health are captured in the main accounts (Table 4) and other cultural services provided by the site are shown in Table 3. Of particular note is the value of Bog Meadows for education, training and scientific investigation. Bog Meadows is the location of the longest running Constant Effort Site (CES) for bird-ringing in Northern Ireland. It is also a site that is rich in biodiversity in the heart of the city, providing opportunities to showcase these qualities to an urban population, some of whom will have little access to other wild spaces, and in an area with high levels of social deprivation.

4.3 Physical and monetary flow accounts

The estimated physical and monetary flows of ecosystem services from Bog Meadows are outlined in Table 4 and full methods are provided in Annex 1. The service of greatest value is **physical health**, with approximately 643 visitors to the site predicted to be meeting recommended activity guidelines. These active visits are associated with an estimated 22.96 Quality Adjusted Life Years (QALYs). This is projected to deliver £459,200 worth of cost savings to the NHS per year (Present Value (PV) £17.0M over 50 years).

The **recreational value** of the site is also considerable and is estimated at £372,000 per annum (PV £9.49M). This is based on over 60,000 visits to the site each year, as measured by tally counters at each of the entrances. Details of the recreational value associated with Bog Meadows by visitors to the site was not available and so this figure is based on averages to greenbelt and urban fringe farmlands in Great Britain.

Bog Meadows contributes to **air quality regulation** through removal of an estimated 0.12 tonnes of PM_{10} per year with an associated value of £10,200 (PV 261,000). Though the site also contributes to SO_2 pollution amelioration, the concentration of SO_2 near the site was very low and so the economic impact of this service is negligible (PV £114).

The site is estimated to **sequester** (capture) 26.57 tonnes of **CO_2** per annum worth £1,760 per year (PV 99,100). The estimated amount of carbon stored within the vegetation and soils at Bog Meadows is 2,544 tonnes.

The **timber/woodfuel production** for Bog Meadows is relatively low, totalling 18.67m^3 per annum. This has an estimated annual value of £295 (PV £7,530).

The area of land in **agricultural production** at Bog Meadows is small with 3.43 ha grazed by beef cattle under a grazing agreement with an external grazier. Agricultural production of

the site based on net farm income is estimated to deliver an annual deficit of £714 (PV £18,200 deficit), once farm payments have been stripped out (i.e. it is only profitable when income support for farmers is included). This assumes average farm gate prices for beef in Northern Ireland.

Greenhouse gas emissions from the cattle at Bog Meadows is estimated at 4.85 tCO_2e per annum, with zero emissions from the land itself as it receives no inorganic fertilizers. This is an emission, hence represents a cost to society of £320 per annum (PV £18,100). However, the amount of carbon emitted from the site due to agricultural production is considerably lower than the amount of carbon sequestered, and the balance between the two will result in a net carbon sequestration rate of 21.7 tCO_2e per annum, valued at £1,440 in 2018.

Table 4. Annual physical and monetary flows, and present values of ecosystem services from Bog Meadows. All valuations use 2018 prices.

Ecosystem service	Annual physical flow	Annual monetary value (£ 2018)	Present value (£)
Carbon sequestration (tCO_2)	26.57	1,756	99,137
Timber/woodfuel production (m^3)	18.67	295	7,530
Air quality regulation (t)			
PM_{10}	0.12	10,220	260,832
SO_2	0.002	4	114
Agricultural production (ha)	3.43	-714	-18,223
Greenhouse gas emissions from agriculture (tCO_2e)	4.85	-320	-18,087
Recreation (number of visits)	60,129	372,009	9,494,174
Physical health (visitors that meet activity guidelines)	643	459,201	16,975,857
TOTAL		**842,450**	**26,801,333**

4.4 Maintenance costs account

The total cost associated with maintaining Bog Meadows is estimated to be approximately £19,386 per annum (PV £494,758) (See Table 5 for a breakdown of these costs). A Northern Ireland Environment Agency (NIEA) grant covers 75% of these costs, although this is only confirmed for 2018 and 2019.

Table 5. Approximate breakdown of annual maintenance costs for Bog Meadows.

Expense	Cost (£)
Staff costs	11,506
Light and heating	100
Overheads	3,069
Volunteer expenses	500
Vehicle costs	210
Materials	500
Insurance	3,000
Visitor counters	500
TOTAL	**19,386**

4.5 Natural capital balance sheet and income

The natural capital balance sheet for Bog Meadows is given in Table 6. The total value of the natural capital assets of Bog Meadows are quantified, together with the total liabilities (both reported in present value terms) with the net value of the natural capital assets of the site outlined. The liabilities are low compared to the asset values, resulting in a net gain of £26.31M of external ecosystem service benefits delivered by the site over a 50-year period.

Table 6. Bog Meadows natural capital balance sheet (2018).

	Private value (PV £M)	External value (PV £M)	Total value (PV £M)
Assets			
Baseline value		26.80	26.80
Cumulative gains/ (losses)	-	-	
Additions/ (disposals or consumption)	-	-	
Revaluations and adjustments	-	-	
Gross asset value	-	26.80	26.80
Liabilities			
Legal provisions	-	-	
Other maintenance provisions	(0.49)	Nil	(0.49)
Total net maintenance provisions	(0.49)		(0.49)
Total net natural capital assets		**26.80**	**26.31**

Although **income** is not an official component of a natural capital assessment, it is interesting to note that despite provision of £26.81M worth of benefits provided by the natural capital assets of Bog Meadows in present value terms, the only source of income to the site is a NIEA grant that covers only 75% of site maintenance costs.

5. Natural capital account for Minnowburn

5.1 Site overview and natural capital asset register

Minnowburn is a National Trust site less than five miles south-west of the centre of Belfast, in the heart of the Lagan Valley Regional Park and Area of Outstanding Natural Beauty. At roughly 52 ha in size, Minnowburn is surrounded by urban areas to the north and countryside to the south and receives a considerable number of local visitors. It is a diverse land holding at the confluence of the River Lagan and Minnow Burn with a range of habitats, areas for grazing and public access. A number of the habitat types found at Minnowburn have been identified as Priority Habitats under the UK Biodiversity Action Plan, including wet woodland, lowland meadows and ancient hedgerows. Considerable effort has been made in recent years to enhance the condition and extent of some of these habitats across the site (lowland meadows and native broadleaf woodland in particular) as well as to improve public access. The site also includes a stand of tall, mature, close-grown beeches, with diverse age structure, including natural beech regeneration, known as the Minnowburn Beeches, for which the site was originally named, as well as a number of large, old trees including ancients.

