NW2045: NATURAL CAPITAL ASSESSMENT

Prepared for: Assynt Development Trust
on behalf of NorthWest2045

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I) Acknowledgements

All efforts for this work have been collaborative, with many hours being volunteered by the NW2045 Working Group, and many individuals finding the time in evenings and weekends to help.

Many people have contributed their data and time for this Natural Capital Assessment, and have also provided valuable feedback to ensure the work is as relevant and useful as possible. NW2045 would like to express gratitude to all those who gave time to the process; contributed data and/or helped us to find data sources:

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NorthWest2045 is made up of individuals from many groups, who have supported the NCA process, and many have provided valuable data and support:

Assynt Development Trust; Federation of Small Businesses; National Farmers Union Sutherland; Highland Council; Highlands & Islands Enterprise; John Muir Trust; North West Highlands Geopark; NatureScot; NHS Highland; Scottish Land Commission; Scottish Wildlife Trust; Scourie Community Development Company; UpNorth! Development Trust; Stirling University; Wildland Ltd.

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Report commissioned on behalf of:

Supporters:

ii) Executive Summary

Regional Land Use Partnership (RLUP) pilot areas have been established to help develop Scotland's approach to land use in support of the transition to carbon net zero by 2045. Habitats in the North West Highlands store tens of millions of tonnes of carbon, and can make a significant contribution to net zero efforts. However, there is a need to consider the environmental, social and economic implications of market and regulatory actions to achieve carbon targets. These include impacts on biodiversity, rural land prices, inequalities and community decision-making. The North West Highlands are very sparsely populated, and the creation of job opportunities and affordable housing are two key priorities that must be considered as part of efforts to achieve net zero.

NorthWest2045 (NW2045) is leading the Highland RLUP, and have partnered with SLR Consulting to carry out a natural capital assessment (NCA). The purpose of the NCA is to better understand the state of assets and ecosystem services in the region; to illuminate how the immense natural wealth in the North West Highlands can better contribute to socio-economic benefits, particularly for the people living there. The NCA is part of NW2045's holistic approach to achieve its Vision for 2045. Mapping of habitats, biodiversity and carbon storage has been carried out for the whole region, and, as a pilot methodology which will inform how we can collect more in-depth data elsewhere in the future, information has also been gathered to support decision-making at the Community Council level in Melness, Tongue and Skerray.

Heathlands and bogs cover over two-thirds of the land in the North West Highlands, proportionally twice as much as that found in other areas of Scotland. Designations cover much of the land, including important areas for plants, animals, habitats, geology and scenery. The societal value of carbon stored in bogs is arguably in excess of £10 billion and, whilst it is important to understand that realising that figure is not possible in practice, there are significant economic opportunities in the region to capture at least part of it. However, the nascent carbon markets as they currently operate have potential negative consequences via: their influence on rural land markets; impacts on other ecosystem services; and (a lack of) inclusion in decision-making and benefit distribution. Policy options at the national level are suggested to mitigate negative impacts and promote community benefits of net zero.

The twin climate and biodiversity crises provide the impetus for positive change. This report can help to facilitate actions in the North West Highlands to improve biodiversity, carbon storage, and other ecosystem services as well as helping with the socio-economic challenges in a way that properly involves communities in decision-making. Recommendations include those to facilitate a Just Transition to net zero, and to improve, extend and apply this NCA.

Definition of Natural Capital:

"Natural Capital can be defined as the stocks of natural assets which include geology, soil, air, water and all living things. It is from this Natural Capital that humans derive a wide range of services, often called ecosystem services, which make human life possible" – Scottish Forum on Natural Capital

iii) Foreword

We know that improved collaboration between local and national government, communities, land-owners, land managers and wider interested parties is essential. The Scottish Government view 'Regional Land Use Partnerships' (RLUPs) as a key way to achieving this, through taking a "natural capital led" approach to land-use change in order to address our climate, biodiversity, and community crises.

Five pilot projects have been set up to test the RLUP approach, one of which fitted perfectly with the NorthWest2045 project zone. 'NorthWest2045' was established in 2020 by a diverse group of local organisations - community groups; local development trusts; statutory bodies; and community, private and environmental non-governmental landowners - from across the North West Highlands, from Coigach in the south, north to Durness and east to Bettyhill. NorthWest2045 are working together to create a future where communities thrive economically, socially, and environmentally. The NorthWest2045 group embarked on the pilot RLUP in late 2021.

The technical language of natural capital does not come easily to most, and certainly presents a communication challenge to the broad range of people around the table in the NorthWest2045 area. However, that is the task the project partners were set by government, and they have risen to the challenge admirably.

This wider understanding of our natural assets and community-led focus is important to my organisation, the Scottish Wildlife Trust, as we believe better access to and use of environmental data, and embedding natural capital thinking, leads to better decision making with better outcomes for nature and people. We also believe it is fundamental to achieving a just transition to net zero and a nature positive future.

To my mind, the key to taking forward this work was the realisation amongst the project group that "you can't manage what you don't measure": how could the steering group comprising diverse community representatives think about potential land use scenarios if we did not have a broad overview of what our natural assets are, and how they might be best managed in the future?

The NorthWest2045 RLUP have taken a collaborative, place-based approach to understanding the area's natural assets, working with SLR Consulting to undertake a community-focused natural capital assessment of the region. The work has helped us begin to understand the vast natural wealth in this area and in the future we hope it will help us understand how potential land use scenarios can bring socio-economic and environmental benefits, particularly for the people living there.

It was not easy. We knew we were in for a challenge with a project area of over 2,000 km^2. The process helped the group understand the substantial data gaps that exist and the difficulties of matching extremely valuable locally held knowledge sets with nationally held data such as soil classification. We also accept that, despite their massive importance to the area, marine and coastal considerations are beyond the scope of this assessment.

This assessment represents a "step one" for the NW2045 group, and it has huge potential to become a tool that enables people to articulate their priorities and actively participate in decision-making processes. I hope the RLUP model, and this natural capital assessment can represent a paradigm shift in how we view our land, the communities who live and work on it, and the land use changes that must be made to achieve a just transition to net zero and nature positive future.

I would like to thank everyone for their hard work and input into this project and look forward to the next stage of this important work.

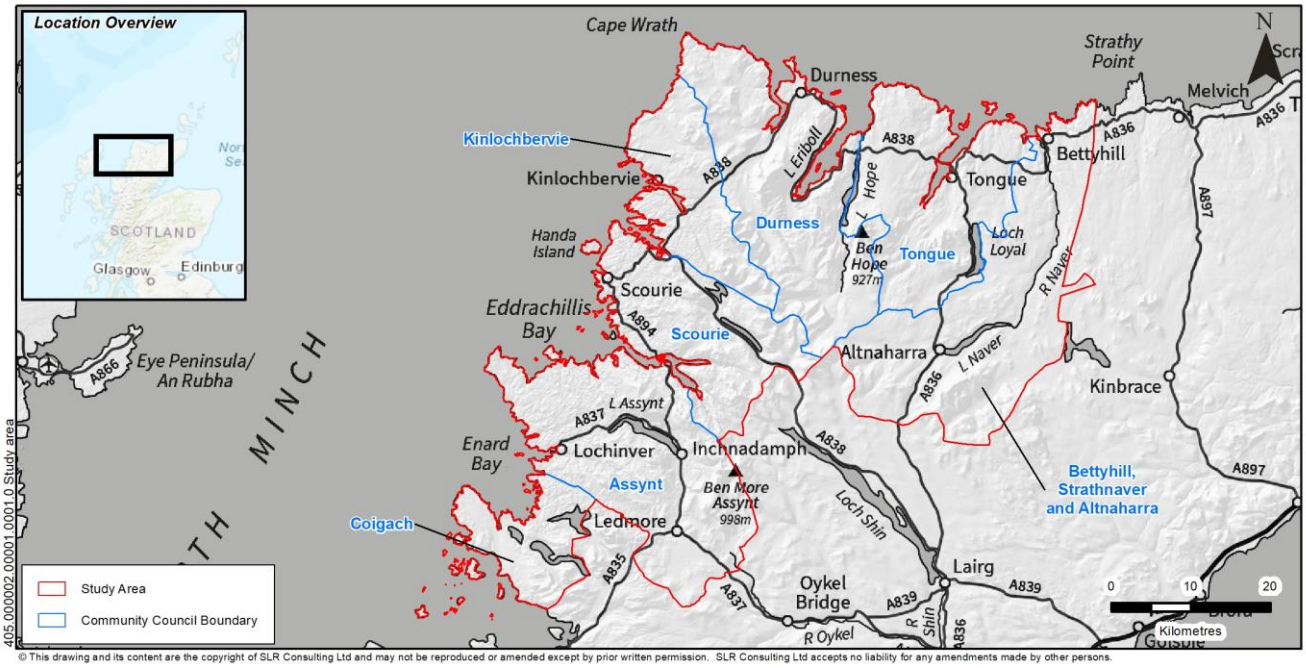
Bruce Wilson, Lead of NorthWest2045 Natural Capital Working Group and
Head of Policy and Advocacy, Scottish Wildlife Trust

1.0 Introduction

NorthWest2045[1] (NW2045) is a collective bringing together diverse individuals and organisations with a common desire for communities to thrive economically, socially and environmentally. Using a partnership approach, NW2045 have provided a Vision to 2045 including ideas for: affordable housing for young people; access to high-speed broadband; multi-use rural hubs; a local food strategy; an inclusive approach to land-management decisions; and providing a community voice to correct a democratic deficit.

The year 2045 adopted by NW2045 is the target year for the Scottish Government's 'net zero' carbon ambition. Five Regional Land Use Partnerships (RLUPs) pilot areas, including the NW2045 region[2], have been established to help develop Scotland's approach to land use in support of the transition to net zero. The pilot RLUPs are being asked by the government to take a 'natural capital approach', including consideration of key natural assets and the benefits they provide to communities and the regional economy. Given that the language around natural capital is not easy to penetrate for many of those engaged with the NW2045, SLR Consulting have been engaged to help carry out an initial natural capital assessment, the first of its type for the Study Area (Figure 1-1).

Figure 1-1
Study Area[3]



The North West Highlands face severe social and economic problems, including a lack of job opportunities and affordable housing, fuel poverty and limited broadband access. Declining populations and prosperities threaten the vibrancy of the region: already one of the most sparsely populated areas of Europe, with around 3,000 people

[1] https://www.northwest2045.scot/

[2] The Highland Council region was selected as one of the five RLUP pilots, and the NW2045 region within this.

[3] Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community. Contains Ordnance Survey data © Crown copyright and database rights (2022) 0100031673.

in total, a further decline of 25% is expected by 2046; High Schools are at less than a third of capacity and pupil numbers are forecast to fall by a further 22% by 2035; a recent university survey of people living in rural areas of Scotland found that 32% of 18-29 year olds felt lonely 'most or all of the time', compared with an average of 8% across all age groups[4]. In short, young people lack opportunities to have a decent life in the region, and there is a risk of the North West Highlands withering to become little more than a tourist park.

Various Scottish policy developments emphasise the need for an integrated approach to tackle environmental issues. For example, the fourth National Planning Framework (NPF4) sets out Scotland's development and infrastructure aspirations to 2045, with improvements to natural capital an essential part. Restoration of 250,000 hectares of peatland by 2030 has been pledged by the government, backed by £250 million of public funding. There is recognition that previous efforts to address ecological decline have been ineffective, for example in the draft Scottish Biodiversity Strategy: "What we have come to understand is that key shortcomings relating to governance and accountability structures and mechanisms for mainstreaming biodiversity into all areas of policy, including economic policy making, have undermined our ambitions.[5]" It is clear therefore that we need more a more integrated approach.

The Just Transition Commission has been established by the Scottish Government to ensure fairness and inclusion for all as part of net zero efforts. Community wealth building is being promoted by the government as, "a people-centred approach to local economic development, which redirects wealth back into the local economy, and places control and benefits into the hands of local people.[6]" This is precisely and urgently what is needed for the North West Highlands: for the region's vast natural wealth to contribute to the local economy in a way that empowers and rewards its residents in the long-term, and in a way that creates secure jobs and attracts new residents to move into affordable homes. The local community have been working to manage the area as a UNESCO Global Geopark without policy or strategic public sector support for the past ten years, which demonstrates that there is already an appreciation of the value of natural capital for human well-being. However, to this point there has been no evidence gathered to understand or quantify that value.

In this report, we will first explain what is meant by a 'natural capital approach' and explore why mapping the region's assets and associated ecosystem services can help. We will next discuss the results of our analysis and finally provide recommendations for NW2045's vital future efforts. Technical parts are included in appendices, including a glossary in Appendix 6. To disseminate the findings of the assessment to a wider audience, a web-based ESRI Storymap[7] provides a non-technical summary of the project, its method and the outputs.

This work was commissioned by NW2045 to better understand how to take a natural capital approach. The work has adapted and developed as NW2045 have worked with SLR - seeking to proactively develop a useful, replicable and collaborative methodology that is possible for communities to apply going forward.

[4] For references in this paragraph, see NW2045's July 2021 Vision document via: https://www.northwest2045.scot/

[5] https://www.gov.scot/publications/scotlands-biodiversity-strategy-consultation/pages/5/

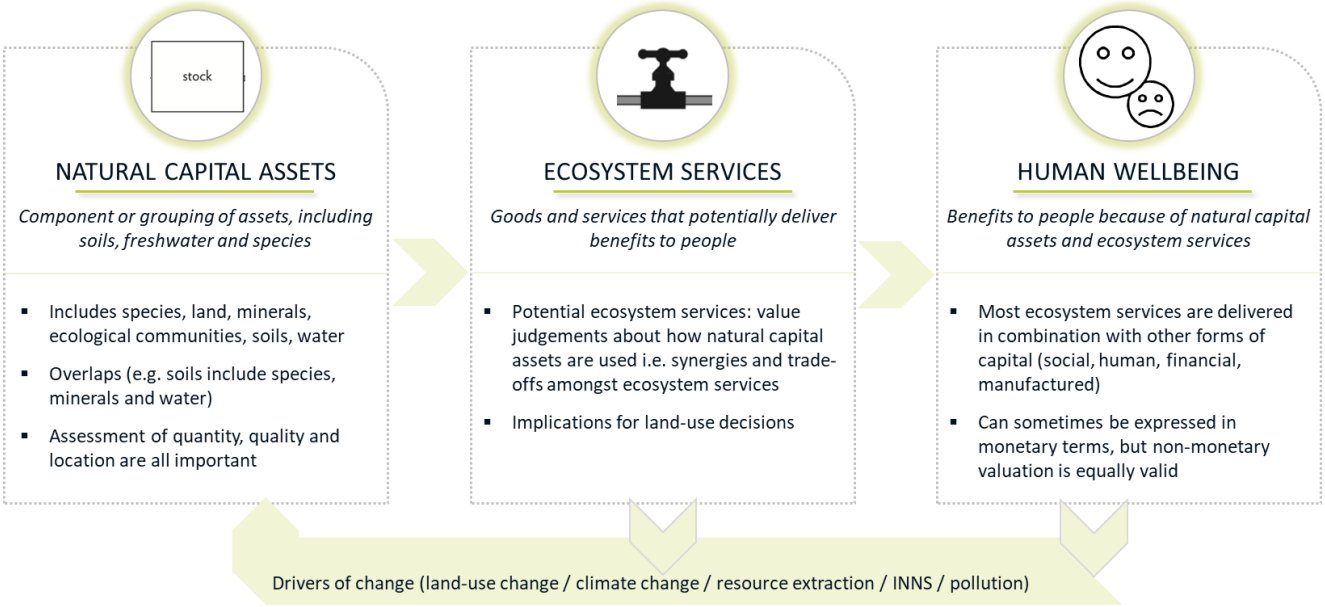
[6] https://www.gov.scot/policies/cities-regions/community-wealth-building/

[7] Until the end of 2022 at least, this will be hosted by SLR at What Does the Land Do for You? (arcgis.com)

2.0 Natural Capital Approach

'Natural capital' is a metaphor for assets including land, species, ecological communities, soils, geodiversity and freshwater. Natural capital provides 'ecosystem services' including food, water, protection from natural hazards such as floods, and opportunities for recreation. Ecosystem services deliver benefits to people in combination with other forms of capital (manufactured, social, human and financial). For example, food from farms is usually processed, transported and sold in markets. Ecosystem services contribute to human well-being in myriad ways, from providing sustenance and security, to aiding physical and mental health, to providing a pleasant place in which to live.

Figure 2-1
Natural Capital, Ecosystem Services and Human Well-being



A 'natural capital approach' requires decision-makers to consider the value of the natural environment for people and the economy. This might seem no more than common sense, but the reality is that the natural environment is undervalued globally, is degraded globally, and ultimately people and the economy are suffering because of humanity's collective failure to understand how natural capital functions and to protect it effectively. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), this is directly due to: land-use change; climate change; resource extraction; pollution; and invasive alien species. IPBES estimate that negative trends in biodiversity – an essential component for natural capital assets - will undermine progress towards 80 percent (35 out of 44) of the Sustainable Development Goal (SDG) targets related to poverty, hunger, health, water, cities, climate, oceans and land (Figure 2-2)[8].

