Forest Sector Case Study – Applying the Natural Capital Protocol Forest Products Sector Guide

Final report

Scottish Forestry

Project number: 60618640

12 November 2020

Quality information

Prepared by	Checked by	Verified by	Approved by
Sarah Krisht (AECOM) Jess Wood (AECOM)	Will Richardson (RDI Associates)	Paul Silcock (Cumulus Consultants)	Steve Smith (AECOM)

Revision history

Revision	Revision date	Details	Authorised	Name	Position
1	30/04/2020	Draft report	30/04/2020	Sarah Krisht	Project Manager
2	12/11/2020	Final report	12/11/2020	Sarah Krisht	Project Manager

Prepared for:

Scottish Forestry

Prepared by:

AECOM Infrastructure & Environment UK Limited
Aldgate Tower
2 Leman Street
London E1 8FA
United Kingdom
aecom.com

Prepared in association with:

RDI Associates

Cumulus Consultants

Table of Contents

Figures

Tables

Executive summary

ES.1 Introduction and study objectives

Business activities rely on nature and affect it. This interdependence creates costs and benefits for businesses and society, generating both risks and opportunities. Maximising these benefits and opportunities is vital both for corporate performance and for the future of nature and society. The Natural Capital Protocol was established to provide a framework for businesses to understand and assess their impacts and dependencies on nature, in order to consider how to blend corporate value with environmental sustainability. The Forest Products Sector Guide recognises the particular relationship between nature and the profitability and sustainability of the forest sector.

This report presents the findings from a study by AECOM, in collaboration with RDI Associates and Cumulus Consultants, and commissioned by Scottish Forestry, in association with Tilhill Forestry and the Scottish Environment Protection Agency (SEPA). The study tests the application of the Natural Capital Coalition's[1] Forest Products Sector Guide[2] of the Natural Capital Protocol[3] to a recent forest creation project at Larriston in the Scottish Borders. Planting at Larriston was completed in 2017.

This study is the first in the UK to apply the Protocol's Forest Products Sector Guide in the forestry sector. The Protocol and Sector Guide provide a standardised approach to assessing the material impacts (i.e. beneficial or adverse effects of forest sector activities) and dependencies (i.e. the forest sector's use of or reliance) on natural capital with respect to forest operations and management. Natural capital is defined as the stock of renewable and non-renewable natural resources on earth (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits or 'services' to people.

ES.2 Key findings

The study covered six different material impacts or dependencies using qualitative, quantitative and/or monetary approaches, depending on the availability of data. Table ES. 1 provides a summary of the areas covered in the study, and whether the impacts or dependencies that were assessed are relevant to the landowner or wider society.

Table ES. 1: Summary of assessment of material impacts and dependencies

Impact / dependency	Private	Societal	Approach	50 years					
				Physical flow			Monetary flow (present value)		
				Estimate	Unit	Con-fidence rating[a]	Estimate	Unit	Con-fidence rating[a]
Timber	✓		Market valuation	194	thousand tonnes	High	2,500	£k	Moderate
Carbon sequestration		✓	Cost-based	145	thousand tonnes of CO_2e	High	9,100	£k	High
Natural hazard regulation		✓	Replacement cost	2,950	thousand m^3	Moderate	600	£k	Low

[1] As of 2019, the Natural Capital Coalition became known as the Capitals Coalition after integrating with the Social and Human Capital Coalition.
[2] Hereafter referred to as the Sector Guide.
[3] Hereafter referred to as the Protocol.

Impact / dependency	Private	Societal	Approach	50 years					
				Physical flow			Monetary flow (present value)		
				Estimate	Unit	Con-fidence rating[a]	Estimate	Unit	Con-fidence rating[a]
Recreation		✓	Not assessed due to limited visitor data						
Aesthetics		✓	Not assessed due to limited economic valuation evidence						
Biodiversity		✓	Stated preference[b]	-	-	Low	7,400	£k	Low

Notes: All monetary values are expressed in 2019 prices. Present value estimates are discounted in line with the Green Book (HM Treasury, 2018). [a]: Indicative rating based on the suitability of the approach used and the strength of the evidence. [b]: Using the 'contingent ranking method', where respondents are presented with a number of scenarios and asked to rank them individually. The value also assumes a distance decay effect i.e. that, while non-use values do not just apply to nearby populations, the values may diminish the further individuals are from the change in biodiversity.

The analysis demonstrated that ecosystem services at the core of the forest creation project's objectives tended to be associated with better data. This was the case for **timber** where the total volume of timber forecast for harvest over 50 years was found to be just under 195,000 tonnes, with a value of around £2.5 million in present value terms.

In contrast, the total volume of **carbon sequestered** by forested areas at Larriston, net of emissions from establishment and ground preparation, was estimated at nearly 145,000 tonnes of carbon dioxide equivalent (CO_2e) over 50 years and valued at £9 million in present value terms. This monetary value is estimated using the Department for Business, Energy and Industrial Strategy's (BEIS) non-traded carbon price, which reflects the marginal abatement cost of carbon to meet the UK's climate change targets. As such they would be meaningful in the context of value for money assessments, to make the case for forest creation at the national level to HM Treasury. The value of carbon sequestration was also considered in terms of the price of verified credits under the Woodland Carbon Code and the Woodland Carbon Guarantee, for the benefit of landowners, project developers and forest managers. The values are significantly lower than the present value of timber that is estimated for Larriston. There is therefore a mismatch between the market and societal value of carbon sequestration which could potentially be explored via other policy levers and incentives, such as public payments for public goods.

For **flood risk protection**, forest cover at Larriston is estimated to store nearly 3 million m^3 of water over a 50-year time horizon, with respect to canopy interception and additional soil water storage. The cost of constructing a reservoir with an equivalent capacity is estimated at £0.6 million over 50 years in present value terms. This cost-based estimate provides a conservative estimate for the value of the benefits from flood risk protection at Larriston.

The non-use value of **biodiversity** was also considered, which represents the value associated with knowing that biodiversity exists rather than from engaging with it in some way. The value assumed that non-use values may diminish the further individuals are from the change in biodiversity (i.e. a distance decay effect). Nearly 25 million households were captured by the analysis based on an area that extended up to 500 km from Larriston. The non-use value of biodiversity was estimated to be around £7 million over 50 years in present value terms. This indicative estimate is subject to a number of assumptions, and is intended to provide a degree of context and spatial heterogeneity compared to the national estimate for the whole of Great Britain, that is mentioned in the main report. Other ecosystem services that were considered in qualitative terms included **recreation** and **landscape aesthetics**. There was a lack of suitable valuation evidence to assess aesthetic values, and a lack of reliable estimates of visitor numbers to assess recreational values.

ES.3 Insights from applying the Sector Guide

The application of the Sector Guide to Larriston shows that a natural capital assessment for forest creation projects can:

- Complement the narrative within conventional Environmental Impact Assessments for forest creation projects and provide evidence to assess performance under the UK Forestry Standard (UKFS).
- Provide different insights depending on the stage at which the assessment takes place. At the planning and design stage, a natural capital assessment could provide a framework for undertaking an options appraisal of different forest design specifications. It could also inform the future management of forest creation sites and provide a basis for engaging with stakeholders including local communities. An assessment after planting has taken place, for example at Larriston, can help with monitoring efforts and identifying lessons learnt for future projects.
- Make the case for forest creation as a form of natural capital investment at the national level in the context of achieving biodiversity targets, net zero carbon emissions and other targets in Scotland and the UK.
- Inform the feasibility of developing payments for ecosystem services (PES) schemes, where additionality can be demonstrated. This could include public payments for public goods which are linked to goals within the UK Government's 25-Year Environment Plan and the devolved administrations' plans for future rural support.
- Demonstrate returns on investment in forest creation projects. This evidence could be used to support initiatives such as the proposed 'Natural Capital Pioneer Fund' within the £1 billion challenge, recently launched by the Scottish Environment Protection Agency (SEPA) and the Scottish Wildlife Trust.

ES.4 Recommendations for future assessments

The application of the Sector Guide to future forest creation projects could be improved by:

- Assessing a project at the design stage to maximise the potential impact and insights of a natural capital approach on the design and future management of a site. This could include assessing the baseline to determine the net impact of a forest creation project.
- Focusing on the open ground (unplanted area) as well as the planted area within a site to provide a holistic approach. This could potentially demonstrate the trade-offs including whether using a natural capital approach at the design stage might suggest a different conclusion as to the split between planted vs. unplanted land within a site.
- Considering impacts and dependencies on social capital (e.g. relationships and trust) given the potential adverse and/or beneficial impacts of forest creation projects on local communities and the potential for concerns about land use change.

In addition to these practical recommendations, further recommendations for future research are provided in the main report.

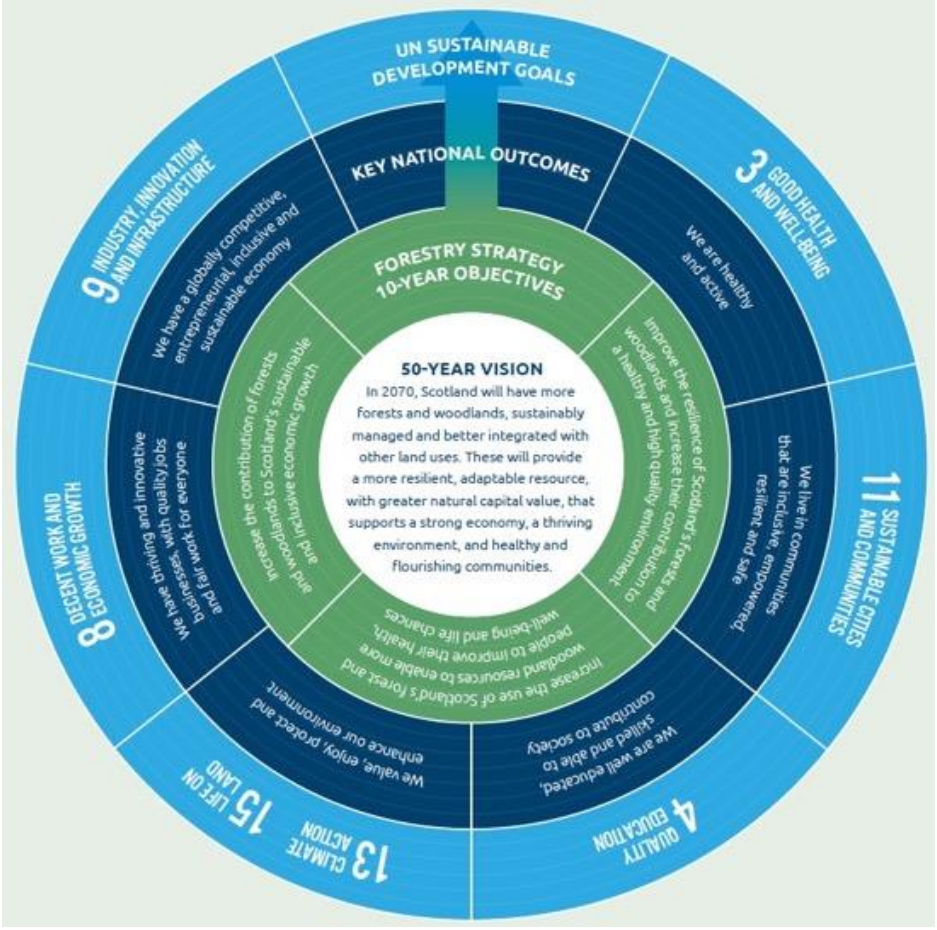
1. Introduction

This report presents the findings from a study by AECOM, in collaboration with RDI Associates and Cumulus Consultants, and commissioned by Scottish Forestry, in association with Tilhill Forestry and the Scottish Environment Protection Agency (SEPA). The study tests the application of the Natural Capital Coalition's[4] Forest Products Sector Guide[5] (Natural Capital Coalition, 2018) of the Natural Capital Protocol[6] (Natural Capital Coalition, 2016) to a recent forest creation project in Scotland. The purpose of the study is to explore the insights from applying the Sector Guide and how this might inform the consideration of natural capital in future forest creation projects.

1.1 Background

In 2019, Scottish Government published Scotland's Forestry Strategy (Scottish Government, 2019) for the period 2019 – 2029. The strategy included a commitment to increase forest cover to 21% of the total area of Scotland by 2032. The goals within the strategy are usefully linked to national outcomes and the UN Sustainable Development Goals (SDGs), as shown in the figure below.

Figure 1.1: Scottish forestry objectives linked to national outcomes and SDGs.



Source: Scottish Government (2019)

[4] As of 2019, the Natural Capital Coalition became known as the Capitals Coalition after integrating with the Social and Human Capital Coalition.
[5] Hereafter referred to as the Sector Guide.
[6] Hereafter referred to as the Protocol.

More broadly, in the UK the role of forest creation in climate change mitigation has been widely recognised including within the Government's 25-Year Environment Plan (HM Government, 2018a); the recently proposed Environment Bill (HM Government, 2020); the Committee on Climate Change's (CCC) recent analysis of land use policies with respect to climate change (CCC, 2020); and the Natural Capital Committee's (NCC) advice on using nature-based interventions[7] to reach net zero carbon emissions by 2050 (NCC, 2020).

The governance process for forest creation projects includes the standards set out in the UK Forestry Standard (UKFS) (Forestry Commission, 2017) and practice guidance on Design Techniques for Forest Management Planning (HM Government, 2018b). The UKFS was first introduced in 1998 and has been subject to four revisions since then. It outlines the context for forestry, sets out the UK Government's approach to sustainable forest management, defines standards and requirements, and provides a basis for regulation and monitoring (facilitating national and international reporting). The UKFS advocates a balanced approach to sustainable forest management, recognising that forests have a range of environmental, social and economic objectives, impacts and dependencies. This approach recognises the concept of natural capital which identifies the environment as an asset that delivers benefits to people.

1.2 Overview of approach

Natural capital is defined as the stock of renewable and non-renewable natural resources on earth (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits or 'services' to people (Natural Capital Coalition, 2016). Natural capital has become important in conceptualising the interaction of forestry with nature and in understanding how forestry both affects nature and relies on it.

This study is the first in the UK to apply the Natural Capital Protocol (Natural Capital Coalition, 2016) to the forestry sector, specifically through the Protocol's Forest Products Sector Guide (Natural Capital Coalition, 2018). Figure 1.2 presents the stages set out in the Sector Guide, which also follows the stages of the Natural Capital Protocol. Together these provide a standardised approach to assessing the material impacts (i.e. beneficial or adverse effects of forest sector activities) and dependencies (i.e. the forest sector's use of or reliance) on natural capital with respect to forest operations and management. Generally, the stages and underlying steps within the Protocol and Sector Guide are intended to be applied in a flexible way. For example, based on the objectives of an application and the level of information available.

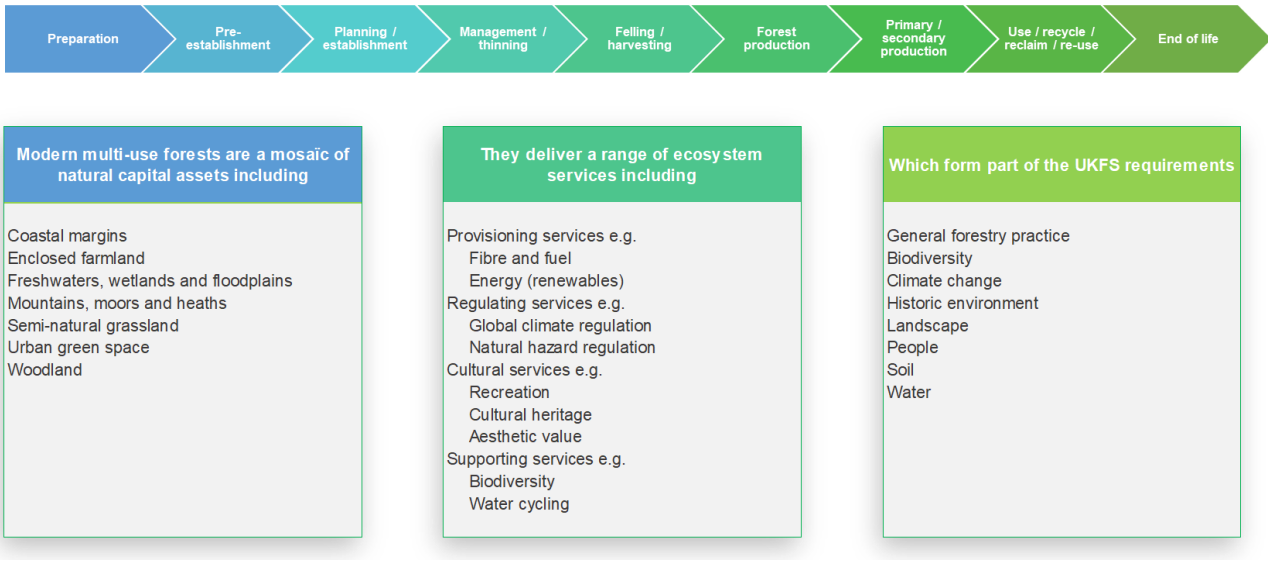
[7] The NCC defines nature-based interventions as measures which restore or enhance natural assets and, as a result, deliver multiple benefits, for example: carbon storage, flood alleviation, human well-being and biodiversity (NCC, 2020).

Figure 1.2: Natural Capital Protocol assessment stages

Source: Natural Capital Coalition (2016; 2018)

The use of a natural capital approach complements the framework provided by the UKFS. Figure 1.3 demonstrates this by considering the forest creation / production cycle in the context of the UKFS, through the lens of a natural capital assessment.

Figure 1.3: Forest creation / production cycle through the lens of a natural capital assessment



As mentioned above, the Protocol defines natural capital as the stock of natural resources that combine to yield a flow of benefits or 'services' to people. As such, natural capital can be broken down into a stock of assets, characterised by their extent and condition (quantity and quality) with their condition in turn determining their capacity to deliver ecosystem services. These ecosystem services, when combined with other inputs (e.g. machinery, labour, human ingenuity, etc.), deliver benefits to landowners and wider society. A natural capital approach is also consistent with the ecosystem approach, which is a framework for analysing how people depend on the condition of the natural environment. The approach explicitly recognises that ecosystems and their biological diversity contribute to individual and social well-being.

There are various ways to categorise natural capital assets and ecosystem services. The typology used in Figure 1.3 draws on:

- The Protocol and the Sector Guide;
- The Millennium Ecosystem Assessment (MEA, 2005);
- The UK National Ecosystem Assessment (UK NEA, 2011);
- The Natural Capital Committee's recommended terminology for natural capital (NCC, 2019); and
- The Department for Environment, Food and Rural Affairs' (Defra) recent guidance on Enabling a Natural Capital Approach (ENCA) (Defra, 2020).

Many of the measures used to track compliance against requirements of the UKFS could be used as indicators of extent or condition of natural capital assets, or the physical flow of ecosystem services delivered by these assets. This is the case across all the stages of the forest creation / production cycle presented in Figure 1.3.

Generally, the use of a natural capital approach aims to augment conventional environmental assessments by (i) focusing on both impacts *and* dependencies; (ii) endeavouring to measure and value these impacts and dependencies, (iii) considering a broader range of issues; and (iv) looking at a study area as an inter-related system (Natural Capital Coalition, 2016; 2018). Table 1.1, taken from the Protocol, provides more information on the additional value of a natural capital approach.