A breakdown of the main habitat types found at Minnowburn and their condition (as determined by the National Trust site managers) is provided in the natural capital asset register (Table 7) and a site map is shown in Figure 4. Broadleaf woodland covers a significant proportion (37.1%) of the site with the dominant species being beech, oak and ash and is generally considered to be in good condition. Approximately 9.5 ha of native mixed broadleaf woodland was planted in 2011 on what was previously agricultural land, using funding from multiple sources, including the Woodland Grant Scheme and sale of carbon credits. Much of the other woodland found at the site was established between the 1960s and 1980s (though some areas of beech stands are older) and include areas of Japanese Larch and Scots Pine as well as broadleaf species. Management to remove the Japanese Larch is ongoing. The wet woodland areas consist primarily of Alder, and a traditional orchard was created in 2013 using traditional Irish apple trees.

Table 7. Natural capital asset register for Minnowburn.

Habitat	Condition	Area (ha)	% Area
Broadleaf woodland	good	18.89	37.1
Coniferous woodland	-	1.04	2.0
Wet woodland	moderate	0.99	1.9
Orchard	-	0.06	0.1
Hedgerow	moderate	0.40	0.8
Lowland meadow	good	6.27	12.3
Semi-improved grassland	moderate	1.95	3.8
Improved grassland	poor	19.82	38.9
Marshy grassland	good	1.34	2.6
Open/standing water	good	0.15	0.3

The wet woodland could be improved in some areas by blocking drains and there is an invasive problem with Himalayan Balsam and Giant Hogweed. The hedgerows are in good condition in places but in a number of other places could be brought into a good condition by laying where they have become gappy at the bottom and planting into gaps.

Areas of lowland meadow are in good condition with the largest area having been created in 2014 using local seed. There is 25.93 ha of farmland which is rented to a single farmer for grazing of young Holstein and Friesians or Aberdeen Angus and British Blues. Grazing occurs from April to November in a fairly even grazing pattern where stock are moved regularly to avoid overgrazing, with a stocking density of three animals per hectare.

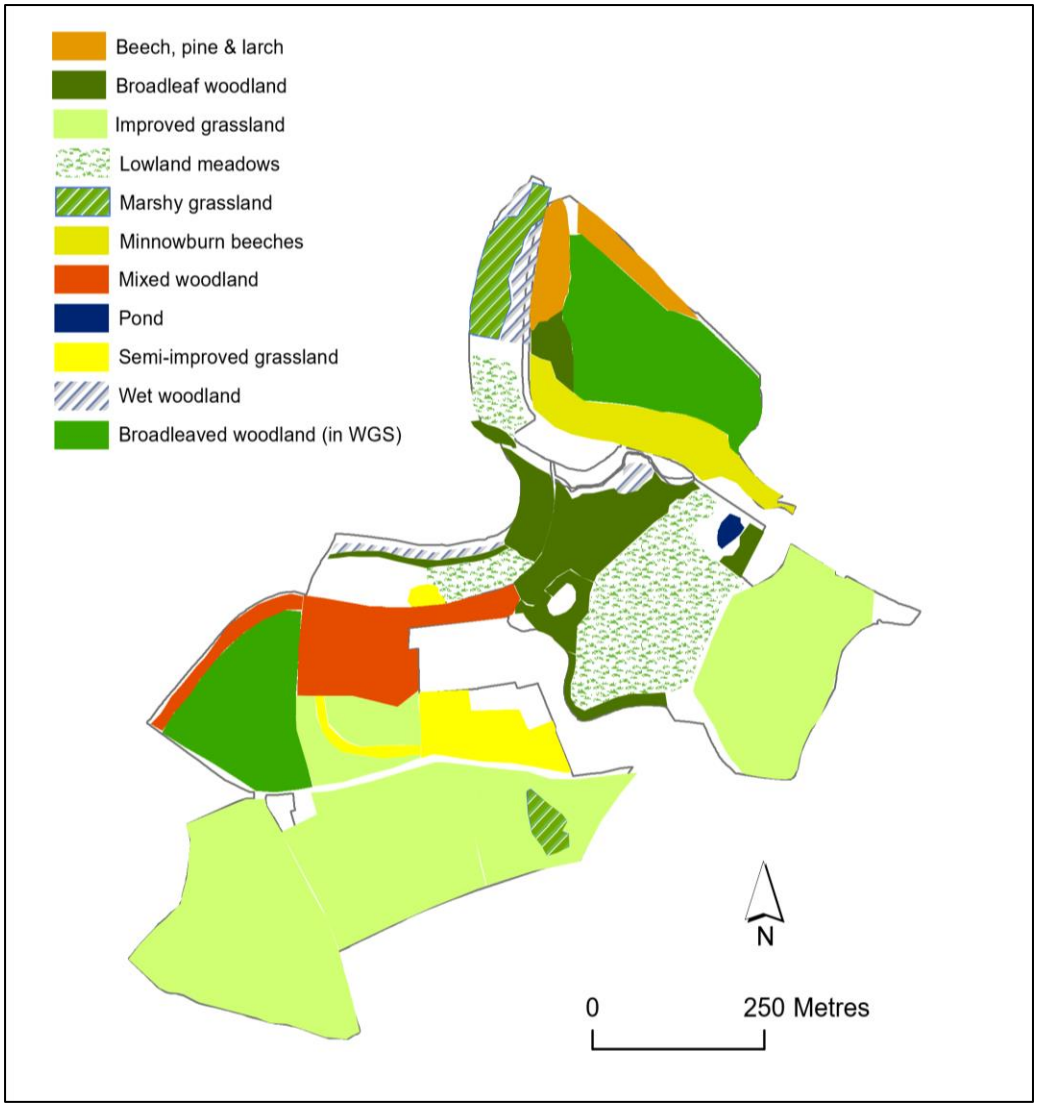

Figure 4. Key habitats present at Minnowburn.

The neutral unimproved grassland would benefit from annual silage cuts over a period of 3 years and thereafter every 2nd or 3rd year. Some spot spraying treatment of docks would also be required. The semi improved grassland has been receiving spot spraying treatment in recent years to tackle dock and creeping thistles. All inputs of fertiliser and slurry was

halted 5 years ago and this has improved the condition. A few more years of the same management will see this grassland reach good condition. The improved grassland is species poor but all inputs have now ceased (although farmyard manure may be allowed in the future). With no inputs and control of docks and thistles this grassland could achieve good semi-natural status within 5-6 years.

