A9 Dualling Programme: Pitlochry to Killiecrankie

Retrospective Natural Capital Assessment Summary Document

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A9 Dualling Programme: Pitlochry to Killiecrankie

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Contents

1. Background

1.1 Proposed scheme

Transport Scotland is upgrading approximately 6.5km road from Pitlochry to Killiecrankie to dual carriageway (Project 4) as part of a wider programme to improve the A9 between Peth and Inverness.

Transport Scotland is looking to better capture environmental outcomes within decision making and is fully committed to the protection and enhancement of the natural environment for transport projects. It is thought that Environmental Impact Assessment (EIA)[1] processes could be supported by additional assessments to:

- Better identify the value of environmental mitigation and enhancement of schemes.
- Shift approaches from the traditional identification of adverse impacts to include scheme benefits and associated value.

A natural capital approach has been identified as a potential approach to support the above and capture the true value of Transport Scotland schemes. A retrospective natural capital assessment, focussing on the preferred option as assessed within the Environmental Statement[2], has been conducted for Project 4.

A retrospective study allows for a natural capital assessment of a scheme which has already been subject to scrutiny by stakeholders (including the public) through the consenting process.

This assessment will enable Transport Scotland to consider the benefits of adopting a natural capital approach in the future.

1.2 Natural Capital

Natural Capital is 'the sum of our ecosystems, species, freshwater, land, soils, minerals, our air and our seas' (Defra, 2018)[3].

Nature provides direct and indirect benefits to people individually and to wider society (known as ecosystem services). Some of these benefits are less obvious than others, but they exist none the less and are important. Applying natural capital approaches ensures that the benefits nature brings are not overlooked and can be protected and enhanced. Natural capital assets provide us with food, clean air and water, fuel, protection from hazards, recreation, physical and mental health benefits and much more.

In 2016 it was estimated that the partial value of natural capital in the UK was near to £1 trillion[4].

[1] The EIA aims to report the significant environmental effects associated with development, with a review to reduce the environmental impact. More information on the EIA process can be found here: https://www.gov.uk/guidance/environmental-impact-assessment [Last accessed: 30 March 2020].

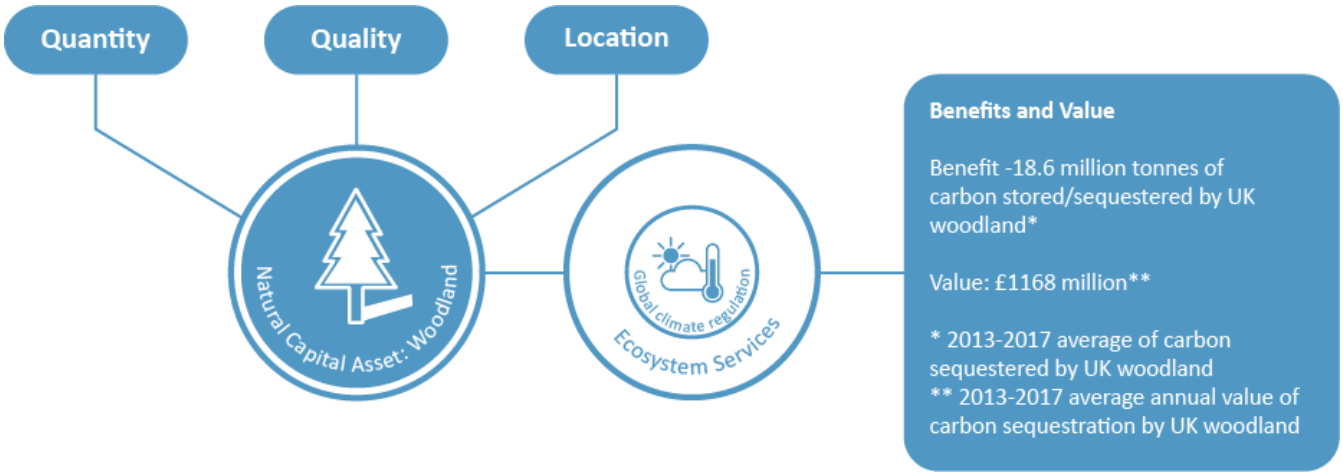
[2] An Environmental Statement is the main output of an EIA. The Environmental Statement for the proposed scheme can be found here: https://www.transport.gov.scot/publication/draft-orders-and-environmental-statement-pitlochry-to-killiecrankie-a9-dualling/ [Last accessed: 18 January 2022].

[3] Defra (2018). 25 Year Environment Plan. Available online at: https://www.gov.uk/government/publications/25-year-environment-plan [Last accessed: 30 March 2021].

[4] UK natural capital accounts. 2019. Available online at: https://www.ons.gov.uk/economy/environmentalaccounts/bulletins/uknaturalcapitalaccounts/2019 [Last accessed: 15 April 2021]

An example of a natural capital asset could be woodland. The ecosystem services that we might associate with woodland include carbon storage, cooling, shading and timber for example. When assessing the benefits and values associated with natural capital and ecosystem services, a logic chain approach (as developed by Natural England[5]) can be used, shown below in **Figure 1-1**.

Figure 1-1: Logic Chain example (global climate regulation by woodland) used for assessing natural capital assets.



1.2.1 Ecosystem services

Ecosystem Services are the direct and indirect benefits that ecosystems provide for human wellbeing and quality of life, and include provisioning, regulating, cultural and supporting services.[6]

Provisioning services: Tangible products that can be obtained from ecosystems that meet human needs.

Regulating services: Ecological processes that regulate and reduce pollution and other adverse effects.

Cultural services: Environmental settings that enable cultural interaction and activity.

Supporting services: These do not produce outputs for final consumption or production, but are essential for the functioning of provisioning, regulating and cultural services, which do provide outputs. This distinction is made to avoid the double counting of services and to recognise the contribution that supporting services make without assessing or valuing them. Examples include soil formation, where a final benefit could be crop production, for example.

Ecosystem services considered for this project were based upon the Eco-Metric approach[7], now known as The Environmental Benefits from Nature (EBN) tool[8] and include:

- Food production
- Wood production
- Fish production
- Water supply
- Flood regulation
- Erosion protection
- Water quality regulation
- Carbon storage
- Air quality regulation
- Cooling and shading
- Noise reduction
- Pollination

[5] Natural England (2018) Natural Capital Indicators: for defining and measuring change in natural capital (NERR076). Available online at: http://publications.naturalengland.org.uk/publication/6742480364240896 [Last accessed: 30 March 2021].
[6] NatureScot (2020) Ecosystem services – nature's benefit. Available online at https://www.nature.scot/scotlands-biodiversity/scottish-biodiversity-strategy/ecosystem-approach/ecosystem-services-natures-benefits [Last accessed: 30 March 2021].
[7] Further information can be found here: https://ecosystemsknowledge.net/ecometric [Last accessed 30 March 2021].
[8] Further information can be found here: http://publications.naturalengland.org.uk/publication/6414097026646016 [Last accessed 10 January 2022].