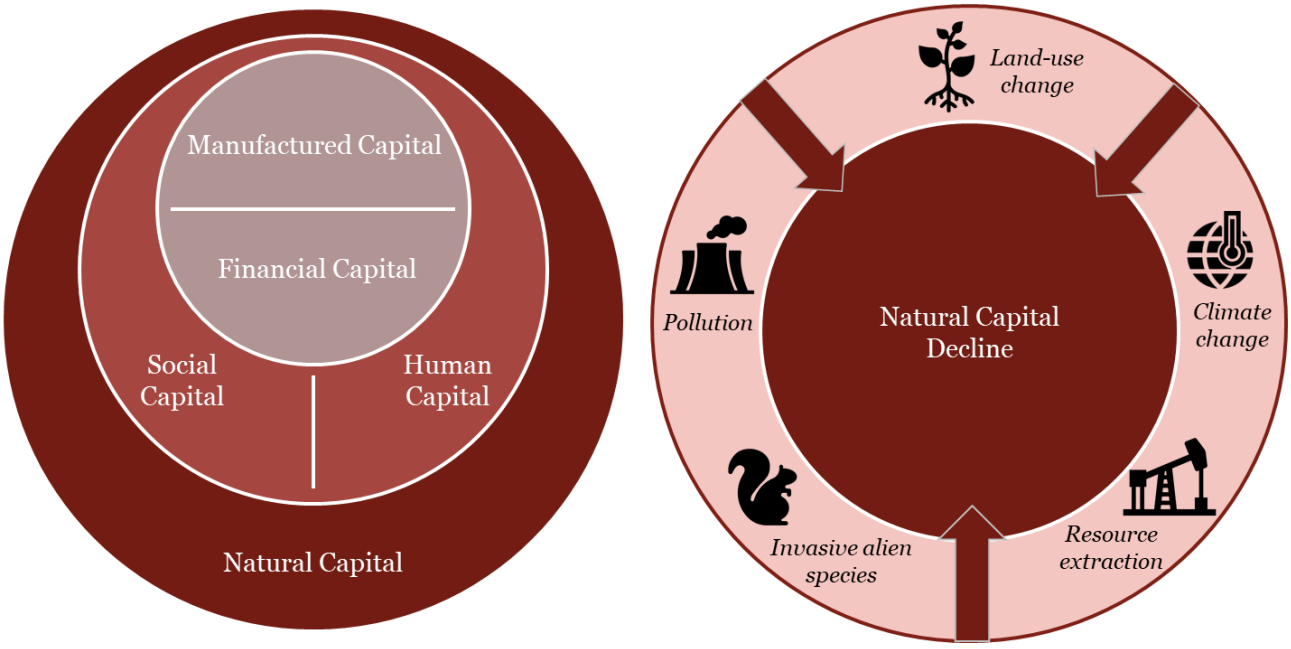
[8] https://ipbes.net/news/Media-Release-Global-Assessment

Figure 2-2:
SDGs Being Most Undermined by Biodiversity Loss

The Five Capitals Model demonstrates that natural capital is fundamental: maintenance of all five capitals is important, but natural capital is the basis not only for economic development, but also for life itself. Natural capital assets often resemble public goods: their use by any one person does not restrict others' access (non-excludable) and does not diminish benefits for others (non-rivalry)[9]. This is a part of what makes natural capital uniquely important, but also helps us understand why natural capital can be invisible in traditional markets: there is 'market failure'. Clean air is a classic example: people generally prefer to breathe air free of particulate matter, but these preferences cannot readily be expressed through markets because clean air is a public good.

In theory, correcting market failure is a matter of a) enforcing property rights and internalizing externalities for private actors (e.g. compensation if natural capital is damaged); and b) public provision of natural capital assets where private markets do not exist or exist to a sub-optimal level. In reality, we continue to witness severe declines in global stocks of natural capital.

Figure 2-3:
Five Capitals Model and Natural Capital Decline (based on Forum for the Future[10])



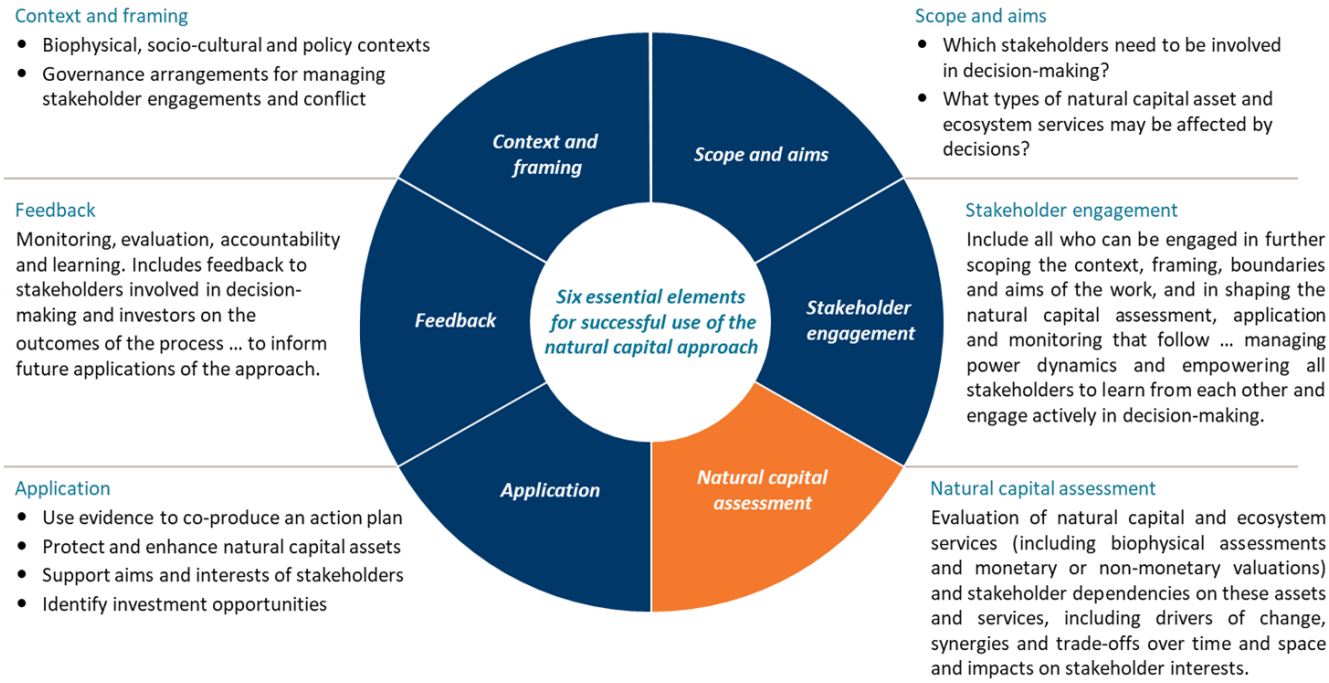
[9] Citing the right to roam as an example, Dieter Helm (2022, page 3) explores why "Much of Scotland's lands are public goods par excellence."

[10] https://www.forumforthefuture.org/the-five-capitals . There are frameworks that include four capitals for instance combining manufactured and financial capital ('economic capital'). An example of this is the Report of the Advisory Group on Economic Recovery provided to the Scottish Government (https://www.gov.scot/publications/towards-robust-resilient-wellbeing-economy-scotland-report-advisory-group-economic-recovery/pages/4/).

The purpose of this natural capital assessment (NCA) is to better understand the state of assets and ecosystem services in the region; to illuminate how the immense natural wealth in the North West Highlands can better contribute to socio-economic benefits, particularly for the people living there.

Reed et al. (2022) have recently reviewed successful partnerships from across Europe, picking out lessons for Scotland's RLUPs from examples of the natural capital approach. Their recommended framework is summarised in Figure 2-4 as it places SLR's efforts in context: there is little value in carrying out a one-off NCA in isolation, but rather it must be part of a cyclical and ongoing process including stakeholder engagement, application and feedback.

Figure 2-4
Framework for a Natural Capital Approach (based on Reed et al. (2022))



Although the terminology can be off-putting, the 'natural capital approach' recommended by Professor Reed and colleagues, and being adopted by NW2045 as part of its holistic approach to achieve its Vision, allows for consideration of three vital questions:

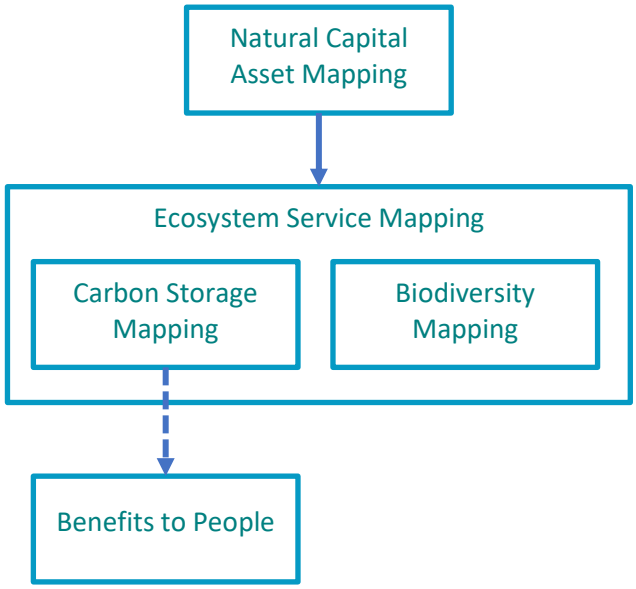
1. What does the land do for you now?
2. What change is within your gift to achieve?
3. What could the land do for you by 2045?

3.0 Methodology

Mapping – whether of habitat extent and quality, condition, ecosystem services, or benefits – is vital to build a common understanding amongst stakeholders. Maps are an efficient way to communicate complex spatial information, such as that required for a natural capital assessment. But maps are a means, not an end, and must be as reliable as they need to be in order to achieve a defined purpose.

Mapping for advocacy purposes - for example raising awareness about the concept of natural capital - requires clarity, but accuracy is not so important. In contrast, mapping oil spill damage as part of a compensation claim must be accurate, but need be understood primarily by legal experts only. This Natural Capital Assessment (referred hereafter as 'the Project') is somewhere in between these two examples: our defined purpose is to deliver something to assist with land-management decisions (this demands a certain degree of accuracy), but to also illuminate the idea of a NCA so it resonates with communities (i.e. to act as advocates for NCA).

Figure 3-1
Project Methodology



The technical methodology for mapping of habitats, condition and ecosystem services as part of the Project is included as Appendix 1, and the datasets considered are included as Appendix 2. An overview of the approach is provided in Figure 3-1; beginning with mapping for natural capital assets via ecosystem services to benefits to people.

3.1 Natural Capital Asset Mapping

To understand the current distribution of natural capital assets within the study area, a variety of datasets were considered, including Land Cover Scotland 1988, the Habitat Map of Scotland (HabMoS), UKCEH's Land Cover Maps, CORINE Land Cover Maps, and Scotland Habitat and Land Cover Maps (SLAM). The SLAM was selected as a source dataset for the following reasons:

- The dataset classifies land cover to European Nature Information System (EUNIS) Habitat Classification Level 2 (a fairly high level, step two of a possible 5 levels of classification detail);

- The dataset has complete coverage of the study area, but at a suitable resolution to identify individual land parcels (20m x 20m);
- The dataset is current, showing landcover from 2020;
- The dataset has a high level of precision, most habitat classes have an accuracy of over 90%; and
- The dataset is provided through an Open Government Licence and was immediately available at the beginning of the study.

The SLAM was validated using aerial photography to identify any significant inaccuracies in habitat classification. As detailed in Appendix 1, SLR's initial approach included using the Integrated Valuation of Ecosystem Services and Tradeoffs[11] (InVEST) tool to map asset quality, but the results did not represent condition to a suitable level of accuracy for the assessment.

3.2 Ecosystem Service Mapping

SLR attempted to map *potential* ecosystem services (stocks) rather than annual fluctuations (flows)[12]. This means for example that we aspired to map carbon storage rather than carbon sequestration/emissions over a specified period of time. An analogy can be made with a company's balance sheet (i.e. stocks of assets and liabilities at a point in time) and profit & loss account (i.e. flows of revenues and costs over a period of time). The reason for our 'balance sheet' focus is that stocks tend to be more useful predictor of future performance, and hence are more useful for making decisions. A further example: a bumper timber harvest (flow) in a year could be profitable, but if that timber was harvested unsustainably the potential for future profits from timber (stocks), not to mention all of the other ecosystem services provided by woodlands, might be jeopardised.

In order to estimate potential ecosystem services (hereafter 'ES' means *potential* ecosystem services, unless stated otherwise) it is sometimes necessary to use flows as a proxy, even if they are imperfect. For example, agricultural yields as a proxy to estimate food ES into the future, but care would need to be taken interpreting yields from drought or flood-affected years. Visitor statistics can be the basis to estimate tourism ES into the future, but then nobody would suggest that visitor numbers from 2020 are a good proxy for future potential. The 'past performance is no guarantee of future results' disclaimer commonly applied to investments very much applies to ecosystem service flows. Indeed, the over-exploitation of natural capital assets to secure flows in the short-term has resulted in tipping points so that what was once renewable becomes non-renewable and eventually disappears. Think of the beaver in Scotland, hunted to extinction throughout the country before recent sanctioned and not-so-sanctioned reintroductions.

There are broadly three ways in which ES can be measured and mapped, each of which has been used in some way for the Project:

1. Direct measurement via observation, monitoring and surveys. Examples include head counts of livestock, measuring the capacity of a flood plain, monitoring water quality, and surveys of people harvesting wild fruit;
2. Indirect measurement, which is as (1) but requires further interpretation, and/or adjustment of units, such as using land cover information. Remote sensing of vegetation is another example, as is mapping trails or camp sites; and
3. Modelling ES, for example using expert judgement or models of planetary cycles. Crop production models and carbon cycle models are commonly applied, and another example is estimating the future use of a nature trail based on access and population data.

[11] https://naturalcapitalproject.stanford.edu/software/invest

[12] Flows are also important. This will be explored throughout this report, in particular with reference to the balance of carbon sequestration and emissions from peatlands.

Direct measurement is generally the most accurate method, but it can be expensive beyond the site or local scale. It is often used for what are referred to as 'provisioning' ES, such as crops, fish, water, timber etc. as relevant statistics are generally recorded by governments, and so no additional measurement is required. For most 'regulating' ES such as erosion control or air and water purification, modelling is the only feasible option. A specific example of modelling is the 'matrix' approach. This method links each ecosystem service to land-cover spatial units, with supply or demand then ranked on a scale of zero (not relevant) to five (very high). The matrix approach is used for Scotland's Natural Capital Asset Index, which tracks change in ES at the national scale from the year 2000. The major advantage of the matrix approach is its simplicity and comprehensiveness, and so it is a good method for advocacy.

Because of tight timescales, SLR have only fully mapped ES for biodiversity[13] and carbon storage. Climate and biodiversity crises are connected and threaten well-being globally[14]. Below provides a summary of the methods to map each service, with further methodological detail included in Appendix 1.

3.2.1 Biodiversity

Biodiversity provision was modelled as a function of habitat distinctiveness and condition, utilising the Biodiversity Metric 3.1 developed by Natural England[15] as a framework for the assessment. In the absence of a Scotland specific biodiversity metric, Metric 3.1 was considered a reasonable starting point for estimating the biodiversity value of the habitats within the study area. Metric 3.1 is a habitat-focused approach in which habitats are allocated a relative 'distinctiveness' score which, combined with a condition score, related to their value for biodiversity, in this case resulting in a relative scale of 0 to 24 biodiversity units/ha[16]. The method does not take account of fauna or specific plant species, although to some extent the presence of these may influence the condition score (which takes into account things like the presence of positive plant indicator species, presence of non-native invasive plant species and signs of grazing/ browsing).

Each EUNIS classification provided in the SLAM was translated to an equivalent UK Habitat Classification to derive a distinctiveness value for each habitat parcel.

A multi-step process was implemented to assign habitat condition, first utilising designated site monitoring information provided by NatureScot. We note that some of this designated site monitoring data may be out of date and no longer represent current conditions. However, they are likely more accurate than a purely assumption based approach.

Where this data was not available, deer density was used as a proxy measurement for habitat condition and downgraded from good to moderate where densities exceed seven deer per square kilometre (five in woodlands)[17]. These threshold densities are specific to red deer which likely make up the majority of the numbers in the deer count dataset that was used.

We acknowledge that this is a broad-brush approach and that the impact of deer on habitats is a very complex issue. Impacts of deer on vegetation can often depend on the existing habitat condition, geographic location and climate etc. For woodland, deer impacts often depend on woodland age and structure and extent to which it has

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[13] The question as to whether biodiversity is an ecosystem service in itself and/or an indicator of habitat condition need not concern us too much; it is both, and of vital importance.

[14] They are being tackled at the highest level globally, for instance as demonstrated by the work by IPBES, IPCC, UNEP and other United Nations organizations: https://www.un.org/sustainabledevelopment/blog/2021/06/tackling-biodiversity-climate-crises-together-and-their-combined-social-impacts/

[15] http://publications.naturalengland.org.uk/publication/6049804846366720

[16] Twenty-four units per hectare is the highest number possible that can be calculated for baseline conditions without taking into account the strategic conservation significance of the location which has been excluded from this model but in theory could raise values to around 27BU/ha

[17] Putman R., Langbein J., Green P., and Watson P. 2011. Identifying threshold densities for wild deer in the UK above which negative impacts may occor.

been exposed to browsing pressures. The presence of other herbivores such as sheep is also important and we did not have data on sheep population densities.

3.2.2 Carbon Storage

Multiple existing datasets were used to understand distribution of carbon storage across the study area:

- Woodland habitat types;
- Carbon and Peatland Map 2016, NatureScot;
- Peat depth from 195 projects across Scotland as part of the Peatland Action project;
- Bare peat in Scotland from Sentinel-2 (taken in the summer of 2018); and
- Topsoil Organic Carbon Concentration 2012, James Hutton Institute.

Further analysis was conducted using the InVEST Carbon Model[18] to estimate the carbon storage across the study area. This model applied estimates of carbon storage for different habitat types to a given land cover dataset to calculate metric tonnes of carbon stored per 20m x 20m pixel.

3.2.3 Other Ecosystem Services at the Community Council Level

For other ES, Appendix 2 contains a list of spatial datasets of interest. Some could be very useful for NW2045's future mapping efforts and would be quite straightforward to map (e.g. timber, water quality). Others are more challenging (e.g. air pollution, tourism) but can certainly be mapped using a combination of measurement and modelling. Other ES are difficult to measure let alone map (e.g. a sense of place), but must not be ignored for this reason, and should be part of land-management decisions.

Although biodiversity and carbon storage are the only ES mapped for the whole region, we have carried out some surveys and analysis for the Melness-Tongue-Skerray Community Council Area (hereafter referred to as MTS), to better understand land use, including food and other crofting activities such as education and nature-based tourism. This is with a view to comparing carbon storage and biodiversity information with other ES in a place-based approach. Community Councils are an important forum for democratic decision-making and the purpose of focussing on MTS is that there is an interesting range of common grazing, tourism (e.g. NC500), land ownership and developments (including the Sutherland spaceport). The place-based approach can be used in other community council areas in the Study Area, and lessons learned from MTS will be shared.