A number of **risks** have been identified by the site manager that pose a threat to the site. Invasive species are a risk at Minnowburn. Himalayan Balsam, Japanese Knotweed and Giant Hogweed all receive ongoing management, although Japanese Knotweed is almost eradicated from the site. Staff chemically treat Giant Hogweed annually but it's unlikely to be eradicated until the problem is dealt with upstream.

Intensive farming has been a threat for many years with overgrazing, and inputs of slurry and chemical fertiliser. This has been dealt with at Minnowburn in recent years but there is still an issue from neighbouring farms and the Minnowburn river suffers from nitrogen and phosphorus enrichment.

The Woodland Grant Scheme woodland at Minnowburn now has Chalara (Ash Dieback). It's been identified in around 12 plants so far, but these woodland blocks are about 15% Ash and Chalara could lead to the loss of these trees. Other trees pathogens are also a risk.

5.2 Qualitative assessment of ecosystem service flows

As for Bog Meadows, a qualitative (expert) assessment was carried out to highlight the full range of services that Minnowburn provides. This shows that Minnowburn is delivering a wide range of ecosystem services (Table 8). The site balances cattle production and woodland, hence providing moderate delivery of both food and fuel / fibre. All the regulating services in Table 8 are being provided at moderate levels by the site. Carbon sequestration, air quality regulation and local climate regulation are being delivered at higher levels than at Bog Meadows, due to the larger proportion of woodland. Water quality regulation and water flow regulation will be slightly lower as there are no wetland habitats or water storage areas at the site, but will still be significant due to the relatively high proportion of woodland, which is effective at reducing surface water runoff and intercepting pollutants.

It is estimated that high levels of cultural services are being provided by Minnowburn at present. The site is well visited, providing opportunities for recreation and to enhance health and well-being (quantified and valued in the next section). It is also well connected to a wider green network with accessible routes, as part of the Lagan Valley Regional Park. It contains popular features of importance for cultural experiences, such as the Minnowburn Beeches, and the combination of these, together with woodland, meadows and the rivers are likely to enhance aesthetics and contribute to sense of place. Moderate levels of biodiversity are supported by the site, although more could be done to further enhance this.

Table 8. Estimated ecosystem service provision scores for Minnowburn: 0 - no delivery; 0.5 - some delivery but not significant, 1 - delivery, 2 -significant delivery, 3 - very significant delivery. List of ecosystem services adapted from CICES v5.1.

Ecosystem service category	Ecosystem service	Estimated provision
Provisioning	Food: crop and livestock production	2
	Fibre and fuel (e.g. timber, woodfuel, wool, peat etc.)	2
	Water (includes for drinking, agriculture and industry)	0.5
Regulating	Carbon sequestration and storage	2
	Local climate regulation	2
	Air quality regulation	2
	Water quality regulation and erosion control	2
	Water flow regulation	2
	Pollination	2
	Pest and disease control	2
	Noise attenuation	2
	Soil quality regulation	2
	Habitat and population maintenance (biodiversity)	2
Cultural	Aesthetic experiences	3
	Education, training and scientific investigation	2
	Recreation and tourism	3
	Health and well-being	3
	Characteristics and features of biodiversity that are valued (existence, option, bequest)	2
	Spiritual and cultural experiences	3

5.3 Physical and monetary flow account

The estimated physical and monetary flows of ecosystem services from Minnowburn are outlined in Table 9. The service of greatest value is **physical health** with approximately 2,515 visitors to the site predicted to be meeting recommended activity guidelines (see Annex 1 for details of how this figure is derived, along with other methodological details). These active visits are associated with an estimated 89.89 Quality Adjusted Life Years (QALYs). This is valued to provide £1.8M worth of cost savings to the NHS per year (PV £66.5M over 50 years). Arriving at these indicative figures involved making some very large assumptions and should therefore be considered with caution.

Data loggers have recorded 145,000 visits to the site each year, although it is considered that this does not capture all visits. The **recreational value** of the site is considerable and is estimated at £897,100 per annum (PV £22.9M). Details of the recreational value associated with Minnowburn by visitors to the site was not available and so this figure is based on averages to greenbelt and urban fringe farmlands in Great Britain. The potential underestimate of total numbers of visits to the site means that the recreational value of the site could be higher. This issue will also have an impact on the estimation of active visits (above), hence the value of physical health may also be higher than stated.

Minnowburn contributes to **air quality regulation** through removal of an estimated 0.74t of PM_{10} per year with an associated value of £32,400 (PV 827,000). Though the site also contributes to SO_2 pollution amelioration, the concentrations of SO_2 nearby are very low and so the economic impact of this service was negligible (PV £458).

It is estimated that 143t of **CO_2** per annum is **sequestered** across the site, worth £9,470 per year (PV 534,000). The projected amount of carbon stored within the vegetation and soils at Minnowburn is 9,358t.

The **timber/woodfuel production** for Minnowburn is estimated at 136m^3 per annum. This has an estimated annual value of £2,180 (PV £55,600).

There are 25.93 hectares of farmland at Minnowburn grazed by beef and dairy cattle under a grazing agreement with an external grazier. **Agricultural production** at the site, based on net farm income with farm payments stripped out, is estimated to deliver an annual deficit of £7,190 (PV £183,400 deficit). This shows that average lowland cattle farms in NI are not making any money without including the income support received in the form of the Basic Payment Scheme.

Greenhouse gas emissions from agricultural production at Minnowburn is estimated at 112 tCO_2e per year. These emissions represent a cost to society of £7,390 per year (PV 417,000). The overall carbon budget for the site is the difference between the amount of carbon emitted through agricultural activities and the amount sequestered through woodland (emissions from forestry activities are already captured in the carbon sequestration figures). Overall, the site is a net sequester of carbon (it captures more than it emits), with a net carbon capture of 31.45 tCO_2e per annum, valued at £2,080 in 2018.

Table 9. Annual physical and monetary flows and present values of ecosystem services from Minnowburn. All valuations were completed in 2018 prices.