- Pest control
- Recreation
- Aesthetic value
- Education
- Interaction with nature
- Sense of place

For this study, the following ecosystem services were considered priorities by stakeholders in the Environmental Steering Group comprised of Historic Environment Scotland (HES), Perth & Kinross Council, Scottish Environment Protection Agency (SEPA), Scottish National Heritage (now NatureScot), Highland Council and the Cairngorms National Park Authority.[9]:

1.2.2 Habitat types in Scotland

A habitat is an ecological or environmental area that is inhabited by a particular animal or plant species[10] and different habitats can deliver differing ecosystem services. Scotland comprises of seven broad habitat types, which are:

- Coastal
- Inland surface waters
- Mires, bogs and fens
- Grassland
- Heathland
- Woodland
- Agriculture and cultivated
- Urban Environments

Definitions for each of the broad habit types present across the study area for this project are provided below, as defined by the European Nature Information System (EUNIS)[11]. The Phase I habitat survey did not identify any specific habitats which are typically associated with the urban environment (such as gardens or allotments for example). The Eco-metric/EBN tools do not identify any ecosystem service provision associated with 'sealed surface and buildings, which were found to be present across the study area. Furthermore, wider urban environments are captured under the assessment of 'cultivated' land wherein the benefits of assets such as open green space is assessed. As a result, the urban environment is not assessed further, with relevant elements contained within other broad habitats.

[9] The icons shown (which depict ecosystem services) are slightly different to those assessed within the Eco-metric/The Environmental Benefits from Nature tool, yet still reflect industry best practice such as the Natural England's *Natural Capital Indicators: For Defining and Measuring Change in Natural Capital (NERR076)*, available online at: http://publications.naturalengland.org.uk/publication/6742480364240896 [Last accessed: 18 January 2022]. It should be noted that as the project developed, it was agreed that 'wild species diversity' i.e. 'biodiversity' would be considered independently of other ecosystem services, with the link between the two being defined more clearly i.e. biodiversity enhances natural capital asset quality and therefore the provision of ecosystem services.

[10] UK National Ecosystem Assessment. Date Unknown. Ecosystems and Habitats. Available online at: http://uknea.unep-wcmc.org/EcosystemAssessmentConcepts/EcosystemsandHabitats/tabid/99/Default.aspx [Last accessed: 15 April 2021]

[11] Further information on EUNIS and habitat types can be found here: https://eunis.eea.europa.eu/habitats-code-browser.jsp [Last accessed: 15 April 2021]

Inland surface waters	Non-coastal, above-ground, open, fresh or brackish waterbodies (e.g. rivers, streams, lakes and pools, springs), including their littoral zones.	
Grassland	Non-coastal land which is dry or only seasonally wet (with the water table at or above ground level for less than half of the year) with greater than 30% vegetation cover. The vegetation is dominated by grasses and other non-woody plants, including mosses, macrolichens, ferns, sedges and herbs.	
Heathland	Non-coastal land which is dry or only seasonally inundated (with the water table at or above ground level for less than half of the year) with greater than 30% vegetation cover. The vegetation is dominated by shrubs or dwarf shrubs of species that typically do not exceed 5m maximum height. Includes shrub orchards, vineyards, hedges (which may have occasional tall trees).	
Woodland	Woodland and recently cleared or burnt land where the dominant vegetation is, or was until very recently, trees with a canopy cover of at least 10%. Includes lines of trees, coppices, regularly tilled tree nurseries, tree-crop plantations and fruit and nut tree orchards.	
Agriculture and Cultivated	Habitats maintained solely by frequent tilling or arising from recent abandonment of previously tilled ground such as arable land and gardens.	

Images of Scotland's broad habitat types originate from the Scotland's Natural Capital Asset Index Story Map [12].

[12] Available online at: https://www.nature.scot/professional-advice/planning-and-development/social-and-economic-benefits-nature/natural-capital/natural-capital-asset-index [Last accessed: 18 January 2022].

1.2.3 Natural Capital in Scotland

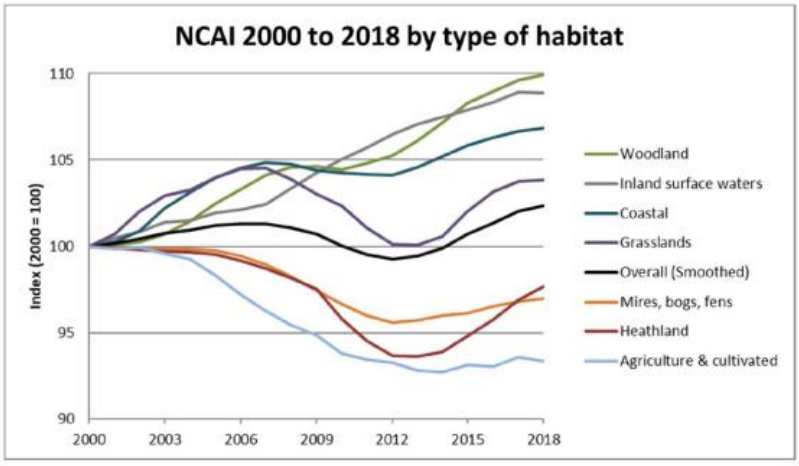
In 2015, the partial asset value of Scottish natural capital was estimated to be £291 billion [13].

The Natural Capital Asset Index (NCAI) [14] tracks the capacity of Scotland's terrestrial ecosystems to provide benefits through an assessment of quantity and quality information. In 2014 the NCAI completed a backcasting exercise, which aimed to understand the long-term trends of natural capital in Scotland. It found that natural capital had been in decline since 1950 and efforts to recover Scotland's natural capital had a long way to go.

Since then, the NCAI has found that Scotland's natural capital is in an 'increasing' state, with a 2% increase between 2016 and 2019. This means that the potential for Scotland's habitats to deliver ecosystem services has improved.

Although the NCAI states that all broad habitat types are increasing, there are declines in some components, such as quality of designated woodlands and upland bird populations. **Figure 1-2Error! Reference source not found.** reflects the changes in potential ecosystem service provision from Scotland's habitats during 2000-2018.

Figure 1-2: NCAI 2000 to 2018 by type of habitat (from Scotland's NCAI).



The £1 Billion Challenge [15] was launched in 2020 by SEPA and the Scottish Wildlife Trust to develop innovative investment and funding models to protect and restore vulnerable ecosystems.

[13] Scottish natural capital: Ecosystem Service Accounts. (2019). Scottish Government. Available online at: https://www.gov.scot/publications/scottish-natural-capital-ecosystem-service-accounts-2019/ [Last accessed 30 March 2021].

[14] The NCAI can be found here: https://www.nature.scot/scotlands-natural-capital-asset-index-2019 [Last accessed: 30 March 2021].

[15] More information on the £1 Billion Challenge can be found here: https://scottishwildlifetrust.org.uk/news/route-map-to-1-billion-for-nature-conservation-published/ [Last accessed: 30 March 2021].