At the point of finalisation of this report (August 2022) SLR and NW2045 have gathered some useful information from grazing clerks and community members but this is not mapped. Further, community engagement is essential for mapping ES, particularly for cultural ecosystem services, and this has been limited to date. More information about this element of the work can be found in section 4.2.3, below.

3.3 Benefits to People

A NCA requires integrated analysis across biophysical, socio-cultural and economic dimensions. Mapping natural capital assets is largely a biophysical exercise (i.e. is determined by a mix of biological and physical characteristics), and many ES are also closely linked to biophysical conditions. Benefits to people means consideration of ES *demand* alongside supply, as well as some consideration as to whether supply and demand are located in the same place ('in-situ') or are spatially separate.

To understand benefits to people ('welfare value') the analysis must include socio-cultural and/or economic valuation. The former includes anything that analyses human preferences in non-monetary terms, including preference assessment, photo-elicitation surveys, scenario planning, deliberative valuation and participatory GIS

[18] http://releases.naturalcapitalproject.org/invest-userguide/latest/carbonstorage.html

mapping. Economic valuation expresses human preferences in monetary terms, and there are a host of techniques that can be used. These techniques range from the simple (market values of timber or entrance fees to parks can be a decent indication of value), to somewhat challenging (restoration expenditures for peatlands provide at least a minimum value for the value they provide; all else being equal, a house situated closer to nature will be more expensive than one next to a busy road), to those that in theory allow for monetary valuation of all types of ES but are prohibitively expensive to do well (asking people to state their willingness to pay for ES; choice experiments where people are asked to make trade-offs between multiple ES and other goods in order to elicit willingness to pay).

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in July 2022 published a 'Values Assessment'[19] urging a move away from economic valuation of nature towards an approach including the multiple values of nature in policy decisions. This is an extremely important piece of work, written by experts from across the world: IPBES is to nature and biodiversity as the Intergovernmental Panel on Climate Change (IPCC) is to climate change.

For the Project, explicit economic valuation has been estimated for carbon only, as discussed in Section 5. However, implicit economic and socio-cultural valuation is relevant throughout, including our categorisation of ecosystem services, and especially in the choices we have made about which ES to map. The very concept of 'natural capital' is anthropomorphic, addressing the deceptively simple question: what does nature do for people?

[19] For more information, see: https://ipbes.net/media_release/Values_Assessment_Published

4.0 Results and Discussion

This Section includes the results of our natural capital asset mapping, ecosystem service mapping, and a discussion of potential benefits to people. Biodiversity and carbon storage are central to the analysis.

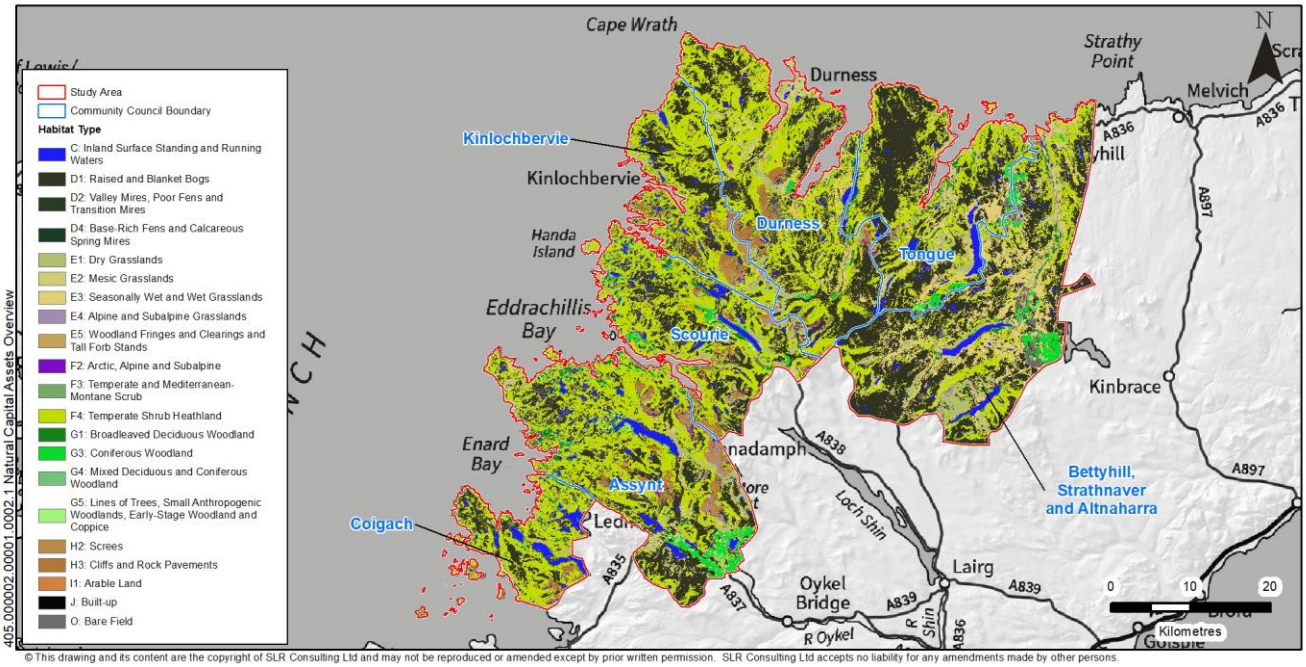
4.1 Natural Capital Asset Mapping

The distribution of the natural capital assets is shown in Figure 4-1. The study area is dominated by heathland and bog, which between them account for approximately 68% of land (Table 4-1). Both habitat types are distributed throughout the study area, with bogs most notably found in the east surrounding Tongue; whilst Heathland is predominantly spread across the west of the study area.

Grassland is a significant proportion of land cover (16%). This is mainly limited to the east of the study area near to Bettyhill, however small patches were identified across the study area, such as in the surroundings of Durness.

Woodlands account for 5% of land cover within the study area. The distribution is largely limited to the Western coastline, and patches in the South-East of the study area (for example along the A837).

Figure 4-1
Natural Capital Assets[20] (see Appendix 1 for larger map).



In comparison to Scotland (through analysis of the SLAM source dataset), the NW2045 study area has a significantly different asset composition. Habitat types notably lower within the study area include grassland, woodland and cultivated habitats. Notably higher proportions of heathland, bog and inland waters are found in the study area.

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Table 4-1
Habitat Areas in the Study Area and Scotland

EUNIS Habitats	NW2045 Study Area		Scotland (Derived from SLAM)	
Habitat Type	Area (Hectares)	Proportion (%)	Area (Hectares)	Proportion (%)
Bare Field	7,211	3	254,377	3
Base-rich fens and Calcareous spring mires	138	<1	1,818	<1
Cultivated And Artificial Habitats	12,686	4	877,647	11
Grasslands & Lands Dominated by Forbs, Mosses or Lichens	44,612	16	2,544,110	32
Heathland, Scrub and Tundra	106,047	37	1,427,914	18
Inland Surface Waters	11,374	4	168,878	2
Mires, Bogs and Fens	88,563	31	1,403,286	18
Woodland, Forest and Other Wooded Land	13,199	5	1,262,941	16
Total	**283,830**	**100**	**7,940,971**	**100**

Differences between the study area and the rest of Scotland reflect its wetter climate, predominance of peat habitats, steep inaccessible terrain, herbivore populations and historic and current management. These factors impose limits both on land use and suitability for the development and persistence of different habitat types. For example, topographical conditions mean that it is largely unsuitable for agriculture (most of land is Class 6.3 – 'Land capable of use as rough grazing with low quality plants' per the Land Capability for Agriculture analysis[21]) and therefore historically less land area has been converted for agriculture than elsewhere in Scotland. Meanwhile, browsing by herbivores limits the extent of native woodland regeneration. It is worth noting, however, that the mapping might not pick up small but significant areas of soil that have been improved over centuries by small-scale farmers, as reflected in recent research[22] and by higher historical population statistics.

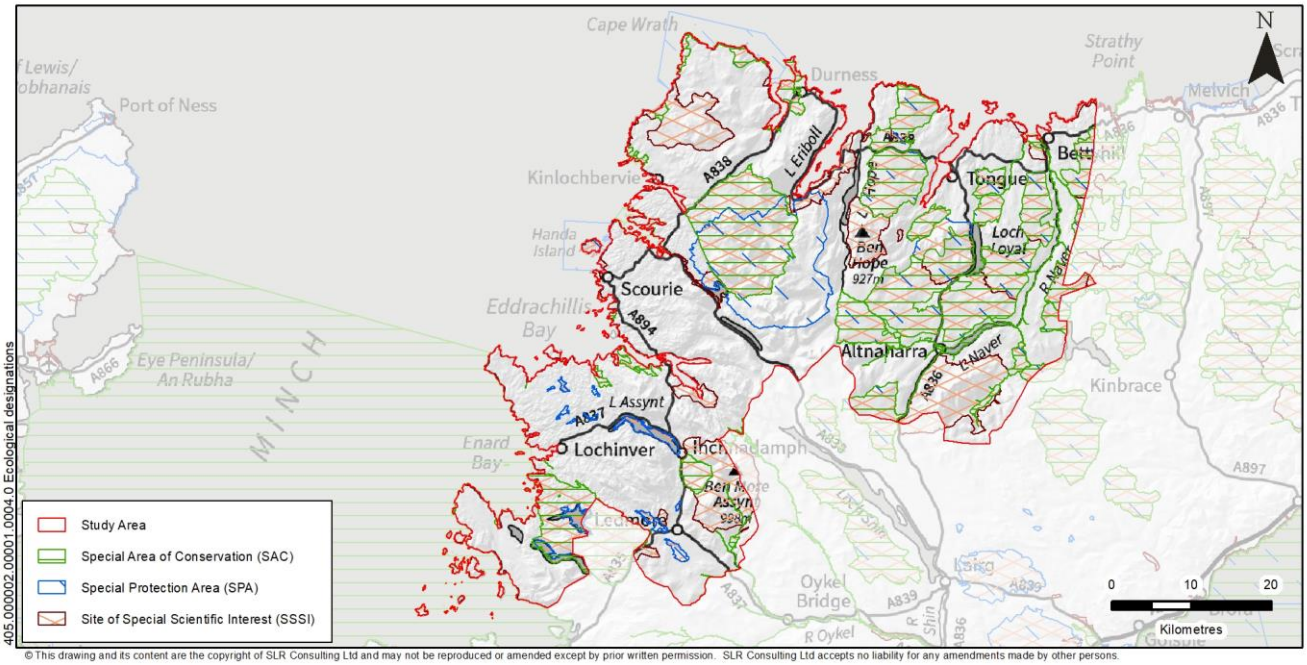
4.2 Ecosystem Service Mapping

4.2.1 Biodiversity

As outlined in Section 3.2.1, biodiversity was modelled using Defra metric 3.1, a habitat focused approach that does not take account of fauna or specific plant species. Habitats have been assumed to be in good condition unless there is evidence to the contrary either in terms of site assessments for areas protected for nature conservation (e.g. SSSIs and SACs – see Figure 4-2) or evidence of deer populations above a certain threshold (see Appendix 1 for more detail). The assumption of good condition is a precautionary approach designed to discourage damage e.g. by increasing the biodiversity value and therefore the required level of mitigation/ compensation in a development context. Equally taking this approach may mask the potential for biodiversity enhancement where nature conservation is the priority.

[21] https://www.hutton.ac.uk/learning/natural-resource-datasets/landcover/land-capability-agriculture
[22] https://www.nwhgeopark.com/current-research/soil-fertility/

Figure 4-2
Ecological Designations in the Study Area[23]



Habitats and habitat condition are a product of a range of factors past and present including soils, climate, land management and herbivore populations. While the Defra Metric 3.1 looks at habitats from a purely biodiversity / conservation perspective it is important to remember that in a wider context what good looks like varies among stakeholder groups and the desired outputs from the land in the short and long-term (food production, recreation, biodiversity, carbon sequestration etc.).

As discussed, the area is dominated by heath and bog habitats, though there is some grassland mixed in with this particularly along watercourses and in coastal areas. Notably, the steep topography and wet climate have resulted in a comparatively high proportion of scree and cliff habitat (4%) and surface water (4%). There is very little built-up land (<1%), and arable land/ bare fields constitute only 4%. The most notable other crop land is coniferous forestry (2%). Broadleaved/ native woodland is limited in extent (c. 4%). See Figure 4-3 for more detail.

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Figure 4-3
Habitat Cover Percentages for the Study Area

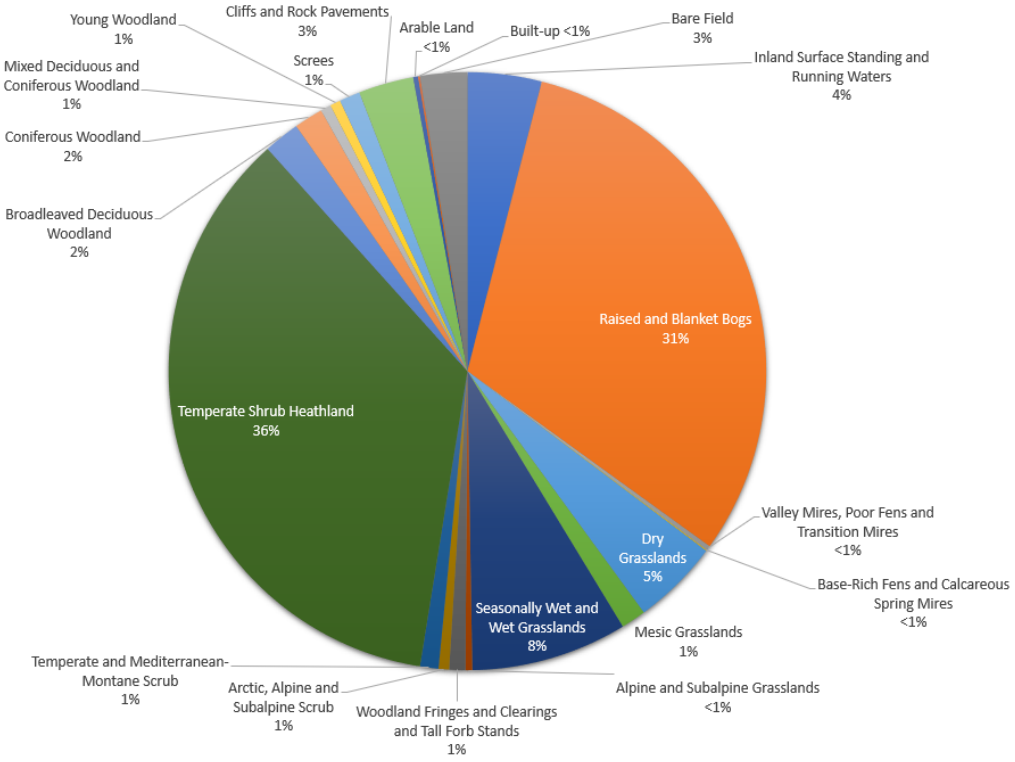
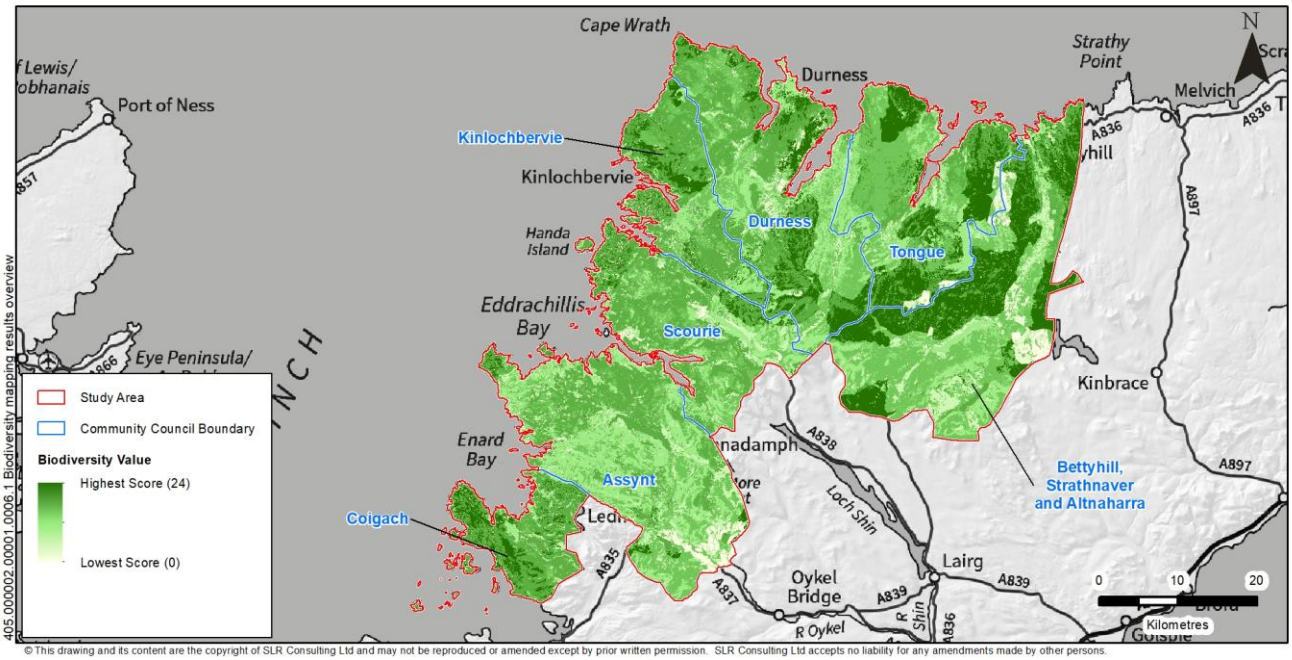


Figure 4-4
Metric 3.1 Biodiversity Map[24]