Ecosystem service	Annual physical flow	Annual monetary value (£ 2018)	Present value (£)
Carbon sequestration (tCO_2)	143.25	9,467	534,489
Timber/woodfuel production (m^3)	136.10	2,179	55,604
Air quality regulation (t)			
PM_{10}	0.74	32,409	827,120
SO_2	0.009	18	458
Agricultural production (ha)	25.93	-7,185	-183,369
Greenhouse gas emissions from agriculture (tCO_2e)	111.80	-7,388	-417,118
Recreation (number of visits)	145,000	897,094	22,895,061
Physical health (visitors that meet activity guidelines)	2,515	1,797,824	66,462,472
TOTAL		**2,724,418**	**90,174,717**

5.4 Maintenance costs account

The maintenance costs for Minnowburn are based on the annual costs of running the site in 2018. The core budget costs for the site are wages (£25,000), maintenance and materials (£8,000), vehicles, fuel and equipment (£6,000) and office and other sundries (£1,000). There are also additional annual costs associated with maintaining access tracks in the Woodland Grant Scheme areas of the site. These were estimated as costing £852 for each year from 2018-2025 (inflated to 2018 prices from 2010 when these costs were calculated at £750). The total annual maintenance costs for Minnowburn are therefore estimated to be £40,852.

The present value (PV) of future maintenance costs were estimated over a 50-year period using rates from the HM Treasury (2018), and the ONS (2014) in line with the PV of future service flow calculations. We used the 2018 maintenance cost total for all years apart from 2025 when additional costs of fence replacement for the Woodland Grant Scheme areas (estimated at £11,932, inflated from 2010 cost of £10,500) scheduled for this year were included, increasing the site maintenance cost total to £52,785. The PV for maintenance costs totalled £1,051,986.

The costs of improving habitats to good condition have also been estimated. Initial capital costs are estimated at £4,500 to cover hedgerow laying, and drain blocking in the areas of wet woodland. Annual maintenance would cost an average of £1,533 over the first 6 years and then £1,113 (at 2018 prices) from then onwards, to cover invasive species control in the wet woodland, and silage cuts and weed control in the grassland habitats. The PV for all these costs comes to a total of £35,207. Note that this does not explicitly include staff costs, although it is likely that these tasks would be undertaken within the existing staff budget.

5.5 Natural capital balance sheet and income

The natural capital balance sheet for Minnowburn is given in Table 10 (overleaf). The total value of the natural capital assets of Minnowburn are quantified together with the total liabilities (both reported in present value terms) with the net value of the natural capital assets of the site outlined. The liabilities are low compared to the asset values, resulting in a net gain of £89.1M of external ecosystem service benefits delivered by the site over a 50 year period.

The costs of improving habitats to good condition are also tiny compared to the overall value of the benefits, although the particular services valued here are unlikely to increase as a result of habitats moving to good condition. Overall benefits would however, increase, with habitat and population maintenance, water quality regulation, water flow regulation, and potentially some of the cultural services likely to be enhanced.

Table 10. Minnowburn natural capital balance sheet (2018).

	Private value (PV £M)	External value (PV £M)	Total value (PV £M)
Assets			
Baseline value		90.2	90.2
Cumulative gains/ (losses)	-	-	
Additions/ (disposals or consumption)	-	-	
Revaluations and adjustments	-	-	
Gross asset value	-	90.2	90.2
Liabilities			
Legal provisions	-	-	
Other maintenance provisions	(1.1)	nil	(1.1)
Total net maintenance provisions	(1.1)		(1.1)
Total net natural capital assets		**90.2**	**89.1**

Although **income** is not an official component of a natural capital assessment, it provides interesting insight. Sources of income to Minnowburn are summarised in Table 11, with the total annual income estimated at £6,190 (PV £157,977). This value pales in comparison to the £90.5M worth of public benefit being delivered by the natural capital assets of the site, nor does it come close to covering the costs of maintaining them. Thus, although the site generates very little income, it delivers considerable benefits to society, which can be highlighted and given a monetary value by taking a natural capital approach.

Table 11. Sources of income to Minnowburn.

Income source	Value (£)
Farm tenant income	4800
Allotments	850
Bee keeping	100
Mobile catering car park rent	1200
Green wood worker at ranger base rent	240
Total	**7190**

6. Conclusions and recommendations

6.1 Key findings

Natural Capital Accounting has been successfully applied to two sites in Belfast; Bog Meadows and Minnowburn. In both cases the accounts have shown that the sites are providing significant benefits to society in the form of public goods and services, and these greatly outweigh the costs of maintaining these sites. The benefits are approximately 50-80 times the maintenance costs for the two sites. Natural capital accounting is useful at highlighting these values, which may otherwise remain hidden. The benefits are, however, all in the form of external values (public goods) rather than private values that could be gained by the land owners, and income for these sites does not cover their annual maintenance costs.

At both sites the value of recreation and physical health vastly outweigh all other benefits. Air quality regulation and carbon sequestration are also important, but are much less valuable than the cultural services. This is a common finding in natural capital valuation and accounting studies, especially in urban sites with good public access. It demonstrates the importance of accessible natural greenspaces for society and the economy, where the impact on health and well-being is substantial.

These are the first natural capital accounts to have been calculated for greenspace in Northern Ireland, as far as we are aware, and one of the aims has been to demonstrate if the approach is feasible in NI. The development of the accounts has shown that there is enough data available to produce meaningful accounts, although it has relied in places on data from England (see below). It is hoped that they can be used to demonstrate best practice to roll out the approach more widely and to communicate and showcase the importance of the natural environment in NI. The accounts can also be used as a baseline against which gains and losses can be calculated in the future.

Overall, Bog Meadows was calculated to be providing approximately £840,000 of benefits each year (with a present value of £26.8M), which was 50 times greater than the costs of maintaining the site. The site lies within the city and is important at providing access to nature, recreation, health and well-being in the heart of an urban area with high levels of social deprivation. It should be noted that it is also important for water quality regulation and water flow regulation. These could not be included in the accounts, although the values are likely to be much smaller than the recreation and health values. It highlights the importance of carrying out an initial qualitative assessment of all ecosystem services that flow from a site, so that a wider range of benefits can be captured and taken into account.

Minnowburn is providing £2.7M of benefits annually, at a present value of £90M, which is over 80 times greater than maintenance costs. Benefits flowing from this site are higher than for Bog Meadows as the site attracts considerably more visitors and visits each year. In addition, the area of woodland is considerably greater, providing increased air quality regulation and carbon sequestration. The qualitative assessment highlighted the importance of a whole range of cultural services at this site.

6.2 Data gaps, assumptions and limitations

Work is progressing rapidly on the calculation of physical and monetary flows of ecosystem services from natural capital assets, but it remains a developing area. A number of ecosystem services remain difficult to quantify and value. Some are highly location specific, for example water flow and flood risk. This can be quantified and valued by running detailed hydrological and flood risk modelling, but it is difficult to generalise to other sites. Others, such as water quality can be modelled, but are very difficult to value, while many of the cultural services, such as aesthetic experiences, cultural heritage, and spiritual experience and sense of place are difficult to even quantify. It should, therefore, be borne in mind that the natural capital accounts presented in this report place values on several key benefits, but these are necessarily incomplete.