As a result of such initiatives, the need for natural capital assessment is growing, with a renewed focus on the natural environment. Scotland's draft fourth National Planning Framework (NPF4)[16] includes Policy 3: Nature Crisis, which focuses on supporting biodiversity. The draft wording states that *'proposals for local development should only be supported if they include appropriate measures to enhance biodiversity*'. However, no standardised method for considering positive effects for biodiversity is currently suggested.

Further, the draft NPF4 Policy 3 expands its focus on biodiversity to also consider ecosystem services, stating that:

- *'Design should take into account the need to reverse biodiversity loss [and] safeguard the services that the natural environment provides'*
- *'Development proposals which integrate nature-based solutions and deliver positive effects for biodiversity should be supported.'*

1.2.4 Natural capital drivers/pressures and risks

Natural capital assets and the associated provision of ecosystem services can be compromised because of environmental trends and competing societal factors.

Drivers/pressures are high-level trends/competing requirements which could have an impact on natural capital.

Risks are specific impacts of drivers/pressures which can have direct impact on ecosystem service provision.

Figure 1-3 presents the natural capital drivers/pressures and risks for the A9 Project 4 Scheme as identified by stakeholders in the Environmental Steering Group.

[16] The draft fourth National Planning Framework is currently out for consultation and can be found here: https://www.gov.scot/publications/scotland-2045-fourth-national-planning-framework-draft/documents/ [Last accessed: 13 January 2022].

Figure 1-3: Drivers/pressures and risks for the A9 Project 4 Scheme.

Climate change:

- Increased frequency and severity of natural hazards.
- Deterioration of peatland which stores carbon yet can act as a carbon source if degraded.

Biodiversity loss:

- Changes in habitat & species distribution, composition & quality.

Development/Changing use of sea and land:

- Impacts on the historic environment (i.e. listed buildings).
- Loss of habitat and increased flood risk to habitats.
- Reduction in slope stability through removal of trees.
- Fragmentation of habitats (reducing biodiversity and creating risks to road users from wildlife crossing roads).

Land Management Change:

- Disturbance to archaeological sites and monuments, potential for soil erosion and changes in water levels affecting archaeological deposits.
- Felling of maturing plantations coupled with climate change increases risk of loss of slope stability.
- Drainage of peatlands to increase grazing potential and heather growth for sporting estates increases risks of deterioration of peatlands.

Pollution:

- Air pollution.
- Changing water quality.
- Noise & light pollution.
- The above elements leading to biodiversity loss.

Invasive non-native species and direct exploitation of organisms:

- Changes in habitat & species distribution, composition & quality.
- Increased need for pest management.

Indirect drivers – Such as consequences of social disconnect with nature:

- Exploitation of nature resulting in over-use and/or mis-management which undermines ecosystem service provision.
- Impacts of climate change, pollution and invasive, non-native species are not managed.

1.2.5 Natural Capital Opportunities

Through effective management of natural capital assets, opportunities for enhancements are possible. **Figure 1-4** displays natural capital opportunities identified for the A9 Project 4 Scheme, as highlighted by the Environmental Steering Group.

Figure 1-4: Natural Capital Opportunities for the A9 Project 4 Scheme

Habitat creation and connectivity (extension of semi-natural habitats).

NatureScot

Use of woodland planting and further habitat creation to stabilise slopes.

NatureScot

Opportunity to address historic habitat fragmentation from A9 via habitat crossings.

Natural England

Improved access and interpretation of historic assets (not in replacement of avoidance measures).

NatureScot

1.3 Areas to note

A core set of tasks were required for the retrospective natural capital assessment, which are set out in the methodology (**Section 2** of this document).

However, the scope of the assessment was expanded to include several additional pilot studies, which have added value to how future natural capital assessments (beyond those completed by Transport Scotland) are undertaken.

Additional pilot studies included:

- Ancient Woodland pilot: Supporting technical note to provide an assessment of ancient woodland across the study area and implications for the existing retrospective natural capital assessment.
- Historic Environment and Natural Capital pilot: A pilot looking at the integration of the historic environment within natural capital assessments, through collaboration with HES.
- Habitat Connectivity pilot: Supporting technical note to provide an assessment of habitat connectivity across the study area and implications for the existing retrospective natural capital assessment.
- Detailed Quantification of Ecosystem Service Flows and Valuation: A pilot quantifying the positive and negative impacts to the flow of ecosystem services from natural capital assets in monetary and non-monetary terms.

A step-by-step approach was undertaken for the retrospective natural capital assessment, with each of the core tasks (outlined in **Section 2** of this document) informing the next and building upon the previous. Technical

notes were then produced for core tasks Two to Six. Typical reporting for a natural capital assessment would not follow this approach; however, one of the purposes of the assessment is to raise awareness and understanding of natural capital approaches across Transport Scotland team members, and therefore it was beneficial to document each stage of the process. It should be noted that as the retrospective natural capital assessment developed, methodologies also evolved (owing to data availability, development of pilot projects etc.) meaning the content of certain tasks was superseded. Where this is the case, this is noted in the assessment outcomes.

The proposed scheme has already been subject to scrutiny by stakeholders (including the public) through the consenting process. Nonetheless, the natural capital assessment has included engagement with stakeholders included within the Environmental Steering Group. Other stakeholders, such as Forestry and Land Scotland, have also been engaged when considered appropriate throughout the assessment. Stakeholder engagement has been invaluable to this retrospective natural capital assessment and has helped define additional pilot projects which will alter the way natural capital assessments are undertaken in the future across the UK. Stakeholders included:

- Forestry and Land Scotland[17]
- Historic Environment Scotland[18]
- NatureScot[19]
- Perth and Kinross Council[20]
- SEPA[21]

1.4 Purpose of document

This summary document aims to provide a non-technical overview of the retrospective natural capital assessment for the A9 Dualling Programme: Pitlochry to Killiecrankie (Project 4), to:

- introduce natural capital and applications for Transport Scotland schemes;
- summarise the outcomes of the retrospective natural capital assessment;
- share the outcomes of the assessment across a wider group; and
- report on a single set of outcomes (allowing the impacts of the additional pilot projects on the core scope of works to be included).

This document includes the following sections:

- Section 1 - Background
- Section 2 - Methodology
- Section 3 - Outcomes
- Section 4 - Conclusion

[17] For more information, visit: https://forestryandland.gov.scot/ [Last accessed: 13 January 2022].
[18] For more information, visit: https://www.historicenvironment.scot/ [Last accessed: 13 January 2022].
[19] For more information, visit: https://www.nature.scot/ [Last accessed: 13 January 2022].
[20] For more information, visit: https://www.pkc.gov.uk/ [Last accessed: 13 January 2022].
[21] For more information, visit: https://www.sepa.org.uk/ [Last accessed: 13 January 2022].

2. Methodology

The methodology for the retrospective natural capital assessment was originally split into six core tasks, as outlined below[22]. However, through the development of the project, it was agreed that an additional five tasks would also be undertaken, including the pilot studies identified in **Section 1.3**. Further information of the core and additional pilot tasks can be found in **Table 2-1**, with an overview of task outcomes presented in **Section 3**.