Table 1.1: The additional value of a natural capital approach (Natural Capital Coalition, 2018)

Area	Existing approaches	Additional value of a natural capital approach
Impacts and dependencies	**Focus on impact** A focus on the impacts to natural capital, rather than dependencies. Water discharge, waste, and carbon are some more advanced issues in relation to determining impact, with concerted efforts to develop tools and instruments around these issues.	**Impacts and dependencies** A natural capital approach importantly includes a consideration of dependencies (e.g. fibre, minerals, pollination, climate regulation, water environment quality) to provide a holistic view of risks and opportunities.
Valuation	**Focus on measurement** Many companies in the forest products value chain are already effectively measuring environmental aspects of their activities. This tends to be focused on measuring quantities of natural resources used as inputs to production (water, minerals, etc.) or the non-product outputs of business activities (emissions, discharges, etc.). Measurement is often undertaken using Life Cycle Assessment (LCAs) with the principles defined in the ISO 14000 standards, e.g., 14040.	**Focus on valuation** A natural capital approach provides an understanding of what these inputs and outputs mean in terms of their relative importance or worth to society and to business (i.e. their value). While a measured environmental input or output might be the same in two different locations, the value is highly location specific. This progression from measurement to valuation is critical in understanding the extent of risk, exposure, and opportunity to better inform decision making.
Scope	**Limited issues** Environmental assessments tend to focus on a relatively limited set of natural capital issues (e.g. relatively little attention is paid to regulating and cultural services).	**Broader range of issues** Able to consider a much wider range of natural capital impact drivers and dependencies, including those which might vary depending on context. Provides increased coverage of regulating services and cultural values. From this broader range, users are then equipped with better information to identify which factors are material.
Connectivity	**Stand-alone** Environmental considerations tend to be seen as a series of stand-alone issues (e.g. climate change is often analysed and treated as a distinct issue to water,	**Inter-related system** Able to treat natural capital as a set of interrelated issues, considering trade-offs and impacts that are additional.

Area	Existing approaches	Additional value of a natural capital approach
	biodiversity, or public health). The consequence is that relationships between these issues can be often missed (e.g. issues of scarcity, multiple uses, and trade-offs).	

Source: Natural Capital Coalition (2018)

The use of a natural capital approach has the added benefit of supporting and providing evidence for all stages of the policy and project cycle from planning and options appraisal, through to delivery and implementation, and on to monitoring and enforcement by:

- Informing project design and options appraisal;
- Scoping investible opportunities including those associated with payments for ecosystem services (PES) schemes;
- Demonstrating social, economic and environmental returns on investment in natural capital;
- Providing a monitoring framework and lessons learnt for future interventions; and
- Providing a basis for engaging with stakeholders about impacts and dependencies on natural capital.

1.3 Study aims and objectives

This study focused on exploring the impacts and dependencies of forest creation on natural capital, by testing the application of the Natural Capital Protocol's Forest Products Sector Guide to a forest creation project in Scotland. The specific aims of this study, as set out in the specification, are to:

- Apply all the stages of the Forest Products Sector Guide to a forest creation project in Scotland;
- Identify which aspects of natural capital and ecosystem services can reasonably be covered in the application;
- Specify data needs and how these can be sourced;
- Identify impacts and dependencies on natural capital;
- Assess where and how the use of the Sector Guide adds value to business planning and operations; and
- Show whether and how a natural capital approach can help inform wider forest creation design and implementation.

The findings from this exploratory study could inform the application of the Sector Guide to other sites in the future, and potentially at earlier stages of the planning and design process. The study may also provide insights into forest operations and land management, including the extent to which a natural capital approach could inform monitoring and data collection for forest creation schemes in the future.

1.4 Report structure

The remainder of this report is structured as follows:

- Section 2 provides an overview of the site that the study focuses on;
- Section 3 applies the **Frame** stage of the Sector Guide which considers how the concept of natural capital applies to the study context;
- Section 4 applies the **Scope** stage and determines the material impacts and dependencies in the context of the study;

- Section 5 applies the **Measure and Value** stage focusing on assessing the material impacts and dependencies in qualitative, quantitative and/or monetary terms; and
- Section 6 provides conclusions and recommendations for the study in the context of the **Apply** stage of the Sector Guide.

The report is supported by the following appendices:

- Appendix A which provides information about the baseline habitats at the study site;
- Appendix B which provides information about the assessment of material impacts and dependencies at the study site;
- Appendix C which provides information about the approach to assessing carbon storage and substitution benefits from harvested wood products; and
- Appendix D which provides information about the dissemination webinars held towards the end of the study.

The next section presents information about the study site. Following this, other sections focus on the application of different stages and underlying steps of the Sector Guide. Where relevant, individual steps are set out consecutively, in particular for the scoping activities which frame the assessment. With regard to the later steps in the Sector Guide, including the Measure and Value stage, steps are combined for clarity and ease of reference.

2. Study site

This section provides an overview of Larriston, the site that this study focuses on. The information in this section is predominantly based on the Environmental Statement for the forest creation proposal at Larriston (Tilhill Forestry, 2015), and supplemented by observations recorded during a visit to the site in January 2020.

Larriston is in the Scottish Borders, an area with nearly 20% forest cover recorded in 2005 (Scottish Borders Council, 2005). The nearest village to Larriston is Newcastleton, around 6 km away to the south west. Prior to receiving consent for forest creation in 2016, the site was used by one farmer for long-term sheep grazing. Larriston is considered to be a preferred area for forest creation in the Scottish Borders Council's woodland strategy (Scottish Borders Council, 2012). The strategy sets out priorities for the wider landscape where Larriston is located, including to retain existing areas of productive forests but to include a higher proportion of open ground and a greater diversity of tree species to achieve a better landscape fit, with wider environmental benefits (e.g. recreational benefits and improved biodiversity) (Scottish Borders Council, 2012).

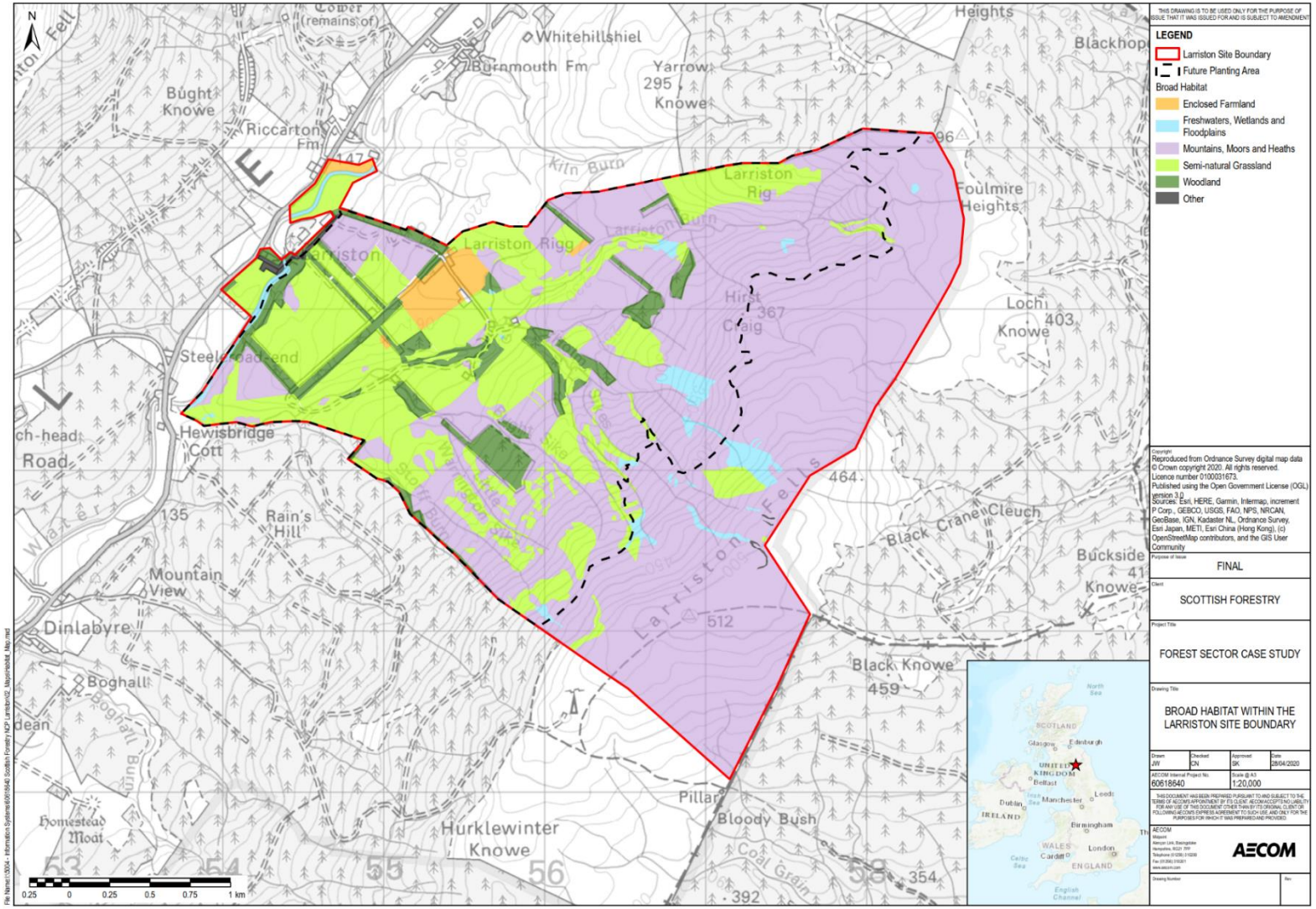
The shift from sheep grazing to forestry was examined in a study by Bell (2014) which compares an established coniferous forest at Eskdalemuir, in the south of Scotland, with agriculture on an equivalent area of land. The previous land use at Eskdalemuir, which has an area of around 20,000 ha, was hill sheep grazing. The study found that forestry produces three times the economic output of farming before subsidies and leads to double the expenditure in the local economy compared to farming. In the long-term, forestry is found to support the same number of jobs as farming and is less dependent on annual subsidy payments to maintain financial viability.

Figure 2.1 present the habitats that were present at Larriston before planting took place, based on the Phase 1 habitat survey for the site. The dominant broad habitats within the site, which has an area of around 1,108 ha, include blanket bog, marshy grassland and improved grassland. Figure 2.2 presents the extent and condition of waterbodies and catchments near Larriston, which includes a waterbody with high water quality within the site.

Larriston was purchased by a private investor in early 2014 and a proposal to afforest the site was prepared and assessed, noting that the site is already surrounded by productive forests. The Environmental Statement states that the primary aims of forest creation at Larriston are (Tilhill Forestry, 2015):

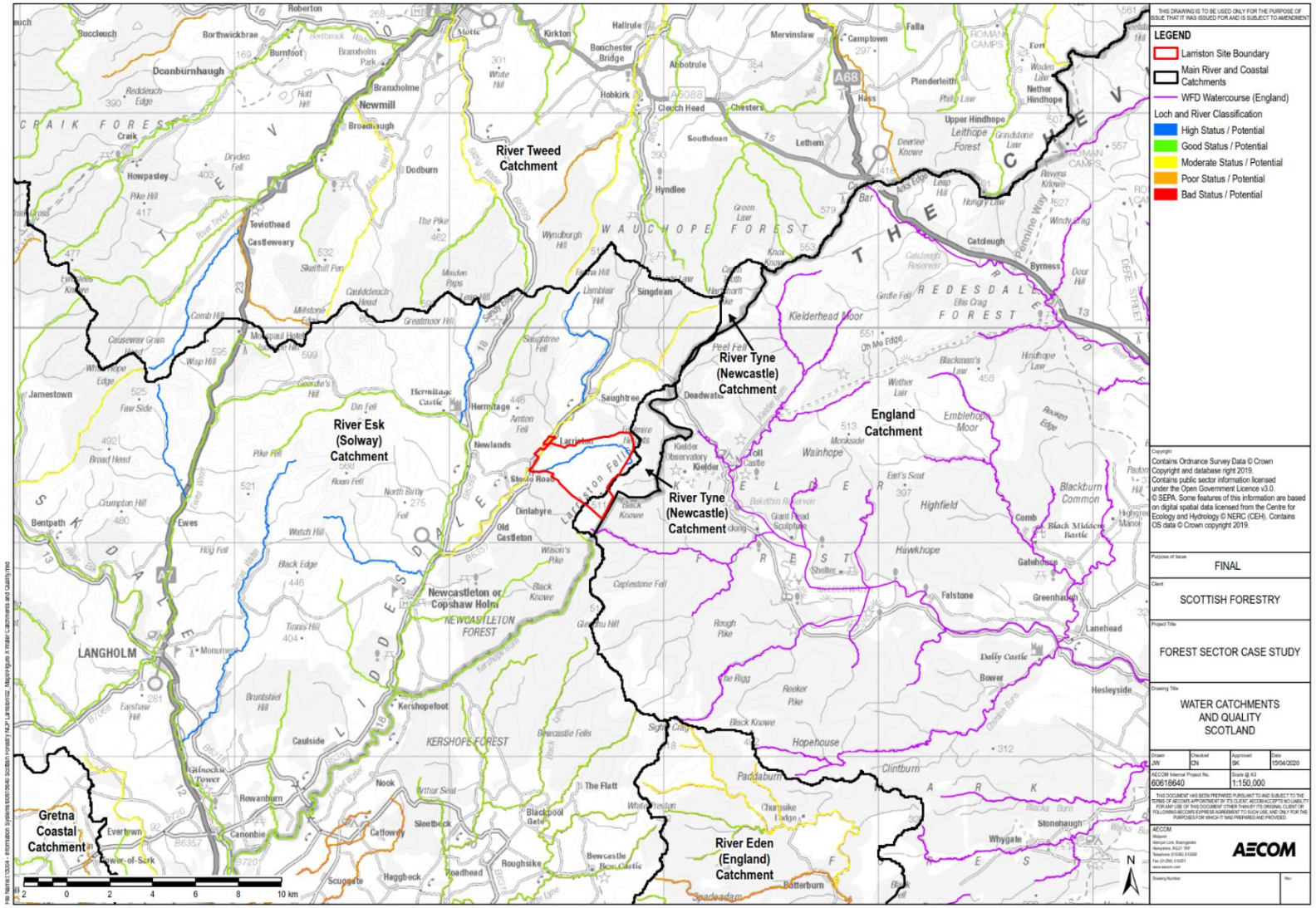
- To establish a multi-purpose mixed woodland on previously grazed hill land for wood and fuel production and to help underpin a sustainable forest products industry, as an alternative to upland sheep farming;
- To enhance the landscape and maintain and extend the existing areas of semi-natural woodland that surround the site;
- To provide community benefits through new opportunities for responsible public access, recreation and interpretation of the cultural resource; and
- To create a carbon sink and improve Scotland's greenhouse gas balance.

Figure 2.1: Baseline habitats present at Larriston before forest creation (2013/14)*



Notes: *Phase 1 habitat data provided by Tilhill Forestry and mapped by AECOM based on UK NEA (2011) broad habitat types. Original map and assumptions are presented in Appendix A.

Figure 2.2: Waterbodies and catchments near Larriston (2018)



The proposal for planting at Larriston set out the objective to establish a productive mixed woodland. Planting at Larriston started in 2016 and was completed in 2017. The site and the planting design are considered to be typical and representative of forest creation projects in Scotland. Figure 2.3 shows the final design for the planting area within site and Table 2.1 presents the breakdown of tree species within this area (560 ha) and within the site's overall gross area (1,108 ha). The areas of broadleaved native woodland, low density edge woodland, and Scots pine are intended to provide other wider environmental benefits, particularly with respect to creating a habitat corridor through the site linking low ground with high ground.

Table 2.1: Breakdown of tree species and open ground within Larriston (2016)

Species / land type	% (of approx. 560 ha planted area)	% (of approx. 1,108 ha gross area)
Sitka Spruce (SS)	71%	36%
Scots Pine (SP)	6%	3%
Western Red Cedar (WRC)	1%	1%
Productive Broadleaves (ASP/BI)	3%	1%
Native Broadleaves (NBL)	5%	3%
Open Ground (OG) in planted area	10%	5%
Edge Broadleaves (EDG)	3%	2%
Open Ground (OG) in unplanted area	-	50%
Total	100%	100%

Notes: Acronyms denote tree species and match Figure 2.3 as follows. ASP/BI: Aspen/Birch; EDG: Edge Broadleaves; WRC: Western Red Cedar; NBL: Native Broadleaves; OG: Open Ground; SP: Scots Pine; SS: Sitka Spruce. Source: Tilhill Forestry (2016)

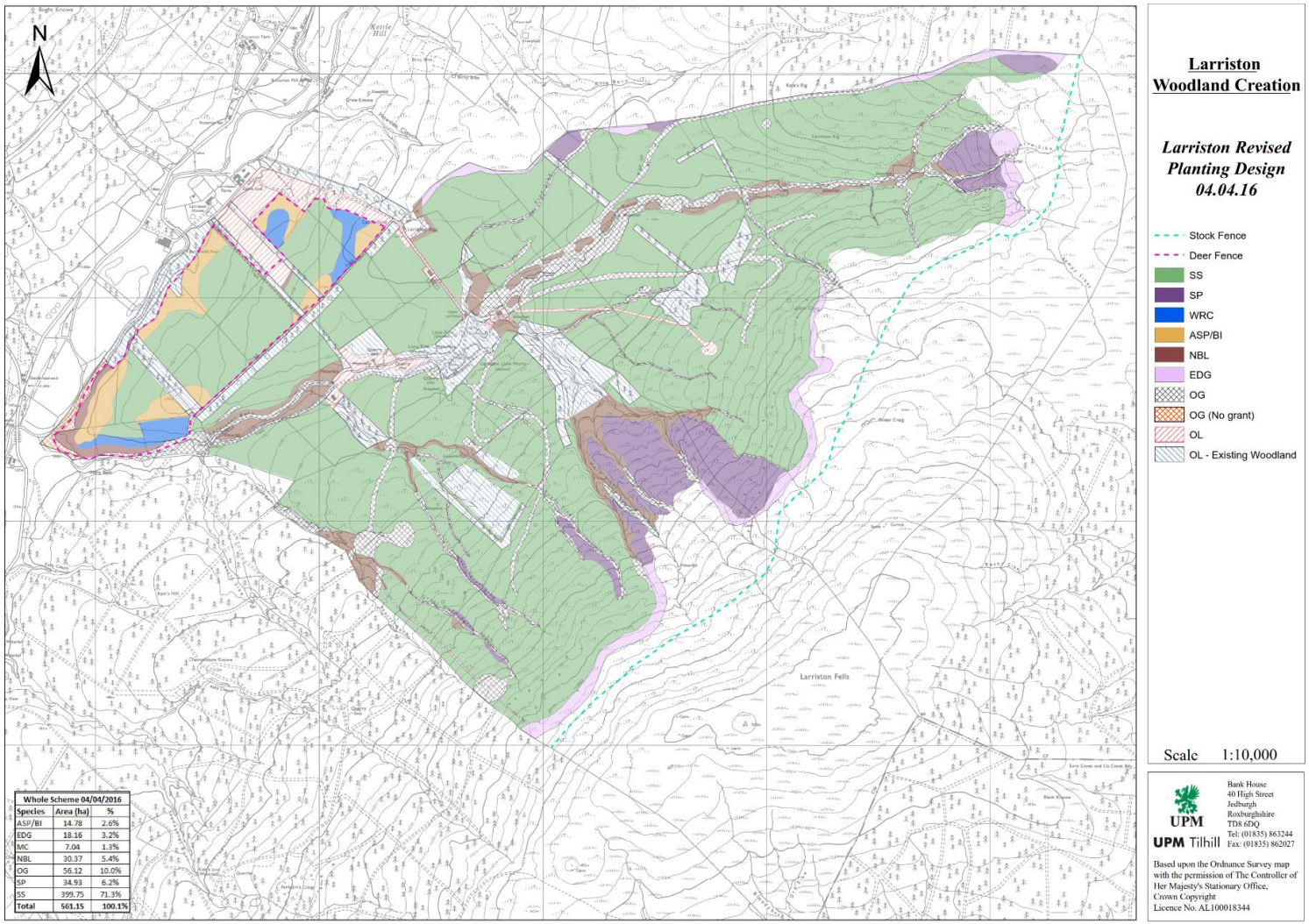
The design of the site takes into account existing archaeological features as shown in Image (a) below, captured during a visit to the site by the project team in January 2020. The design also considers the surrounding landscape including other forests, by aiming to connect other forested areas and 'softening' and blending their boundaries. Around 50% of the site was left as unplanted open ground, as shown in Table 2.1, including blanket bog and species-rich wetlands. This area of open ground will remain under non-active management which will likely lead to rewilding and deliver biodiversity improvements in the long-term. The forest is currently in its establishment phase as shown in Image (b), captured by the Forest Manager. Discussions with the Forest Manager during the site visit confirmed that productive tree species (Sitka Spruce, Scots Pine, Western Red Cedar, and Productive Broadleaves) would be thinned at year 15 of the project[8], and their rotation would range between 35 to 50 years, when they would be felled and subsequently restocked.