For the services that have been included in the accounts, a range of assumptions have been made, and these are outlined when describing the methodology (See Annex 1). For most ecosystem services these assumptions are minimal, as established production functions exist, linking natural capital to ecosystem service production, and levels of production to monetary value. For some services, despite fast developing research in relevant areas, broad assumptions have to be made because these links are not clear. This is particularly the case for physical health, and this estimate should, therefore, be used with care. In addition, for certain services we had to rely on data from England, as equivalent data did not exist for Northern Ireland, although we believe that it is unlikely that this would significantly alter the results.

Valuation of ecosystem services is appropriate at indicating the magnitude of benefits, and has allowed these to be compared across a broad suite of services. It was important to demonstrate the range of benefits that the natural environment can provide in an urban context. However, these results need to be interpreted with care, and in the knowledge that whilst the highest quality and most readily available data were used, there are limitations and assumptions that need to be kept in mind.

6.3 Recommendations for progressing natural capital policy in Northern Ireland

General principles

- The benefits of maintaining and investing in natural capital are considerable and should be taken into account in decision-making.
- Access to greenspace for people can be highly beneficial for physical and mental health and well-being. Benefits are numerous and include enhancing attention and cognitive function, improving mental health and well-being, improving pregnancy and birth outcomes, reducing mortality rates (especially related to cardiovascular and respiratory diseases), and encouraging physical activity. In addition, evidence suggests that in urban areas the presence of natural features can be used to deter crime and anti-social behaviour.
- The monetary value of these benefits can be extremely high and are generally much higher than all other benefits. Innovative public health initiatives that utilise green

infrastructure (e.g. green and social prescribing, walking for health, reducing obesity, tackling air pollution through tree planting) can be promoted and have the potential for considerable cost-savings. Presently only some of the health and well-being benefits of green infrastructure can be given a monetary value, so the full value will be higher still.

- Green infrastructure (GI) can also make important contributions to air quality regulation, climate change mitigation, natural flood risk management, water quality enhancements, local climate amelioration, and noise screening. A full list of benefits is provided in Annex 2 for reference. GI is multi-functional, meaning that an investment focussing on one benefit (e.g. natural flood risk management), can deliver multiple additional benefits, hence offering excellent value for money.
- The location and type of GI should be related to demand, which varies considerably across a city or region. Trees or woodland should be planted close to pollution sources, such as along main roads. Accessible greenspace should be created close to where people live. Mapping the spatial location and distribution of benefits (especially in relation to demand) provides valuable additional information.
- Investing in green infrastructure can help to address issues of social inequality when located within or close to deprived communities, such as around Bog Meadows. Projects should consider both capital works to create and enhance access to greenspaces, and programmes to encourage people from these communities to use their local greenspaces. Projects that encouraged greater use of assets such as Bog Meadow[2] are likely to increase the benefits delivered by the site. If estimates could be calculated of the number of additional visits and visitors predicted to use the site as a result of such activities, it would be possible to use the same natural capital accounting approach described in this report to estimate the net benefits of such projects. It is also possible to combine natural capital approaches with social impact assessment to fully appraise the social, environmental and economic impact of such projects.
- Natural capital approaches, including quantifying, mapping, and valuing the supply and demand of benefits, can now be used to assess the benefits provided by greenspaces, and also to determine the potential impact of proposals and plans. Natural capital accounting can be used to compare benefits to costs. Such approaches are being actively promoted by UK policymakers. Natural capital (and environmental) net gain is being pursued as an objective for all new developments in England (promoted by the UK Government's 25 Year Environment Plan) and comparable policies would bring similar advantages for Northern Ireland.

Specific recommendation for Northern Ireland

- Develop a new policy framework to encourage the wider use of natural capital approaches, including assessment and accounting (as described above), and require it

[2] Some suggestions provided by Ulster Wildlife to encourage greater use of Bog Meadows include having a permanent post on site offering green prescription activities, employability training through involvement in outdoor skills, activities such as nature tots, and reminiscing for the elderly.

for all major development and investment decisions in Northern Ireland. Natural capital approaches should be integrated into Strategic Planning, Local Development Plans and Environmental Impact Assessments (EIAs) as an integral component of decision making. It can be applied to the development sector through the Local Development Plan process and should be written into planning requirements, perhaps as part of the environmental statement or design and access statement for major developments. Natural capital accounting should also be encouraged at a business level in the private sector, as part of reporting duties. This is an area that is receiving much attention through, for example, the Natural Capital Coalition and their Natural Capital Protocol.

- Enact a natural capital and biodiversity net gain policy, so that all new developments and investments have to achieve net benefit for people and the environment. The policy should be introduced at national level, but applied at local government level. This could be accompanied by an offsetting approach, whereby if it was not possible to achieve net gain on-site, investments in natural capital would be required elsewhere. Environmental NGOs (or others) could have a number of projects in preparation, where costs and benefits have been calculated, to receive funding. This could be a valuable way to increase funding for both enhancement projects at existing sites and to fund new sites.
- Undertake natural capital accounting at a range of sites across NI. This would highlight the benefits of the natural environment to decision makers, across a broad array of locations. This should also be accompanied by mapping the supply and demand for ecosystem services using a Geographic Information System (GIS), as this is able to reveal a much greater depth and breadth of information. Mapping can be completed at a city or local authority scale to demonstrate hotspots and coldspots for ecosystem service delivery, identify areas of high demand where natural capital (or access to natural capital) should be improved, areas that should be protected, and areas that would be most suitable for development.
- Linked to the above, habitat opportunity mapping would be a useful land use planning tool if applied to parts of NI. Habitat opportunity mapping is a GIS based approach used to identify potential areas for the expansion of key habitats. It aims to identify possible locations where new habitat can be created that will be able to deliver particular benefits, whilst taking certain constraints into account. For example, opportunities can be mapped to enhance biodiversity, to reduce surface water runoff, to reduce soil erosion and improve water quality, to ameliorate air pollution, and to increase access to natural greenspace. Maps can also be combined to highlight areas that could deliver multiple benefits.
- Develop natural capital investment strategies or plans for strategic locations across NI, to establish and present the business case for investing in natural capital. These highlight the current stock and value of natural capital, identify opportunities for habitat creation / restoration, measure costs (capital and operational expenditure) and benefits of this work in monetary terms, present the case for investment and identify investment vehicles. The end product is a prospectus that can be presented to businesses and other

interested parties. Natural capital investment strategies would probably work best if developed at local government level, taking into account local priorities and plans.