Core Tasks

- **Task One:** Framing the assessment
- **Task Two**: Natural capital baseline assessment
- **Task Three:** Scheme impacts on natural capital (pre-mitigation)
- **Task Four:** Effects of mitigation, compensation and enhancement and development of a 'balance sheet'
- **Task Five:** Identification of alternative mitigation, compensation and enhancement measures
- **Task Six**: Capturing wider benefits (social value)

Additional Pilot Tasks

- Ancient woodland pilot
- Historic environment and natural capital assessments pilot
- Habitat connectivity pilot
- Summary document (this document)
- Detailed quantification and valuation of ecosystem services

The following sections highlight the rationale for each of the additional pilot tasks.

Ancient Woodland Pilot

When task outputs of the retrospective natural capital assessment were shared with stakeholders, SEPA identified that it was not overtly clear whether woodland affected by the scheme was ancient or non-ancient woodland.


(NatureScot)

In Scotland, ancient woodland is defined as land that is currently wooded and has been continually wooded, at least since 1750[23].

Typically, within natural capital assessments, ancient woodland is considered as a quality indicator of natural capital assets. The retrospective natural capital assessment aligned with this typical approach acknowledging that ancient woodland has intrinsic importance due to:

- its age and inability to be replaced;

[22] Core tasks seven and eight involved presentation of the project findings and communication and project management.

[23] NatureScot. 2020. A guide to understanding the Scottish Ancient Woodland Inventory (AWI). Available online at: https://www.nature.scot/guide-understanding-scottish-ancient-woodland-inventory-awi#:~:text=In%20Scotland%2C%20Ancient%20Woodland%20is,wooded%2C%20at%20least%20since%201750.&text=They%20include%20all%20remnants%20of,of%20the%20original%20Atlantic%20forests. [Last accessed: 18 January 2022].

- its value as a habitat for the species it supports and habitat connectivity; and
- its significant carbon stores.

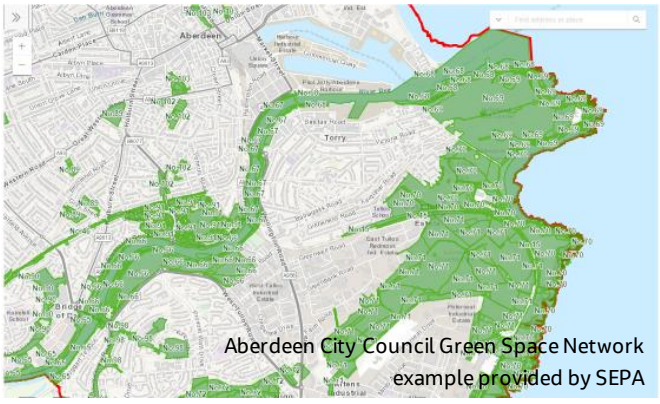
Despite this, as the coverage of ancient woodland is significant across the study area, it was agreed that further consideration should be given to ancient woodland as a distinct natural capital asset, in the form of an Ancient Woodland Pilot, to fully capture its ecological and cultural value. This pilot took into account the significant work previously undertaken to accurately map and verify ancient woodland sites across the A9 projects.

Historic environment and natural capital assessments pilot

Whilst there is an acknowledgement across the natural capital discipline that the historic environment provides more than cultural services, traditionally, the historic environment is captured through the assessment of cultural services[24] within a natural capital assessment.

Feedback from stakeholders requested that the historic environment be considered beyond cultural services to acknowledge its importance, for example as a contributing factor to wider ecosystem service provision, including provisioning and regulating services. Accordingly, a Historic Environment and Natural Capital Assessment Pilot was agreed to be completed, with HES working alongside Jacobs and Transport Scotland to develop an approach which allows the historic environment to be better integrated within natural capital and wider environmental assessments.

Habitat connectivity pilot



Aberdeen City Council Green Space Network example provided by SEPA

Upon reviewing outcomes of the retrospective natural capital assessment, stakeholders identified that location elements and respective contributions to ecosystem service provision could benefit from being explored further.

As such, it was recommended that additional pilot work could be undertaken to explore the contribution of natural capital asset location (and specifically habitat connectivity[25]) to the provision of ecosystem services.

Summary document (this document)

Once all tasks were complete it was considered beneficial to produce a summary document to outline each of the tasks and their outputs, to summarise methodologies used and tie together the outcomes of the retrospective natural capital assessment. This summary document will provide an overview of the assessment which aims to be accessible to a wider audience than the technical notes provided to date, allowing wider sharing of key assessment outcomes and take-home messages. The summary document (i.e. this document) is not included in **Table 2-1** as information regarding description and purpose is provided within the wider document.

Detailed quantification and valuation of ecosystem services

Finally, it was decided that a detailed quantification and valuation of the changes in natural capital assets and ecosystem services associated with the A9 Project 4 should be undertaken. This exercise was undertaken to allow Transport Scotland to understand the monetary value associated with changes in natural capital and ecosystem service provision associated with the proposed scheme.

[24] Cultural services can be described as 'environmental settings that enable cultural interaction and activity' and typically include recreation, aesthetic value, education, interaction with nature, and sense of place.

[25] Habitat connectivity refers to the degree of movement of organisms or processes within and between ecosystems (Crooks, K.R. and Sanjayan, M. 2006. Connecting conservation: maintaining connections for nature. In: Crooks, K.R. and Sanjayan (Eds) Connectivity Conservation, pp 1-20. Cambridge University Press, Cambridge).

The description, method, and purpose of each task is outlined below in **Table 2-1**.

Table 2-1: Outline of completed tasks.