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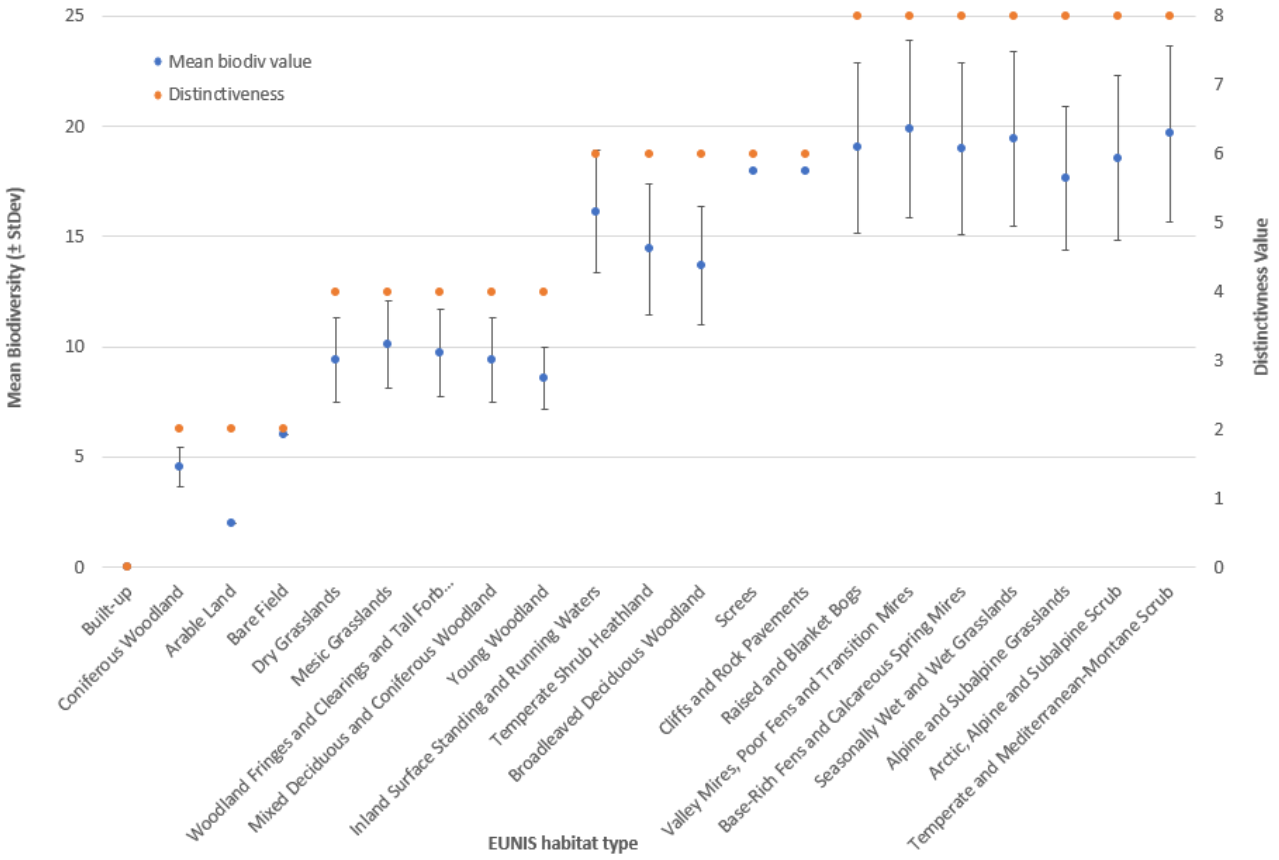
Most of the land area scores toward the upper end of the ranges of biodiversity calculated, with 16% in the 23-24 units/ha range and 30% in the 17-18 units/ha range. This largely reflects the maximum distinctiveness values (8) of the bog, mire and alpine habitats which dominate this area. Areas with the lower scores include cultivated areas, commercial forestry and dry grasslands. Native woodlands and heathland have intermediate scores, due to their intermediate distinctiveness scores of 6. Where heath and woodland are in better condition, they also contribute to the upper end of the biodiversity values calculated.

The biodiversity value within each different habitat type varies reflecting differences in habitat condition (see Figure 4-5). This indicates that there is potential for improvements. Habitat condition improvements may also result in better delivery of other ecosystem services, such as water retention and carbon sequestration.

Figure 4-5
Variation in Habitats' Biodiversity Scores



Note that when considering changing land use and the potential impact on biodiversity using the Metric 3.1 approach, the conversation of one habitat type to another involves consideration of the time until target condition (some level of maturity). For woodland this is a relatively long time, such that conversion of grassland to native woodland may not be reflected as a biodiversity gain in many instances. However, it is not clear if Scotland will adopt Metric 3.1, and it is therefore possible that any approach adopted in Scotland may reflect the biodiversity value of transitions from grassland to woodland and other habitat changes differently.

SLR recommend that a fauna-specific mapping assessment be undertaken. This for example may highlight areas such as arable land that have low biodiversity value in Metric 3.1 but may be of high importance for example to foraging birds at certain times of year. This assessment could make use of the UK ecological status map[25] and

[25] https://eip.ceh.ac.uk/apps/ecostatus/

other sources of information such as those datasets collected for protected areas and via national monitoring programs.

Metric 3.1 also does not explicitly address the freshwater or marine environment. Assessment of these would require consideration of a range of factors including habitats, species, water quality, water levels and water temperature. Some of this information is already available for freshwater environments e.g. via Scotland River Temperature Monitoring Network[26]. It relates to recommendations for tree planting to reduce the impacts of climate change on water temperature and salmon populations[27].

4.2.2 Carbon Storage

Analysis using the InVEST model for different habitat types identified that the majority of carbon in the area is held within bogs, with smaller amounts stored within heathlands and grasslands (Table 4-2). Woodland was found to contain only 3.5% of carbon for the study area.

Table 4-2
Land Cover and Carbon Storage in the Study Area

	Land Cover		Carbon	
Habitat Type	Area (Hectares)	Proportion (%)	Carbon ('000s Metric Tonnes CO2e)	Proportion (%)
Bare Field	7,211	3	31	<0.1
Base-rich fens and Calcareous spring mires	138	<1	20	<0.1
Cultivated And Artificial Habitats	12,686	4	97	0.1
Grasslands & Lands Dominated by Forbs, Mosses or Lichens	44,612	16	4,227	6.2
Heathland, Scrub and Tundra	106,047	37	10,547	15.4
Inland Surface Waters	11,374	4	113	0.2
Mires, Bogs and Fens	88,563	31	51,196	74.6
Woodland, Forest and Other Wooded Land	13,199	5	2,432	3.5
Total	**283,830**	**100**	**68,663**	**100**

The NW2045 study area contains approximately 68.7 million tonnes of carbon, which equates to 242 tonnes per hectare. Most of the carbon is stored within the east of the study area. Within the Community Councils with less

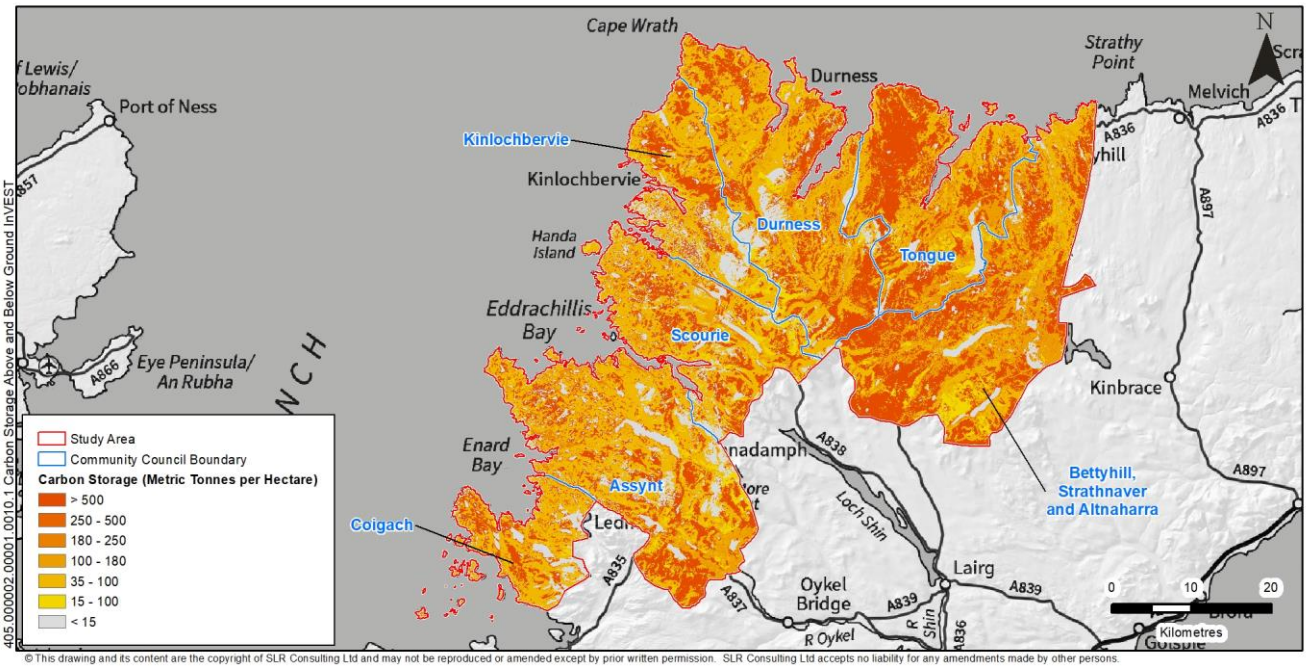
[26] https://www.gov.scot/publications/scotland-river-temperature-monitoring-network-srtmn/
[27] https://www.gov.scot/publications/where-to-plant-trees-to-protect-rivers-under-climate-change/

carbon there are still patches of high carbon densities, for example the heathlands south east of Scourie (Table 4-3 and Figure 4-6).

Table 4-3
Carbon Storage for Each Community Council Area

	Land Cover		Carbon	
Community Council Area[28]	Area (Hectares)	Proportion (%)	Carbon ('000s Metric Tonnes CO2e)	Proportion (%)
Assynt	55,245	19.5	11,555	16.8
Bettyhill, Strathnaver and Altnaharra	59,604	21.0	17,485	25.5
Coigach	17,135	6.0	3,235	4.7
Durness	52,200	18.4	12,284	17.9
Kinlochbervie	23,997	8.5	4,798	7.0
Scourie & District	34,513	12.2	6,894	10.0
Melness, Tongue & Skerray	41,136	14.5	12,413	18.1
Total	**283,830**	**100**	**68,663**	**100**

Figure 4-6
Carbon Storage (tCO2e per hectare) Using the InVEST Model[29]



[28] See Community Councils | Community Councils | The Highland Council for a map showing Community Council areas.

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As explained in Appendix 1, our carbon storage analysis for bogs in the NW2045 region (just over 51 million tonnes stored across less than 90,000 hectares, averaging 576 tonnes per hectare) is based on the average depth being one metre, which is a conservative estimate given that NatureScot's Peatland ACTION project found that the average depth across 195 projects in Scotland was 1.37 metres (including some on The Moine in between Loch Eriboll and the Kyle of Tongue that is up to six metres deep). Even with our conservative assumptions, 75% of the NW2045 region's carbon is stored in peatlands even though it constitutes less than a third of NW2045's land cover.

Two existing datasets detail the distribution of below-ground carbon within NW2045 – the Carbon and Peatland Map 2016 and Topsoil Organic Carbon Concentration (Figure 4-7 and Figure 4-8). The highest concentrations of carbon largely correspond to areas which are predominantly peat (Class 1) which is to be expected. Notable concentrations can be found near Tongue, to the West of Durness and surrounding the A837. Topsoil organic carbon concentrations over 40% are the norm for the vast majority of the Study Area that lies to the east of Loch Eriboll. A band of lower carbon concentration was identified along the western coast of the study area, which corresponds to Class 2 areas in the Carbon and Peatland Map. The lowest concentrations of carbon correspond to areas which have mountainous terrain, riparian habitats or waterbodies.

Figure 4-6, Figure 4-7 and Figure 4-8 essentially all tell the same story of very high below-ground carbon storage in the north and west of the study area and of high storage in most other areas, though there are some localised differences.

The dominant form of above-ground carbon storage is woodland. As identified within the Natural Capital Asset Mapping, woodland accounts for a small proportion of land cover within NW2045 (less than 5%, compared with 16% for Scotland as a whole) and is predominantly limited to coastal or riparian areas, and sporadic plantation woodlands in the South and East (Figure 4-9).

Figure 4-7
Carbon and Peatland Map (2016)[30]

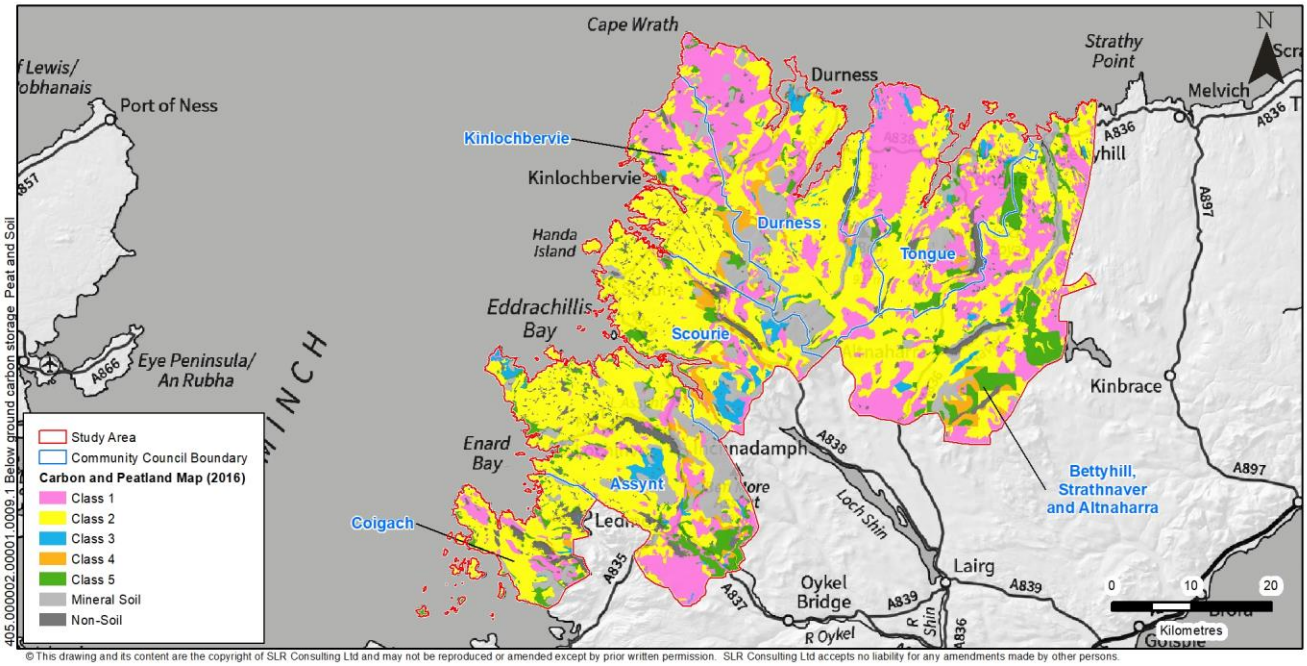


Figure 4-8
Topsoil Organic Carbon Concentration Percentage[31]

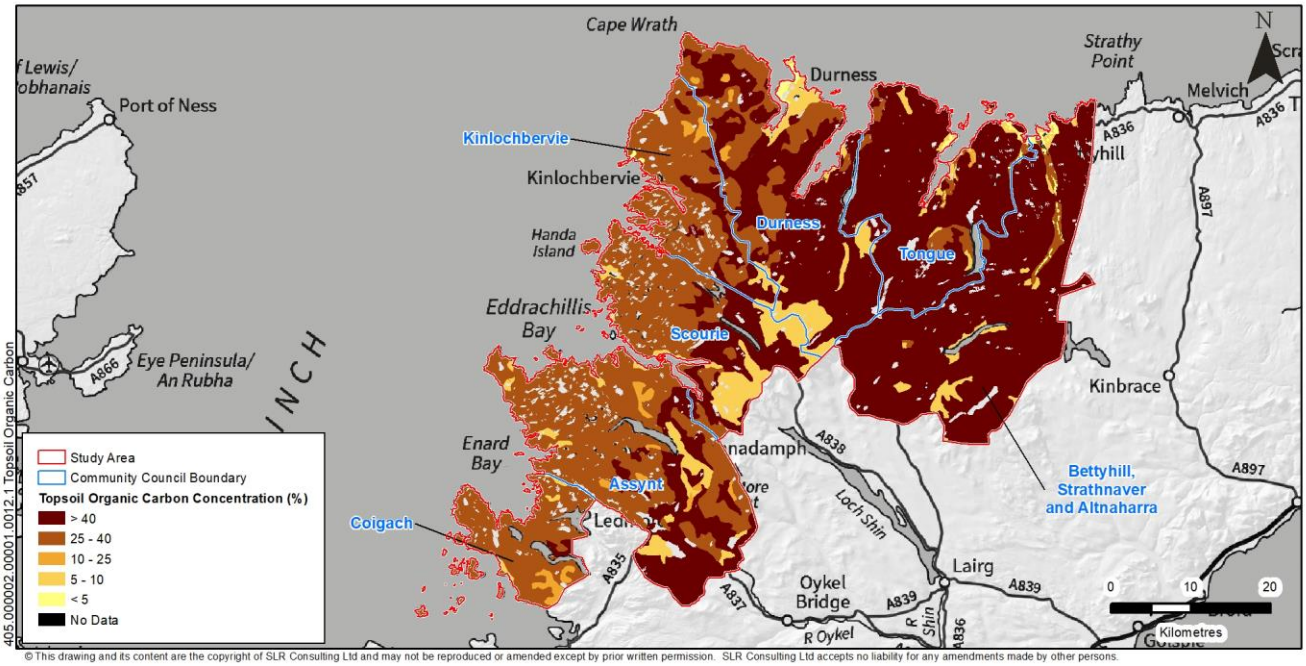
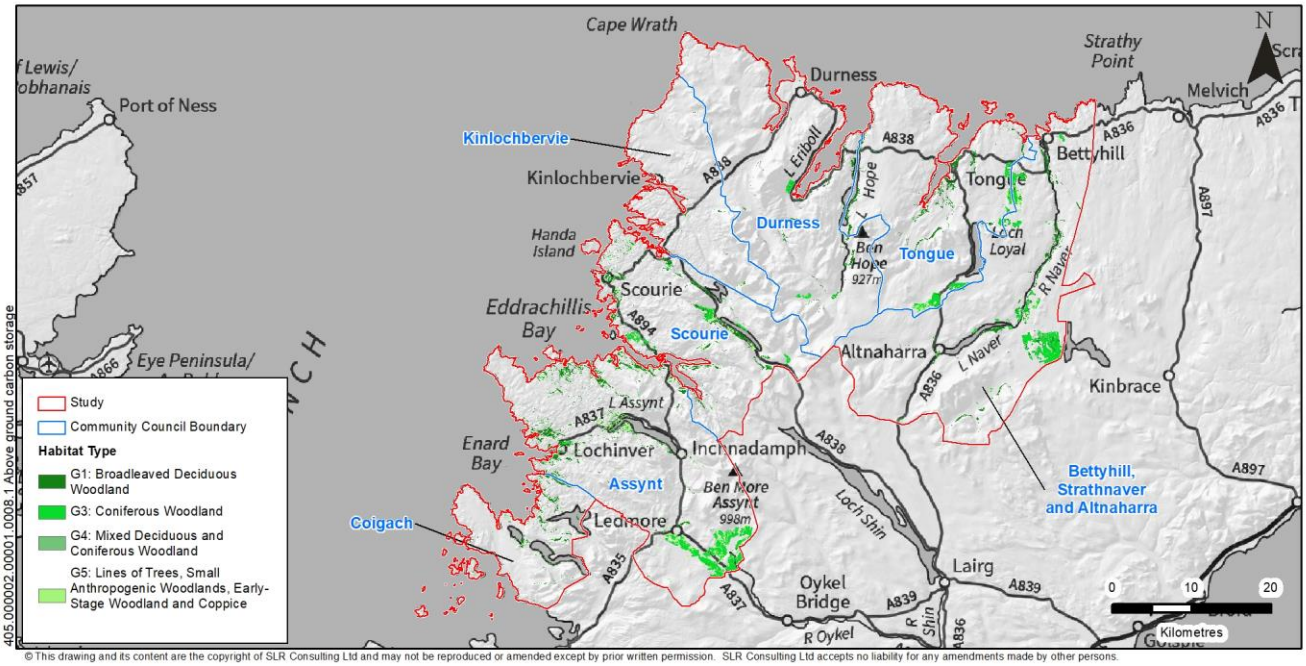