- Collect data on the recreational use of greenspaces and its impact on health and well-being. In particular, a survey such as England's Monitor of Engagement with the Natural Environment (MENE) or Scotland's People and Nature Survey (SPANS), which collect a range of data on people's interactions with the natural environment, would be beneficial. This would collect data on how frequently people use greenspaces, the distances that they travel, the proportion of visits that meet activity guidelines, and numerous other factors.

References

ABC (2015) The Agricultural Budgeting and Costing Book. 81st edition, Agro Business Consultants Ltd.

BEIS (2017) Valuation of energy use and greenhouse gas, supplementary guidance to the HM Treasury Green Book on Appraisal and Evaluation in Central Government.

Binner, A., Smith, G., Bateman, I., Day, B., Agarwala, M. and Harwood, A. (2017) Valuing the social and environmental contribution of woodlands and trees in England, Scotland and Wales. Forestry Commission Research Report. Forestry Commission, Edinburgh. i–iv + 1–112pp.

Cantarello, E., Newton, A.C. & Hill, R.A. (2011) Potential effects of future land-use change on regional carbon stocks in the UK. *Environment Science & Policy*, 14, 50-52.

DAERA (2016) Report on the implementation of the 2015 Northern Ireland Biodiversity Strategy 'Valuing Nature'. Department of Agriculture, Environment and Rural Affairs.

DAERA (2018) Northern Ireland Air, air quality in Northern Ireland. Air quality data archive. http://www.airqualityni.co.uk/

Defra (2015) Modelling of Ambient Air Quality (MAAQ) https://uk-air.defra.gov.uk/data/pcm-data.

Defra (2015) Air quality economic analysis. Damage costs by location and source. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/460398/air-quality-econanalysis-damagecost.pdf

Defra/EA (2004) Annex A: Preliminary guidance on the use of benefits transfer for riverine recreation and angling and coastal recreation. R&D Project Record FD2013/PR2.

DOENI (2015a) Valuing nature – a biodiversity strategy for Northern Ireland to 2020. Department of the Environment Northern Ireland.

DOENI (2015b) Strategic Planning Policy Statement for Northern Ireland (SPPS): Planning for Sustainable Development. Department of the Environment Northern Ireland.

Eftec, RSPB and PwC (2015) Developing Corporate Natural Capital Accounts: Guidelines. Report for the Natural Capital Committee.

Forestry Commission (2016) Timber price indices. Data to March 2017.

HM Treasury (2018) The Green Book. Central government guidance on appraisal and evaluation, version 3. London.

MA (2005) *Ecosystems and Human Well-being: Synthesis*. Island Press, Washington DC.

Natural Capital Committee (2014) Towards a Framework for Measuring and Defining changes in Natural Capital, Natural Capital Committee Working Paper, Number 1.

Natural Capital Committee (2017) *How to do it: a natural capital workbook*. Version 1.

ONS (2014) UK natural capital – initial and partial monetary estimates. UK.

ONS (2016) Annex 1: Background and methods for experimental pollution removal estimates. UK National Accounts. https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/annex1backgroundandmethodsforexperimentalpollutionremovalestimates.

ONS (2017) Principles of Natural Capital Accounting. https://www.ons.gov.uk/economy/environmentalaccounts/methodologies/principlesofnaturalcapitalaccounting.

Powe, N., A., & Willis, K.G. (2004) Mortality and morbidity benefits of air pollution (SO2 and PM10) absorption attributable to woodland in Britain. *Journal of Environmental Management,* 70, 119-128.

White, M.P., Elliot, L.R., Taylor, T., Wheeler, B.W., Spencer, A., Bone, A., Depledge, M.H. & Fleming L.E. (2016) Recreational physical activity in natural environments and implications for health: A population based cross-sectional study in England. *Preventative Medicine,* 91,383-388.

Woodland Carbon Code (2012a). Carbon Lookup Tables V1.5, Forestry Commission. http://www.forestry.gov.uk/forestry/infd-8jue9t.

Woodland Carbon Code (2012b). Estimating woodland carbon sequestration from the Carbon Lookup Tables, Version 1.4, Forestry Commission. http://www.forestry.gov.uk/forestry/infd-8jue9t.

Annex 1: Methodology

This annex provides detailed information regarding the methods used to develop the Natural Capital Accounts for Bog Meadows and Minnowburn, including sources of data and assumptions made. The methods used to determine physical and monetary flows for each ecosystem service are described in turn.

A1.1 Carbon sequestration & storage

Carbon sequestration from woodland areas were calculated following the UK Woodland Carbon Code methodology and look-up tables (Woodland Carbon Code 2012a,b). Values for hedgerows and scrub were calculated at 50% of the storage capacity of broadleaf woodland. The sequestration rates were averaged over a 60 year period for coniferous tree species and 100 years for deciduous species (these being the time periods after which they are typically harvested). The average annual sequestration rates were then multiplied by the area of each woodland type and added together to give the total sequestration estimate for woodland at the site.

Monetary flows were calculated using the government's non-traded central carbon price (£66 per tonne) in 2018 prices (BEIS 2017). We use the non-traded carbon price because it is a better reflection of the 'real' value of carbon sequestration if it were to be exchanged, than market prices. Using the latter reflects the current institutional set up of carbon markets, rather than the true value of carbon sequestration.

The present value (PV) of the ability of the woodland to sequester carbon into the future was calculated over a 50 year period, using the discount rates suggested in HM Treasury (2018), and the formula within ONS (2016). We used the predicted carbon prices for the next 50 years to account for change over time in the value of this service and assumed that the area of woodland remains static.

Site carbon stocks were calculated using average carbon storage values for different land-use types taken from a review of a large number of previous studies in the scientific literature (Cantarello et al. 2011). This combines the carbon storage in the vegetation and the top 30 cm of soil. These carbon storage values are then multiplied by the areas of each land-use type at the site to give the total amount of carbon storage. Carbon storage was calculated for all habitat types except for open/standing water (assumed to have zero carbon and are therefore not considered in carbon accounting (Cantarello et al. 2011)). Note that natural capital accounting is concerned with the flow of ecosystem services (i.e. the accrued benefits over a period of time), whereas carbon in vegetation and soil is a stock (i.e. a quantity of resource measurable at a fixed point of time). Incorporating the two approaches in the same set of accounts would be misleading, therefore we have not provided a monetary value for carbon stocks, it is simply presented as a physical amount as a point of interest. Carbon sequestration is a flow, as it is measuring the uptake of carbon over a period of time, and hence is included in the accounts.