Task	Description	Method	Purpose	Outputs
Task One	Framing the assessment	▪ Workshop with the Environmental Steering Group held on 7th July 2020 to: - Define aims, objectives, and outcomes of the project. - Provide an overview of the methodology. - Gather information to inform the natural capital assessment. - Understand perceived opportunities, benefits, and values associated with natural capital assets across the study area. - Discuss how a natural capital approach fits in with wider A9 strategic documents. - Gain feedback on the proposed approach and answer any queries. ▪ Prior to the workshop, a briefing pack was provided to Environmental Steering Group members to complete, including similar information to the workshop, yet in more detail. ▪ Following the workshop, a data framework, containing an overview of the proposed data to be used for the natural capital assessment, was circulated to attendees for comment. ▪ Following stakeholder feedback, additional sources of data were identified.	**Defining suitable data for the assessment:** To determine what data was available for the identification of asset quantity, quality, and location. **Early stakeholder engagement:** To gain buy-in to the approach and to allow for a more detailed understanding of client (and wider stakeholder) viewpoints.	▪ Briefing pack ▪ Workshop ▪ Workshop notes ▪ Data framework
Task Two	Natural capital baseline assessment	Use of logic chain (introduced in Section 1 of this report) to identify: ▪ natural capital assets in terms of quality, quantity, and location; ▪ types of ecosystem services which may be provided by such assets; ▪ types of benefits we gain from services; and ▪ examples of value associated with benefits (monetary and non-monetary). Identification of drivers/pressures and risks relating to natural capital across the region.	**Defining a natural capital baseline:** Collation of information (inclusive of that presented within the Environmental Statement) allows for the development of a natural capital asset register, which acts as a snapshot of the existing natural capital across the study area. **Identifying drivers/pressures and risks:** An understanding of existing trends is important, allowing differentiation between impacts of the A9 Project 4 Scheme and wider externalities which may result in ecosystem change and may need to be managed in the future.	Task Two technical note including appendices relating to: ▪ Natural capital asset register (quantity assessment) ▪ Natural capital (quality assessment) information ▪ Natural capital (location assessment) information ▪ Habitat mapping
Task Three	Scheme impacts on natural capital (pre-mitigation[26])	▪ Review of Environmental Statement chapters for the proposed scheme[27] to determine potential impacts on natural capital assets and ecosystem services, pre-mitigation. ▪ Spatial analysis[28] to determine which natural capital assets are located in areas subject to works (and potential temporary and permanent impacts on ecosystem service provision).	Identify impacts of the proposed scheme (pre-mitigation) on natural capital assets/habitat types and associated ecosystem service provision.	Task Three technical note Graphic demonstrating links between natural capital and EIA methodologies

[26] Mitigation refers to measures intended to avoid, reduce, or offset potential adverse environmental impacts.
[27] The Environmental Statement for the proposed scheme can be found here: https://www.transport.gov.scot/publication/draft-orders-and-environmental-statement-pitlochry-to-killiecrankie-a9-dualling/ [Last accessed 18 January 2022].
[28] Spatial analysis involves the use of Geographical Information Systems (GIS) to visually display data, usually in the form of a map, making it easier to observe patterns.

Task	Description	Method	Purpose	Outputs
		▪ Development of a graphic which demonstrates similarities and differences between EIA and natural capital methodologies.	Identify key similarities and differences between the EIA process and natural capital assessment, to raise awareness and support future application of joint approaches.	
Task Four	Scheme impacts on natural capital (post-mitigation) and development of a 'balance sheet'	▪ Review of the Environmental Statement for the proposed scheme to identify significant residual impacts and implications for natural capital and associated ecosystem services (post-mitigation). ▪ Spatial analysis of environmental mitigation defined within the Environmental Statement to determine impacts on natural capital and ecosystem services (post-mitigation). ▪ Review of relevant documents (such as the A9 Dualling Programme – Strategic Environment Assessment Environmental Report (2013)) to reflect on early perceptions of 'what good looks like', to determine whether this is reflected in natural capital outcomes. Similarly, consideration was given to how the proposed scheme aligns with policy documents, such as the National Transport Strategy[29] and Draft Infrastructure Investment Plan Consultation[30] in relation to natural capital.	Provide an overview as to where natural capital assets have been impacted (either adversely or beneficially) as a result of the scheme and when considering mitigation, compensation, and enhancement measures.	Task Four technical note
Task Five	Identification of alternative mitigation, compensation, and enhancement measures	▪ Collation of outcomes from previous tasks ▪ Stakeholder workshop to summarise the outcomes of the retrospective natural capital assessment to date and to identify opportunities for natural capital enhancement. ▪ Wider discussion with other environmental disciplines to share outcomes of the retrospective natural capital assessment and identify opportunities for enhancement [31]. ▪ Review of the Environmental Statement to identify any further opportunities for natural capital and ecosystem service enhancement beyond existing environmental commitments. ▪ Review of previously identified drivers/pressures and risks when considering the outcomes of the retrospective natural capital assessment and whether further recommendation for inclusion can be made.	Provide an understanding of how natural capital assets (and associated ecosystem services) could have been enhanced as a result of the alternative/additional measures.	▪ Task Five technical note ▪ Workshop ▪ Workshop notes
Task Six	Capturing wider benefits (social value)	▪ Social value mapping through use of the A9 Dualling Programme community benefit toolkit[32]. ▪ Within the toolkit, the metrics were broadly captured under the Scottish Government's National Performance Framework (NPF) outcomes. However, for ease of analysis, and to allow the individual metrics to be mapped against the NPF outcomes, the metrics were captured across six broad themes: community, employment, education, poverty, economy and environment. ▪ Community benefit toolkit metrics were then mapped against three documents: - A9 Dualling: Perth to Inverness Sustainability Strategy; - Scottish Government's National Performance Framework; and - Jacobs and Simetrica-Jacobs' Before & Beyond the Build.	Provide an understanding of the wider social, environmental, and economic benefits that could be explored within scheme development and provided during construction and delivery. Make recommendations as to how wider benefits and greater social value could be generated by the proposed scheme.	Technical note, supported by a Social Value Mapping Exercise

[29] The National Transport Strategy can be found online at: https://www.transport.gov.scot/our-approach/national-transport-strategy/ [Last accessed: 18 January 2022].
[30] The Draft Infrastructure Invest Plan Consultation can be found online at: https://www.gov.scot/publications/national-mission-local-impact-draft-infrastructure-investment-plan-scotland-202122-202526/ [Last accessed: 18 January 2022].
[31] This primarily comprised discussions between the internal Jacobs team and the EIA lead and ecology disciplines.
[32] The A9 Dualling Programme Community benefit toolkit is a series of metrics aimed to generate wider value across the programme.