Figure 4-9
Woodland Habitats in the Study Area[32]



As with land-use decisions affecting biodiversity, it is not always clear whether the priority should be to improve areas that already store carbon, or to improve conditions where carbon storage is currently limited. There are trade-offs and synergies with other ecosystem services that must be considered. However, as explored in Section 5, decisions around carbon storage are easier in theory than with biodiversity: Scotland has a net zero target by 2045, and a significant proportion of reductions can be made via carbon sequestration. Peat that is degraded (e.g. drained or burned) will contribute to carbon emissions, whereas peat that is being restored will contribute to carbon sequestration, or at least mitigate emissions. It is often Class 2 peatlands (in yellow in Figure 4-7) that provide the most opportune areas for restoration.

Figure 4-10 demonstrates that there is often good local information about peatland, which can be used for targeted improvement actions. The area shown is just west of Kinloch, and includes data from: the Carbon and Peatland Map (2016); Peat depth as part of the Peatland Action project; and bare peat from the Sentinel-2 earth observation mission. The bog shown is 'Class 1', and in parts has a depth of up to four metres, but is in poor condition elsewhere, being less than 50cm deep. The Sentinel-2 earth observation further shows that there are some areas of bare peat. From a carbon sequestration perspective, it is therefore possible to target interventions for this area.

[30] Contains Ordnance Survey data © Crown copyright and database rights (2022) 0100031673. © SNH and JHI available under an Open Government Licence. Note that Class 1 refers to 'nationally important carbon-rich soils, deep peat and priority peatland habitat'. Class 5 indicates no peatland habitat, and may include areas of bare soil. For a fuller explanation of each Class shown on this map, see: https://soils.environment.gov.scot/maps/thematic-maps/carbon-and-peatland-2016-map/

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[32] Contains Ordnance Survey data © Crown copyright and database rights (2022) 0100031673. Contains SNH information licensed under the Open Government Licence v3.0.

Figure 4-10
Peatland Information from Multiple Sources at 1km Scale[33]

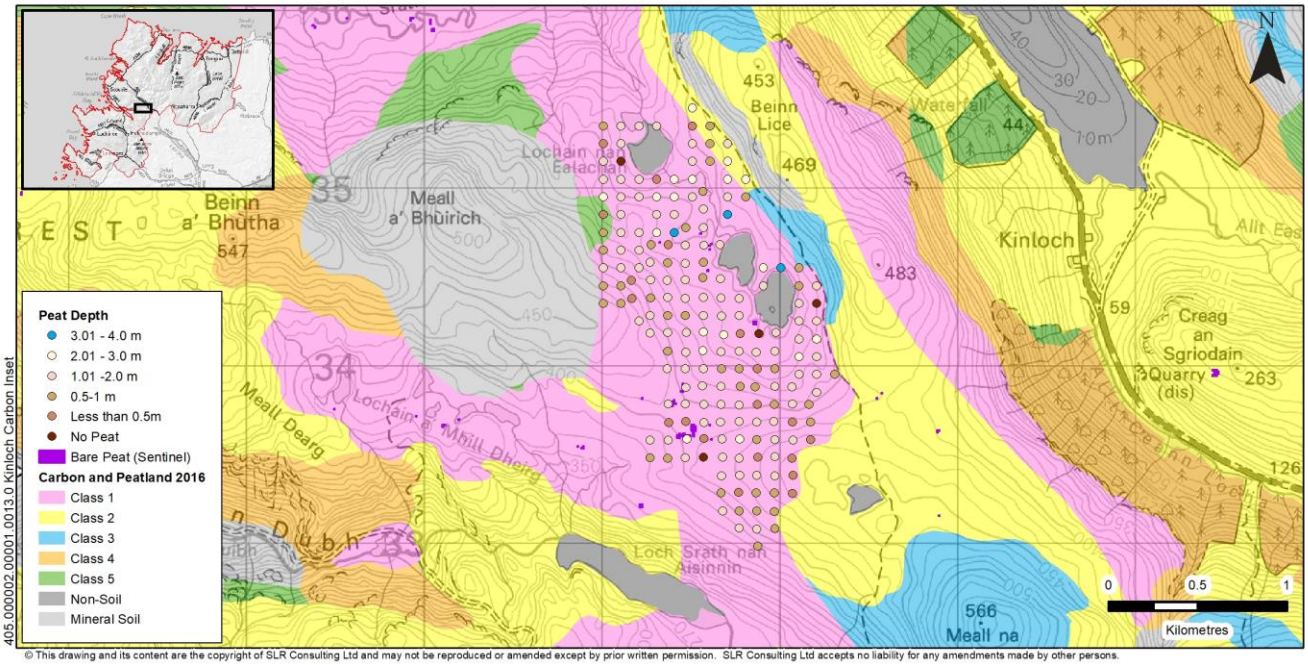
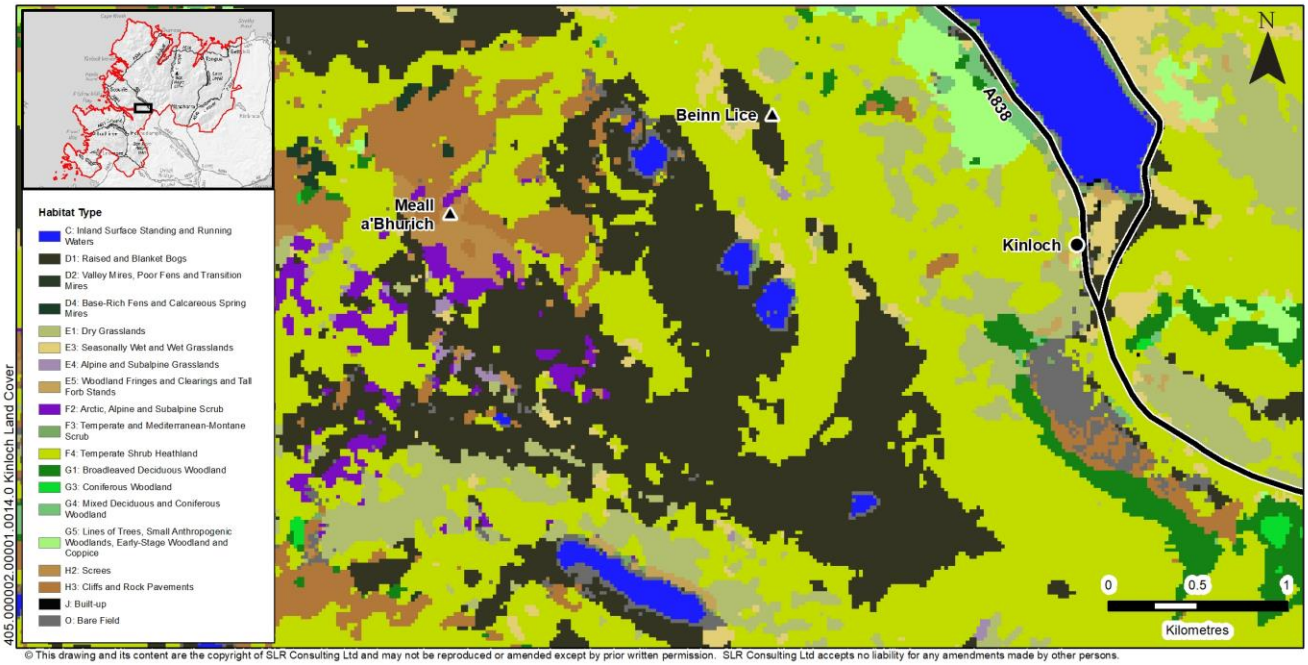


Figure 4-11
Habitat Types for Area West of Kinloch[34]



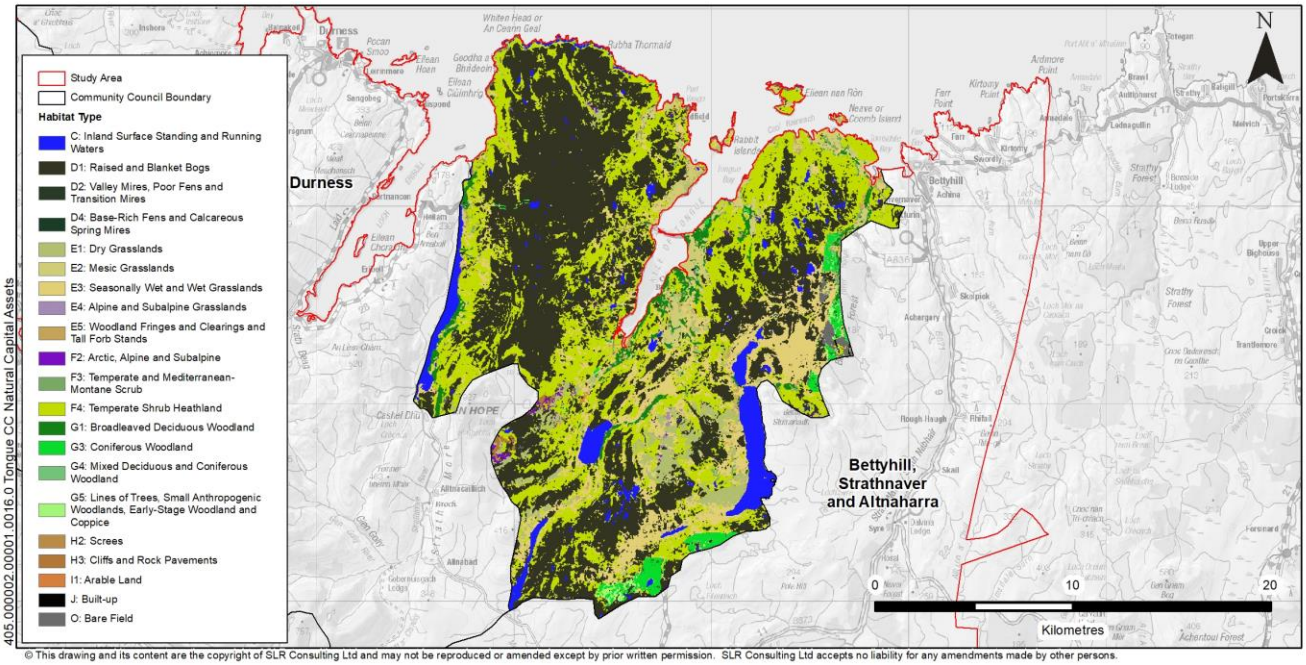
4.2.3 Other Ecosystem Services at the Community Council Level

As mentioned, there is very little arable land in the region and, apart from some patches that are capable to be used as improved grassland, most of the area is currently capable for use as rough grazings only[35]. (It is interesting to note that historical maps show cereal crops growing over a far wider area than they are today; the decline is

likely due is to a combination of changes in agricultural standards, socio-economic factors governing viability, or climate.) Crofting townships predominate, with common grazing for sheep and cattle. Crofters are increasingly using their crofts for diverse purposes including tourism and renewable energy. There are also some active aquaculture sites in the region[36] though these are predominantly seawater sites and are outside the scope of the Project.

Figure 4-12 shows the MTS Community Council area's habitats. Separate Common Grazing areas cover the settlements of Borgie, Skerray, Melness and Tongue. As part of the Project, all grazing clerks generously provided information. Questions are shown in Appendix 5 and below is a summary of responses.

Figure 4-12
Habitats in Melness-Tongue-Skerray Community Council[37]



The Borgie crofting settlement contains 1,488 hectares of common grazing, plus nine crofts across a further 50 hectares. About 25% of the land us used for crops, and the rest grazing by sheep and cattle. Bracken and whins are problematic invasives, covering approximately 10% of the area. Deer have also caused damage in the area (to hay crops) and predation by an unknown species caused the loss of 30 lambs in the summer of 2021. Muirburn is not used as a management operation, though has been in the past. There is no renewable energy, education tourism or other diversification activity in the settlement.

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[34] Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community. Contains SNH information licensed under the Open Government Licence v3.0.

[35] For more information, see the Land Capability for Agriculture maps: https://www.hutton.ac.uk/learning/natural-resource-datasets/landcover/land-capability-agriculture

[36] For details, see: http://aquaculture.scotland.gov.uk/map/map.aspx

[37] Basemap: Contains Ordnance Survey data © Crown copyright and database rights (2022) 0100031673. HLCM 2020: Contains SNH information licensed under the Open Government Licence v3.0.

The situation is similar in Skerray, though almost the whole area is used for common grazing. Similar invasive problems exist with bracken and whins (gorse), though the proportion of affected land is a little lower. Deer numbers have increased, with trees protected by fencing. Muirburn has not been carried out for many years, though they are considering this in the future. Loss of lambs happens, but to a lesser extent than identified by Borgie. There is limited diversification activity, although some land has been sold for housing. There is significant interest in peatland restoration for carbon storage, but a lack of available funding has meant that no projects have been established to date. (In Section 5, we explore how this is likely to change in the near future.)

The Spaceport[38] is being developed across 307 hectares of the total of around 4,450 in the Melness district. There are around 80 crofters across the estate, though only around a quarter use Common Grazings (for sheep and cattle). Some walking tours and stalking takes place on the land, and some of the land is used for crops. Wildlands Limited own significant parts of the land, and partly due to their actions, deer numbers in the area have declined in recent years. Concerns in the area include water security, lack of housing, affordability of crofts, and ensuring the whole community benefits from carbon and other ES markets.

The Tongue crofting settlement covers some 2,272 hectares, mainly for grazing cattle and sheep, with very few crops grown in the area. Muirburn is currently used, as is fencing around woodland areas and apportionments. Foxes are controlled to protect lambs. There is limited diversification activity in the settlement.

A short questionnaire about was circulated to the 'Community Leads Forum' which brings together representation from the MTS area via Frances Gunn, Chair of the UpNorth! Development Trust; eleven members of the MTS community responded to the questions which focused on the meaning of land for them. Food production and recreation were mentioned by many respondents, and inspiration was a common theme: a return to sanity; a belief in a higher power; a sense of place; and good mental health. The need for more affordable housing, sustainable energy, income from carbon storage, and food production were all mentioned as priorities for improvement. The Spaceport was mentioned by many as an example of encouraging new industries and job opportunities.

4.3 Benefits to People

The value of biodiversity is multi-faceted and it is not particularly meaningful to try to assign monetary values to biodiversity as a whole. Most other ES are supported by biodiversity and would not be possible without the species that support them. Conversely, it is possible to put a monetary value on carbon storage and Section 5 that follows includes a discussion of what this value is, including implications for the North West Highlands.

In Section 3, we noted that Scotland's Natural Capital Asset Index[39] (NCAI) is an example of a 'matrix' approach to measuring ES. NatureScot first published the NCAI ten years ago, and it represents an attempt to track the relative contribution of habitats to the well-being of those who live in Scotland. In their categorisation, 'biodiversity' is understood not as a separate ES, but as a supporting service, and is part of the suite of indicators used (e.g. bird and butterfly indicators). The most important ES per the NCAI is climate regulation, though it is worth noting that this is estimated at little more than 8% of the overall well-being contribution of all ES in Scotland. Soil formation (6%), pest and disease control (5%) and 'mediation of mass flows and erosion' (5%) are other important services according to the NCAI[40].

Scotland's Natural Capital Accounts were first published in 2020 and are arguably a misnomer, identifying as they do three-quarters of the annual monetary flow value being from fossil fuels (£11.6bn from a total of £15.6bn).

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[38] Full Planning Application documents for the Spaceport, including Environmental Impact Assessment and Economic Impact Assessment, can be found on The Highland Council website: https://wam.highland.gov.uk/wam/applicationDetails.do?activeTab=documents&keyVal=Q5CD2AIHKTF00

[39] For more information about the NCAI, see: https://www.nature.scot/doc/scotlands-natural-capital-asset-index-2022-summary

[40] Of course, the way that ES are classified influences how we perceive importance. For 'food', the NCAI includes 'cultivated crops' (3.85% of overall importance), 'reared animals and their outputs' (2.88%), 'wild animals, plants and algae (and their outputs)' (1.73%) and 'animals, plants and algae from in-situ aquaculture' (also 1.73%). Much, though not all, of these ES are related to food.