Image (a)
Archaeological feature at Larriston (2020)

Image (b)
Established trees at Larriston (2020)

[8] Thinning at year 15 is an estimate at this stage of the plantation and could be extended to 20 years or even not thinned depending on future tree growth and market conditions.

Figure 2.3: Final design for forest creation at Larriston (2016)



Notes: SS: Sitka Spruce; SP: Scots Pine; WRC: Western Red Cedar; ASP/BI: Aspen/Birch; NBL: Native Broadleaves; EDG: Edge Woodland; OG: Open Ground; OL: Other Land. Source: Tilhill Forestry (2016)

3. Stage 1: Frame (why?)

This section applies the Frame stage of the Protocol and Sector Guide to the study site.

3.1 Step 01: Get started

The aim of Step 01 is to consider how the concept of natural capital applies to the study context. Step 01 describes the risks and opportunities that an assessment can help address and the potential uses of the assessment results. These findings can then be used to support a more detailed scoping exercise in Steps 02–04 and help to build support for undertaking a natural capital assessment for the site. The outputs of this step are presented in the following sub-sections which mirror the structure of the Sector Guide.

Consider the basic concepts of natural capital in the context of the study

The Protocol and Sector Guide define natural capital as the stock of renewable and non-renewable natural resources on earth (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits or 'services' to people. Some examples of natural capital assets that may be relevant to this study include farmland and peatland in the baseline (pre-forest creation). Following the establishment of the forest creation scheme, key natural capital assets would include woodlands and peatlands.

The concept of natural capital applies to the study context as follows:

- The study focuses on a forest creation scheme, which is a form of land use change;
- Land use change is reflected in changes in the extent and condition (quantity and quality) of different habitat types which are considered to be natural capital assets; and
- Changes in the extent and condition of natural capital assets result in changes in the provision of ecosystem services and the private and societal benefits that these services deliver.

In this context, the concept of natural capital is related to different risks and opportunities that are set out in the Sector Guide, including for example:

- Operational and financial risks and opportunities, because the extent and condition of natural capital can affect the viability and profitability of timber production on the site;
- Legal and regulatory risks and opportunities, because the extent and condition of natural capital is a reflection of the design of the site which is linked to guidelines and requirements such as those set out in the UKFS for example; and
- Societal risks and opportunities, because woodlands that are designed in line with the UKFS have the potential to deliver environmental benefits such as recreational opportunities and flood risk protection benefits for example.

Prepare for the natural capital assessment

To prepare for the natural capital assessment, the objectives of the assessment were discussed and agreed by the project team and project Steering Group. This exercise included setting out a series of analytical tasks that follow the structure of the Protocol and Sector Guide including scoping activities, data collection, data analysis, reporting and dissemination. In addition, the project team visited Larriston in January 2020 to learn more about the study site, its local context and characteristics. The site visit included discussions with the Tilhill Forest Managers and Ecologist.

4. Stage 2: Scope (what?)

This section applies the Scope stage of the Protocol and Sector Guide to the study site.

4.1 Step 02: Define the objective

The aim of Step 02 is to identify the objectives of the natural capital assessment following the framing stage above. The outputs of this step are presented in the following sub-sections which mirror the structure of the Sector Guide.

Identify the target audience including stakeholders and the appropriate level of engagement

The target audience for the assessment is wide-ranging and includes:

- Landowners;
- Land managers;
- Local communities in and around areas where land use change may occur;
- Downstream users of fibre and fuel; and
- Public bodies including local authorities, regulators, and Government agencies.

The findings and insights from the assessment may also be of interest to other practitioners who undertake natural capital assessments.

The key stakeholders for the assessment include members of the project Steering Group as follows:

- Scottish Forestry, the agency responsible for forestry policy, support and regulation in Scotland;
- Tilhill Forestry, a UK forestry management, timber harvesting and landscaping company, offering a range of forest and woodland management services including investment expertise. Note that Tilhill Forestry manages the forest creation scheme at Larriston;
- Scottish Environment Protection Agency (SEPA), the environmental regulator responsible for the protection and improvement of Scotland's environment;
- James Jones and Sons Ltd, a timber processing group based in Scotland, operating across Europe, that manufactures a range of timber products;
- RTS Forestry, an independent forest management organisation in Scotland and Northern England; and
- The Confederation of Forest Industries (Confor), a trade association for forest owners, wood users and related interests, which aims to support sustainable forestry and wood-using businesses.

The project Steering Group was consulted at the start of the study to agree the study objectives and the approach to, and level of engagement with, stakeholders. Engagement with the Steering Group continued throughout the study via meetings, calls, and the provision of feedback at different stages of the study.

Other stakeholders with a potential interest in the project include:

- NatureScot, the public body responsible for Scotland's natural heritage, especially its natural, genetic and scenic diversity;
- Scottish Wildlife Trust, a charity focused on wildlife and environmental conservation in Scotland;
- The Scottish Borders Council, the local authority in which Larriston is located; and

- Members of the local community that are impacted by the forest creation scheme and may therefore have an interest in the study.

More generally, stakeholders were engaged during the dissemination webinars that took place at the end of the study. These webinars align with the final stage of the Sector Guide and 'Apply' the findings from the study, to determine the insights from applying the Sector Guide.

Articulate the objective of the assessment

The objective of the assessment is rooted in the objectives of the overall study which is intended to:

- Determine the forest creation project's impacts and dependencies on natural capital;
- Explore what the application of the Sector Guide would look like for a forest creation scheme and what insights it could provide;
- Determine how this could inform future applications of the Sector Guide to other forest creation projects;
- Determine the data needs and sources that future applications of the Sector Guide would require;
- Assess where and how the use of the Sector Guide adds value to business planning and operations; and
- Show whether and how a natural capital approach can help inform wider forest creation design and implementation.

More generally, the use of a natural capital approach in the context of forest creation, aligned to the UKFS, could also potentially:

- Complement conventional approaches, for example Environmental Impact Assessments (EIAs), by assessing the impacts and dependencies of forest creation in a holistic manner and over the longer-term;
- Identify, quantify and potentially value these impacts and dependencies at the scheme design stage to inform the selection of a preferred design option; and
- Provide evidence to feed into engagement and communication with stakeholders.

4.2 Step 03: Scope the assessment

The aim of Step 03 is to help with planning the assessment by setting out key considerations and parameters that may affect the results. The outputs of this step are presented below.

Determine the organisational focus

The organisational focus for a natural capital assessment may be at the corporate, project or product level. For this study, the assessment is focused on the land use change associated with forest creation. The assessment is therefore undertaken at the project level i.e. from the perspective of the site and the nature of the project rather than landowner(s) or manager(s) (although taking their views into account).

Determine the value chain boundary

The Protocol considers three major parts of the value chain including upstream, direct operations, and downstream. As a minimum, an assessment should consider direct operations. The selected organisational focus of the assessment has implications for how the different parts of the value chain are defined, as follows:

- Direct operations: in the context of this study, the organisational focus of the assessment is at the project level, which is also equivalent to the site level. In this way, the site is a productive forest,

and more generally a productive natural capital asset. The 'direct operations' of the site are expressed as changes in the extent and condition of habitats within the site's boundary, as well as changes in the delivery of ecosystem services and in turn the benefits to the landowner. This could include the benefits from timber production on site which accrue to the landowner. This aspect of the value chain is considered to be within the scope of the assessment.

- Downstream: this relates to:
  - Impacts on wider society such as the benefits from enhanced carbon sequestration on site. These types of benefits are considered to be within the scope of the assessment.
  - Downstream uses of timber harvested from the site, for example, by organisations that produce end products in the construction sector. Depending on the type of downstream use, there could be carbon substitution benefits associated with carbon stored in harvested wood products with long life cycles. The study investigated the possibility of including the carbon storage and substitution benefits of harvested wood products. However, it was found that the data and approaches were not amenable to a site-level assessment, as they are generally intended for developing national greenhouse gas inventories. These issues could not be overcome in the time and resources available for this study, but it is recommended that they are investigated as part of future research. These benefits could, in principle, also be captured in the natural capital assessments of downstream organisations. Section 5.2 provides further details about this issue.
- Upstream: this relates to inputs to the forest creation project including suppliers of raw materials such as plants, seeds, soil, fertilisers, machinery, labour, etc. Some of these materials, such as machinery and labour, are outside the scope of the study as they are components of manufactured and human capital respectively, rather than natural capital. In particular, although machinery is a component of manufactured capital, its use for different ground preparation methods, in establishing new forests, affects natural capital in terms of soil disturbance, associated emissions from soil, and water environment quality. Other materials such as plants, seeds and soil are considered to be components of natural capital and are therefore relevant to the study. More specifically, they are considered to be dependencies of the forest creation project since they are required for planting to proceed. These dependencies were not assessed given the time and resources available for the study. These materials could be captured in the natural capital assessments of upstream suppliers.

Specify whose value perspective

The Protocol states that an assessment may focus on private values to the landowner and/or on wider societal values. This study considers both private and wider societal benefits that are delivered by the forest creation project at Larriston. This is particularly the case given that natural capital assessments have the advantage of revealing non-market values that accrue to society, compared to conventional financial assessments that would otherwise generally focus on values accruing to the landowner. Section 5 sets out the receptors for each of the material impacts or dependencies that are considered in this study.

Decide on assessing impacts and/or dependencies

An assessment may consider impacts and/or dependencies on natural capital, which can both be relevant to any organisational focus and value chain boundary. The Protocol states that these impacts and dependencies can be considered in the three components of a complete natural capital assessment listed below. Given that the organisational focus of the assessment is at the site/project level, these three components overlap with the three parts of the value chain discussed above (direct operations, downstream and upstream).

- **Impacts on the business** (as a result of changes in natural capital arising from the project): in the context of this study, this refers to the impacts of the forest creation project on the landowner. This

is equivalent to the 'direct operations' within the value chain. This could include the benefits from timber production on site which accrue to the landowner. This is considered to be within the scope of the assessment.

- **Impacts on society** (as a result of changes in natural capital arising from the project): in the context of this study, this refers to the impacts of the forest creation project on wider society, which is equivalent to the 'downstream' parts of the value chain. This could include the benefits from carbon sequestration on site which accrue to wider society. These types of benefits are considered to be within the scope of the assessment. In theory, downstream aspects could also include benefits of downstream uses of timber harvested from the site. As mentioned above, it was found that the data and approaches to account for harvested wood products were not amenable to a site-level assessment, as they are generally intended for developing national greenhouse gas inventories. These issues could not be overcome in the time and resources available for this study, but it is recommended that they are investigated as part of future research. Section 5.2 provides further details about this issue.
- **Business dependencies** (benefits to the business from using natural capital): in the context of this study, this could refer to dependencies of the forest creation project on inputs from suppliers of raw materials. These aspects are equivalent to 'upstream' parts of the value chain. They would be captured in the natural capital assessments of those upstream suppliers. These dependencies were not assessed given the time and resources available for the study.

Decide which type of value to consider

The Protocol states that the value of impacts and dependencies may be assessed and considered in different ways including qualitatively, quantitatively, and in monetary terms. In the context of this study, all three types of values were considered, including:

- A description of the baseline (prior to the forest creation project) in qualitative terms;
- A description of the material impacts and dependencies of forest creation in qualitative terms; and
- A quantitative and monetary assessment of material impacts and dependencies as a result of forest creation, where data is available. Using the example of carbon sequestered by the site, this could include a qualitative and quantitative breakdown of the habitats that sequester carbon, the annual volume of carbon sequestered expressed in tonnes of carbon, and the value of carbon sequestered in £ based on the non-traded price of carbon (which reflects the abatement cost of meeting national climate change targets) as determined by the Department for Business, Energy & Industrial Strategy (BEIS).

The use of different types of analysis is intended to provide a balanced view of the impacts and dependencies with respect to forest creation at Larriston, whereas a purely quantitative and/or monetary analysis would be inevitably be narrower in scope given data limitations.

Consider other technical issues (i.e. baselines scenarios, spatial boundaries, and time horizons)

Some of the key technical issues associated with the assessment were as follows:

- Baseline: this is considered to be the pre-forest creation baseline where sheep farming was practiced at Larriston. The baseline is described in qualitative terms in Sections 2 and 5.
- Scenario(s): the baseline is contrasted against the scenario of forest creation at Larriston, which is described in Section 2 and reflects the final design for the site.
- Spatial scope: the spatial scope of the study covers the gross area of the forest creation project (1,108 ha) which combines the planted area and the open ground that is retained at Larriston. Some impacts and/or dependencies may go beyond the boundary of the site, such as flood risk protection which is considered at the catchment level.

- Time horizon: generally, the time horizon depends on the objectives for the site and the nature of the material impacts and dependencies that are assessed. The site visit confirmed that the planting rotation at Larriston is expected to range between 35 and 50 years. This would suggest that a time horizon of 50 years should be considered as a minimum.

Address key planning issues

Key planning issues that were considered throughout the project included:

- Gaps within data held by different stakeholders which could result in a partial assessment;
- Difficulty in collecting the relevant data (e.g. communication difficulty, tight timescales etc.) which could result in a partial assessment; and
- The need to consider engagement with different stakeholders at key points in the project.

4.3 Step 04: Determine the impacts and/or dependencies

The aim of Step 04 is to identify the impacts and/or dependencies that are most relevant for inclusion in the natural capital assessment. In the Protocol, an impact or dependency is material if consideration of its value, as part of the set of information used for decision-making, is judged to have the potential to alter that decision. A materiality assessment is the process that involves identifying what is (or is potentially) material in relation to the decision in hand. The outputs of this step are presented below.

List potentially material natural capital impacts and dependencies

The potentially material natural capital impacts and dependencies relate to natural capital assets that are present at Larriston and the ecosystem services that these assets provide. There are various ways to categorise natural capital assets and ecosystem services, which are referenced in Section 1.2. The natural capital assets that are potentially relevant to the assessment include the following broad habitat types:

- Freshwaters, wetlands and floodplains;
- Mountains, moors and heaths;
- Semi-natural grassland; and
- Woodland.

The ecosystem services that are potentially relevant to the assessment include a range of provisioning, regulating, cultural and supporting services shown in Table 4.1.

Identify the criteria for the materiality assessment and gather relevant information

The Protocol states that impacts and dependencies as a result of changes in the stock of natural capital assets and the flow of ecosystem services are considered to be material if they are likely to have an impact on decision-making. Depending on the context, this may differ from the way ‘significance’ is defined in an EIA which is linked to the magnitude of an impact and the sensitivity of receptors. In the context of this study:

- A change in the stock (condition and/or extent) of natural capital assets was considered to be material if it is a form of land use change associated with the forest creation project at Larriston. For example, the afforestation of agricultural land formerly utilised for sheep farming is considered material.
- A change in the flow of ecosystem services was considered to be material if its delivery is associated with one or more objectives for the forest creation project. For example, the benefits

associated with timber harvested from the site, which accrue to the landowner, are considered material because one of the objectives of the site is to provide timber.

- A potential impact was not considered material when evidence from the Environmental Statement confirmed that the impact was not considered to be significant.

The following references were considered in undertaking the materiality assessment:

- The objectives of the study;
- The information contained with the Environment Statement for Larriston (Tilhill Forestry, 2015); and
- The information collected during the site visit to Larriston.

Complete the materiality assessment

The materiality assessment was completed based on the information gathered from the references listed above. The results are summarised in Table 4.1 with more details provided in Appendix B. Information is recorded in cases where the sources above provided evidence of a relationship between a natural capital asset and an ecosystem service. The relationships are colour-coded as follows:

- '-' denotes that no evidence is available in the EIA for Larriston regarding the relationship between the natural capital asset and ecosystem service;
- **Grey** denotes that evidence is available in the EIA regarding the relationship between the natural capital asset and ecosystem service, but the change in land use and consequent change in ecosystem service provision is offset by specific mitigation measures set out in the EIA;
- **Light blue** denotes that evidence is available regarding the relationship between the natural capital asset and ecosystem service, but the change in land use and consequent change in ecosystem service provision is of small or negligible magnitude or is offset by another impact that is expected to occur (i.e. it is not additional);
- **Dark blue** denotes that evidence is available regarding the relationship between the natural capital asset and ecosystem service, with a significant net change in land use and a consequent change in ecosystem service provision.

Table 4.1: Summary of material natural capital assets and ecosystem services at Larriston

Ecosystem services		Natural capital assets*			
		FW	MMH	SNG	W
Provisioning	Crops and livestock	-	-	●	-
	Fibre and fuel	-	-	-	●
	Water supply	-	-	-	-
Regulating	Global climate regulation	-	●	●	●
	Local climate regulation	-	-	-	●
	Air quality regulation	-	-	-	●
	Natural hazard regulation (e.g. flooding, erosion, etc.)	-	●	-	●
	Water quality regulation	●	-	-	●
	Pollination	-	-	-	-
	Disease and pest control	-	-	-	●

	Ecosystem services	Natural capital assets*			
		FW	MMH	SNG	W
	Soil quality regulation	-	-	●	●
Cultural	Recreation	-	-	-	●
Cultural	Cultural heritage	-	-	-	●
Cultural	Aesthetic value	-	-	-	●
Supporting	Biodiversity	-	-	-	●
Supporting	Soil formation	-	-	-	-
Supporting	Nutrient cycling	-	-	-	-
Supporting	Water cycling	-	-	-	-

Notes: *FW: Freshwaters, wetlands and floodplains; MMH: Mountains, moors and heaths; SNG: semi-natural grasslands; W: Woodland.

The following relationships between broad habitats and ecosystem services are colour-coded in **dark blue** in Table 4.1 and were considered to be material and were taken forward to subsequent stages of the assessment:

- **Fibre and fuel:** there was an impact in terms of an increase in timber production associated with afforestation at Larriston. This was considered to be a significant net change in land use and ecosystem service provision;
- **Global climate regulation:** there was an impact to be considered in terms of short-term carbon emissions due to soil disturbance as a result of preparing the site for afforestation including through ploughing and mounding, which expose soil and can release carbon. In the long-term this would be significantly outweighed by an increase in carbon sequestration by woodland as a result of the afforestation scheme;
- **Natural hazard regulation:** there is an impact in terms of a long-term increase in flood risk protection within the catchment, as trees become established and the roughness of vegetation increases thereby slowing the flow of surface water and run-off.
- **Recreation:** there is a potential impact in terms of improved access to the site which may encourage more recreational users. It is possible that the type of users of the site could change but the overall number of users might remain relatively stable. For example, users that are more inclined to use defined tracks could displace users that prefer open landscapes that are not heavily forested. This impact is nevertheless considered to be significant given information regarding the scale of recreational visits, e.g. by runners and cyclists, to other nearby sites.
- **Aesthetic value:** the site design considers the surrounding landscape including other forests, by aiming to connect other forested areas and 'softening' and blending their boundaries. The EIA for Larriston states that at Larriston Rigg, located near the planting area, the retention of the flat fields on the valley bottom helps to re-enforce landscape character. The EIA states that planting of much of the lower ridge with spruce would result in the existing woodland being subsumed into the forest, resulting in loss of diversity and a lack of differentiation between the character of Larriston Rigg and the fell. However, this was mitigated in the final planting design, which includes other tree species (Western Red Cedar, Aspen / Birch) to provide a different landscape character. Overall, there is an impact on aesthetic values associated with the site given that the forest creation at Larriston is a form of land use change that ultimately changes the look and feel of the site compared to the baseline.

- **Biodiversity:** there is an impact on biodiversity values associated with the site. This includes improvements in species richness and diversity, compared to the sheep grazing baseline. There is also the potential for improved habitat connectivity because Larriston is connecting other existing surrounding forests and therefore reducing habitat fragmentation.

5. Stage 3: Measure and value (how?)

This section applies the Measure and Value stage of the Protocol and Sector Guide to the study site. This stage is broken down into a series of steps and sub-tasks presented in Table 5.1.