Task	Description	Method	Purpose	Outputs
Ancient Woodland Pilot	Supporting technical note to provide an assessment of ancient woodland across the study area and implications for the existing retrospective natural capital assessment	▪ Spatial analysis to identify areas of ancient and non-ancient woodland within the study area. ▪ Research to identify the level of ecosystem service provision associated with ancient woodland, when compared to non-ancient woodland. ▪ Application of research findings to ancient woodland assets identified. ▪ Decision making as to whether the ability of ancient woodland to provide services such as biodiversity and cultural services should be revisited to reflect special qualities of the ancient woodland environment.	To consider whether ancient woodland should be considered as a separate asset within the retrospective natural capital assessment, independent of wider woodland (and therefore part of the 'quantity' assessment). To consider whether the ability of ancient woodland to provide services such as biodiversity and cultural services should be revisited to reflect special qualities of the ancient woodland environment. To progress the natural capital discipline and consideration of ancient woodland within such assessments.	Ancient woodland pilot technical note Literature review of ancient woodland and ecosystem service provision
Historic Environment and Natural Capital Assessment Pilot	Pilot looking at integration of the historic environment within natural capital assessments, through collaboration with HES (outcomes included within the Ancient Woodland Pilot report as synergies existed between both pilots)	▪ Consideration of the historic environment data currently available such as the Historic Land-use Assessment (HLA).[33] ▪ Discussion between HES and Jacobs as to how existing datasets could support future natural capital assessments. ▪ Preliminary work undertaken by HES to apply historic environment data across woodland environments. ▪ Discussions as to whether natural capital methodologies could be adapted to include age/time-depth in landscape as one of the key components of a natural capital asset, which determines the level of ecosystem service provision.	To understand how the historic environment could be better incorporated within natural capital assessments, beyond consideration of cultural services.	Ancient woodland pilot technical note (Section 6 provides a supplement on 'Integrating the Historic Environment within Natural Capital Assessments'.
Habitat Connectivity Pilot	Supporting technical note to provide an assessment of habitat connectivity across the study area and implications for the existing retrospective natural capital assessment	▪ Identifying a suitable habitat connectivity method to meet the needs of the project. ▪ Identification of which ecosystem services are most dependent on locational factors. ▪ Mapping exercise to determine habitat connectivity and connectivity for people, allowing for a habitat connectivity baseline for the study area to be developed. ▪ Assessment of the proposed scheme's impact on habitat connectivity and natural capital pre- and post-mitigation.	To explore the contribution of natural capital asset location (particularly habitat connectivity considerations) to the provision of ecosystem services and how this is impacted by the proposed scheme. The outcomes of the assessment will contribute to the development of the natural capital discipline and consideration of locational factors for future assessments.	Habitat connectivity pilot technical note Supporting mapped outputs displaying habitat connectivity and connectivity for people
Detailed Quantification of Ecosystem Service Flows and Valuation	Pilot quantifying the positive and negative impacts to the flow of ecosystem services from natural capital assets in monetary and non-monetary terms.	▪ Identifying which ecosystem services could be quantified and monetised based on the availability of data and appropriate methods. ▪ Application of ecosystem service valuation methods informed by the Scottish Natural Capital Accounts[34] and Defra's Enabling a Natural Capital Approach guidance[35]. ▪ Comparison of the monetary values associated with changes in ecosystem services, using values converted into real base year costs and discounting in line with HM Treasury's Green Book Guidance[36].	To understand the monetary value associated with changes in natural capital and ecosystem service provision associated with the proposed scheme.	Detailed Quantification of Ecosystem Service Flows and Valuation pilot technical note

[33] HLA is an ongoing project designed to map past and present land use across Scotland to help inform how today's landscape has been influenced by human activities in the past. Scotland's Environment (2020). Historic Environment. Available online at: https://www.environment.gov.scot/our-environment/people-and-the-environment/historic-environment/#:~:text=Historic%20Land%2DUse%20Assessment%20(HLA,change%20in%20the%20historic%20environment. [Last accessed: 16 April 2021].

[34] The Scottish Government produces annual estimates of the quantity and value of the services supplied by Scottish Natural Capital. The Detailed Quantification of Ecosystem Service Flows and Valuation was informed by methods used in the production of the 2020 Scottish Natural Capital Accounts, which are available online at: https://www.gov.scot/publications/scottish-natural-capital-accounts-2020/pages/1/ [Last accessed: 13 January 2022].

[35] For more information, visit: https://www.gov.uk/guidance/enabling-a-natural-capital-approach-enca [Last accessed: 13 January 2022].

[36] For more information, visit: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent/the-green-book-2020 [Last accessed: 13 January 2022].

3. Outcomes

This section provides an overview of the key outcomes of the core and additional tasks.

3.1 Task Two: Natural capital baseline assessment

The primary outcome of Task Two was the development of a natural capital baseline which was used in subsequent tasks to understand the impact of the proposed scheme (pre- and post-mitigation).

In regards asset quantity, the ecosystem services afforded by the grassland and woodland environments were considered as the most prevalent across the study area, owing to the extent of habitat coverage.

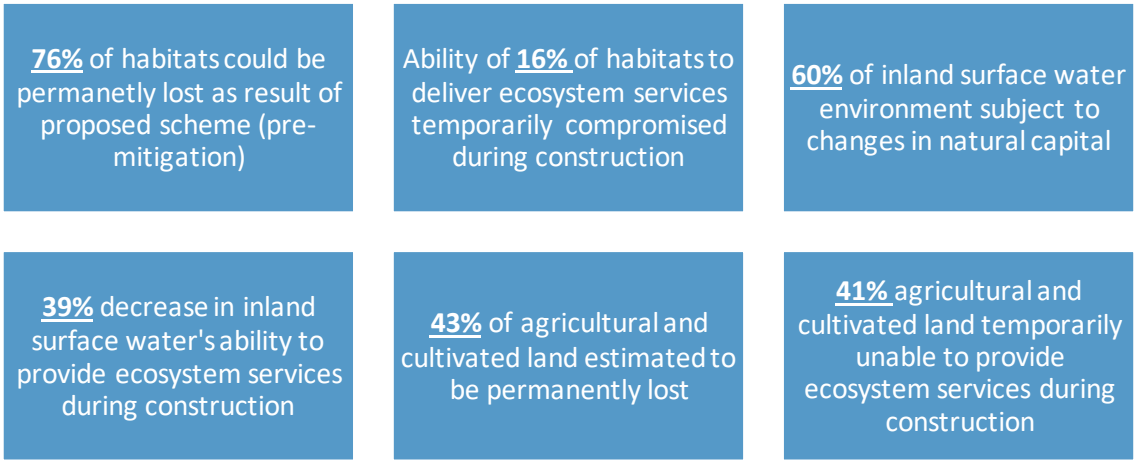
The natural capital baseline assessment found that asset quality and location resulted in minor changes to the provision of ecosystem services, accordingly outcomes were largely driven by asset quantity.

Drivers/pressures and risks were identified by Task Two (with an overview provided in **Section 1.2.4** of this document).

3.2 Task Three: Scheme impacts on natural capital (pre-mitigation)

Task three found that 76% of habitats could be permanently lost because of the proposed scheme (pre-mitigation), with permanent losses of grassland, heath and woodland habitats anticipated. Furthermore, the ability of a further 16% of habitats to deliver ecosystem services could be temporarily compromised during construction.

Pre-mitigation, 60% of the inland surface water environment is subject to changes in natural capital and there is likely to be a temporary decrease in 39% of the inland surface water environment to provide ecosystem service provision during construction. Moreover, 43% of agricultural and cultivated land is estimated to be permanently lost, with 41% of agricultural and cultivated land being temporarily unable to provide ecosystem services during construction when compared to previous levels of provision.



Habitats impacted by the proposed scheme and the ecosystem services most associated with them are listed below. The ability of these habitats to provide these ecosystem services will likely be reduced because of the proposed scheme.

- **Inland surface waters**: water quality regulation, flood regulation, erosion protection, cultural services, water support, fish production and pest control.
- **Grassland:** food production, water supply, erosion protection, pollination, pest control and cultural services.

- **Heathland:** water supply, erosion protection, pollination, pest control, flood regulation, carbon storage, air quality regulation, cooling and shading, noise reduction and cultural services. Impacts on ecosystem service provision will be dependent upon the sub-asset affected (i.e. bracken or scrub for example).
- **Woodland:** woodland can provide all ecosystem services assessed within the retrospective natural capital assessment for the A9 Project 4 (apart from fish production) and therefore impacts on ecosystem service provision are likely to be significant.
- **Agriculture and cultivated:** water supply, recreation, and food production.