Because fossil fuels are non-renewable, their asset value of £51bn represents 'just' one quarter of the £206bn total, with recreation's value being higher at £62bn. The asset value of carbon sequestration is estimated at over £38bn, with gross carbon sequestered of 3.17 million tCO2e having an annual flow value of £0.75bn. Also included in the accounts is 'agricultural biomass' including crops, fodder and grazing. This has an asset value of £17bn, with the annual value being £651 million. Biodiversity does not feature explicitly in the accounts[41]. The figures quoted in this paragraph require caveats and explanations that are outside the scope of SLR's work. Most importantly, the conception of 'exchange value' for these monetary estimates is not the same as the 'welfare value' definition that is of interest for making choices related to human well-being. There is a disconnect between how much people are willing to spend to visit the area ('hedonistic pricing')[42] and the self-reported state of health and well-being for the population living here[43]. The reason for this disconnect could be an interesting and useful question for partners to interrogate in future work.

Formal accounting for natural capital is at an experimental stage, and there are significant gaps in terms of what can be measured. The NCAI and Natural Capital Accounts are both attempts to highlight the importance of nature for people, the former in welfare value terms, and the latter in exchange value terms (i.e. equivalent to market values). The accounts include abiotic assets such as oil and gas deposits, whereas the NCAI does not.

[41] Ecosystem services are catagorised differently in the accounts compared with the NCAI. Included in the 2022 accounts are: a) 'Provisioning services' of agricultural biomass, fish capture, timber, water extraction, minerals, fossil fuels and renewable energy; b) 'regulating services' of carbon sequestration, air pollution removal, noise mitigation and urban cooling; and c) 'cultural services' which are not separately categorised, but where analysis largely relates to recreation and tourism only. See https://www.gov.scot/publications/scottish-natural-capital-accounts-2022/documents/ for more information.

[42] https://www.researchgate.net/publication/344385042_Blue_space_health_and_well-being_A_narrative_overview_and_synthesis_of_potential_benefits

[43] https://www.aspiringcaithnessandsutherland.com/_files/ugd/b606bb_8d7f011e8e994f72add5a70de8f01560.pdf

5.0 Carbon Storage and Sequestration

Climate change is by far the most prominent environmental issue globally. The commitment to achieve net zero in Scotland by 2045 has implications for every environmental, social and economic issue facing the North West Highlands. This section explores the implications of net zero, given what we know about the status of natural capital assets and other capital assets in the region.

Carbon is atypical insofar as the source of sequestration (or emission) is irrelevant: for every other ecosystem service, there is a closer spatial link between supply and demand[44]. Benefits of carbon stored in the NW2045 region's habitats are shared globally but costs to enable sequestration (or mitigate emissions) are generally incurred locally. A Just Transition requires at the very least that if the overall benefits of maintaining and adding carbon storage in the NW2045 region are judged to exceed costs, then it is not local communities who lose out.

Per Scotland's Natural Capital Accounts, carbon sequestration assets are some £13bn less valuable than fossil fuel assets – this cannot be the case if Scotland is interested in mitigating climate change; more of the fossil fuels need to be recognised as 'stranded assets', never to be exploited – and the £38bn carbon sequestration asset value is based on an experimental methodology. A fuller explanation is included in Appendix 1, but for our purposes one useful estimate is that the 'non-traded price of carbon', representing *societal value* of one tonne of carbon dioxide equivalent (tCO2e), is valued at £248 in 2022. This is the 'non-traded price of carbon', used by the UK Government to appraise all projects and policies.[45]

Carbon stored in the North West Highlands is extremely valuable to society: if one tCO2e has a societal value of £248, then the estimated 68.7 million tCO2e stored within the NW2045 region is worth a remarkable £17bn. (This figure is distinct from the price that some of this carbon might realise via the nascent carbon markets; see section 5.1.) It is also true that an extra tonne of emissions has costs equivalent to the benefits provided by an extra tonne of sequestration: in a net zero nation, all emissions must be offset.

Cycling of carbon tends to be in equilibrium for upland habitats if they are in good condition (Baggaley et al, 2021[46]). Unfortunately, 80% of Scotland's peatlands are in poor condition (although this proportion is lower in the North West Highlands), and therefore act as a source of emissions, in the order of 6 million tCO2e every year (Defra, 2017[47]). IUCN[48] estimate that emissions from drained (dry) peatlands are around 2.5 tCO2e per hectare per year, and for eroding (bare) peatland almost 25 tCO2e per hectare per year.

There are insufficient market incentives (or regulatory requirements) to protect peatlands. The societal value of carbon is an order of magnitude higher than current market prices for carbon; it is challenging to establish markets, and 'market failure' is common. Markets tend only to value projects that demonstrate additional carbon sequestration (or emission reductions) over time, and not the storage itself. Only a minuscule percentage of the £17bn societal value of carbon stored is reflected in (peat)land asset prices. Not only is the true value of carbon storage only partly reflected in market prices, but perverse incentives abound because peatland in degraded condition can be a more valuable asset than peatland in good condition: where there is degradation there is the

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[44] The 'Service Providing Area' for carbon sequestration is spatially separated from the 'Service Benefitting Area' (the service is said to be 'non-directional').

[45] For an explanation of how the 'non-traded price of carbon' is calculated, including why it is far higher than traded carbon values, see https://www.gov.uk/recgovernment/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation.

[46] http://dx.doi.org/10.7488/era/1021

[47] https://uk-air.defra.gov.uk/library/reports?report_id=980

[48] https://www.iucn-uk-peatlandprogramme.org/peatland-code-0

opportunity for restoration, and hence income. Incentives for peatland 'capital maintenance' are not sufficiently delivered by private markets.

It is logical, therefore, to wonder whether the 50 million plus tonnes of carbon stored in NW2045's peatlands is better framed as a potential £12bn liability rather than an asset (by definition, an asset provides future income flows). This perspective points to the importance of avoiding further deterioration of peatlands, and the evidence that benefits of restoration exceed costs is overwhelming[49].

The remainder of this section explores how carbon markets are emerging in Scotland, and how market and institutional arrangements mean that communities in the North West Highlands and elsewhere in Scotland risk missing out on a share of benefits. The Section concludes with an urgent call for the regulation of carbon markets such that communities like those throughout the NW2045 region are able to increase the carbon stored in habitats, and also contribute to equitable socio-economic prosperity via local job opportunities.

5.1 Carbon Markets

The term 'carbon market' refers to both mandatory and voluntary arenas for trade. The former is where organisations are legally obliged to offset their emissions, the largest example of which is the European Union's Emissions Trading System. Voluntary carbon markets in the UK include the Woodland Carbon Code (WCC) and the Peatland Code (PLC), and market participants enter freely. Incentives to 'voluntarily' offset carbon emissions have increased significantly in recent years, and not only because of policy targets such as net zero. The largest 1,300 UK-registered listed companies are now required to disclose climate-related financial information, and many have their own net zero targets. Almost every organisation, whether public or private, faces pressure to reduce its emissions.

The current framework includes the WCC and PLC alongside the UK Land Carbon Registry which, as the name suggests, is a database that stores and publicly displays data about the status of all WCC and PLC projects. The Scottish Government endorses these codes and provides institutional support and funding, for example through the Forestry Grant Scheme and the Peatland Action Fund.

To 31 March 2022, 119 projects over 4,400 hectares and almost 2 million tCO2e have been verified for the WCC across the UK, and almost 1,500 more projects (over 50,000 hectares; almost 17 million tCO2e) are validated or awaiting validation[50]. This is a moderate amount, but there has been significant progress in the past five years: at March 2017 only three projects had been verified. The NW2045 region has no verified projects and only three validated WCC projects to date: 189 hectares at Druim Suardalain just east of Lochinver; 144 hectares at Ledbeg; plus a further 89 hectares nearby at Ledmore. The PLC is nascent, with no verified and only 15 validated projects across the UK as at 20 May 2022. In NW2045, projects are under development covering 131 hectares at Cul Mor in Assynt, and 111 hectares at Swan Lochs in Achfary, though each are yet to be validated.

Income flows depend on market prices for carbon, rather than societal values. Reliable information about market prices is not available, though prices via the WCC and PLC are somewhere around the range of £15-£20 per tCO2e; as noted, this is an order of magnitude lower than social values. Future predictions to 2050 of prices between 50 and 100 dollars per tCO2e are common[51], and potentially far beyond this especially given demand from UK companies for UK-based carbon sequestration and the quality assurances provided by schemes such as the WCC and PLC.

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[49] For example, Horsburgh et al (2022) estimate that 65% of Scotland's peatlands could be restored for a cost of between £2 and £17 per tCO2e saved. https://doi.org/10.1016/j.jenvman.2022.114486

[50] For the WCC and PLC, there is an initial project check to check whether statements about predicted carbon sequestration are correct, and this is referred to as 'validation'. Verification is ongoing evaluation to assess actual carbon sequestration. More details can be found on the WCC website: https://woodlandcarboncode.org.uk/landowners-apply

[51] For example, see: https://www.inenco.com/insight/blog/voluntary-carbon-market-predicted-to-rise-tenfold-by-2050/

The limited activity under the WCC and PLC to date can in part be explained by the fact that all projects must be 'additional'; they must not have been financially viable without the income from carbon markets. The additionality requirement protects the integrity of voluntary carbon markets – buyers of carbon units via the WCC and PLC can be confident that extra carbon sequestration has occurred *because of* their purchase – but adds significant transaction costs. The tests for additionality for the WCC are due to be simplified from October 2022, but will remain off-putting to many. Involvement in carbon markets such as the WCC and PLC is not always salient, particularly for companies with their own emissions to offset. Two high-profile examples being BrewDog's purchase of large parts of the Kinrara estate, or Shell's £5 million outlay to extend the Glengarry forest. In these examples, companies are looking to offset their own carbon emissions through land purchases and associated tree planting and/or peatland restoration, and although any claims will be certified this will not necessarily be via the WCC or PLC, because they are unlikely to pass additionality tests

5.2 Consequences of Carbon Markets

Three potential implications of carbon markets will be introduced in this sub-section, each of which has significance for the NW2045 region: the influence on rural land markets; impacts on other ecosystem services; and inclusion in decision-making and benefit distribution.

Recent research from the Scottish Land Commission (McMorran et al. 2022) found that Scottish farmland value increased by almost a third in 2021 alone (with the value of poor livestock land increasing by over 60%), and that 'agriculture quality is no longer the key determinant of farmland value'. High prices for timber, competitive forestry grants and carbon markets are cited as drivers. The £247 million invested in Scottish estates in 2021 was more than double that in 2020. Carbon offsetting opportunities, including from corporate buyers, is cited as a key reason for the increase in demand. These trends are particularly relevant for the NW2045 region as carbon is, "of greater importance in upland regions and areas with larger extents of peatland, lower quality agricultural land and smaller less productive farm holdings." (McMorran et al. 2022, Page 40). Land sales are increasingly being carried out 'off-market' which reduces transparency and means that some buyers, including local residents interested in community buyouts, are excluded. A combination of very high demand and limited supply threatens to severely constrain access to land for new farming / crofting, as well as other rural business and community purposes.

Guidance for the WCC suggests that projects have safeguards in place so that 'environmental impacts are likely to be positive' and part of the verification process includes a requirement in the Project Design Document to demonstrate impacts including to species, designated sites and visual character. For the PLC, the required Restoration Management Plan includes environmental impacts such as biodiversity. There are also Environmental Impact Assessment requirements for some afforestation and peatland restoration projects. That said, none of this amounts to a legal compliance audit, and there is no requirement to monitor environmental impacts over time. Requirements are more stringent where WCC projects receive funding through the Forestry Grant Scheme (e.g. compliance with the UK Forestry Standard, which has diversification stipulations) but if carbon market prices increase there will be less need for government support, especially if driven by corporates looking to offset emissions. There is therefore a risk that a focus on just one ecosystem service – carbon sequestration – is to the detriment of other services, most of which are even more invisible in markets. National policies such as the Land Use Strategy and Land Rights and Responsibilities Statement recognise the need for stewardship of Scotland's natural resources, but the existing design for both the WCC and PLC does not ensure that environmental impacts aside from carbon are positive.

WCC projects last up to 100 years, with the landowner committing to permanent land-use change. PLC projects are for a minimum of 30 years. Clearly, decisions made today will have consequences far beyond 2045. Both the WCC and PLC include provisions for local community engagement, but there are similar issues as with wider environmental impacts: recommended good practice does not equate to a requirement, and therefore community needs are inadequately considered. The Just Transition Commission explicitly noted the need for fairness: "Without careful design and meaningful engagement there is a risk that [carbon sequestration] benefits

may flow mainly to large landowners and opportunities for community benefit will be missed." Robbie and Jokubauskaite (2022, page 12) point out two issues that exacerbate this problem: landowners receiving public grants that can generate carbon units (part of the controversy over BrewDog's purchase of Kinrara includes their potentially receiving over £1 million from the Forestry Grant Scheme), and with peatland restoration landowners might be rewarded for rectifying damage they have caused in the past through unsustainable land management.

5.3 Policy Options

Recommendations for the NW2045 RLUP are included in Section 6 of this report. This section's final sub-section takes a broader perspective, and reviews national policy options that are urgently required in order to mitigate the potential negative consequences as set out above.

Dieter Helm chaired England's influential Natural Capital Committee between 2012 and 2020, and has advised the Scottish Government on post-Covid recovery. In a recent discussion paper for the Scottish Land Commission (Helm, 2022) he explains why there is confusion in the carbon offsets discussion, and questions the credibility of Scotland's climate change policy. One issue he identifies is that carbon offsets are being used by companies to facilitate emissions. He calls for example for peatlands to be properly treated as a public good and for the government to pay for their protection and enhancement[52], rather than allowing companies to offset their own emissions through restoration projects. Helm argues that by treating carbon storage as a private good – it is a public good - the Scottish government's net zero target is a myth. Helm, however, recognises the reality is that private incentives are also required to provide public goods, such as via carbon markets, and suggests three steps for this:

1. Work out how to value a carbon offset;
2. Ensure that there are no losses to other natural capital; and
3. Prevent social capital consumption.

For (1) above, Helm recommends an independent baseline assessment of carbon storage and for any offsets to be net of 'capital maintenance'. This means for example that if land use changes – say from open hills or farmland to forestation - carbon that otherwise would not have been emitted is taken into consideration. Next, genuine additional carbon sequestration requires carbon impacts of the improvements themselves to be deducted. For tree planting, the labour for planting has associated carbon emissions, as does protecting saplings from deer, or squirrels and voles. Pest control has associated carbon emissions (e.g. from vehicles and equipment use). These are all complicated calculations, as is consideration of the end of life for trees. There is no scheme of accreditation / verification of carbon offsets that takes all of Helm's points into account, and the estimates of monetary carbon sequestration in Scotland's Natural Capital Accounts are for 'gross' land-use changes only and also do not consider emissions associated with habitat management.

For (2), Helm makes the point that increasing carbon in soils tends to be correlated with increased biodiversity too[53]. But with trees, and in particular conifer, this is often not the case. This is why he recommends a natural capital baseline: the net zero carbon target must not lead to damage to other natural capital assets.

For (3), Helm urges caution in allowing private landowners to sell carbon offsets to private companies, describing the current situation as a "wild west" of offsetting, and says that the government needs to clearly define the rules. His conclusion is that: "Rebuilding vibrant communities throughout Scotland, around great natural capital, should help to maintain and enhance social capital. It would be a tragedy if instead a rush for carbon offsets considered in isolation from the other natural capitals resulted in another clearance – this time with local people

[52] 'Public money for public goods' is a more pithy way of making the same vital point.

[53] Also nutrient retention, water infiltration and reduced runoff and flooding. See the Scottish Government's recent 'Soil Organic Carbon Sequestration: Scoping Study' (here) for more information.

displaced for carbon harvests in dense single-species forests, following on from the displacement by sheep." (page 13).

The Scottish Land Commission has recently published a 'Responsible Natural Capital and Carbon Management Protocol' for landowners and other relevant organisations, and Community Land Scotland have published an insightful paper ('Community Wealth Building and a Just Transition to Net Zero'). Robbie and Jokubauskaite (2022) outline four possible models for regulation of carbon markets, with extremes being the current situation ('facilitative model' which the authors politely describe as 'sub-optimal') and full prohibition of carbon unit trading. Other models are 'public carbon planning' whereby the Scottish Government actively shapes carbon markets for instance via NPF4, and also introduces measures to "Integrate carbon project planning within the emerging Regional Land Use Partnerships." (page 17). The final model is 'enhanced oversight of carbon markets in the public interest' for example with a Carbon Commissioner, which the authors compare to the Tenant Farming Commissioner role. SLR believe that either of the latter models could be suitable for Scotland, so long as Dieter Helm's recommendations are incorporated. If RLUPs are tasked with carbon project planning, it would of course be necessary to ensure funding for what will be a vital coordination role, facilitating partnerships between landowners and communities.

As noted, these recommendations require action at the national policy level, but are of such importance that all RLUPs will be severely hindered without clearer rules, and none more so than NW2045, with its exceptional peatland habitats. The Scottish Government's laudable recent Interim Principles for Responsible Investment in Natural Capital[54] – which focus on integrated land use, community benefits, engagement, environmental integrity and diverse land ownership – are simply not going to be realised without carbon market reforms. Consultation on the Land Reform Bill is open until 30 October 2022[55], with a view to its introduction by the end of 2023. This is an essential opportunity to ensure that communities benefit from Net Zero.

[54] https://www.gov.scot/publications/interim-principles-for-responsible-investment-in-natural-capital/

[55] Land Reform in a Net Zero Nation: https://consult.gov.scot/agriculture-and-rural-economy/land-reform-net zero-scotland/

6.0 Recommendations

The Highlands of North West Scotland are extraordinary: rugged coastlines, beautiful landscapes and dramatic peaks provide spectacular. Multiple national and international designations underline the area's qualities – from many diverse Sites of Special Scientific Interest (SSSI) which cover almost 70,000 hectares, to the 200,000 hectare UNESCO World Heritage Site Geopark; the area is home to some of the most distinctive plants, animals, rocks and landforms in the nation.