Table 5.1: Steps within the Measure and Value stage

Step	Description
Step 05 - Measure impact drivers and/or dependencies	• Mapping activities against impact drivers and/or dependencies • Considering which impact drivers and/or dependencies to measure • Considering how to measure impact drivers and/or dependencies e.g. using primary and/or secondary data • Collecting data and checking data quality
Step 06 – Measure changes in the state of natural capital	• Considering changes in natural capital associated with activities and impact drivers • Considering changes in natural capital associated with external factors including natural and human-induced changes • Considering trends affecting the state of natural capital given internal and external factors • Selecting approaches to measure these changes • Undertaking the measurement of changes
Step 07 – Value impacts and/or dependencies	• Defining the consequences of impacts and/or dependencies • Determining the relative significance of associated costs and/or benefits • Selecting appropriate monetary valuation techniques • Undertaking the valuation of changes

The following sub-sections cover each of the material impacts and dependencies set out in Section 4, focusing on:

- The approach to the assessment including their impact or dependency pathway and the data used for the assessment; and
- The preliminary results of the assessment.

Structuring the stage into these two points provides a balanced approach which covers the different steps set out in the Sector Guide, but also establishes a flow and linkages between steps.

5.1 Fibre and fuel

This section focuses on timber harvested from Larriston, which was considered to be an impact and dependency on natural capital. Before forest creation took place at Larriston, the site was an upland sheep farm and, while there were small areas of woodland present on site, no timber production was carried out.

Table 5.2 sets out the impact/dependency pathway for timber production following forest creation at Larriston.

Table 5.2: Impact/dependency pathway for timber production

Impact/dependency pathway	Description
1. Activity	• Forest creation
2. Impact/dependency on natural capital	• Timber production which depends on the wider environment including soil quality, biodiversity, exposure to wind, precipitation, etc. • It also impacts on the site owner due to the sale of harvested timber, and on downstream users of harvested timber for end products
3. Receptor	• Site owner; downstream users

Impact/dependency pathway	Description
4. Effect on natural capital (physical flow)	• Volume of harvested timber in m^3
5. Value (monetary flow)	• Monetary value of timber production based on sale price

In order to assess timber harvested at Larriston, data regarding the breakdown of tree species at the site was collected, as shown in Table 5.3. For the purposes of the assessment, assumptions were made regarding the years when thinning and clearfelling would take place. Estimates of the average yield of timber per ha were also collected. This allowed the volume and value of timber harvested at Larriston to be estimated at the first thinning and at clearfelling for one rotation, as shown in Table 5.4 and Table 5.5, respectively.

Table 5.3: Breakdown of tree species at Larriston

Species	Type	Area (% of 560 ha planted area)	Spacing (m)	Estimated yield class	Harvested?	Notes
Sitka Spruce	Coniferous	71%	2	22	Yes	All data provided by Tilhill Forestry. Yield class estimates were validated by Tilhill Forestry in comparison with two mature adjacent forest properties' achieved yield classes and with reference to Forest Research's Ecological Site Classification Decision Support System (Forest Research, 2020c).
Scots Pine	Coniferous	6%	2	12	Yes	
Western Red Cedar	Coniferous	1%	2	14	Yes	
Productive Broadleaves	Broadleaved	3%	2	10	Yes	
Native Broadleaves	Broadleaved	5%	3	6	No	
Edge Broadleaves	Broadleaved	3%	4.5	-	No	
Open Ground	-	10%		-	No	
Total	-	100%	-	-	-	

Table 5.4: Timber harvested at first thinning at Larriston

Species	Year of thinning	Timber yield (tonnes/ha)	Volume of timber harvested (tonnes)	Average price (£/tonne)	Value of timber harvested (£k)	Notes
Sitka Spruce	15	30	12,000	32	390	Price of timber calculated based on estimates from Confor (2020b) and Forest Research (2020b) of ~£34 per tonne and ~£31 per tonne, respectively. This assumes that 100% of harvested timber from the first thinning is non-sawlogs which was verified by the Forest Managers at Tilhill Forestry. All other data provided by Tilhill Forestry.
Scots Pine	15	25	900	32	30	
Western Red Cedar	15	30	200	32	10	
Productive Broadleaves	15	20	300	35	10	Price of timber calculated based on estimates for from Confor (2020b) and Grown in Britain (2018) of ~£44 per tonne and ~£27 per tonne, respectively. This assumes that 100% of harvested timber from the first

Species	Year of thinning	Timber yield (tonnes/ha)	Volume of timber harvested (tonnes)	Average price (£/tonne)	Value of timber harvested (£k)	Notes
						thinning is firewood which was verified by the Forest Managers at Tilhill Forestry. All other data provided by Tilhill Forestry.
Native Broadleaves	-	-	-	-	-	Not harvested
Edge Broadleaves	-	-	-	-	-	
Open Ground	-	-	-	-	-	
Total	-	-	13,400	-	440	-

Notes: Estimates are rounded to avoid spurious accuracy. All monetary values are expressed in 2019 prices.

Table 5.5: Timber harvested for first rotation at Larriston

Species	Aver-age rotation (years)	Timber yield (tonnes/ha)	Volume of timber harvested (tonnes)	Average price (£/tonne)	Value of timber harvested (£k)	Notes
Sitka Spruce	35 - 40	400	159,900	44	7,040	Price of timber calculated based on estimates for from Confor (2020b) and Forest Research (2020b) for (i) non-sawlogs of ~£34 per tonne and ~£31 per tonne, respectively, and (ii) for sawlogs of ~£49 per tonne and ~£59 per tonne, respectively. A weighted average price is calculated assuming that 70% of harvested timber from the first rotation is sawlogs and the remaining 30% is non-sawlogs. This was verified by the Forest Managers at Tilhill Forestry. All other data provided by Tilhill Forestry.
Scots Pine	45 - 50	400	14,000	44	620	
Western Red Cedar	45 - 45	400	2,800	44	120	
Productive Broadleaves	35 - 40	300	4,400	35	160	Price of timber calculated based on estimates for from Confor (2020b) and Grown in Britain (2018) of ~£44 per tonne and ~£27 per tonne, respectively. This assumes that 100% of harvested timber from the first rotation is firewood which was verified by the Forest Managers at Tilhill Forestry given the species planted (Aspen and Birch) and the upland location of the site. All other data provided by Tilhill Forestry.
Native Broadleaves	-	-	-	-	-	Not harvested
Edge Broadleaves	-	-	-	-	-	
Open Ground	-	-	-	-	-	
Total	-	-	181,100	-	7,940	-

Notes: Estimates are rounded to avoid spurious accuracy. Estimates are based on the midpoint of the range for each species' rotations. All monetary values are expressed in 2019 prices using the Consumer Price Index.

Table 5.6 presents the total volume and value of timber forecast for harvest at Larriston over the 50-year time horizon adopted for the study. This covers thinning and clearfelling at the end of one rotation period for all harvested species. The total volume of timber harvested over 50 years is just under 195,000 tonnes with a value of around £2.5 million in present value terms. Note that the results presented in Table 5.6 are considered to be net of the baseline because there was no timber harvested at Larriston before forest creation took place at the site.

Table 5.6: Summary of volume and value of timber harvested at Larriston (50 years)

Species	Area (% of 560 ha planted area)	50 years		
		Volume of timber harvested (tonnes)	Total value of timber harvested (£k)	Present value of timber harvested (£k)
Sitka Spruce	71%	172,000	7,430	2,280
Scots Pine	6%	15,000	640	150
Western Red Cedar	1%	3,000	130	30
Productive Broadleaves	3%	5,000	170	50
Native Broadleaves	5%	-	-	-
Edge Broadleaves	3%	-	-	-
Open Ground	10%	-	-	-
Total	100%	194,000	8,370	2,510

Notes: Estimates are rounded to avoid spurious accuracy. All monetary values are expressed in 2019 prices using the Consumer Price Index. Present value estimates are discounted using a 3.5% declining discount rate which is consistent with the Green Book (HM Treasury, 2018).

These estimates provide an indication of the order of magnitude of timber production from the site. They are subject to various assumptions including:

- The volume of timber harvested is based on average yield estimates that are applied at the midpoint of the range for each species' rotations. These assumptions do not explicitly account for the impact of climate change on timber harvesting. Climate change is expected to increase the speed of tree growth and the length of the growing season. It may also increase the risk and prevalence of diseases and pests, and is expected to cause extreme weather events which would compromise the growth of trees and the volume of timber harvested in the future.
- The value of timber harvested is assumed to be fixed over time. This assumption is consistent with the convention used in Forestry England's natural capital accounts (Forestry England, 2019). It is adopted in the absence of other information to establish a long-term plausible trend and forecast for the price of timber over the next 50 years. In practice, the price of timber may change over time. For example, macroeconomic changes including economic expansion or contraction may cause changes in the price. This is particularly relevant given the on-going and evolving economic effects of the COVID-19 global pandemic.
- Present value estimates are discounted using a 3.5% declining discount rate in line with the Green Book (HM Treasury, 2018). However, given that Larriston is privately owned and managed as a productive site, an alternative discount rate that is more aligned to private sector interests and decision-making could conceivably have been explored.

5.2 Global climate regulation

This section focuses on carbon sequestered by the planted area at Larriston, which was considered to be an impact of the forest creation project on wider society. Before forest creation took place at Larriston, the site was used for upland sheep farming, which was likely a source of carbon emissions.

In addition, peatland is a prominent habitat at Larriston, and the EIA for the site reports that peatland was highly modified by long-term grazing and drainage impacts. As such, it was not certain whether the peatland had been generating carbon savings over time.

Table 5.7 sets out the impact/dependency pathway for carbon sequestration following forest creation at Larriston.

Table 5.7: Impact/dependency pathway for carbon sequestration

Impact/dependency pathway	Description
1. Activity	• Forest creation
2. Impact/dependency on natural capital	• Carbon sequestration which depends on the wider environment including soil quality, land management, etc. • It also impacts on wider society in terms of global climate regulation and climate change mitigation
3. Receptor	• Wider society
4. Effect on natural capital (physical flow)	• Volume of carbon sequestered by forested areas in Larriston expressed in tonnes of CO_2e
5. Value (monetary flow)	• Monetary value of carbon sequestration from forested areas in Larriston

In order to assess carbon sequestration at Larriston, data regarding the breakdown of tree species at the site was used, as shown in Table 5.3. This included assumptions regarding the years when thinning and clearfelling would take place.

The estimated volume of carbon sequestered by forested areas at Larriston was assessed using look-up tables within the Woodland Carbon Code[9] calculation spreadsheet (Scottish Forestry, 2020b). The calculator estimates emissions from establishment based on the area over which different interventions take place, as shown in Table 5.8 for Larriston. It also allows for emissions from ground preparation to be estimated, as shown in Table 5.9 for Larriston. As mentioned in Section 4, forest creation can involve a range of ground preparation methods, which can include the use of machinery. While machinery is a component of manufactured capital, it has an impact on natural capital in terms of soil disturbance, associated emissions from soil, and water environment quality.

Table 5.8: Emissions for establishment at Larriston

Activity	Affected area		Carbon emissions rate		Volume of carbon emissions (tCO_2e)
	Estimate	Unit	Estimate	Unit	
Seedlings	456.5	ha	-0.38	tCO_2e/ha	-173
Ground Preparation (Fuel)	463.38	ha	-0.06	tCO_2e/ha	-28
Tree Shelters	63.31	ha	-0.82	tCO_2e/ha	-52
Fencing	67.34	ha	-1.64	tCO_2e/ha	-110
Herbicide	836.21	ha	-0.001	tCO_2e/ha	-1
Roads	-	km	-43.13	tCO_2e/km	-
Total	-	-	-	-	-364

Notes: Estimated using Woodland Carbon Code calculation spreadsheet. Data on affected areas for establishment activities provided by Tilhill Forestry. Estimates are rounded to avoid spurious accuracy.

[9] The Woodland Carbon Code is the voluntary standard for UK woodland creation projects where claims are made about the carbon dioxide they sequester. Independent validation and verification to this standard provides assurance and clarity about the carbon savings of these sustainably managed woodlands (Scottish Forestry, 2020c).

Table 5.9: Emissions for ground preparation at Larriston

Previous land use	Intervention technique	Disturbance/ site preparation	Area (ha)	Soil C emissions (tCO_2e/ha)	Soil C emissions (tCO_2e/area)
Pasture	Ploughing	Medium Disturbance: Shallow/rotary (<30cm) plough, Disc/line scarification/continuous mounding	267.16	-59	-15,673
Pasture	Continuous mounding	Medium Disturbance: Shallow/rotary (<30cm) plough, Disc/line scarification/continuous mounding	149.5	-59	-8,771
Pasture	Excavator mounding	Low disturbance: Hand turfing, inverted, hinge & trench mounding, patch scarification, subsoiling, drains	46.72	-29	-1,370
Pasture	Direct planting	Negligible Disturbance: Hand screefing only	41.65	0	0
Total	-	-	505	0	-25,815

Notes: Estimated using Woodland Carbon Code calculation spreadsheet. Data on intervention technique and affected areas for ground preparation activities provided by Tilhill Forestry. Estimates are rounded to avoid spurious accuracy.

The look-up tables within the Woodland Carbon Code calculator were also used to estimate carbon sequestration from forested areas at Larriston. Estimates are based on carbon sequestration rates for different species, spacing of trees, yield classes and management regimes (thinned, not thinned, clearfelled). The analysis assumes that one rotation occurs for productive species within the planting area. The analysis does not account for the potential reduction in carbon emissions that occurred as a result of the changes in land use from sheep farming to forestry. This is because these emissions could have been potentially displaced to an alternative location rather than being eliminated, which is a form of activity-shifting leakage.[10]

The results from this assessment are presented in Table 5.10 over the 50-year assessment period for the study. The total volume of carbon sequestered by forested areas at Larriston, less emissions from establishment and ground preparation, is estimated at around 145,000 tonnes of carbon dioxide equivalent (CO_2e) over 50 years. The volume of carbon sequestered differs between species and their associated areas within the site. This demonstrates that it may be useful to assess carbon sequestration benefits at the design stage of a forest creation project to try to optimise carbon sequestration, when different species and patterns of planting are being considered. This is particularly relevant given that forest creation is expected to contribute to helping the UK achieve net zero carbon emissions by 2050.

Table 5.10: Summary of volume and value of carbon sequestration at Larriston (50 years)

Species	Area (% of 560 ha planted area)	50 years				
		Gross carbon sequestration (thousands of tonnes of CO_2e)	Emissions (thousands of tonnes of CO_2e)	Net carbon sequestration		
				Volume (thousands of tonnes of CO_2e)	Total value undiscounted (£k)	Present value (£k)
Sitka Spruce	71%	128	-	-	-	-
Scots Pine	6%	7	-	-	-	-

[10] The Woodland Carbon Code (Scottish Forestry, 2020a) defines activity-shifting leakage as a context where the activity (agriculture or other) which is taking place on the forest creation site is moved and causes land use change elsewhere.

Species	Area (% of 560 ha planted area)	50 years				
		Gross carbon sequestration (thousands of tonnes of CO_2e)	Emissions (thousands of tonnes of CO_2e)	Net carbon sequestration		
				Volume (thousands of tonnes of CO_2e)	Total value undiscounted (£k)	Present value (£k)
Western Red Cedar	1%	1	-	-	-	-
Productive Broadleaves	3%	5	-	-	-	-
Native Broadleaves	5%	19	-	-	-	-
Edge Broadleaves	3%	11	-	-	-	-
Open Ground	10%	-	-	-	-	-
Total	100%	172	-26*	145	18,810	9,080

Notes: *From Table 5.9. Estimates are rounded to avoid spurious accuracy. All monetary values are expressed in 2019 prices using the Consumer Price Index. Present value estimates are discounted using a 3.5% declining discount rate which is consistent with the Green Book (HM Treasury, 2018).

The monetary value of net carbon sequestration at Larriston is estimated at around £9 million in present value terms over 50 years. This value would accrue to wider society. This figure was estimated using the non-traded carbon price from the Department for Business, Energy & Industrial Strategy (BEIS, 2019) which reflects the cost of meeting the UK's climate change targets. Note that, over the same period of 50 years, the value of carbon sequestration benefits is over three times the value of timber harvested from the site. This demonstrates the significant value that non-market benefits provided by natural capital can have, and the potential insights of using the Sector Guide to assess forest creation projects, alongside conventional EIAs.

While the results presented in Table 5.10 are derived using the Woodland Carbon Code look-up tables, the forest creation project at Larriston did not receive funding via the Woodland Carbon Code. This is because carbon sequestration achieved by the project would have been realised without funding from the Woodland Carbon Code i.e. the project does not meet the financial test of additionality under the Woodland Carbon Code.

However, it is useful, for the benefit of project developers, to provide a basis to compare the carbon sequestered at Larriston to other projects that are eligible for funding under the Woodland Carbon Code. This is done by subtracting 'buffers' from carbon sequestration estimates, which are applied to projects to cover any unanticipated losses from individual project failures. These buffers safeguard the investment made by carbon buyers and maintain and protect the integrity of verified Woodland Carbon Units (WCUs) (i.e. a tonne of CO_2 which has been sequestered by a project). Table 5.11 presents the estimates for Larriston, net of the Woodland Carbon Code buffers, over the 50-year assessment period for the study. The total volume of carbon sequestered by forested areas at Larriston, less emissions from establishment and ground preparation and the Woodland Carbon Code buffers, is estimated at around 90,000 tonnes of carbon dioxide equivalent (CO_2e) over 50 years.

Table 5.11: Summary of volume and value of carbon sequestration at Larriston net of Woodland Carbon Code buffers (50 years)

Species	Area (% of 560 ha planted area)	50 years				
		Gross carbon sequestration (thousands of tonnes of CO_2e) excluding 20% buffer	Emissions (thousands of tonnes of CO_2e)	Net carbon sequestration		
				Volume (thousands of tonnes of CO_2e)	Total value undiscounted (£k)	Present value (£k)
Sitka Spruce	71%	102	-	-	-	-
Scots Pine	6%	6	-	-	-	-
Western Red Cedar	1%	1	-	-	-	-
Productive Broadleaves	3%	4	-	-	-	-
Native Broadleaves	5%	15	-	-	-	-
Edge Broadleaves	3%	9	-	-	-	-
Open Ground	10%	-	-	-	-	-
Total	100%	138	-26*	90	450 - 890	210 - 430

Notes: *From Table 5.9. Estimates are rounded to avoid spurious accuracy. All monetary values are expressed in 2019 prices using the Consumer Price Index. Present value estimates are discounted using a 3.5% declining discount rate which is consistent with the Green Book (HM Treasury, 2018).

The monetary value of net carbon sequestration at Larriston, excluding the Woodland Carbon Code buffers, was estimated using the average price of verified credits under the Woodland Carbon Code which ranges between £5 and £10 per tonne of CO_2e. This provides a basis for project developers to compare the value of carbon sequestered at Larriston, based on the voluntary market, to other projects that are validated under the Woodland Carbon Code. This results in an estimated value of carbon sequestration, net of the Woodland Carbon Code buffers, of £0.2 to £0.4 million in present value terms over 50 years. An alternative approach could be to use the average price, of £24.11 per tonne of CO_2e, that stems from Woodland Carbon Guarantee (Scottish Forestry, 2020d).[11] This results in a value of carbon sequestration benefits at Larriston of around £1 million in present value terms over 50 years, net of emissions and buffers.

These alternative estimates can be used to compare the market value of carbon sequestration at Larriston to other real-world examples, which would be meaningful to landowners, project developers and forest managers. In contrast, the estimates in Table 5.10, derived using the BEIS non-traded carbon price, reflect the value of carbon sequestration in terms of the marginal abatement cost of carbon to meet the UK's climate change targets. As such they would be meaningful in the context of value for money assessments, to make the case for forest creation at the national level to HM Treasury.

These estimates provide an indication of the order of magnitude of carbon sequestration benefits from the site. They are subject to various assumptions including:

[11] The Woodland Carbon Guarantee is a scheme that aims to help accelerate woodland planting rates and develop the domestic market for woodland carbon for the permanent removal of carbon dioxide from the atmosphere. It provides the option to sell captured carbon in the form of verified carbon credits to the government for a guaranteed price (Scottish Forestry, 2020d).