3.3 Task Four: Effects of mitigation, compensation and enhancement, and development of a 'balance sheet'

The outcomes presented in this section were developed prior to the later stages of the natural capital assessment and subsequent pilots (i.e. the ancient woodland pilot etc.). As such, there is some variation between the outcomes of Task Four and those of some of the proceeding sections. This is to be expected due to the iterative process adopted by the assessment.

Outcomes of task four identified that the provision of food production and air quality regulation post-delivery of the proposed scheme is reduced when compared to the baseline. All other ecosystem services see an increase in provision because of the proposed scheme and associated mitigation, bar fish production where no permanent impacts are identified.

The ecosystem services with the biggest rate of increase in provision include cultural services. However, it is recognised that the methodology for determining ecosystem service provision associated with natural capital assets indicates high values for cultural services, with the potential for many habitats to score highly across the five cultural services identified[37]. Taking this into account, the following services see significant increases in provision:

- pollination;
- erosion protection;
- water quality regulation;
- carbon storage; and
- water supply.

The broad habitat types which benefit most from the proposed scheme include inland surface waters, grassland environments and woodland. This is again caveated by the fact that the spatial analysis does not assess loss of ancient woodland, more the losses and gains of woodland and associated ecosystem service provision. Heathland and agricultural environments are shown to be impacted adversely by the proposed scheme. It should be noted that the Environmental Statement captures and details agricultural losses alongside other areas of habitat loss.

3.4 Task Five: Identification of alternative mitigation, compensation, and enhancement measures

Task five identified several opportunities for natural capital enhancement, which are as follows:

- Protection and enhancement of the heathland environment.
- Enhanced air quality regulation provision.
- Greater diversity of post-scheme habitats.

[37] The methodology used was the Eco-metric approach, which assigns a level of ecosystem service provision (out of 10), per ecosystem service, for each habitat type. More information can be found here: https://ecosystemsknowledge.net/ecometric The Eco-metric tool is now known as The Environmental Benefits from Nature (EBN) Tool.

- SuDS design (already nature-based) to be developed with a broader range of ecosystem service considerations in mind.
- Enhanced consideration of trade-offs (inter- and intra-habitat)[38].
- Opportunities for creating partnerships outside of the study area to enhance natural capital and ecosystem service provision (e.g. with owners of tourist hotspots and with Nature Scot to promote conservation of the freshwater pearl mussel).
- Further enhancement of non-motorised user (NMU) provision (through additional signage and further promotion of active travel across communities and businesses).
- Further hedgerow creation to promote biodiversity benefits and natural flood management (amongst other ecosystem services and opportunity for habitat connectivity).
- Integration of green surfaces alongside the design of noise barriers to provide a wealth of ecosystem services. Green bridges and green walls could also be considered for integration.
- Measures to further reduce and dispose of soilborne pests and diseases; animal and crop diseases; tree pests and diseases; and invasive species.
- Transport Scotland's soft estate provides the potential for significant ecosystem service provision if managed appropriately. Whilst remaining cognisant of maintenance and safety requirements, the potential to develop seed mixes for best natural capital and ecosystem service benefit could be considered.

It was recommended that consideration be made for future projects to adopt natural capital approaches alongside the development of the mitigation measures committed to in the Environmental Statement. This would allow for wider benefits and values to be identified, alongside the assessment and mitigation of adverse impacts.

It was also found that natural capital approaches should be integrated early within the development of a project. This would allow for natural capital considerations to inform and contribute to the design and development of the scheme.

3.5 Task Six: Capturing wider benefits (social value)

The social value mapping highlighted that the majority of the community benefit toolkit metrics/indictors are focused on the wider benefits of the A9 Dualling Programme that can be achieved through the procurement and employment process of the proposed scheme. Further social value could be achieved by continuing to use the metrics across the operation and maintenance phases of the proposed scheme.

The following community benefit toolkit metrics have the potential to be effectively implemented during operation and maintenance of the proposed scheme and therefore have the potential to generate additional social value:

- Community metrics: Donations to local community projects and volunteer hours on local community projects.
- Employment metrics: All of the employment metrics could be continued through all phases of the Proposed Scheme.
- Poverty metrics: Initiatives to tackle homelessness and child poverty.

Overall, the community benefit toolkit metrics contribute substantial social value beyond the original purpose of the A9 Dualling Programme. It was recommended that these metrics are employed across Project 4 Pitlochry to Killiecrankie in order to achieve wider benefits and greater social value for the proposed scheme. It was also

[38] The underlying idea of trade-offs relative to natural capital is that gains in some ecosystem services can result in the loss of others. Similarly, whilst a gain in the grassland environment is achieved due to scheme mitigation, there are in fact losses in the grassland sub-habitat type 'Neutral grassland – semi-improved'.

recommended that the metrics are considered across all phases (construction, operation and maintenance) of the proposed scheme.

3.6 Ancient Woodland Pilot

The Ancient Woodland Pilot found that extensive mitigation measures outlined in the Environmental Statement have protected much of the ancient woodland present across the study area; however, a significant area is still lost because of the proposed scheme.

Previous tasks identified that woodland was one of the broad habitat types that would benefit most from the proposed scheme. However, once ancient woodland is considered as an independent asset, the loss of ecosystem services becomes apparent and woodland can no longer be considered as a broad habitat to have benefitted from the proposed scheme (in the short-term, prior to reaching target condition).

Owing to the significant loss of ancient woodland, it is likely that the provision of the following ecosystem services will be impacted significantly.

- flood regulation
- erosion protection
- carbon storage
- air quality regulation
- cooling and shading
- noise reduction
- pest control
- recreation
- aesthetic value
- education
- sense of place

Two key recommendations were made as a result of the ancient woold pilot, which should be taken forward by Transport Scotland and acknowledged across the wider discipline:

- Ancient woodland should be considered as a discrete asset in natural capital assessments, independent from non-ancient woodland. Typically, an ancient woodland designation is used as an indicator of asset condition rather than a separate asset category.
- An appropriate method of assessing the varying level of ecosystem service provision associated with ancient and non-ancient woodland should be applied for future natural capital assessments.

3.7 Historic Environment and Natural Capital Assessment Pilot

The Historic Environment and Natural Capital Assessment Pilot was included as a supplement to the Ancient Woodland Pilot as the two pilots are complimentary.

Key findings and recommendations from the Historic Environment and Natural Capital Assessment Pilot include:

- It is possible to use natural capital asset data alongside historic environment data to draw conclusions as to the contribution of the historic environment to natural capital assets and ecosystem service provision.
- It is possible to identify time-depth in land-use, as piloted with woodlands surrounding the A9. This understanding of time depth in woodlands shows a pattern of historic land-use that influences both the preservation of heritage assets, which has implications for project planning and mitigation, and has implications for ecosystem service provision.
- Natural capital assessments should involve assessment of the historic environment and cultural heritage.
- Time-depth within a landscape is simple to assess in Scotland's landscapes, and available data seems robust for woodlands (with tests on other habitat types proving promising).
- Time-depth has implications for ecosystem service scoring, in terms of cultural (especially in relation to cultural heritage), provisioning, regulating, and supporting services.