The urgency of the climate and biodiversity crises present an opportunity for real change. There are few places in the UK with the wealth of natural capital assets as in the NW2045 region, and this can drive local prosperity if the benefits are properly recognised and equitably shared. Socio-economic challenges are acute, not least population declines. The NW2045 region covers 3.6% of Scotland's land mass, but has just 0.06% of the population: the population density is some sixty times lower than the national average, with each square kilometre containing only one person.

This Natural Capital Assessment can help NW2045 realise its Vision, but it is a modest start, representing just one element of what is needed. But the urgency of the climate and biodiversity crises means that there is an opportunity for real change.

This final section begins with a note of the limitations of the Project, and then sets out key drivers of change and recommendations for NW2045's future work.

6.1 Limitations of the Project

The research carried out for the Project has largely been desk-based, and the maps are only as good as the information we have used to generate them. That said, a lot of the information sources are of high quality and community support has been immensely helpful throughout. The three main categories of mapping carried out for this project (natural capital assets; biodiversity; and carbon storage) are of sufficient accuracy that they can be the basis for land-management decisions.

SLR initially intended to use the InVEST tool to map asset quality but, as detailed in Appendix 1, it was judged to be of limited use for the NW2045 region. Appendix 2 details our attempts to collect spatial data for this project, and we reviewed over 200 datasets. Unfortunately, coordination between the numerous government agencies, research bodies and other organisations is challenging and important sources might have been missed. The Scottish Government's proposed mapping app created for the RLUP pilots would have been very helpful for this project, though SLR understand that technical issues mean that there is an indefinite delay. It is important that RLUPs such as NW2045 have better data management support, as it is currently difficult to collect and interpret what is available[56]. We encourage readers to interrogate Appendix 2: what datasets should SLR have used, and how could it have improved our analysis?

Other limitations related to resources and scope include:

- The SLR project team is not based in the Highlands, although we live in Scotland, are familiar with the North West Highlands from past visits, and have taken guidance from the NW2045 Steering Group;
- Marine habitats are not included in the analysis;

[56] The need for digital integration of land-use statistics in Scotland has been made by Gagkas (2021) 'Scoping for developing an integrated digital data approach for land-use statistics in Scotland' (available for download here).

- ES that we have not attempted to map include: clean water; aquaculture; timber; air pollution mitigation; pest control; flooding control; recreation; and tourism.
- Beyond recreation and tourism, cultural ES cannot readily be mapped without community participation (Burkhard, 2017) and this is an issue for all NCAs that requires proper resourcing and careful analysis;
- We have tried to identify key drivers of change (particularly in Section 5 and 6.2 below) and as appropriate for this stage this has been done at a high-level; and
- Explicit monetary valuation has only been carried out for carbon storage. Monetary valuation is only one way to understand human preferences, and can overshadow other socio-cultural values delivered by ecosystem services.

6.2 Drivers of Change in the North West Highlands

The Driver-Pressure-State-Impact-Response (DPSIR) Framework[57] can be useful for understanding complex environmental and social systems. As described in Section 2, IPBES have identified land-use change, climate change, resource extraction, pollution and invasive alien species as key *drivers* of natural capital decline. Section 5 of this report mainly details Scotland's *response* to climate change, and the associated socio-economic (e.g. inequalities, land price increases) and environmental (e.g. carbon storage, other ES) *impacts*.

In this sub-section, we briefly discuss the main drivers of change for the North West Highlands context, namely land use and climate change. Scottish Government policy responses are noted, although our discussion is not intended to be exhaustive. The table in Appendix 4 sets out the main drivers of habitat change and the most notable responses per the fourth National Planning Framework (NPF4).

Land use is likely to be the biggest driver of change both of habitat type and condition and therefore of biodiversity value. Scottish Government policy and growth in markets relating to carbon sequestration are likely to result in an increase in afforestation and bog restoration. Growth in the voluntary biodiversity market is also likely to result in an increase in both of these activities alongside habitat condition enhancement for a wider range of habitats, potentially involving reducing herbivore populations to appropriate levels to support these aims as appropriate.

Climate change will also change the suitability of areas to support different habitats via changes in annual patterns of rainfall and temperature, as well as increases in extreme events including flooding and wind storms[58]. Policy responses to climate change, such as river restoration, bog restoration and tree planting will in turn influence drivers of change.

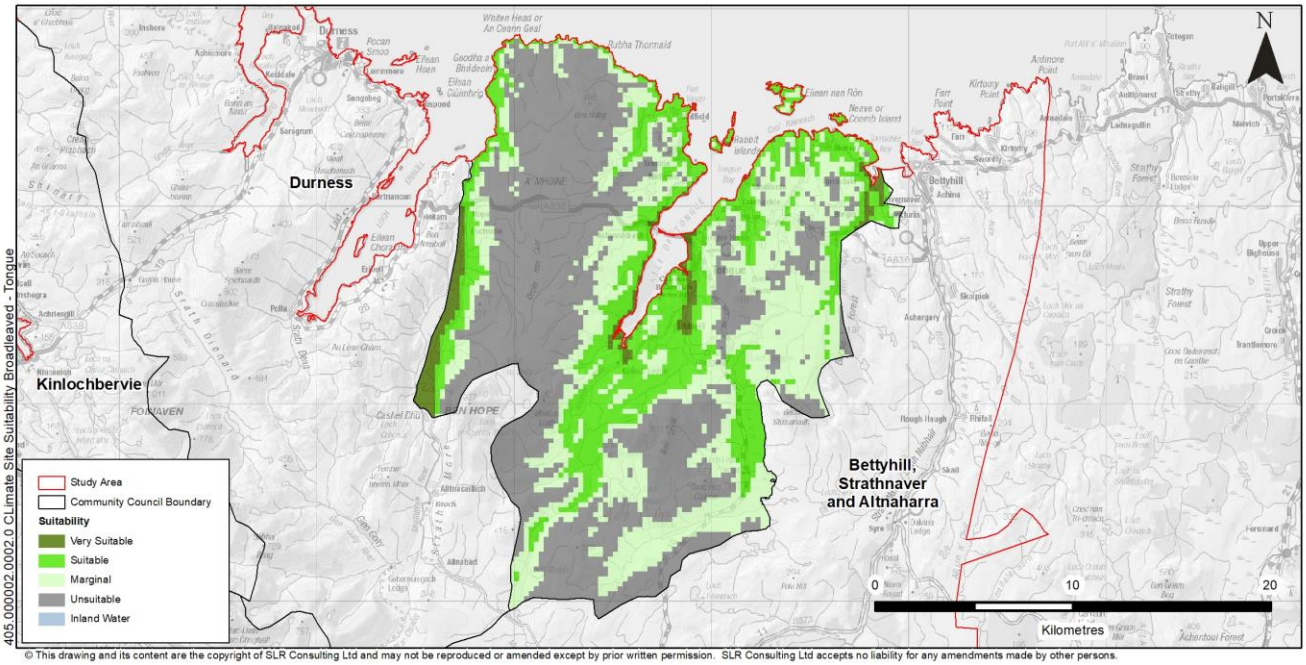
Repopulation of the Highlands is a theme in the NPF4, and the Scottish Government are committed to developing a strategic plan concerning depopulation across Scotland by early 2023. In MTS, as part of the community engagement survey that was completed by eleven residents for the Project, the provision of housing for young families was mentioned multiple times as vital. Housing is recognised as a key factor needed to rebuild communities in the region, and the Highland Council's recently announced scheme to buy properties was welcomed, although cap on cost is a major limitation - there are no properties in the area that would be under it. Community Councils were identified as important, as was the need to include the voice of people who live, work on and have shaped the land.

For a holistic approach, biodiversity and carbon storage maps can be used to help make decisions about housing developments, as can some of the other environmental spatial information listed in Appendix 2. As an example, Figure 6-1 shows areas in MTS suitable for broadleaved woodlands.

[57] An overview of the DPSIR Framework can be found here: https://encyclopedia.pub/entry/3195

[58] For more information about how land temperatures and rainfall are already affecting Scotland, and projections for the future, see here.

Figure 6-1
Broadleaves Suitability in the Melness-Tongue-Skerray Area[59]



Other policy responses to the environmental, social and economic issues facing the North West Highlands have been discussed throughout this report, including the draft Scottish Biodiversity Strategy, the Just Transition Commission, the Land Reform Bill, and of course the RLUPs and proposed Regional Land Use Framework. Also of key importance is the review of the Highland-wide Local Development Plan[60] which is being undertaken.

6.3 Recommendations for NW2045

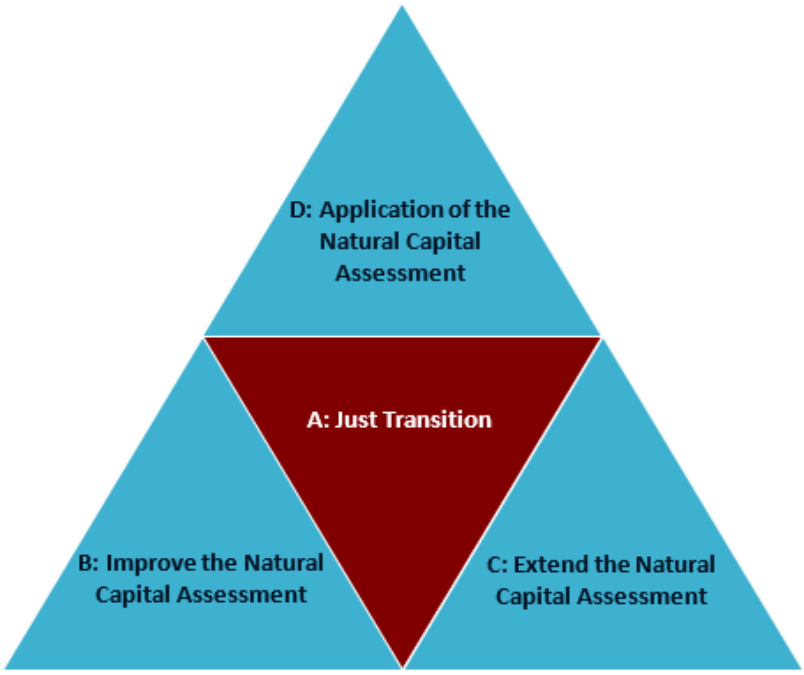
SLR have 15 separate recommendations for NW2045 and partners to use a natural capital approach to help achieve its 2045 Vision. These are divided into four areas:

- Just Transition (A1 to A4): Success for NW2045 and other RLUPs is contingent upon a Just Transition to net zero, in which costs and benefits are shared fairly and communities have meaningful opportunity to engage. These recommendations are mainly outside of NW2045's control, except to the extent that the Scottish Government respond to feedback from the RLUPs;
- Improve the NCA (B5 to B7): A critical review of the Project's data collection and mapping for the initial natural capital assessment, including via community feedback;
- Extend the NCA (C8 to C12): Ensure that the Project is not a one-off exercise, but is rather the basis for ongoing and robust natural capital measurement for the North West Highlands; and
- Application of the NCA (D13 to D15): Begin using the natural capital assessment now, even though it is imperfect. As confidence and familiarity improves, ensure that the natural capital approach is embedded in all land-use decisions.

[59] FGS Climate Suitability Broadleaved: Reproduced by Permission of Ordnance Survey on behalf of HMSO. © Crown copyright and database right 2022. Ordnance Survey Licence number 100021242.
[60] https://www.highland.gov.uk/info/178/local_and_statutory_development_plans/199/highland-wide_local_development_plan

Figure 6-2 illustrates these recommendations, with a 'Just Transition' being the essential foundation for all of the other recommendations that follow. To give some indication of timescales, recommendations in **bold** could, with funding and capacity support, reasonably be enacted within the next year (i.e. by October 2023).

Figure 6-2
Recommendations Around Four Themes



A: Just Transition

A1: Proper financial and institutional support for RLUPs, including the delayed mapping app. Without this, most recommendations made below will not be possible to implement. Reed et al. (2022, page 28) conclude that 'long-term, core funding for RLUP co-ordinators' is of particular importance, alongside the facilitation of natural capital assessments and market funding opportunities.

A2: Ensure that the Interim Principles for Responsible Investment in Natural Capital[61] are fully incorporated into relevant arrangements including: Community Wealth Building; the Land Rights and Responsibilities Protocols; the WCC; PLC; and National Strategy for Economic Transformation. The current rush for land acquisitions from private organisations - often primarily to secure carbon credits - is inadequately supervised, opaque, and as set out in Section 5 is potentially damaging for communities.

A3: Mandate the requirement for 'biodiversity net gain' for new developments in NPF4. The current draft framework looks to secure 'positive effects for biodiversity', but there is no consistent way to measure and monitor the biodiversity being lost. SLR recognise that measurement is difficult, but attempts being made in England to mandate the use of the Biodiversity Metric 3.1 – and adopted by SLR as part of its biodiversity mapping for this project – address the urgency of the biodiversity crisis.

A4: Ensure public money supports the protection and enhancement of public goods. There is an opportunity for post-CAP arrangements to provide better outcomes for public goods, and for the RLUPs to be a key forum for agri-environment decision-making. This can be supported by robust natural capital accounting at both the

[61] Interim Principles for Responsible Investment in Natural Capital - gov.scot (www.gov.scot)

national and regional levels, including information about 'capital maintenance' costs (see recommendation C12). This will include things like a publicly accessible database of peatland projects, and mapping of muirburn licences.

B: Improve the NCA

B5: Critically evaluate the Project's methodology and use of data (as set out in Section 3 and Appendices 1 and 2). How could our mapping be improved? Are other RLUPs approaching the challenges in a different way? Which datasets could we have included? For example, to increase confidence in SLR's biodiversity assessment, we recommend that a few small areas are selected using a stratified sampling approach. The GIS model could be interrogated to identify areas with the highest potential for biodiversity improvements in line with local goals (e.g. habitat condition enhancement, afforestation, farmland expansion etc.). SLR also recommend that a fauna-specific mapping assessment be undertaken for biodiversity.

B6: Use the Storymap to engage communities, demonstrating this Project's carbon storage and biodiversity assessments. Ground-truth the maps and build understanding of synergies and trade-offs.

B7: Work with other RLUPs to summarise initial lessons from natural capital baseline assessment efforts. This could have a joint purpose of raising awareness (being advocates for the natural capital approach) and to promote good practice and consistency amongst RLUPs. It could also help to highlight the data challenges that all RLUPs are facing, demonstrating the need for further support from the Scottish Government.

C: Extend the NCA

C8: Map more ES. Priorities should include food, education, recreation and tourism. SLR advise NW2045 to pick from one of the many available classifications of ecosystem services, and systematically decide – with community input – which ES are not relevant or necessary to map. All others should be mapped to provide a holistic framework for land-management decisions. Gaps in data and knowledge should be transparent, but a limited focus on easy to map ES means that there is a risk of ignoring others.

C9: For NW2045 or a partner body to host the Project's Storymap and work closely with partners to ensure regular updates. This will help to engage communities in the longer term (e.g. recommendation B6 above) and can be a 'live' means of communicating progress (e.g. as ES are mapped they are added to the Storymap).

C10: Include marine habitats in the natural capital assessment. This will be challenging (many other assessments, such as the NCAI, do not include marine habitats[62]) but necessary. The draft NPF4, for example, places an emphasis on building thriving coastal communities in the North West Highlands, supported by the 'blue economy'.

C11: Carry out valuations for a fuller range of ES, using methods that recognise enable more than one ES to be assessed simultaneously, where possible, especially for cultural ecosystem services. SLR highly recommend that the recent IPBES Values Assessment[63] guidance for policymakers is used and promoted by NW2045 to investigate the 50-plus methods available to incorporate diverse values into policymaking. This will help to ensure that both supply and demand for ES are considered, including visibility of where supply is spatially located away from demand (as with carbon storage).

C12: Pilot formal natural capital accounting for one community council area in the NW2045 region (possibly MTS), whilst recognising that accounting efforts are experimental, incomplete and that the monetary values represented are 'exchange values' rather than 'welfare values' (see recommendation C11). Accounting includes: a register of all natural capital assets; a statement of ecosystem service flows in biophysical terms; a statement of ecosystem service flows in monetary terms; a schedule of maintenance costs; and a balance sheet.

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[62] A feasibility study by the Marine Biological Association reviewed the potential for adding marine habitats to the NCAI, including suitable indicators: https://www.mba.ac.uk/projects/feasibility-study-marine-natural-capital-asset-index-scotland

[63] This was released on 11 July 2022: https://ipbes.net/media_release/Values_Assessment_Published

D: Application of the NCA

D13: At the community council level, beginning with MTS, identify and map opportunity hotspots for improving certain ES and/or achieving defined development outcomes[64]. This will include participatory approaches and citizen science projects (e.g. measurement of peat depths), and will necessarily be an iterative process as recommendations B5 to C12 are implemented. NW2045 can begin to review the drivers of change alongside SLR's mapping outputs straight away, as the information for such decisions will never be perfect.

D14: Facilitate local delivery and community benefit from natural capital markets, including local job creation. This will be driven by the WCC and PLC but also international carbon markets (e.g. with methodologies approved by Gold Standard and Verra) as well potential future UK markets such as the Hedgerow Code, Saltmarsh Code and Farm Soil Carbon Code. A priority needs to be peatlands, including 'capital maintenance' costs. In England, Biodiversity Net Gain for developments will be mandatory from 2023, and though this is not yet the case in Scotland, biodiversity markets are yet another potential source of income. NW2045 and other RLUPs should try to ensure that communities share in the income-generating opportunities. In part this is by influencing national policy (e.g. post-CAP rules), but also by ensuring market integrity and helping communities navigate what is an increasingly complicated market landscape.

D15: Use natural capital evidence to support investments. Make use of other available tools and initiatives, including following NatureScot's approach used in the Tweed catchment and also their landscape-scale natural capital tool[65], Peatland ACTION, Riverwoods, and the excel-based models being provided by the Scottish Government to understand local economic impacts of a) coastal restoration; b) peatland restoration; c) woodland creation; and d) regenerative agriculture.