- The emissions from establishment and ground preparation are considered to occur in the first year of the project.
- Carbon sequestration rates in the Woodland Carbon Code are available in five-year increments. They are split equally into yearly estimates in order to assess the profile of carbon sequestration over time.
- In order to recognise the trade-off between timber and carbon on-site, a clearfell cap is applied to productive species. This reflects the maximum amount of sequestration for a given rotation length. It is assumed that the clearfell cap is reached at year 25 for all species that are clearfelled. This is consistent with the Woodland Carbon Code's guidance, which states that the cap would be reached between years 25 and 30.
- The assessment does not consider the carbon storage and substitution benefits from harvested wood products. These factors would need to be considered if comparisons are to be made between the relative volume of carbon sequestered by different species. This analysis was investigated in Appendix C, but ultimately not included given the time and resources available for this study.

5.3 Natural hazard regulation

This section focuses on the flood risk protection benefits delivered by the planted area at Larriston. This was considered to be an impact of the forest creation project on wider society. The EIA for Larriston reports the presence of a Potentially Vulnerable Area (PVA) in relation to flood risk, approximately 6 km south west of Larriston at Newcastleton on the Liddel Water. The catchment has moderate flood storage and attenuation capacity due to the dense network of agricultural surface drains/grips and mole drains across the catchment which includes Larriston.

Table 5.12 sets out the impact/dependency pathway for flood risk protection following forest creation at Larriston.

Table 5.12: Impact/dependency pathway for flood risk protection

Impact/dependency pathway	Description
1. Activity	• Forest creation
2. Impact/dependency on natural capital	• Flood risk protection which depends on the wider environment including soil quality, biodiversity, exposure to wind, precipitation, etc. • It also impacts on the downstream catchment
3. Receptor	• Downstream catchment population
4. Effect on natural capital (physical flow)	• Volume of flood water stored by woodland at Larriston in m^3
5. Value (monetary flow)	• Replacement cost of flood storage benefits from woodland at Larriston based on cost of constructing a flood storage reservoir

In order to assess the benefits of flood risk protection at Larriston, a study by Forest Research (2018), which explores the valuation of flood regulation services to inform natural capital accounts, was used. The study relies on a replacement cost approach which uses the costs of mitigating actions as a proxy for the value of an ecosystem service. In particular, the study estimates the value of woodland flood water storage, compared to a counterfactual of grassland habitat, based on the cost of the alternative of constructing a reservoir to store an equivalent amount of flood water. It is important to note that a replacement cost approach could underestimate the value of an ecosystem service. However, the approach is adopted here in the absence of other evidence and for illustrative purposes.

Forest Research (2018) used the Joint UK Land Environment Simulator (JULES) model[12] to estimate the volume of water stored in m^3 from (i) canopy interception; (ii) additional soil water storage capacity; and (iii) floodplain woodland based on meteorological data from 2006 to 2015. Data on the extent of floodplain woodland at Larriston was determined via spatial analysis undertaken by Forest Research as part of this study.

The volume of water stored in m^3 was then valued using an average cost of replacing woodland water storage with a built flood storage reservoir, which has an estimated equivalent annual value of £0.43 per m^3 in 2019 prices. This figure is based on a range of costs for seven reservoir construction projects, and a number of additional costs which were applied to reflect initial procurement, enabling works, general maintenance, monitoring and inspection associated with reservoir safety.

Table 5.13 presents the results for the volume and replacement cost of flood water storage for Larriston. Following the approach set out in Forest Research (2018), forest cover at Larriston is estimated to store nearly 3 million m^3 of water over a 50-year time horizon in terms of canopy interception and additional soil water storage. The cost of constructing a reservoir with an equivalent capacity is estimated at £0.6 million over 50 years in present value terms. This cost-based estimate likely provides lower-end value of the benefits from flood risk protection at Larriston. Note that the results presented in Table 5.13 do not explicitly tease out the level of flood risk protection provided by the sheep farming baseline at Larriston. The estimates are, however, considered to be net of the baseline because they are based on modelling in Forest Research (2018) which assumes a baseline of grassland land cover, which is applicable to Larriston. The estimates presented are subject to various assumptions including:

- The analysis uses estimates from Forest Research (2018) for Scotland, which reflect both publicly and privately owned forests.
- Flood water storage from canopy interception is assumed to cease when productive species are clearfelled. Moreover, the analysis considers one planting rotation for these species.
- The area of floodplain woodland was estimated to be 0.818 ha based on spatial analysis undertaken by Forest Research. This represents the extent of woodland within an area that is prone to fluvial flooding. This area was assumed to be planted with native broadleaves based on the planting design at Larriston which shows that surface waters within the site are lined by native broadleaves (see Figure 2.3).
- The analysis in the source study does not differentiate between forest age. Instead, it assumes that all forests are established. The analysis presented in Table 5.13 could have delayed the replacement cost estimates until trees at Larriston were established (around year 5). However, this assumption was not applied because it was considered that the capital costs within the replacement cost estimates should occur in the first year of the time horizon.
- The study by Forest Research (2018) finds that the JULES model overestimates the flood water storage by grassland habitat which is the counterfactual in the study. In addition, the model is found to underestimate the flood water storage capacity of coniferous tree species, which tends to be higher than that of broadleaved species. As such Forest Research (2018) assumes that all forest cover within the scope of the study is broadleaved. For Larriston, which has a planted area that is dominated by coniferous species, this analysis underestimates the volume and replacement cost of flood water storage.
- By adopting a replacement cost approach, the analysis does not consider the benefit of improved flood risk protection from forest creation in terms of avoided damages to properties, roads and other assets. Estimates of avoided damages are available in the literature. Nisbet et al. (2015), for

[12] JULES is a process-based model that couples land surface processes to Met Office global circulation models. It simulates fluxes of carbon, water, energy and momentum between the land surface and atmosphere to facilitate weather forecasting and climate change prediction. Different versions of the JULES model have been developed for investigating the impact of climate change on land carbon sinks, methane emissions from wetlands, atmospheric aerosols and tropospheric ozone.

example, estimated avoided damages to properties from flood storage of £1.20/m^3 per year (central estimate), due to the Slowing the Flow at Pickering project. Such estimates are not considered to be transferable due to their context-specific nature, which requires bespoke catchment-level modelling.

Table 5.13: Summary of volume and replacement cost of flood water storage at Larriston (50 years)

Species	Area (% of 560 ha planted area)[a]	Average rotation (years)[a]	Canopy interception		Woodland soil storage capacity		Floodplain woodland storage			50 years		
			Average (m^3 per ha)[b]	Total at Larriston (thousands of m^3 per year)[c]	Average (m^3 per ha)[b]	Total at Larriston (thousands of m^3 per year)[c]	Average (m^3 per ha)[b]	Total area of floodplain woodland	Total at Larriston (thousands of m^3 per year)[c]	Total flood water storage at Larriston (thousands of m^3; 50 years)	Average replacement cost (equivalent annual value; £ per m^3)[b]	Present value replacement cost of flood storage at Larriston (£k, 50 years)
Sitka Spruce	71%	35 - 40	9.1	4	108.6	43	520	-	-	2,310	0.43	490
Scots Pine	6%	45 - 50	9.1	0.3	108.6	4	520	-	-	210	0.43	40
Western Red Cedar	1%	45 - 45	9.1	0.1	108.6	1	520	-	-	40	0.43	10
Productive Broadleaves	3%	35 - 40	9.1	0.1	108.6	2	520	-	-	90	0.43	20
Native Broadleaves	5%	-	9.1	0.3	108.6	3	520	0.818	0.4	200	0.43	40
Edge Broadleaves	3%	-	9.1	0.2	108.6	2	520	-	-	110	0.43	20
Open Ground	10%	-	-	-	-	-	-	-	-	-	-	-
Total	100%	-	-	5	-	55	-	0.818	0.4	2,950	-	620

Notes: Sources: [a]: Tilhill Forestry; [b]: Forest Research (2018) estimates for public and private woodland in Scotland; [c]: Calculated; [d]: Estimated based on spatial analysis by Forest Research. EAV: equivalent annual value. Estimates are rounded to avoid spurious accuracy. All monetary values are expressed in 2019 prices using the Consumer Price Index. Present value estimates are discounted using a 3.5% declining discount rate which is consistent with the Green Book (HM Treasury, 2018).

5.4 Recreation

This section focuses on recreational benefits from visits to Larriston, which were considered to be an impact of the forest creation project on wider society. The EIA for Larriston notes that there are a number of lightly used recreation and hill routes in the area near Larriston, including:

- The Waverley Way, a multi-use trail following the route of the old Waverley railway;
- The Public Right of Way running from Larriston Rigg Cottage along Kate's Rigg to the border at Blackhope; and
- A cross border route (Core Path) ascending to the ridge from Dinlabyre to the Toll Pillar and Kielder Forest.

Table 5.14 sets out the impact/dependency pathway for recreation following forest creation at Larriston.

Table 5.14: Impact/dependency pathway for recreation

Impact/dependency pathway	Description
1. Activity	• Forest creation
2. Impact/dependency on natural capital	• Recreational visits which depend on the wider environment which determines the characteristics of the site including soil quality, biodiversity, exposure to wind, precipitation, etc. • It also impacts on visitors to the site in terms of recreational access and opportunities
3. Receptor	• Recreational visitors e.g. local residents, day visitors, etc.
4. Effect on natural capital (physical flow)	• Volume of recreational visits to Larriston
5. Value (monetary flow)	• Monetary value of recreational benefits associated with visits to Larriston

In the context of assessing recreational benefits, the common challenge tends to be associated with finding reliable visitor data for specific sites, rather than issues with valuation estimates. This is the case for Larriston which is why a range of estimates were considered to provide a broad indication of the possible scale of visits to the site. For example:

- In 2017, Visit Scotland (2017) reported results from the Great Britain Tourism Survey (GBTS) which showed that, in 2016, there were around 267,000 trips from destinations within Great Britain to the Scottish Borders, where Larriston is located. Table 5.15 presents this information and shows that over 90% of these trips were for leisure purposes. There were also around 30,000 trips from overseas destinations to the Scottish Borders, of which 60% were for leisure purposes. A very rough calculation is possible using the area of Larriston (1,108 ha), which makes up around 0.23% of the area of the Scottish Borders (473,200 ha). This proportion can then be applied to the number of visits to the Scottish Borders for leisure purposes, estimated at 259,000. This results in a rough estimate for the number of visits to Larriston of around 600 visits per year.
- The ORVaL (Outdoor Recreation Valuation) Tool developed by the University of Exeter, and focused on England and Wales, can also be used to estimate the number of visits to nearby sites in England. For example, Kielder Forest, in England, is near Larriston. The ORVaL tool estimates that there are 73 visits to Kielderhead National Nature Reserve within Kielder Forest each year. Note that the tool provides rough estimates of the number of visits to a site based on spatially disaggregating top-down estimates of visitor numbers at a relatively coarse spatial resolution. As such, the tool does not consider unique characteristics and features of a site and can under- or over-estimate visitor numbers. For example, it is not clear how estimates from the tool relate to the

number of visits to Kielder Water and Forest Park which was estimated at around 370,000 in 2013 (Kielder Water and Forest Park, 2013).

- The Strava app, which tracks cycling and running exercises using GPS data, could also be used to provide an indication of the number of people visiting the site. The app highlights 10 paths at a time for users who are looking for cycling or running routes. Data was collected as part of this study to explore the range of information available for paths in the Scottish Borders and near Kielder Forest in England. However, the results were inconclusive because they varied significantly, ranging from 100 to 2,000 visitors per location, over timescales that were unclear. It was also not possible to identify a pattern of visits across different characteristics of recreational sites such as the length of routes and the type of activities.

Table 5.15: Visits to the Scottish Borders in 2016

Purpose of visit	Number of visits to Scottish Borders in 2016 (thousands of visits)		
	From Great Britain	From overseas	Total
Holiday	241	18	259
Visiting friends and relatives	17	9	26
Business	9	3	12
Study	0	0	0
Other	0	1	1
Total	267	30	297

Source: Visit Scotland (2017)

The rough estimates set out above vary substantially and are therefore not considered to be representative of the plausible number of visits to Larriston, before or after afforestation took place. This process, however, demonstrates the importance of collecting user information for sites particularly given the potential magnitude and value of visits.

5.5 Aesthetic value

This section focuses on aesthetic value, which was considered to be an impact of the forest creation project at Larriston on local residents and day visitors. Before forest creation took place at Larriston, the EIA for the site reported that there were no internationally, nationally or locally designated landscapes within or surrounding the site and productive forestry was an integral part of the surrounding landscape. The site covers multiple regional and local Landscape Character Areas and has four noteworthy viewpoints, which are generally assessed as having low visual sensitivity.

Table 5.16 sets out the impact/dependency pathway for aesthetic value following forest creation at Larriston. The impact is discussed in qualitative terms only given the limited evidence available in the literature.

Table 5.16: Impact/dependency pathway for aesthetic value

Impact/dependency pathway	Description
1. Activity	• Aesthetic value
2. Impact/dependency on natural capital	• Dependency on wider environment including soil quality, biodiversity, exposure to wind, precipitation, etc. • Impact on local residents and other day visitors in terms of change in landscape and character of the site
3. Receptor	• Local residents and day visitors
4. Effect on natural capital (physical flow)	• Change in welfare of local residents and day visitors due to change in aesthetics of site • Not assessed in physical terms due to a lack of evidence

Impact/dependency pathway	Description
5. Value (monetary flow)	• Not assessed in monetary terms due to a lack of evidence

The site design considers the surrounding landscape including other forests, by aiming to connect other forested areas and 'softening' and blending their boundaries. The EIA for Larriston states that, at Larriston Rigg, located near the planting area, the retention of the flat fields on the valley bottom helps to re-enforce landscape character. The EIA states that planting of much of the lower ridge with spruce would result in the existing woodland being subsumed into the forest resulting in loss of diversity and a lack of differentiation between the character of Larriston Rigg and the fell. However, this was mitigated in the final planting design which includes other tree species (Western Red Cedar, Aspen / Birch) to provide a different landscape character. Overall, there is an impact on aesthetic values associated with the site given that the forest creation at Larriston is a form of land use change that ultimately changes the look and feel of the site compared to the baseline.

The concept of aesthetics is considered in a broader sense in the context of natural capital assessments. For example, this could include the fact that the aesthetics of Larriston may have an impact on people who visit the site. This would at least be partly captured in the recreational benefits of visiting the site. Aesthetics may impact local residents who live close to Larriston and can see the site from their homes. This is likely to be limited given that there are few people who live close enough to the site to experience this type of impact. This was confirmed during a visit to the site by the project team in January 2020. Moreover, valuation evidence that could be relevant to this type of impact tends to focus on inferring aesthetic values based on house prices for people living in close proximity to urban green spaces (e.g. Gibbons et al., 2014). There could also be an impact on people who see the site from their car while they are driving. This is because the site contributes to the overall character of its surrounding landscape. This type of impact is considered in Garrod (2002) which elicits people's willingness to pay (WTP) for visual or recreational access to different forest landscapes, using a choice experiment. On average, the study report that WTP is over £320 per household per year, in 2019 prices, for views of urban fringe broadleaved woodland on journeys. However, the study reported that results for coniferous forests, which make up the majority of the planted area at Larriston, were not statistically significant. The limited evidence to assess these types of impacts is consistent with Defra's guidance on Enabling a Natural Capital Approach (ENCA) (Defra, 2020). This impact is therefore not quantified or monetised given evidence limitations.

More generally, depending on the type of land use change, and the affected population, the different impacts described above can have positive or adverse effects. This is particularly relevant given the growing number of forest creation projects in the UK and the relatively significant contribution that forest creation is expected to make to meeting the UK's net zero carbon emissions targets by 2050. This is reinforced by other ambitions that represent competing pressures on land, including, for example, public payments for public goods, the need to decarbonise the grid drawing on renewable energy, socio-economic targets related to housing delivery, and others. Together these drivers and pressures could mean significant changes to the character of landscapes in the UK. A primary valuation study that focuses on the aesthetic value of changes in land use and landscapes, in both rural and urban settings, could therefore be helpful for a range of decision-making contexts.

5.6 Biodiversity

This section focuses on the impact of forest creation at Larriston on biodiversity. Biodiversity is defined by the Convention on Biological Diversity (CBD) as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within species, between species and ecosystems" (CBD, Article 2). Biodiversity supports the condition and productivity of natural capital

assets, as well as the range of benefits these assets deliver.

The UK Forestry Standard (UKFS) highlights the importance of the link between biodiversity and forest design and management (Forestry Commission, 2017). This can include the consideration of priority habitats and species, ecological connectivity, invasive species, etc. Further, a recent report by Confor focuses on the potential biodiversity benefits of modern forestry and wood production (Confor, 2020a). The report provides an overview of evidence regarding the role of forestry and timber production in the UK, in the context of tackling habitat decline and climate change. The study presents evidence that demonstrates how new forests, planted in the UK for wood production, can provide complementary habitats for biodiversity. The study also highlights how wood production can help to improve the condition of native woodlands. For example, increased thinning can help increase light levels within forests which can support certain light-demanding species such as heather.

Focusing more specifically on Larriston, prior to forest creation, the site had 356 ha of blanket bog, 320 ha of marshy grassland, 23.59 ha of unimproved neutral grassland, and 4.7 ha of base-rich grassland, all of which are classified as priority habitats within the UK Biodiversity Action Plan which, in turn, is reflected in the Scottish Borders Local Biodiversity Action Plan. The EIA reports that a total of 45 bird species were identified on the site, 39 of which were likely to breed. Of these breeding bird species, 20 are of conservation concern in the UK, and nine are UK BAP priority species. Other protected species found on site and/or in the surrounding area include red squirrels, otters, badgers and eight bat species. Generally, the EIA states that the forest creation project at Larriston would result in an improvement in biodiversity over and above the baseline.

When considering impacts on biodiversity, EIAs tend to highlight impacts and mitigation measures for individual species within a site. In contrast, a natural capital approach can focus on the different components of the total economic value of biodiversity in terms of:

- Use values which are associated with direct or indirect use of biodiversity; and
- Non-use values which are not associated with the direct or indirect use of biodiversity e.g. valuing biodiversity in its own right (existence value), for future generations (bequest value), etc.

Some components of biodiversity, such as use value, are captured within the analysis of other benefits such as recreation or aesthetics for example. For this reason, this study focuses on the non-use value of biodiversity. Table 5.17 sets out the impact/dependency pathway for biodiversity following forest creation at Larriston.

Table 5.17: Impact/dependency pathway for biodiversity

Impact/dependency pathway	Description
1. Activity	• Forest creation
2. Impact/dependency on natural capital	• Biodiversity which is a function of species richness and diversity, including plant life and wildlife
3. Receptor	• Use and non-use population
4. Effect on natural capital (physical flow)	• Valuation is not based on annual physical flow that represents a measurement of biodiversity • Based on size and type of forest created (e.g. upland coniferous)
5. Value (monetary flow)	• Non-use value of biodiversity as a result of forest creation, based on stated preference (contingent ranking) approach

In order to assess the benefits of improved biodiversity at Larriston following forest creation, evidence from the study by Hanley at al. (2002) was used. The study was selected because it is consistent with the approach and evidence used by Scottish Forestry for the economic valuation of changes in

biodiversity. The study by Hanley et al. (2002) uses evidence from a study by Garrod and Willis (1997) to estimate the non-use value of changes in biodiversity delivered by different types of forests. The study uses a stated preference approach, more specifically a contingent ranking method, where respondents are presented with a number of scenarios and asked to rank them individually on a semantic or numerical scale. The value from the study for upland coniferous forests is suitable for the forest creation project at Larriston. The value is estimated to be £0.50 per household per year in 2019 prices, for a 12,000 ha forest. This translates to a value of £0.02 per household per year in 2019 prices for Larriston, based on its planted area of just over 500 ha.

The value is aggregated in two ways for Larriston, to illustrate how the valuation of changes in biodiversity may be approached. The first approach consists of aggregating the value across the whole population of Great Britain. This approach is relevant because non-use values are not necessarily exclusively held by nearby populations to Larriston. The approach uses the total number of households in Great Britain as a basis. In 2019, there were nearly 26 million households in Great Britain (ONS, 2019). Assuming a value per household of £0.02 per year, the aggregate non-use value of biodiversity for Larriston is estimated to be just over £0.5 million per year. Over the 50-year time horizon for the study, the non-use value of biodiversity is estimated to be around £13 million in present value terms.