Previously, the assessment of ecosystem assets has included quantity, quality, and location. However, considering the above findings and recommendations, future assessments could also include time-depth as a factor to assess ecosystem service provision. Alternatively, when considering 'quality', time-depth could be considered.

Future Transport Scotland projects which are looking to apply a natural capital approach should seek to understand the latest guidance from HES as to how the historic environment can be embedded within natural capital assessments.

3.8 Habitat Connectivity Pilot

It was found that functional connectivity[39] was important for several ecosystem services within the study area, in particular services which involve the movement of organisms through the landscape (mainly relating to pollination and pest control). In addition, a network of accessible paths and spaces is important for the connectivity of people, and the cultural value of natural capital assets is heavily influenced by their accessibility for people.

The pilot also found the following, which could provide a better understanding of the value of natural capital assets:

- There could be an application of multipliers to methodologies used to determine ecosystem service provision associated with natural capital assets to better reflect the impact of habitat connectivity on ecosystem service provision. These will adjust the base scores depending on the level of functional connectivity, as well as connectivity for people.
- Habitat connectivity may also be considered as a contributing factor of asset quality as habitat connectivity may build the resilience of natural capital assets and help to sustain the provision of ecosystem services in the long-term[40].
- The spatial relationship between an asset and a specific feature within the landscape is a crucial consideration. As an example, a habitat may be more effective at regulating water quality if positioned between a source of pollution and a waterbody.

Understanding habitat connectivity can inform the placement of ecological mitigation to maximise biodiversity benefit. Using a natural capital lens can further shape the strategic placement of mitigation to deliver multiple benefits by also enhancing ecosystem service provision. An opportunity for enhancement for the A9 Project 4 could be the planting of heathland habitat within areas strategically located to improve habitat connectivity for people and biodiversity.

3.9 Detailed Quantification and Valuation of Changes in Natural Capital Assets and Ecosystem Services

It was found that the initial overall impact, in partial monetary terms, of the proposed scheme on the provision of ecosystem services immediately following construction would be negative. However, the benefits derived from newly created habitat often develop over time as the habitat matures. Taking a more long-term perspective using total present values, it was found that proposed scheme will have a positive impact on the value provided by natural capital assets within the study area. This was based on the partial valuation of the following ecosystem services:

[39] Functional connectivity refers to the ability of different species to move from one patch of habitat to another based upon their ability to disperse through the land cover between them. How difficult it is for species to move between this intervening land cover is a key element in considering connectivity.

[40] Resilience refers to the ability of ecosystems to respond to disturbances, either by resisting them, recovering from them, or adapting to them, while retaining the ability to deliver ecosystem services (Natural Resources Wales. 2016. State of Natural Resources Report: Assessment of the Sustainable Management of Natural Resources. Technical Report. Available online at: https://cdn.naturalresources.wales/media/679405/chapter-4-resilience-final-for-publication.pdf [Last Accessed: 16 April 2021]). If a habitat is well connected and diverse, it is more resilient and less vulnerable to shocks/changes e.g. extreme weather events. Therefore, habitats with greater connectivity are less subject to degradation and adverse impacts on quality.

- Air quality regulation
- Carbon storage
- Flood regulation
- Food production
- Water quality regulation
- Wood production

Based on the approach taken, the most substantial losses in natural capital value came from the proposed scheme's impact on air quality regulation and wood production through woodland clearance. However, these losses were outweighed by the likely carbon storage benefits of new areas of woodland planting for mitigation purposes. The findings of the detailed valuation broadly align with those of the previous Tasks.

Sensitivity analysis was used to demonstrate how natural capital assessments can inform the choice of mitigation measures by highlighting the trade-offs associated with different mitigation designs. This emphasises the need for a considered and holistic approach to valuation when making decisions regarding land-use change.

On future schemes, natural capital assessments could look to ensure that mitigation is appropriately balanced across ecosystem services whilst still meeting regulatory requirements. This would be possible through demonstrating where there are trade-offs between different ecosystem services. That is to say, where losses in one service are being balanced out by gains in another, thereby hiding the true impact.

4. Conclusion

Natural capital assessments along with the consideration of wider social value and the historic environment provide a complementary approach to the EIA process. Undertaking these additional assessments presents an opportunity to reframe the way transport schemes interact with their surrounding environment, better identifying the value of both the existing environment and proposed mitigation. In this way, these assessments support schemes to deliver wider benefit creation by moving away from purely considering and mitigating adverse impacts to exploring additional opportunities for enhancement.

The key benefits of this retrospective study have been:

- The development of a blueprint natural capital assessment methodology that can be applied to future projects wishing to adopt a natural capital approach. This methodology is aligned with best practice, such as the Scottish Natural Capital Accounts[41], Defra's Enabling a Natural Capital Approach guidance[42], and HM Treasury's Green Book[43].

- The methodology includes a robust and defensible approach to the monetary valuation of ecosystem service change that could be incorporated into the cost-benefit analysis of future schemes, to support business case development.

- A contribution to the discipline, particularly regarding how ancient woodland and the historic environment are considered within natural capital assessments, aspects which are arguably overlooked and undervalued in existing methodologies. The study also explored the underdeveloped area of how habitat connectivity and ecosystem service provision are interrelated. The approach to habitat connectivity could be developed further for future schemes to address historic habitat fragmentation and support the delivery of nature networks under NPF4.

- The development of a methodology that accounts for the value of ancient woodland, allowing future projects to better preserve the strong sense of place that comes from these important natural assets. This will support Transport Scotland's decision making in a policy landscape where key stakeholders such as NatureScot are putting a greater focus on place making.

- Engaging with stakeholders has highlighted the need for collaboration in adopting a natural capital approach to successfully delivering environmental enhancements in line with statutory consultees' requirements.

- The study has demonstrated alignment with wider social value policy and generated recommendations as to how wider benefits and greater social value could be embedded across future projects.

- The study has highlighted how natural capital assessments can add value to the EIA process. Reviewing information and data through a natural capital lens can identify additional opportunities for enhancement. For example, the development of mitigation designs that better support increased biodiversity and provide a wider range of ecosystem services.

- Through this summary report, the study has provided accessible and transparent outcomes, thereby supporting the wider sector's understanding of natural capital principles and the benefits of taking a natural capital approach.

[41] For more information, see: https://www.gov.scot/publications/scottish-natural-capital-accounts-2020/pages/1/ [Last accessed: 13 January 2022].
[42] For more information, see: https://www.gov.uk/government/publications/enabling-a-natural-capital-approach-enca-guidance [Last accessed: 24 January 2022].
[43] For more information, see: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent/the-green-book-2020 [Last accessed: 24 January 2022].