A1.2 Timber/woodfuel production

Annual physical flows of timber/woodfuel production were calculated in terms of overall yield, by multiplying the yield class of the different species by the area of each woodland type. Where yield classes were not known, the average yield class for the species of interest was used. The monetary flows for the woodland areas were calculated by multiplying the yield by the standing price of timber or woodfuel. The average price for softwood in 2017 was taken from the Forestry Commissions Coniferous Standing Sales Price Index (Forestry Commission 2017) and inflated to 2018 prices (£20.17). The price for broadleaved timber in 2015 ranged from £15 to high quality timber reaching £250 per m^3 standing (ABC 2015). As the sites are not being managed as commercial forestry, we have assumed that most output would be in the form of fuelwood and hence use the lower price inflated to 2018 value (£15.80). The present/asset value of the ability of the woodland created to provide timber into the future was calculated over a 50 year period, as outlined in Section A1.1 above. It was assumed that the management and extraction rate does not change over time and that the area of woodland remains static. The unit price is also assumed to be constant.

A1.3 Air quality regulation

We measured the ability of the vegetation at the sites to absorb two key pollutants, particulate matter ≤10µm in diameter (PM_{10}) and sulphur dioxide (SO_2). Quantifying the physical flow of the air quality regulation service provided by the woodland and grassland was based on the absorption calculation in Powe & Willis (2004) and the method in ONS (2016). Scrub and hedgerow were calculated as having half the absorption capacity of deciduous woodland. The deposition rates for PM_{10} and SO_2 in coniferous woodland, deciduous woodland and grassland were taken from Powe & Willis (2004). Average background pollution concentrations for PM_{10} were calculated using Defra data (Modelling of Ambient Air Quality 2015). Data from 2015 (the most recent year available at the time of analysis) for Belfast City Council was used for Bog Meadows, and Lisburn City and Castereeagh District Council for Minnowburn. DEFRA background maps were not available for SO_2 and so data from DAERA's air quality data archive (DAERA 2018) were used instead. We took a three year average (2014-2016) of SO_2 concentrations from monitoring stations in close proximity to each site (Belfast Centre for Bog Meadows and Lisburn Dunmurry Seymour Hill for Minnowburn). These data are likely to be higher than the equivalent background concentrations more commonly used for air quality regulation analyses, hence the SO_2 regulation capacity and value at Bog Meadows and Minnowburn may be a slight overestimate. SO_2 concentrations were, however, very low and so this will have minimal impact on the overall natural capital balance sheet for the sites.

The surface area index of coniferous and deciduous woodlands in on-leaf and off-leaf periods was taken from Powe & Willis (2004). Japanese larch was considered as deciduous for the purpose of these calculations. The proportion of dry days (rainfall <1mm) for Northern Ireland was estimated using MET office regional value data (http://www.metoffice.gov.uk/climate/uk/summaries/datasets). Data from 2015 was used for PM_{10} calculations and the average across 2014-2016 for SO_2 calculations to match the years

of the pollutant concentration data. The proportion of on-leaf relative to off-leaf days was estimated at the UK level using the average number of bare leaf days for five of the most common broadleaf tree species (ash, beech, horse chestnut, oak, silver birch) in the UK using the Woodland Trust data averages tool (http://www.naturescalendar.org.uk/findings/dataaverages.htm).

The air quality regulation service was valued using guidance from Defra that provides estimates of the damage costs per tonne of emissions across the UK (Defra 2015). These are social damage costs based on avoided mortality and morbidity. Therefore, it was assumed that the value of each tonne of absorbed pollutant by the tree stock was equal to the average damage cost of that pollutant. The average damage cost for SO_2 across all locations was used (2018 £2060). The PM_{10} damage cost estimates depend on the location (urban size or rural) and source of pollution. Bog Meadows was classed as urban large (with an associated damage cost of £88,785 2018) and Minnowburn as urban small (£44,085 2018) to reflect its peri-urban location. It was assumed that the rate of absorption and damage cost of PM_{10} and SO_2 would be constant over time, as well as the areas of habitat for the present value calculations over time.

A1.4 Agricultural production

The physical annual flow of agricultural production at the sites was measured as the area of land used for grazing. The monetary value of agricultural production was calculated based on Net Farm Income minus the income received from the Basic Farm Payment. Net Farm Income (NFI), the return to farm operators once all expenses have been deducted, were obtained from DAERA's Farm Business Survey for the main types of agricultural land use and farming systems in the Belfast area, namely lowland cattle farms for Minnowburn, and Less Favoured Area cattle farms for Bog Meadows (to reflect the low productivity of this site). This takes into account farm gate prices, to give gross output, and subtracts typical variable costs (e.g. fertilizers, husbandry, feed and forage costs) and fixed costs (labour, machinery, fuel, buildings). Annual NFI estimates were obtained for the period 2011/12 to 2015/16 and were then adjusted to remove the effects of Basic Farm Payments (income support). This gives a return to the land resource itself after deducting all costs associated with production and excluding income support subsidies, although unpaid family labour has not been taken into account.

A1.5 Greenhouse gas emissions from agriculture

Agricultural activities release CO_2 and other greenhouse gasses such as methane and NO_2 into the atmosphere, with emissions highly variable depending on the type of farming practices employed. These emissions can therefore negate the benefits obtained through carbon sequestration of habitats within a site.

The greenhouse gas emissions of the sites were calculated by multiplying area (i.e. grazing type e.g. rough grazing/permanent pasture) and numbers of livestock by emissions figures for each grassland and livestock type in Bateman et al. (2013). These emission figures are based on three types of agricultural emissions:

1. Emissions from typical farming practices (e.g. tillage, sowing, spraying, harvesting, and the production, storage and transportation of fertilizers and pesticides)
2. Emissions of N_2O from fertilizers
3. Emissions of N_2O and methane from livestock, caused by enteric fermentation and the production of manure

Grassland was classed as rough grazing at Bog Meadows (associated with zero greenhouse gas emissions) and permanent grassland at Minnowburn (emissions of 1.24 tCO_2e/ha). The total physical flow of greenhouse gas emissions was calculated by adding crop type and livestock emissions (in tCO2e). These were monetised using the BEIS (2017) non-traded central carbon price (£66 £2018), as described for carbon sequestration in Section A1.1.