The second approach incorporates the effect of distance decay into the analysis. This recognises that, while non-use values do not just apply to nearby populations, the values may diminish the further individuals are from the change in biodiversity. The approaches utilises spatial analysis as follows:

- The number of households in Great Britain were mapped using a combination of data from the Office for National Statistics' census for England and Wales and from the National Records of Scotland.
- Using the centre of Larriston as a reference point, five buffers were created within 100 km, 200 km, 300 km, 400 km and 500 km of the site.
- The width of the buffers was selected considering that the first 100 km would include nearly all the Scottish Borders, which is they key area affected by the forest creation project at Larriston.
- The number of buffers was selected to provide enough spatial coverage, without going too far from Larriston. The rationale for this is that, the further the buffers extend, the more households are likely to substitute or trade-off between sites for which they hold a non-use value for biodiversity, given their budget constraint. This is consistent with the literature where the distance decay effect is found to be confounded with other effects such as use values (Hanley et al., 2003) and cultural 'ownership' (Bakhtiari et al., 2018).
- For simplicity, the non-use value of £0.02 per household per year from Hanley et al. (2002) was assumed to occur in full within the first 100 km from the site. The value was assumed to decline by 20% in each subsequent buffer (200 km, 300 km, 400 km, 500 km).

Table 5.18 presents the results from the analysis and Figure 5.1 maps the results within the assumed buffers. The majority of the households captured by the buffers within 500 km of the site were from England and Wales. The buffer within 400 km of Larriston had the greatest number of households at the Great Britain level. The location in Figure 5.1 with the highest non-use value is in Lancaster, and this result is due to two factors: (i) the location is within 200 km of Larriston, which means there is a relatively minor distance decay effect, and relatively higher non-use value per household compared to further locations; and (ii) the location is relatively densely populated.

Overall, nearly 25 million households were captured by the analysis (out of a possible 26 million, see above). The non-use value of biodiversity was estimated to be around £7 million in present value terms over the 50-year time horizon for the study. As expected, this is lower in magnitude than the aggregate value of £13 million that applies to all households in Great Britain. The disparity between these values illustrates the sensitivity of assessing non-use values, with respect to the assumed beneficiary population.

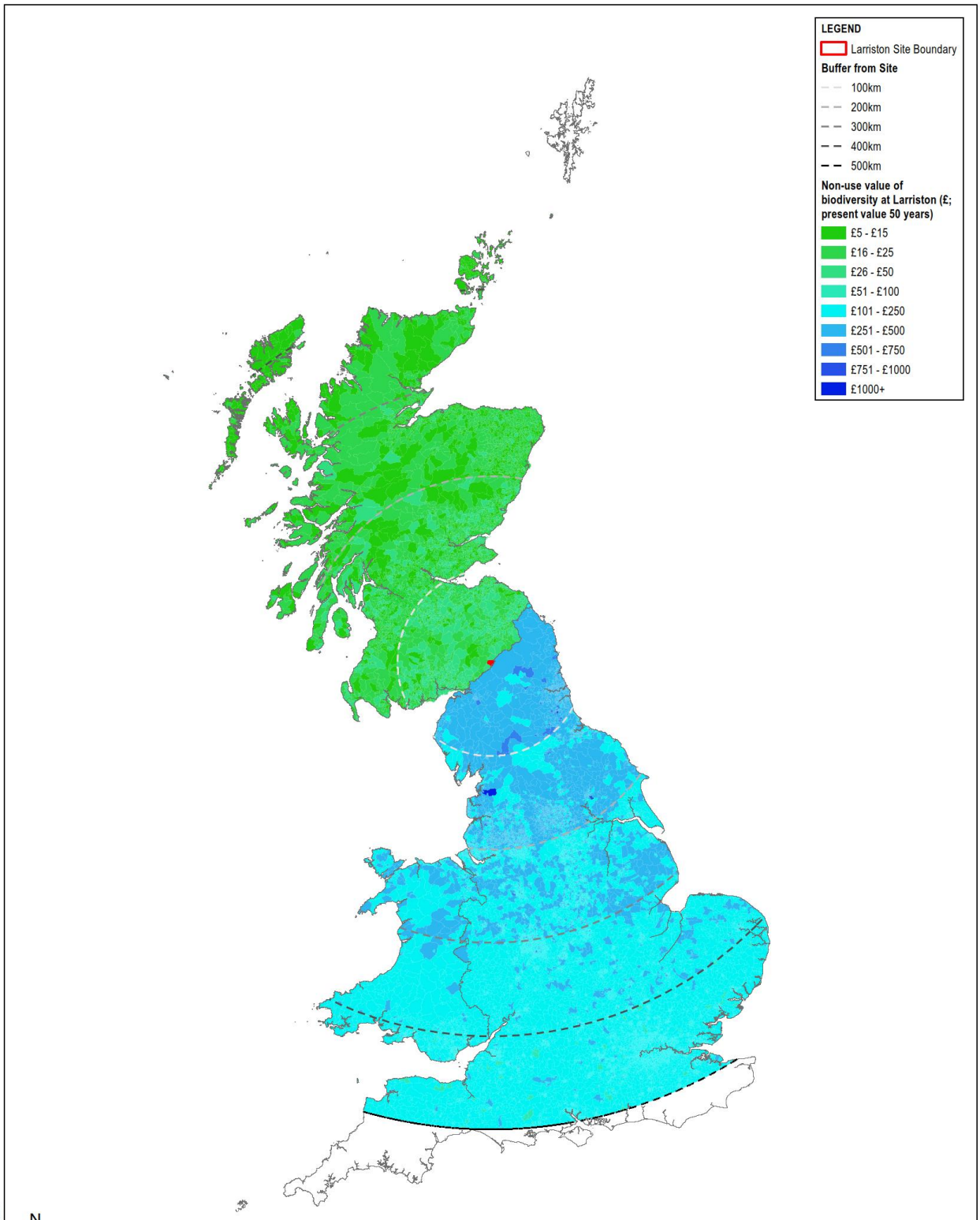
The estimates presented are subject to various additional assumptions including:

- The selected unit value is from a relatively less dated study that does not consider current developments in economic valuation methods, survey design, sampling and survey implementation. Further, the use of less recent evidence assumes that preferences are constant over time which tends to be the case in the short-term but less so in the long-term.
- The confounding effects between distance decay, use values, cultural ownership, and other factors were not disentangled and controlled for in the analysis.
- The assessment does not consider the non-use value of biodiversity from the habitats that were lost as a result of forest creation.

In general, the use of the distance decay approach is not considered to provide definitive estimates as there are a number of assumptions involved. Instead, this alternative approach can provide a degree of context and spatial heterogeneity compared to the national estimate for the whole of Great Britain. It is recommended that further research is undertaken to provide up-to-date valuation evidence for forest biodiversity that is transferable across different types of sites. This recommendation echoes the recommendations in a recent study for the Forestry Commission which assesses the feasibility of valuing forest biodiversity (eftec, 2019). It would be useful if this evidence is developed with the view of using it in natural capital assessments that are consistent with the Protocol, the Sector Guide and the emerging biodiversity guidance linked to the Protocol.[13]

[13] See https://naturalcapitalcoalition.org/biodiversity/

Figure 5.1: Estimated non-use value of biodiversity for households within 500 km of Larriston (present value, 50 years)



File Name:C:\Users\abbie.pearce\Documents\PopulationDensity.mxd

Project Title/Drawing Title: NON-USE VALUE OF BIODIVERSITY AT LARRISTON (£; PRESENT VALUE 50 YEARS)	Client: SCOTTISH FORESTRY		AECOM MidPoint Alençon Link, Basingstoke Hampshire, RG21 7PP Telephone (01256) 310200 Fax (01256) 310201 www.aecom.com
	Drawn: AP	Checked: SK	Approved: SK
	Date: 14/08/2020	Scale @ A3: 1:3,750,000	Purpose of Issue: FINAL
	Drawing Number: FIGURE 1		Rev: Rev

Table 5.18: Summary of non-use value of biodiversity at Larriston assuming distance decay effect (50 years)

Distance band	Scotland			England and Wales			Total (Great Britain)		
	Number of households per year (thousands)	50 years		Number of households per year (thousands)	50 years		Number of households per year (thousands)	50 years	
		Total value undiscounted (£k)	Present value of non-use value of biodiversity (£k; 50 years)		Total value undiscounted; (£k)	Present value of non-use value of biodiversity (£k; 50 years)		Total value undiscounted; (£k)	Present value of non-use value of biodiversity (£k; 50 years)
Within 100 km	550	10	280	960	10	490	1,510	20	780
Within 200 km	1,440	20	590	3,370	40	1,390	4,810	50	1,980
Within 300 km	330	3	110	4,510	40	1,480	4,830	40	1,590
Within 400 km	30	0.2	10	4,180	30	1,100	4,210	30	1,110
Within 500 km	20	0.1	0	9,350	50	1,970	9,360	50	1,970
Total	2,370	30	1,000	22,360	170	6,430	24,730	190	7,420

Notes: Estimates are rounded to avoid spurious accuracy. All monetary values are expressed in 2019 prices using the Consumer Price Index. Present value estimates are discounted using a 3.5% declining discount rate which is consistent with the Green Book (HM Treasury, 2018).

6. Stage 4: Apply (what next?)

This section sets out the Apply stage of the Protocol and Sector Guide, which focuses on interpreting and testing results, as well as taking action. In the context of this study, this is interpreted as providing conclusions and recommendations. This stage also incorporates insights from the dissemination webinars that took place towards the end of the study. The webinars were attended by nearly 40 people, from over 20 organisations as follows:

- 37% of attendees were from the private sector
- 37% were from the public sector
- 16% were from NGOs; and
- 11% were from academic institutions.

Further information about the webinars is presented in Appendix D.

6.1 Summary

The study aimed to apply all the stages of the Sector Guide, which is primarily aimed at organisations in the forest products value chain. In general, the Sector Guide provided a useful breakdown of steps, especially in the Scope stage which helped with deciding on the parameters of the assessment. In many cases, there was a need to 'translate' the steps and terminology used in the Sector Guide given that this study focused on a site rather than a specific organisation or forest product. For example, steps within later stages of the Sector Guide were combined because the distinction between them was not considered to be essential in the context of this study. In general, the approaches and evidence used in the study are considered to be transferable to other forest creation projects, assuming sufficient data availability and co-operation with the site owners and/or managers. If a larger area or network of sites were to be assessed, it is expected that there would be a trade-off between the spatial or technical breadth of the assessment, and the level of in-depth analysis achieved.

Overall, the study covered six different material impacts or dependencies encompassing provisioning, regulating and cultural ecosystem services. These ecosystem services were covered using qualitative, quantitative and/or monetary approaches, with the choice of approach generally depending on the availability of data. Table 6.1 provides a summary of the areas covered in the study, and whether the impacts or dependencies that were assessed accrue to the landowner or wider society. Table 6.1 also provides an indicative rating of the relative confidence associated with different estimates (high, moderate or low) based on the suitability of the approach used and the strength of the evidence.

Table 6.1: Summary of assessment of material impacts and dependencies

Impact / dependency	Private	Societal	Approach	50 years					
				Physical flow			Monetary flow (present value)		
				Estimate	Unit	Con-fidence rating*	Estimate	Unit	Con-fidence rating*
Timber	✓		Market valuation	194	thousand tonnes	High	2,500	£k	Moderate
Carbon sequestration		✓	Cost-based	145	thousand tonnes of CO_2e	High	9,100	£k	High

Impact / dependency	Private	Societal	Approach	50 years					
				Physical flow			Monetary flow (present value)		
				Estimate	Unit	Con-fidence rating*	Estimate	Unit	Con-fidence rating*
Natural hazard regulation		✓	Replacement cost	2,950	thousand m^3	Moderate	600	£k	Low
Recreation		✓	Not assessed due to limited visitor data						
Aesthetics		✓	Not assessed due to limited economic valuation evidence						
Biodiversity		✓	Stated preference (contingent ranking)	-	-	Low	7,400	£k	Low

Notes: *Indicative rating of the relative confidence associated with different estimates (high, moderate or low) based on the suitability of the approach used and the strength of the evidence. All monetary values are expressed in 2019 prices using the Consumer Price Index. Present value estimates are discounted using a 3.5% declining discount rate which is consistent with the Green Book (HM Treasury, 2018).

The analysis demonstrated that ecosystem services at the core of the forest creation project's objectives tended to be associated with better data. This was the case for timber where the total volume of timber forecast for harvest over 50 years was found to be just under 195,000 tonnes, with a value of around £2.5 million in present value terms. These estimates were driven by the presence of Sitka Spruce, which covers over 70% of the planted area, and just over 35% of the gross area of Larriston.

In contrast, the total volume of carbon sequestered by forested areas at Larriston, net of emissions from establishment and ground preparation, was estimated at nearly 145,000 tonnes of carbon dioxide equivalent (CO_2e) over 50 years. The monetary value of net carbon sequestration at Larriston is estimated at around £9 million in present value terms over 50 years. This is over three times the value of timber harvested from the site over the same period. This demonstrates the significant value that non-market benefits provided by natural capital can have and the potential insights of using the Sector Guide, or a natural capital approach more generally, to assess forest creation projects.

The value of carbon sequestration was also considered in terms of the price of verified credits within the voluntary carbon market, for the benefit of project developers. The total volume of carbon sequestered by forested areas at Larriston, net of emissions from establishment and ground preparation and the Woodland Carbon Code buffers, was estimated at around 90,000 tonnes of carbon dioxide equivalent (CO_2e) over 50 years. This provides a basis for project developers to compare the value of carbon sequestered at Larriston, based on the voluntary market, to other projects that are validated under the Woodland Carbon Code. This results in an estimated value of carbon sequestration, net of the Woodland Carbon Code buffers, of between £0.2 and £0.4 million in present value terms over 50 years. This is based on an average price of verified credits under the Woodland Carbon Code which ranges between £5 and £10 per tonne of CO_2e. An alternative approach could be to use the average price, of £24.11 per tonne of CO_2e, that stems from Woodland Carbon Guarantee. This results in a value of carbon sequestration benefits at Larriston of around £1 million in present value terms over 50 years, net of emissions and buffers.

These alternative estimates can be used to compare the market value of carbon sequestration at Larriston to other real-world examples, which would be meaningful to landowners, project developers and forest managers. The values are significantly lower than the present value of timber that is estimated for Larriston. In contrast, the estimates in Table 6.1, derived using the BEIS non-traded

carbon price, reflect the marginal abatement cost of carbon to meet the UK's climate change targets. As such they would be meaningful in the context of value for money assessments, to make the case for forest creation at the national level to HM Treasury. There is therefore a mismatch between the market and societal value of carbon sequestration which could potentially be explored via other policy levers and incentives, such as public payments for public goods.

For flood risk protection, following the approach set out by Forest Research (2018), forest cover at Larriston is estimated to store nearly 3 million m^3 of water over a 50-year time horizon, with respect to canopy interception and additional soil water storage. The cost of constructing a reservoir with an equivalent capacity is estimated at £0.6 million over 50 years in present value terms. This cost-based estimate provides a lower-end value of the benefits from flood risk protection at Larriston.

The non-use value of biodiversity was also considered in the study. The value was aggregated across the whole population of Great Britain, using the total number of households in Great Britain in 2019 (nearly 26 million). Over the 50-year time horizon for the study, the non-use value of biodiversity was estimated to be around £13 million in present value terms. This was contrasted with an alternative approach, which incorporated a distance decay effect, which recognised that, while non-use values do not just apply to nearby populations, the values may diminish the further individuals are from the change in biodiversity. Overall, nearly 25 million households were captured by the analysis based on an area that extended up to 500 km from Larriston. The non-use value of biodiversity was estimated to be around £7 million in present value terms over the 50-year time horizon for the study. As expected, this is lower in magnitude than the aggregate value of £13 million that applies to all households in Great Britain, and does not recognise a potential distance decay effect. The disparity between these values illustrates the sensitivity of assessing non-use values, with respect to the assumed beneficiary population. In general, the use of the distance decay approach is not considered to provide definitive estimates as there are a number of assumptions involved. Instead, this alternative approach can provide a degree of context and spatial heterogeneity compared to the national estimate for the whole of Great Britain.

Other ecosystem services that were considered in qualitative terms included recreation and landscape aesthetics. There was a lack of suitable valuation evidence to assess aesthetic values, and a lack of reliable estimates of visitor numbers to assess recreational values. Impacts on landscape aesthetics are likely to become increasingly relevant as the number of forest creation projects in the UK grows and contributes to the UK's net zero carbon emissions targets. This is reinforced by other ambitions that represent competing pressures on land, including, for example, public payments for public goods, the need to decarbonise the grid drawing on renewable energy, socio-economic targets related to housing delivery, and others. Together these drivers and pressures could mean significant changes to the character of landscapes in the UK.

6.2 Insights from applying the Sector Guide

The application of the Sector Guide to Larriston shows that a natural capital assessment for forest creation projects can:

- Demonstrate how the Protocol and Sector Guide can be applied to a forest creation project. This includes demonstrating the range of impacts, dependencies and metrics that can be covered. The Sector Guide has the added flexibility of considering material impacts and dependencies which help define a more manageable scope and develop a scalable approach, which can be extended to other sites and larger areas. This is particularly promising for forestry, given the forestry sector benefits from relatively more evidence than other habitat types e.g. the marine environment.
- Complement the narrative within conventional Environmental Impact Assessments for forest creation projects. EIAs tend to focus on minimising and mitigating adverse impacts, whereas

natural capital assessments focus on revealing impacts and dependencies including the possible benefits of forest creation.

- Provide evidence to assess performance under the UK Forestry Standard (UKFS), which advocates a balanced approach to sustainable forest management, recognising that forests have a range of environmental, social and economic objectives, impacts and dependencies. Future assessments can also contribute to the evolution of the UKFS over time.
- Provide different insights depending on the stage at which the assessment takes place. The assessment at Larriston was an ex-post assessment of an established forest creation project where planting had already been completed. As such, the analysis can help with efforts to monitor the forest creation project over its lifetime and to potentially inform the design of other sites in the future. In contrast, an ex-ante assessment could provide a framework for undertaking an options appraisal of different forest design specifications. It could also inform the future management of forest creation sites.
- Provide the basis for communicating the impacts and dependencies of forest creation to local communities. This could feed into consultation with stakeholders depending on the stage at which the assessment is completed.
- Make the case for forest creation as a form of natural capital investment at the national level. Such efforts could contribute to achieving various targets in Scotland and the UK including biodiversity targets, net zero carbon emissions, etc.
- Scope investible opportunities by identifying beneficiaries of different impacts from the forest creation projects, as well as the magnitude and value of these impacts. This could include informing the feasibility of developing payments for ecosystem services (PES) schemes, where additionality can be demonstrated, based on the estimated value of different benefits. This could include additional carbon sequestration benefits delivered by forest creation, which could qualify under the Woodland Carbon Code or the Woodland Carbon Guarantee. This could also include public payments for other public goods which are linked to goals within the UK Government's 25-Year Environment Plan (e.g. 'enhancing beauty, heritage and engagement with the natural environment') and the devolved administrations' plans for future rural support.
- Demonstrate returns on investment in forest creation projects, both in terms of private benefits (e.g. revenue from the sale of harvested timber) and societal benefits (e.g. benefits from carbon sequestration). This evidence could be used to support initiatives such as the proposed 'Natural Capital Pioneer Fund' within the £1 billion challenge launched by the Scottish Environment Protection Agency (SEPA) and the Scottish Wildlife Trust (SEPA and Scottish Wildlife Trust, 2020).[14]

6.3 Recommendations for future assessments

The application of the Sector Guide to future forest creation projects could be improved by:

- Assessing a project at the design stage to maximise the potential impact and insights of a natural capital approach on the design and future management of a site.
- Assessing the baseline to determine the net impact of a forest creation project. This is particularly relevant when considering the impact of forest creation on biodiversity, including the potential displacement of certain species.
- Focusing on the open ground (unplanted area) as well as the planted area within a site to provide a holistic approach. This could potentially demonstrate the trade-offs including whether using a

[14]The Natural Capital Pioneer Fund would use a tried and tested model to target enterprises looking to grow or change their business activities in order to enhance biodiversity. The fund would offer unsecured loans, delivering both seed and accelerator funding, to businesses not yet able to access traditional lending due to the size of their asset base.

natural capital approach at the design stage might suggest a different conclusion as to the split between planted vs. unplanted land within a site.

- Considering impacts and dependencies on social capital (e.g. relationships and trust) given the potential adverse and/or beneficial impacts of forest creation projects on local communities and the potential for concerns about land use change.

In addition to these areas for further improvement, the following research recommendations have emerged from the study:

- It is recommended that on-going monitoring of forest creation projects should take place after the forest is established at the site. At the most basic level, a forest creation project is a live project that will change over time. An on-going monitoring system can track the evolution of projects, and provide a steady stream of data that could inform land management at that site, facilitate stakeholder engagement or provide lessons learnt for other sites.
- It is recommended that social capital issues are considered alongside natural capital issues in the context of forest creation. Social capital focuses on relationships and trust and it is expected that these issues will become more pertinent as different policies involve competing uses of land and affect a range of stakeholders. This area may also help with teasing out the social issues that land use change can raise. Having a better understanding of these issues can help project developers plan for them, and could make the planning and implementation processes run more smoothly.
- It is also recommended that further research is undertaken to provide up-to-date valuation evidence for forest biodiversity that is transferable across different types of sites. This echoes the recommendations in the recent study for the Forestry Commission which assesses the feasibility of valuing forest biodiversity.
- It is recommended that an approach to assessing biodiversity in physical terms is trialled on a forest creation project. This could make use of the Defra Biodiversity Net Gain metric 2.0 (Natural England, 2019) or NatureScot's Natural Capital Asset Index (SNH, 2019). This exercise could demonstrate the added benefits to biodiversity, over-and-above the baseline, as a result of forest creation and provide an easy-to-use metric for future projects.
- Alongside changes in biodiversity, it will be useful to explore how changes in aesthetic value and landscape character can be better captured. This could, for example, involve exploring how photos shared via social media reflect people's preferences for certain landscapes.
- More broadly it could be useful to develop meta-analyses functions for woodlands which could achieve what the Brander et al. (2008) meta-analysis function did for wetlands.[15] These could encompass benefits relating to flooding, aesthetics, biodiversity, recreation and potentially other regulating services which tend to be overlooked.
- It is recommended that the trade-off between timber and carbon is explored in future research particularly for productive sites. This could include developing a first-cut approach to assessing the carbon storage and substitution benefits from harvested wood products for forest creation projects and other site-level assessments.

[15] The study by Brander et al. (2008) uses existing data on economic values of local ecosystem services for an assessment of these values at a larger geographical scale. The proposed methodology makes use of meta-analysis to produce a function that is applied to individual European wetland sites. Site-specific, study-specific and context-specific variables are used to model a value that captures differences between sites and over time.

Glossary

Biodiversity: The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within species, between species and ecosystems (Convention on Biological Diversity, Article 2).

Broad habitat: A means of classifying ecosystems. The UK National Ecosystem Assessment (UK NEA, 2011) defines ecosystems based upon recognised 'broad habitats' within the UK. These are: (i) coastal margins; (ii) enclosed farmland; (iii) freshwater, wetlands and floodplains; (iv) marine; (v) mountains, moors and heaths; (vi) semi-natural grasslands; (vii) urban (green space); and (viii) woodland.

Contingent ranking: a stated preference approach where respondents are presented with a number of scenarios and asked to rank them individually on a semantic or numerical scale.

Counterfactual: A potential baseline scenario that describes a plausible alternative situation, and the environmental conditions that would result if the forest creation activity did not proceed.

Dependency pathway: A dependency pathway shows how a particular activity depends upon specific features of natural capital. It identifies how observed or potential changes in natural capital affect the costs and/or benefits of forest creation.

Discounting: The process of expressing future values in present value terms. This allows for the comparison of flows of cost and benefit over time regardless of when they occur.

Distance decay: The pattern of declining unit values as the distance from a change in the provision of a non-market good or service increases.

Ecosystems: A dynamic complex of plants, animals, and microorganisms, and their non-living environment, interacting as a functional unit. Examples include forests and wetlands (Millennium Ecosystem Assessment, 2005).

Ecosystem services: Functions and products from nature that can be turned into goods and services with varying degrees of human input. Ecosystem services consist of: (i) provisioning services such a fibre and fuel or fresh water; (ii) regulating services such a natural hazard regulation and pollination; (iii) cultural services such as recreation and aesthetics; and (iv) supporting services, such as water cycling and biodiversity, which underpin the provision of all other ecosystem services.

Ecosystem approach: a framework for analysing how people depend on the condition of the natural environment. The approach explicitly recognises that ecosystems and their biological diversity contribute to individual and social well-being.

Existence value: A type of non-use value derived from knowing that a resource continues to exist, regardless of using it.

Impact driver: A measurable quantity of a natural resource that is used as an input to or a measurable non-product output of forest creation activity (adapted from Natural Capital Committee, 2016).

Impact pathway: An impact pathway describes how, as a result of a specific activity, a particular impact

driver results in changes in natural capital and how these changes in natural capital affect different stakeholders.

Materiality: An impact or dependency on natural capital is material if consideration of its value, as part of the set of information used for decision making, has the potential to alter that decision.

Measurement: The process of determining the amounts, extent, and condition of natural capital and associated ecosystem and/or abiotic services, in physical terms.

Meta-analysis: An empirical study that collates data from multiple valuation studies on a particular good, with the purpose of identifying the key factors that influence estimated economic values.

Monetary valuation: Valuation that uses money as the common unit to assess the values of natural capital impacts or dependencies.

Natural capital: Defined by the Natural Capital Protocol (2016) as the stock of renewable and non-renewable natural resources on earth (e.g., plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits or 'services' to people. Defined by the Natural Capital Committee (2014) as the elements of nature that directly and 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 assessment: A qualitative and/or quantitative assessment of impacts and/or dependencies on natural capital that includes one or more of the following: (i) an assessment of the extent (quantity) of natural capital assets; (ii) an assessment of the condition (quality) of natural capital assets; (iii) an assessment of physical flow of ecosystem services delivered by natural capital assets; and/or (iv) an assessment of the monetary flow of the ecosystem services delivered by natural capital assets, which could include the cost of maintaining these flows.

Natural capital dependency: An activity's reliance on or use of natural capital.

Natural capital impact: The negative or positive effect of an activity on natural capital.

Natural Capital Protocol: A standardised framework to identify, measure, and value direct and indirect impacts (positive and negative) and/or dependencies on natural capital.

Non-use population: Population group(s) that derive economic value from a resource without making direct or indirect use of it (i.e. non-use value).

Present value: A future value (cost or benefit) expressed in present terms by means of discounting.

Replacement cost approach: An approach that uses the cost of mitigating actions required if a service is lost or if its productivity decreases, as a proxy of the value of an ecosystem service.

Total economic value (TEV): The economic value of a resource comprised of its use and non-use values.

Use value: The economic value that is derived from using or having potential to use a resource.

Use population: Individuals making direct use of a resource or indirect use of a resource.

Value chain boundary: The part or parts of the value chain to be included in a natural capital assessment.

Willingness to pay (WTP): The monetary measure of the value of obtaining a gain in the provision of good or service or avoiding a loss.

References

Bakhtiari F., Jacobsen J., Thorsen J-B., Lundhede T., Strange N. and Boman M. (2018) "Disentangling distance and country effects on the value of conservation across national borders" Ecological Economics, 147, 11-20.

Bell, J. (2014) Eskdalemuir: A Comparison of Forestry and Hill Farming – Productivity and Economic Impact. Report prepared for Confor.

Brander, L. M., Ghermandi, A., Kuik, O., Markandya, A., Nunes, P. A. L. D., Schaafsma, M., & Wagtendonk, A. (2008). Scaling up ecosystem services values: methodology, applicability and a case study. European Environment Agency, Copenhagen (Final report).

Building Research Establishment (BRE) (2018) The IMPACT database. https://www.bregroup.com/impact/the-impact-database/ [Accessed August 2020].

Brown P., Cardenas L., Choudrie S., Jones L., Karagianni E., MacCarthy J., Passant N., Richmond B., Smith H., Thistlethwaite G., Thomson A., Turtle L., D. Wakeling (2020) UK Greenhouse Gas Inventory, 1990 to 2018: Annexes. Annual Report for Submission under the Framework Convention on Climate Change.

Committee on Climate Change (2020) Land use: Policies for a Net Zero UK. https://www.theccc.org.uk/publication/land-use-policies-for-a-net-zero-uk/ [Accessed February 2020].

Confederation of Forest Industries UK (Confor) (2020a) Biodiversity, forestry and wood: An analysis of the biodiversity benefits of modern forestry and wood production. https://www.confor.org.uk/media/247782/confor-biodiversity-forestry-final.pdf [Accessed August 2020].

Confederation of Forest Industries UK (Confor) (2020b) Forestry and Timber News. April 2020, Issue 98.

Department for Business, Energy & Industrial Strategy (BEIS) (2019) Carbon Valuation. https://www.gov.uk/government/collections/carbon-valuation--2 [Accessed March 2020].

Department for Environment, Food and Rural Affairs (Defra) (2020) Enabling a Natural Capital Approach (ENCA). January 2020. https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca [Accessed February 2020].

eftec (2019) Feasibility Study for the Valuation of Forest Biodiversity. Final report for the Forestry Commission, September 2019.

Findlay Ecology Services (2014) Larriston Estate: Vegetation Survey 2014.

Forestry England (2019) Natural Capital Accounts. https://www.forestryengland.uk/article/natural-capital-accounts [Accessed April 2020].

Forest Research (2018) Valuing flood regulation services of existing forest cover to inform natural capital accounts. https://www.forestresearch.gov.uk/research/valuing-flood-regulation-services-

existing-forest-cover-inform-natural-capital-accounts/ [Accessed March 2020].

Forest Research (2020a) Conversion factors https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2016-introduction/sources/timber/conversion-factors/ [Accessed April 2020].

Forest Research (2020b) Ecological Site Classification Decision Support System (ESC-DSS). https://www.forestresearch.gov.uk/tools-and-resources/ecological-site-classification-decision-support-system-esc-dss/ [Accessed April 2020].

Forest Research (2020c) Timber prices. https://www.forestresearch.gov.uk/tools-and-resources/statistics/statistics-by-topic/timber-statistics/timber-price-indices/ [Accessed March 2020].

Forestry Commission (2017) The UK Forestry Standard: The Governments' Approach to Sustainable Forestry. https://www.gov.uk/government/publications/the-uk-forestry-standard [Accessed February 2020].

Garrod G. (2002) Social & Environmental Benefits of Forestry Phase 2: Landscape Benefits. https://forestry.gov.scot/publications/672-the-social-and-environmental-benefits-of-forests-in-great-britain-landscape-report/download [Accessed April 2020].

Garrod, G. D., & Willis, K. G. (1997). The non-use benefits of enhancing forest biodiversity: a contingent ranking study. Ecological Economics, 21(1), 45-61.

Gibbons, S.; Mourato, S.; and Mendes Resende, G. (2014) The amenity value of English nature: a hedonic price approach. Environmental and Resource Economics, 57 (2). pp. 175-196.

Grown in Britain (2018) Price / Size Curve Data for British Hardwoods – Sycamore. https://www.growninbritain.org/wp-content/uploads/2020/04/BritishHardwoodsData-Sycamore.pdf [Accessed May 2020].

Hanley, N., Schläpfer, F., & Spurgeon, J. (2003). Aggregating the benefits of environmental improvements: distance-decay functions for use and non-use values. Journal of environmental management, 68(3), 297-304.

Hanley, N., Willis, K., Powe, N. and M. Anderson (2002) Valuing the benefits of biodiversity in forests. Report to Forestry Commission, Edinburgh.

HM Government (2018a) A Green Future: Our 25 Year Plan to Improve the Environment. https://www.gov.uk/government/publications/25-year-environment-plan [Accessed February 2020].

HM Government (2018b) Create a Woodland: Overview. https://www.gov.uk/guidance/create-woodland-overview [Access February 2020].

HM Government (2020) Environment Bill 2020. https://www.gov.uk/government/publications/environment-bill-2020 [Accessed February 2020].

HM Treasury (2018) The Green Book. https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent [Accessed April 2020].

Intergovernmental Panel on Climate Change (IPCC) (2013) 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol. https://www.ipcc-nggip.iges.or.jp/public/kpsg/pdf/KP_Supplement_Entire_Report.pdf [Accessed August 2020].

International Union for Conservation of Nature (IUCN) UK (2020) The Peatland Code. https://www.iucn-uk-peatlandprogramme.org/funding-finance/peatland-code/projects [Accessed March 2020].

Kielder Water and Forest Park (2013) Kielder Water & Forest Park officially the best tourism experience in England. http://www.visitkielder.com/news/2013/05/kielder-water-forest-park-officially-the-best-tourism-experience-in-engl- [Accessed April 2020].

Millennium Ecosystem Assessment (MEA), 2005. Ecosystems and Human Well-being: General Synthesis. Island Press, Washington, DC.

Natural Capital Coalition (2016) Natural Capital Protocol. www.naturalcapitalcoalition.org/protocol [Accessed February 2020].

Natural Capital Coalition (NCC) (2018) Natural Capital Protocol – Forest Products Sector Guide. https://naturalcapitalcoalition.org/wp-content/uploads/2018/07/NCC_ForestProductsSectorGuide_Web.pdf [Accessed February 2020].

Natural Capital Committee (NCC) (2019) Natural Capital Terminology. August 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/824604/ncc-terminology.pdf [Accessed February 2020].

Natural Capital Committee (NCC) (2020). Advice on using nature based interventions to reach net zero greenhouse gas emissions by 2050. https://www.gov.uk/government/publications/a-natural-capital-approach-to-attaining-net-zero-nature-based-interventions [Accessed April 2020].

Natural England (2019) The Biodiversity Metric 2.0 (JP029). http://publications.naturalengland.org.uk/publication/5850908674228224 [Accessed April 2020].

Nisbet, T.R., Roe, P., Marrington, S., Thomas, H., Broadmeadow, S.B., and Valatin, G. (2015). Slowing the Flow at Pickering. Final report for Phase 1 for Defra FCERM Multi-objective Flood Management Demonstration project RMP5455. https://www.forestresearch.gov.uk/documents/1013/stfap_final_report_Apr2011.pdf [Accessed June 2020].

Office for National Statistics (2019) Labour Force Survey (LFS).

Read, D.J., Freer-Smith, P.H., Morison, J.I.L., Hanley, N., West, C.C. and Snowdon, P. (eds). 2009. Combating climate change – a role for UK forests: An assessment of the potential of the UK's trees and woodlands to mitigate and adapt to climate change. The Stationery Office, Edinburgh.

Scarpa, R. (2003) The recreation value of woodlands. Report for the Forestry Commission.

Scottish Borders Council (2005) Scottish Borders Woodland Strategy: New Ways for Scottish Borders Trees, Woodlands and Forests. https://www.scotborders.gov.uk/downloads/file/1098/scottish_borders_woodland_strategy [Accessed February 2020].

Scottish Borders Council (2012) Scottish Borders Woodland Strategy: Technical Advice Note. https://www.scotborders.gov.uk/download/downloads/id/1099/technical_advice_note.pdf [Accessed April 2020].

Scottish Environment Protection Agency (SEPA) and Scottish Wildlife Trust (2020) The £1 billion Challenge: How to Finance Biodiversity and Help Achieve the Sustainable Development Goals. https://scottishwildlifetrust.org.uk/wp-content/uploads/2020/05/202001_1-Billion-Challenge-Document_FINAL.pdf[Accessed August 2020].

Scottish Forestry (2020a) 3.2 Carbon leakage. https://www.woodlandcarboncode.org.uk/standard-and-guidance/3-carbon-sequestration/3-2-carbon-leakage#whatisleakage [Accessed June 2020].

Scottish Forestry (2020b) 3.3 Project carbon sequestration. https://www.woodlandcarboncode.org.uk/standard-and-guidance/3-carbon-sequestration/3-3-project-carbon-sequestration [Accessed March 2020].

Scottish Forestry (2020c) UK Woodland Carbon Code. https://www.woodlandcarboncode.org.uk/ [Accessed August 2020].

Scottish Forestry (2020d) Woodland Carbon Guarantee. https://www.woodlandcarboncode.org.uk/woodland-carbon-guarantee [Accessed August 2020].

Scottish Government (2019) Scotland Forestry Strategy: 2019-2029. https://www.gov.scot/publications/scotlands-forestry-strategy-20192029/pages/5/ [Accessed February 2020].

Scottish Natural Heritage (SNH) (2019) Natural Capital Asset Index. https://www.nature.scot/professional-advice/planning-and-development/social-and-economic-benefits-nature/natural-capital-asset-index [Accessed April 2020].

Tilhill Forestry (2015) Environmental Statement: Proposal for Mixed Woodland – Larriston Scottish Borders. September 2015.

UK National Ecosystem Assessment (UK NEA) (2011). The UK National Ecosystem Assessment: Synthesis of the Key Findings. UNEP-WCMC, Cambridge.

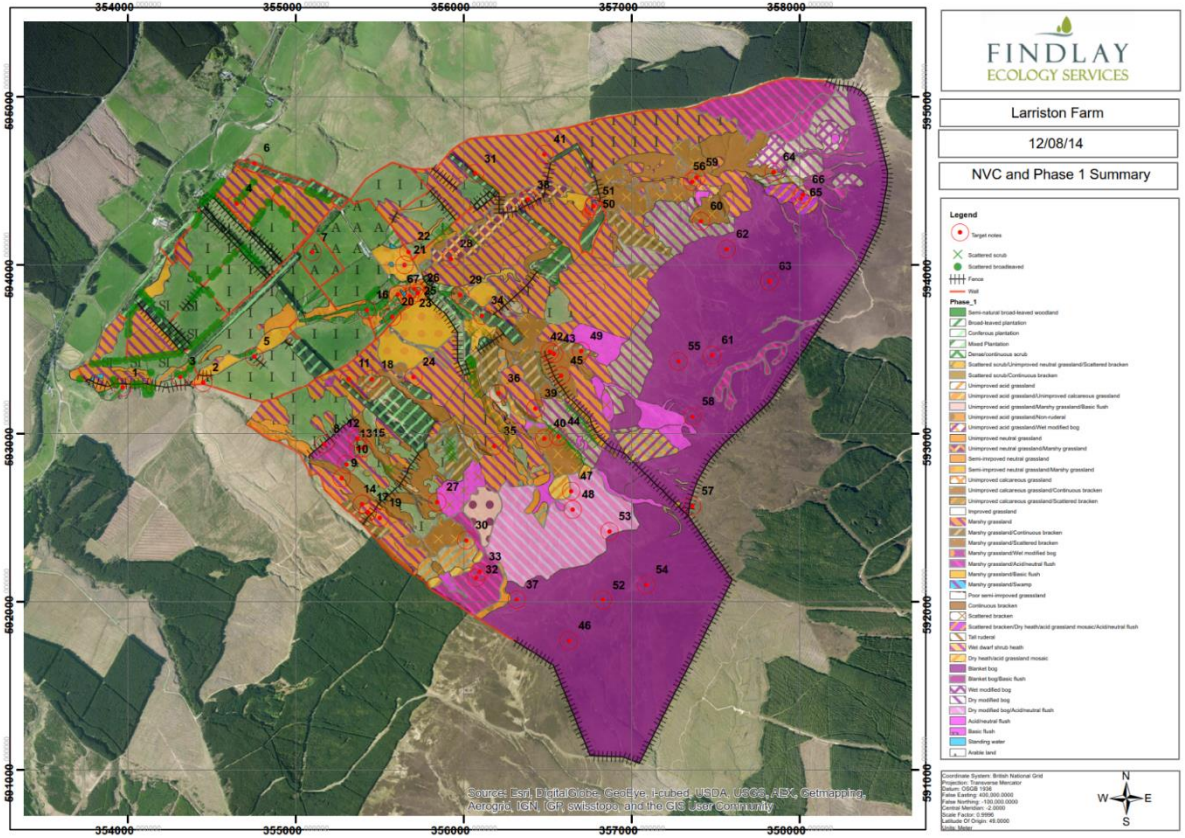
University of Exeter (2020) Outdoor Recreation Valuation Tool (ORVaL: Version 2.0). https://www.leep.exeter.ac.uk/orval/ [Accessed April 2020].