A1.7 Recreation

The importance of access to the natural environment is being increasingly recognised. Visits to natural areas have been shown to enhance physical and mental health and well-being, increase social cohesion and contribute greatly to the local economy. There are various methods for calculating the recreational value of a site including, for example, using visitor spend and contribution to the local economy. Given the limited opportunities for spending at either Bog Meadows or Minnowburn we instead use recreational value derived by Sen et al. (2014) from a meta-analysis of just under 300 previous assessments of the value of outdoor recreational visits to different habitat types in Great Britain. The physical flow of the recreation service to sites was calculated as the estimated number of visits from site counter data. The annual monetary flow for recreation was estimated by multiplying the number of visits by the per person per trip recreational value for greenbelt and urban fringe farmlands (£6.19 2018) from Sen et al. (2014). Note that this was derived from studies in Great Britain rather than Northern Ireland, but as Sen et al. (2014) is a meta-analysis of a large number of studies and there is no equivalent data from NI, it was considered an appropriate source to use.

A1.8 Health and well-being

There is now a growing body of evidence to show the positive effect that the natural environment can have on human health and well-being. Monetising these benefits remains a challenge with mental health in particular lacking a generic measure that is commonly applied, making it very difficult to value at present (Binner et al. 2017). Physical health is more commonly valued, although methods are still being refined. We measured the physical flow of health benefits delivered by the sites, using an approach developed by White et al. (2016) who analysed the implications of recreational physical activity in the natural environment on health in England. The method relies on estimates of visitors to natural environments who meet recommended activity guidelines (based on both duration and intensity of physical activities). These can be translated into Quality Adjusted Life Years (QALYs) scores, with 30 minutes of moderate to intense physical activity (if taken 52 weeks a year) being equal to 0.0107 of a QALY. QALY scores have an associated monetary value through estimated savings in health care costs. We are, therefore, able to value this physical

health benefit by calculating the total number of QALYs from active visits to sites that meet guidelines, and multiplying this by the QALY value. The social value of one QALY has been estimated to be worth £20,000 (White et al. 2016). Note, however, that the HM Treasury has just (March 2018) published an update to the Green Book (the Government's key guidance document on appraisal and evaluation), in which the value associated with one QALY has been increased to £60,000 (HM Treasury 2018). Given the large monetary benefit that would be assigned if using the higher QALY figure and the large number of assumptions involved in calculating this value, we have taken a conservative approach and used the lower estimate of £20,000, as has been used in previous natural capital assessments. But note, therefore, that the estimates for the value of physical health presented here could be considered to be much higher.

The first step in these calculations was to convert the number of visits to the sites into numbers of visitors (thereby accounting for repeat visits by the same individuals). We followed the DEFRA/EA (2004) guidance, treating Bog Meadows as a local site of upper importance with a predicted visit rate of 27.6 per adult per year and Minnowburn as a honeypot site of mid importance with a predicted visit rate of 17 per adult per year. The total number of visits to each site was divided by the visit rate to give the total number of visitors.

The next step is to determine the number of these visitors who met physical activity guidelines at the two sites. However, no appropriate data is available for Northern Ireland (data is available on the proportion of the overall population of Belfast who meet activity guidelines, but not the proportion who meet these guidelines in greenspace). We subsequently used the proportions of active visits to urban greenspaces that met physical activity guidelines (based on Monitoring Engagement with the Natural Environment data for England), and applied it to both sites to work out estimated number of QALYs and associated monetary value.

The present value (PV) of the ability of sites to deliver physical health benefits into the future was calculated over a 50 year period, using the discount rates suggested in HM Treasury (2018) and the formula within ONS (2016). Discount rates for QALY effects are recommended at 1.5%, declining to 1.29% after 30 years (differing from the 3.5% declining to 3% rates recommended for other service indicators).

A number of assumptions are used in these calculations and the results should therefore be interpreted with caution; it is the ecosystem service with the greatest degree of uncertainty out of all those assessed here. In addition, we have used data from England as no equivalent data is collected from NI.

Annex 2: The benefits of green infrastructure

Table A2: The ecosystem service benefits provided by green infrastructure and some of the ecological, economic and social implications of these services.

Ecosystem services	
Regulating services	
Reducing rate and volume of storm water runoff	Providing shade
Reducing flood risk	Reducing summer air temperatures and the urban heat island effect
Enhancing infiltration and recharging ground water	
Reducing soil erosion	Providing shelter from wind
Trapping sediment	Reducing energy use
Enhancing water quality	Reducing glare
Absorbing air pollution – particulate matter (PM), NO_x, SO_3, ozone, carbon monoxide, ammonia	Attenuating noise
	Screening unattractive or noisy places
Removing dust and odour	Supporting pollinators
Producing oxygen	Enhancing pest and disease control
Sequestering and storing carbon – in plants and in soil	
Cultural services	
Providing and enhancing landscape character	Enhancing community cohesion
Contributing to sense of place and identity	Reducing aggression, violence and crime rates
Part of cultural heritage	Increasing security
Enhancing aesthetics	Enhancing driver and pedestrian safety
Benefiting physical health – reducing blood pressure, stress, asthma	Reducing road traffic speeds
	Enhancing privacy
Speeding recovery from surgery and illness	Bringing people closer to nature
Enhancing attention and cognitive function	Providing setting for outdoor learning
Improving mental health and well-being	Improving educational outcomes through improvements in concentration and performance and reduced time off for illness
Improving pregnancy and birth outcomes	
Reducing mortality rates – especially related to cardiovascular and respiratory diseases	Enhancing quality of life
	Providing spiritual value and meaning
Encouraging physical activity	Supporting biodiversity and wildlife viewing
Enhancing connectivity	
Provisioning services	
Source of timber, fuel, fodder, and fibre	Source of biofuels
Location and source of food production	Location for solar, wind and hydro energy
Enhancing water supply	Source of ornamental resources and crafts
Ecological benefits	
Habitat provision, improvement & connectivity	
Economic benefits	
Increasing land and property prices	Increasing property taxes
Reducing 'time on market' for selling property	Enhancing rental income
Attracting business and customers	Increasing tourism and visitor revenues
Reducing health care costs	Reducing screening costs especially next to main roads
Reducing expenditure on air pollution removal	Reducing agricultural costs and enhancing farmer income
Reducing expenditure on storm water infrastructure	
Reducing expenditure on flood defences	Providing potential for carbon offsetting trade
Saving investment in new power supplies	Generating income from sales of food, fibre, biofuels and ornamental / craft produce
Generating income from renewable energy	
Reducing heating and cooling costs	Creating jobs and employment in environmental sector