Visit Scotland (2017) Insight Department: Tourism in Scotland's Regions 2016. https://www.visitscotland.org/binaries/content/assets/dot-org/pdf/research-papers-2/insights---tourism-in-scotlands-regions-2016_update-may-18.pdf [Accessed April 2020].

Appendix A – Baseline Phase 1 habitats at Larriston

This appendix sets out how the baseline Phase 1 habitat types at Larriston are mapped to the UK NEA (2011) broad habitat types, to produce Figure 2.1. Figure A. 1 presents the baseline Phase 1 habitats at Larriston. Table A. 1 provides a comparison of the classification of Phase 1 habitats to the UK NEA broad habitats.

Figure A. 1: Baseline Phase 1 habitats present at Larriston before forest creation (2013/14)



Source: Findlay Ecology Services (2014).

Table A. 1: Comparison of Phase 1 habitat classification to UK NEA broad habitat classification

Phase 1 habitat		Corresponding UK NEA broad habitat
Code	Description	
B1.1	Acid grassland - unimproved	Semi-natural grassland
E1.6.1/E2.1	Blanket bog/Basic flush	Mountains, moors and heaths
E1.6.1	Blanket sphagnum bog	Mountains, moors and heaths
C1.1	Bracken - continuous	Mountains, moors and heaths
C1.2	Bracken – scattered	Mountains, moors and heaths
A1.1.2	Broadleaved woodland - plantation	Woodland
A1.1.1	Broadleaved woodland - semi-natural	Woodland
B3.1	Calcareous grassland - unimproved	Semi-natural grassland
A1.2.2	Coniferous woodland - plantation	Woodland
J1.1	Cultivated/disturbed land - arable	Enclosed farmland
D5	Dry heath/acid grassland	Mountains, moors and heaths
E1.8	Dry modified bog	Mountains, moors and heaths
E1.8/E2.1	Dry modified bog/Acid/neutral flush	Mountains, moors and heaths
E2.1	Flush and spring - acid/neutral flush	Freshwaters, wetlands and floodplains
B4	Improved grassland	Semi-natural grassland
B5	Marsh/marshy grassland	Mountains, moors and heaths
B5/E2.1	Marshy grassland/Acid/neutral flush	Mountains, moors and heaths
B5/E2.2	Marshy grassland/Basic flush	Freshwaters, wetlands and floodplains
B5/C1.1	Marshy grassland/Continuous bracken	Mountains, moors and heaths
B5/C1.2	Marshy grassland/Scattered bracken	Mountains, moors and heaths
B5/F1	Marshy grassland/Swamp	Freshwaters, wetlands and floodplains
B5/E1.7	Marshy grassland/Wet modified bog	Mountains, moors and heaths
A1.3.2	Mixed woodland - plantation	Woodland
B2.2	Neutral grassland - semi-improved	Semi-natural grassland
B2.1	Neutral grassland - unimproved	Semi-natural grassland

Phase 1 habitat		Corresponding UK NEA broad habitat
Code	Description	
-	Other Habitat	Other
C3.1	Other tall herb and fern - ruderal	Semi-natural grassland
B6	Poor semi-improved grassland	Semi-natural grassland
C1.2/D5/E2.1	Scattered bracken/Dry heath/acid grassland mosaic/Acid/neutral flush	Mountains, moors and heaths
A2.2/C1.1	Scattered scrub/Continuous bracken	Mountains, moors and heaths
A2.1	Scrub - dense/continuous	Semi-natural grassland
A2.2	Scrub – scattered	Semi-natural grassland
B2.2/B5	Semi-improved neutral grassland/Marshy grassland	Semi-natural grassland
G1	Standing water	Freshwaters, wetlands and floodplains
B1.1/B5/E2.2	Unimproved acid grassland/Marshy grassland/Basic flush	Semi-natural grassland
B1.1/C3.2	Unimproved acid grassland/Non-ruderal	Semi-natural grassland
B1.1/B3.1	Unimproved acid grassland/Unimproved calcareous grassland	Semi-natural grassland
B3.1/C1.1	Unimproved calcareous grassland/Continuous bracken	Semi-natural grassland
B3.1/C1.2	Unimproved calcareous grassland/Scattered bracken	Semi-natural grassland
B2.1/B5	Unimproved neutral grassland/Marshy grassland	Semi-natural grassland
D2	Wet dwarf shrub heath	Mountains, moors and heaths
E1.7	Wet modified bog	Mountains, moors and heaths

Appendix B – Supporting information for materiality assessment

The following table presents the details of the assessment of material impacts and dependencies on natural capital as a result of the forest creation project at Larriston. The relationships between natural capital assets and ecosystem services are colour-coded as follows:

- '-' denotes that no evidence is available in the EIA for Larriston regarding the relationship between the natural capital asset and ecosystem service;
- **Grey** denotes that evidence is available in the EIA regarding the relationship between the natural capital asset and ecosystem service, but the change in land use and consequent change in ecosystem service provision is offset by specific mitigation measures set out in the EIA;
- **Light blue** denotes that evidence is available regarding the relationship between the natural capital asset and ecosystem service, but the change in land use and consequent change in ecosystem service provision is of small or negligible magnitude or is offset by another impact that is expected to occur (e.g. it is not additional);
- **Dark blue** denotes that evidence is available regarding the relationship between the natural capital asset and ecosystem service, with a significant net change in land use and a consequent change in ecosystem service provision.

Table B. 1: Materiality assessment as a result of forest creation at Larriston

Ecosystem services		Natural capital assets			
		Freshwaters, wetlands and floodplains	Mountains, moors and heaths	Semi-natural grassland	Woodland
Provisioning	Crops and livestock	-	-	• Impact in terms of loss of agricultural output associated with land use change from grassland to woodland. • However, this is not considered to be material given the relatively lower returns from sheep grazing compared to forestry.	-
	Fibre and fuel	-	-	-	• Impact in terms of increase in timber production associated with afforestation on site. • This is considered to be a significant net change in land use and ecosystem service provision.
	Water supply	-	-	-	-

Ecosystem services		Natural capital assets			
		Freshwaters, wetlands and floodplains	Mountains, moors and heaths	Semi-natural grassland	Woodland
Regulating	Global climate regulation	-	• Potential impact associated with peatland within the open ground in the site which may deliver carbon sequestration benefits. • However, the peatland is in degraded condition and its active management or restoration is not expected to take place. For this reason, this benefit is not expected to be realised and is not considered to be material.	• Impact in terms of reduction in greenhouse gas emissions associated with loss of agricultural output as a result of land use change from grassland to woodland.	• Potential impact in terms of short-term carbon emissions due to soil disturbance as a result of preparing the site for afforestation including ploughing and mounding, which expose soil and can release carbon. • In the long-term this would be significantly outweighed by an increase in carbon sequestration by woodland as a result of the afforestation scheme.
	Local climate regulation	-	-	-	• Potential impact in terms of cooling effect from trees. • However, this is not considered to be material given the rural location of the site and the small number of receptors.
	Air quality regulation	-	-	-	• Potential impact in terms of air quality benefits from trees. • However, this is not considered to be material given the rural location of the site and the small number of receptors.
	Natural hazard regulation (e.g. flooding, erosion, etc.)	-	• Potential impact associated with peatland within the open ground in the site which may deliver flood risk benefits. • However, the peatland is in degraded condition and its active management or restoration is not expected to take place. For this reason, this benefit is not expected to be realised and is not considered to be material.	-	• Potential impact in terms of short-term increase in flood risk during ground preparation. However, this is mitigated by a buffer zone approach and Diffuse Pollution Control Plan (DPCP). • Impact in terms of long-term increase in flood risk protection within the catchment, as trees become established and roughness of vegetation increases thereby slowing the flow of surface water and run-off.
	Water quality regulation	• Potential impact in terms of short-term decrease in water quality of surrounding surface waters during ground preparation. • However, this is mitigated as ground preparation, herbicide use, track construction and watercourse	-	-	• Potential impact in terms of short-term decrease in water quality of surrounding surface waters during ground preparation. • However, this is mitigated as ground preparation, herbicide use, track construction and watercourse crossings are designed to comply with relevant guidance and standards.

Ecosystem services		Natural capital assets			
		Freshwaters, wetlands and floodplains	Mountains, moors and heaths	Semi-natural grassland	Woodland
		crossings are designed to comply with relevant guidance and standards. This includes applying a minimum 20 metre buffer zone to all major watercourses. • Potential impact in terms of long-term improvement in water quality of surface waters due to tree planting.			This includes applying a minimum 20 metre buffer zone to all major watercourses. • Potential impact in terms of long-term improvement in water quality of surface waters due to planting.
	Pollination	-	-	-	• -
	Disease and pest control	-	-	-	• Potential dependency of trees on incidence of disease and pests. • However, this is not considered to be material given that the design of the site incorporates different habitats to avoid single species being affected by pests and diseases.
	Soil quality regulation	-	-	• Potential impact in terms of cultivation of rush-pasture and improved grassland, which will expose mineral water-absorbing substrates and increase the water absorption capacity of the soil.	• Potential impact in terms of short-term soil water logging during periods of high rainfall. • This is managed during operations by using rainfall alerts so that site work which poses a risk is stopped during periods of high rainfall and/or saturated soils. The risk of disturbing deep organic soils is avoided because they are excluded from the planting design. • For these reasons, this impact is not considered to be material.
Cultural	Recreation	-	-	-	• Potential impact in terms of improved access to the site which may encourage more recreational users. • It is possible that the type of users of the site could change but the overall number of users might remain relatively stable. For example, users that are more inclined to use defined tracks could displace users that prefer open landscapes that are not heavily forested. • This impact is nevertheless considered to be significant given information regarding the scale

Ecosystem services		Natural capital assets			
		Freshwaters, wetlands and floodplains	Mountains, moors and heaths	Semi-natural grassland	Woodland
					of recreational visits, e.g. by runners and cyclists, to other nearby sites.
	Cultural heritage	-	-	-	• Potential impact of planting on the site's archaeological features. • However, this is mitigated by buffering which is implemented to protect archaeological sites. This impact is therefore not considered to be material.
	Aesthetic value	-	-	-	• Potential impact on aesthetic values associated with the site. • The design considers the surrounding landscape including other forests, by aiming to connect other forested areas and 'softening' and blending their boundaries. • The EIA states that at Larriston Rigg, located near the planting area, the retention of the flat fields on the valley bottom helps to re-enforce landscape character. The EIA states that planting of much of the lower ridge with spruce will result in the existing woodland being subsumed into the forest resulting in loss of diversity and a lack of differentiation between the character of Larriston Rigg and the fell. • However, this was mitigated in the final planting design which includes other tree species (Western Red Cedar, Aspen / Birch) to provide a different landscape character. • Overall though, here is an impact on aesthetic values associated with the site given that the forest creation at Larriston is a form of land use change that ultimately changes the look and feel of the site compared to the baseline. This impact is considered to be significant.
Supporting	Biodiversity	-	-	-	• Potential impact in terms of improved species richness and diversity, compared to the sheep grazing baseline, as well as habitat connectivity because Larriston is connecting other existing surrounding forests and therefore reducing habitat fragmentation.

Ecosystem services		Natural capital assets			
		Freshwaters, wetlands and floodplains	Mountains, moors and heaths	Semi-natural grassland	Woodland
	Soil formation	-	-	-	-
	Nutrient cycling	-	-	-	-
	Water cycling	-	-	-	-

Notes: FW: Freshwaters, wetlands and floodplains; MMH: Mountains, moors and heaths; SNG: semi-natural grasslands; W: Woodland

Appendix C – Harvested wood products

As part of the assessment of carbon flows as a result of the forest creation project at Larriston, the study investigated the potential to assess the carbon storage and carbon substitution benefits of harvested wood products, which is outlined in this appendix.

C.1 Carbon storage

The assessment of carbon storage within harvested wood products is set out in the UK Greenhouse Gas Inventory (Brown et al., 2020), which is rooted in the Intergovernmental Panel on Climate Change's guidance regarding methods and good practice arising from the Kyoto Protocol (IPCC, 2013).

The approach considers the total harvested volume of timber in terms of merchantable stem volume and the harvesting residue pool which is assumed to be left on-site thereby entering the litter pool. The merchantable stem volume is allocated to various wood products. This is based on data for the production of semi-finished wood products, which is sourced from the Forestry Commission. The categories of harvested wood products that are considered are:

- Long-lived sawn timber e.g. timber used for construction;
- Short-lived sawn timber e.g. timber used for fencing;
- Particleboard;
- Paper; and
- Fuel.

To determine the volume of carbon stored within each harvested wood product, a conversion from green tonnes of biomass to over dry tonnes is required.[16] Following this, the carbon content of biomass is assumed to be 50% for all categories of wood products. A carbon retention curve is used to estimate product decay and return of carbon to the atmosphere. Each wood product category has its own carbon retention curve using the default half-lives in the IPCC guidance (2013). This considers the decay rate of wood products and the service life as influenced by socio-economic factors. The half-lives are as follows:

- 35 years for sawn wood;
- 25 years for wood panels;
- 2 years for paper; and
- Timber used as woodfuel is assumed to instantaneously oxidise.

The derivation of carbon retention curves and product decay are considered to be Tier 2 and 3 methods in the IPCC (2013) guidance, as opposed to Tier 1 methods which are considered for first-cut analysis. The guidance provide two formulas as part of these methods. One formula relies on understanding the baseline stock of carbon in a given country, and the other relies on understanding the average carbon inflow for a particular category of harvested wood product in the last 5 years. This approach does not readily apply to a site-level assessment such as the one for Larriston, which is why the study did not consider this further, in the context of the time and resources available.

[16] For green tonnes (weight when freshly felled), a moisture content of 52% is assumed, leaving 48% as biomass, based on advice from industry experts (Forest Research, personal communication, July 2020).

C.2 Carbon substitution benefits

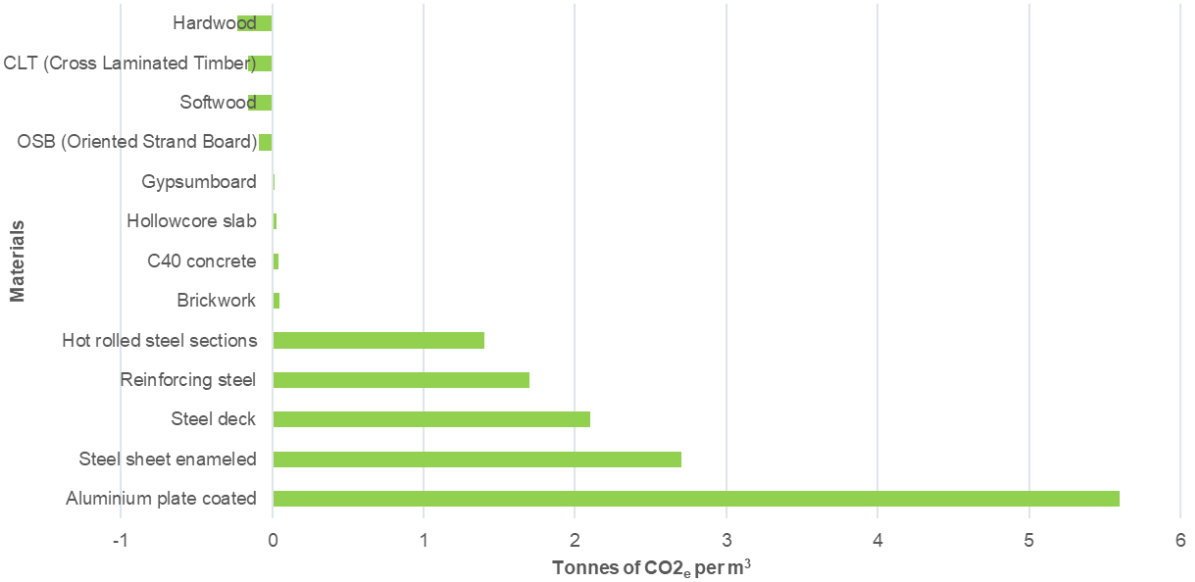
In addition to the carbon stored within harvested wood products, there are also substitution benefits associated with the use harvested wood products over other more carbon-intensive materials. These carbon substitution benefits are challenging to assess because they are dynamic and depend on various factors including (Read et al., 2009):

- Location;
- Design of end products and uses;
- Technological progress;
- Timing including the effect of decarbonisation over time;
- The extraction and transportation of construction materials; and
- The treatment of products at their end of life including recycling, energy recovered, disposal in landfills, etc.

In addition, there are accounting issues associated with whether the volume of carbon sequestered in harvested wood products is credited to the country of growth or the country where the timber is used. In light of these challenges the carbon substitution benefits of harvested wood products were not assessed given the time and resources available for this study.

For illustrative purposes, however, data was collected as part of this study to demonstrate differences between the embodied carbon of various materials including selected wood products. This data is presented in Figure C. 1 which shows the negative carbon embodied (showing a net carbon storage) by wood products, compared to other materials.

Figure C. 1: Illustrative estimates of embodied carbon per m^3 of materials (tonne of CO_2e per m^3)



Notes: Estimates are based on data from (BRE Group, 2018).

The estimates are based on the eToolLCD, used for Life Cycle Assessments (LCAs), and the BRE IMPACT Database (Version 5) (BRE Group, 2018). The underlying database is produced by the Building Research Establishment (BRE) Centre for Sustainable Products and is fully compliant with the international standard EN 15804. The model uses primary data from various trade associations and representative manufacturers, where applicable.

Appendix D – Overview of dissemination webinars

This appendix provides information about the two dissemination webinars held towards the end of the study. The agenda for the webinars is presented in Table D. 1.

Table D. 1: Webinar agenda

Agenda item		Approx. time (cumulative)
1	Purpose and objectives of study	3 min (3 min)
2	Overview of webinar objectives, the Protocol, the Sector Guide and key terms	5 min (8 min)
3	Overview of study site	3 min (11 min)
4	Overview of Scope and Frame stages	5 min (16 min)
5	Overview of Measure and Value stage	15 min (31 min)
6	Overview of Apply stage	4 min (35 min)
7	Q&A	5 min (40 min)
5 min buffer to allow participants to leave the main webinar to join breakout group		
8	Breakout groups	25 min (70 min)
5 min buffer to allow participants to leave the breakout group and re-join the main webinar		
9	Feedback from breakout groups	10 min (85 min)
10	Final Q&A, next steps and close	5 min (90 min)

The webinars featured breakout group discussions which were structured based on the following questions posed to participants:

- What were your general thoughts on the study approach, analysis and results?
- What are the main insights from the approach and how could it be applied in the future?

Overall, nearly 40 stakeholders attended the webinars from over 20 organisations, listed in Table D. 2.

Table D. 3 provides a breakdown of webinar attendees across different sectors.

Table D. 2: Organisations participating in webinars

Organisation	Sector
James Hutton Institute	Academic
Scotland's Rural College (SRUC)	Academic
University of Edinburgh	Academic
Northumberland Wildlife Trust	NGO
Royal Society for the Protection of Birds (RSPB) Scotland	NGO
Scottish Forum on Natural Capital	NGO
Scottish Wildlife Trust	NGO
Woodland Trust	NGO
a2b maps	Private
Confor	Private
Forest Carbon	Private
Gresham House Forestry	Private
James Jones and Sons Ltd	Private
Pennine Forestry	Private
RTS Forestry	Private
Scottish Woodlands Ltd	Private
Tilhill Forestry	Private
Forestry and Land Scotland	Public
Scottish Environment Protection Agency (SEPA)	Public
Scottish Forestry	Public
NatureScot	Public
Scottish Water	Public

Table D. 3: Sectoral breakdown of webinar attendees

Sector	Number of organisations	%
Academic	4	11%
NGO	6	16%
Private	14	37%
Public	14	37%
Total	38	100%