The recommendations require significant resourcing, but there is an opportunity to regenerate the North West Highlands, spurred by the urgency of the climate crisis and associated income sources. The natural capital approach requires partnerships, and we conclude with the hope that the admirable work being undertaken by NW2045 and by dozens of other organisations and hundreds of individuals in the region can include these 15 recommendations.

[64] This could include modelling future scenarios. For example, the InVEST model has been used in this project to estimate carbon storage. It is possible to include multiple scenarios for future land use and land cover and the InVEST model will calculate differences in storage.

[65] This tool is under development and aims to support integrated and collaborative approaches to land management, and so will be of particular relevance for the RLUPs. For NatureScot's report for the Tweed catchment, see Facilitating Local Natural Capital Investment project: https://www.nature.scot/doc/naturescot-research-report-1272-facilitating-local-natural-capital-investment-project-report

APPENDIX 01

Detailed Methodology

Appendix 01 – Detailed Methodology

This appendix sets out the collaborative efforts between SLR, NW2045 and other partners for the Project.

Asset Mapping

The Scotland Habitat and Land Cover Map (SLAM) was used as an initial source of habitat (asset) distribution. Produced by Space Intelligence in partnership with NatureScot using a Prediction Model, it incorporates various remotely sensed datasets (such as Sentinel-2 and Sentinel-1) with several existing training datasets (such as Habitat Map of Scotland, National Forest Inventory and Ordnance Survey products) to classify habitats according to EUNIS Level 2. This was selected for the following reasons:

- The dataset has complete coverage of the study area, but at a suitable resolution to identify individual land parcels (20m x 20m).
- The dataset is current, showing landcover from 2020.
- The dataset has a high level of accuracy, most habitat classes have an accuracy of over 90%.
- The dataset is provided through an Open Government Licence and was immediately available at the beginning of the study.

Alternative datasets were considered for the asset mapping. Below are the alternatives and the justification as to why they were excluded.

- Habitat Map of Scotland – this dataset was already incorporated into the process to create the SLAM.
- Ordnance Survey MasterMap Topography – Although this may provide a more accurate depiction of land parcels in urban areas (captured at 1:1,250), in moorland areas land parcels are captured at a larger scale (captured at 1:10,000). Mapping through this process could have missed small pockets of habitat within these land parcels which may have been valuable for the study. Ordnance Survey products were also incorporated in the process to create the SLAM.
- Centre for Ecology and Hydrology Land Cover Map 2020 – The data licence was not available for the Project.
- CORINE Land Cover Map 2018 – This dataset has a minimum mapping unit of 25 hectares, which would result in a generalisation of the habitats present in the study area.
- The Land Cover of Scotland 1988 (LCS88) – This dataset was created in 1993 and represents land cover from 1988. The land cover and habitats will have changed over the 30 years and therefore would be a misrepresentation of assets.

Although the accuracy of the SLAM was over 90% for most habitats, it was validated through comparison with aerial photography for the study area to identify major inaccuracies. The most common issue found was the incorrect classification of scree or cliff habitats as urban land (probably due to the similar colour values within the remotely sensed data). Where identified these habitat parcels were reclassified. Given the desk-based nature of the validation, it was not possible to identify incorrect classifications between similar habitat types, such as differing woodland or grassland types.

Local habitat datasets provided by the client group were considered for use in this validation process, however the age and spatial accuracy meant they were not included within the validation process. It was not possible to validate the dataset through site surveys given the timescales of the study.

Asset Quality Mapping

Habitat or asset quality was initially assessed using the InVEST Habitat Quality Model, an open-source tool which utilises spatial data to estimate relative habitat quality over a study area. The model assumes habitat quality to be a function of:

- The relative impact of threats which may degrade habitats, such as pollution or invasive species (some threats may be more damaging than others)
- The proximity of the habitats to the threats (closer habitats are more likely to be damaged)
- The sensitivity of each habitat type to each threat

https://storage.googleapis.com/releases.naturalcapitalproject.org/invest-userguide/latest/habitat_quality.html

Several threats which could affect habitat quality were proposed for the initial application of the model based on best practice and client feedback (table below).

Proposed Factors	Rationale	Proposed Dataset
Deer Grazing	Grazing has a significant influence on habitat condition and successional processes.	Deer Counts (Scottish Natural Heritage)
Air/Noise Pollution from Roads	Habitats closer to roads are more likely to be recipients of air pollutants.	OS OpenMap Local (Ordnance Survey)
Disturbance from Members of the Public	Habitats closer are more likely to be disturbed by humans.	OS OpenMap Local (Ordnance Survey) OS Open Greenspace (Ordnance Survey) Core Paths
Water Pollution from Arable Land and Watercourses within Close Proximity to or Downstream of Arable Land	Habitats closer to these locations are more likely to be recipients of agricultural chemicals from runoff.	Habitat and Land Cover Map 2020 (Nature Scot) OS Open Rivers (Ordnance Survey)
Invasive/Non-Native Species – Mink, Plants, Aquatic	Habitats closer to these locations are at more risk of infestation.	No available dataset was identified within the project timescale. Invasive species data on the National Biodiversity Network Atlas was not available for inclusion due to data licence restrictions.
Sheep/ cattle grazing	Grazing has significant influence on habitat condition and successional processes.	No available dataset was identified within the project timescale.

Proposed Factors	Rationale	Proposed Dataset
		Open Data provided by the Crofting Commission was not spatially accurate for inclusion. https://crofting.scotland.gov.uk/open-data
Peat Extraction	Peat extraction, removes carbon from the area and in addition frequently leads to drying/ degradation of surrounding peat resulting in reduced biodiversity value and potentially a reversal of habitat from a carbon sink to a carbon source.	No available dataset was identified within the project timescale.
Wildfire/Muirburn	Can result in significant changes to habitat condition / biodiversity as well as damaging peat and carbon sequestration processes.	No available dataset was identified within the project timescale. Wildfire records through the Copernicus programme were identified, however this was not representative of wildfire in the study area (records were spatially and temporally limited).
Tree Disease	Woodland closer to these locations are at more risk of infestation.	No available dataset was identified within the project timescale. Data from Forestry Commission was not available for inclusion due to data licence restrictions.

The threats which were included in the initial application was dependent on data availability and suitability. The initial application included the following threats in the model:

- Damage from Deer Grazing
- Air/Noise Pollution from Roads
- Disturbance from Members of the Public
- Water Pollution from Arable Land and Watercourses within Close Proximity to or Downstream of Arable Land

Threats were ranked relative to each other and given a maximum distance of likely influence and a decay rule over that distance e.g. linear or exponential. For each threat, every habitat was assigned a sensitivity such that the at the same distance from the threat different habitats would be predicted to be more or less severely impacted. This method requires a number of assumptions about the severity of the treats at source, and does

not take into account various factors that can affect the sphere of influence such as topography and geology, and that different elements of biodiversity can be conversely affected (e.g. recreation may be very disturbing to birds using a habitat but have very little impact on the habitat itself). The approaches usefulness is therefore, largely in providing a visual starting point for discussions targeted at refining the model/ modelling approach.

The following approach was initially taken to deer grazing. Five levels of sensitivity were selected. Young woodland which can be completely removed by high browsing pressure was considered to be the most sensitive habitat and ranked at 1. Other habitats were ranked relatively. Native woodland and dwarf-shrub (heath and bog habitats) were considered to be next most sensitive as high browsing pressure can result in these habitats transitioning to grasslands. Grasslands were ranked intermediately, with mature coniferous woodland ranked as slightly more tolerant and unvegetated/ largely inaccessible habits such as cliffs ranked as most tolerant.

Following the initial run of the model and feedback from the NW2045 team, it was decided that the resolution of data around all the threats with the exception of deer was insufficient to provide realistic / meaningful output and therefore the model was re-run with only the deer data. Ultimately, we used biodiversity as a proxy for habitat condition, but the following information is included for transparency.

The maximum distance for the influence of deer was assigned 10km based on core roaming distance[66]. The below table shows the relative sensitivity applied to each habitat within the InVEST model.

EUNIS Code	EUNIS Classification	Relative Deer Sensitivity 0-1 (1 = most sensitive)
C	Inland surface standing and running waters	0.83
D1	Raised and blanket bogs	0.83
D2	Valley mires, poor fens and transition mires	0.83
D4	Base-rich fens and calcareous spring mires	0.83
E1	Dry grasslands	0.67
E2	Mesic grasslands	0.67
E3	Seasonally wet and wet grasslands	0.67
E4	Alpine and subalpine grasslands	0.83
E5	Woodland fringes and clearings and tall forb stands	0.83
F2	Arctic, alpine and subalpine scrub	0.83
F3	Temperate and Mediterranean-montane scrub	0.83
F4	Temperate shrub heathland	0.83
G1	Broadleaved deciduous woodland	0.83
G3	Coniferous woodland	0.50
G4	Mixed deciduous and coniferous woodland	0.67
G5	Young woodland	1.00
H2	Screes	0.00
H3	Cliffs and rock pavements	0.83
I1	Arable land	0.67
J	Built-up	0.00

[66] e.g. Catt, D.C., and Staines B.W. 1987. Home range use and habitat selection by Red deer (Cerrus elaphus) in a Sitka spruce plantation as determined by radio tracking. Journal of Zoology: 211(4), pp681-693

EUNIS Code	EUNIS Classification	Relative Deer Sensitivity 0-1 (1 = most sensitive)
O	Bare field	0.00

Ecosystem Service Mapping

Biodiversity

Biodiversity provision was modelled as a function of habitat distinctiveness and condition, utilising the Biodiversity Metric 3.1 developed by Natural England as a framework for the assessment. In the absence of a Scotland specific biodiversity metric, Metric 3.1 was considered a reasonable starting point for estimating the biodiversity value of the habitats within the study area. It is worth noting however that Metric 3.1 was designed primarily for England and should a Scottish version be created, there may be discrepancies in the habitats which are included and the distinctiveness values.

The outputs of the asset mapping stage were used to identify the distribution of habitats across the study area for input into the biodiversity mapping. The following details how the distinctiveness and condition values were assigned.

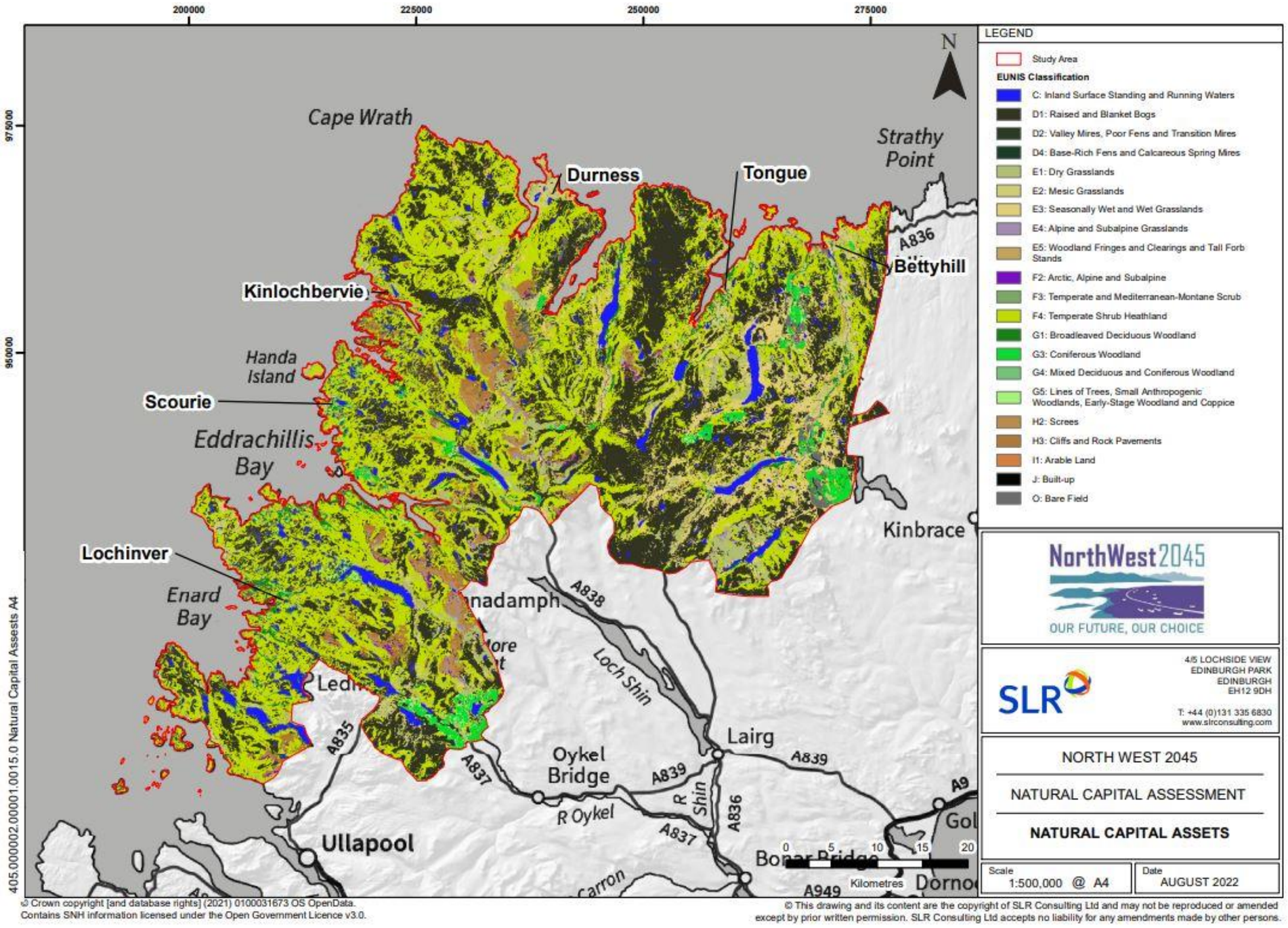
Distinctiveness Value

Each EUNIS classification was assigned an equivalent UK Habitat Classification (UKhab). In some cases there was not a direct equivalent UKhab for each EUNIS classification, the below table details the justification for each translation. The corresponding distinctiveness value from the Metric 3.1 was then applied (a value between 0-8).

L1	EUNIS code	EUNIS name	UKhab to EUNIS conversation table	UKHab Selection where > 1 option	Metric 3. 1 Step 1 Broad Habitat	Metric 3. 1 Step 2 - Habitat Type (Assumed)	Habitat Distinctiveness	Classification notes
C	C	Inland surface waters	r	r1	Lakes	Peat Lakes where >2ha	6	Assumes all mapped water bodies are peat lakes, this may overestimate the value of some habitats with lower distinctiveness such as reservoirs. Rivers are not mapped.
					Lakes	Ponds (Priority Habitat) <=2ha	6	Assumes that all ponds fall into the priority habitat category and may overestimate the value of lower distinctiveness ponds
D	D1	Raised and blanket bogs	f1a blanket bog f1b raised bogs	f1a – blanket bog	Wetland	Blanket Bog	8	Most bog in the study area is expected to be blanket rather than raised bog.
D	D2	Valley mires, poor fens and transition mires	f2a lowland fens f2c upland flushes, fens and swamps	f2c8 – transition mires and quaking bogs (upland)	Wetland	Transition mires and quaking bogs	8	Oceanic valley mires (≈ D2.1) and transition mires (≈ D2.2a, poor fen; and D2.2c, Intermediate fen and soft water spring mire), have the same distinctiveness/ value in the metric. Oceanic mires are however not explicitly split out from transition mires in UKhab methodology. In addition, the EUNIS factsheet distributions maps indicate association with predominantly upland areas within the study area, such that f2c is considered more appropriate than f2a. Furthermore, based on ENUIS fact sheets habitats falling into the transition mires category D2.2a[1] and D2.2c[2] are more widespread in Scotland than oceanic valley mire D2.1 [3] and therefore we have coded all D2 habitats as transition mire, in the metric which does allow for oceanic valley mires (D2.1).
	D3	Patterned mire complexes of the artic, sub artic and northern boreal zone	No entry in conversion table	f2c8	Wetland	Transition mires and quaking bogs	8	Distribution in the UK of D3 (most likely D3.2 aapa mire, as D3.1 palsa mire is restricted to areas with sporadic permafrost in the subartic[4]) is unknown[5], and there is no direct conversion of it to Ukhab. Notes on the EUNIS habitat fact sheet[6] indicate D3 is typically a small component of mires bogs and fens including transition mires. Transition mire was therefore selected as likely to be the most similar habitat category in the metric.
E	E1	Dry grasslands	g1 acid grassland g2 calcareous grassland	g1	Grassland	Upland acid grassland	4	Most of the dry grassland in the study area more likely to be upland acid than lowland dry acid grassland or calcareous grassland based on altitude, latitude (although this habitat is typically associated with elevations >300m (above the level of enclosed farmland), particularly in the northwest of the UK it can be found at sea level) and geology. We have therefore coded this habitat as upland acid grassland. Note however that this approach will underestimate the value of any lowland dry acid or calcareous grassland encompassed in these polygons both of which are higher distinctiveness habitats.
E	E2	Mesic grasslands	g1 acid grassland g2 calcareous grassland g3 neutral grassland g4 modified grassland	g3	Grassland	Other neutral grassland	4	We have already accounted for upland acid grassland under E1 (above), due to the area's geology and low abundance of agricultural/ pastoral land calcareous and modified grassland likely only contribute a small proportion of E2 habitat, the majority is considered most likely to be neutral grassland. Note that this classification of other neutral grassland in the metric could underestimate the biodiversity value of priority habitats that fall within g3

L1	EUNIS code	EUNIS name	UKhab to EUNIS conversation table	UKHab Selection where > 1 option	Metric 3. 1 Step 1 Broad Habitat	Metric 3. 1 Step 2 - Habitat Type (Assumed)	Habitat Distinctiveness	Classification notes
								such as upland hay meadows if present or overestimate the value of modified grassland. The majority of the area is unlikely to be these priority habitat types so we have used g3 to try to keep the assessment proportionate. A precautionary approach would to be to code E2 as one of the priority habitats.
E	E3	Seasonally wet and wet grasslands	secondary code 119	g3	Wetland/Grassland	Purple moor grass and rush pastures	8	Note that this classification could underestimate the biodiversity value of priority habitats that fall within g3 such as upland hay meadows if present. The majority of the area is unlikely to be the priority habitat types so we have used g3 to try to keep the assessment proportionate. A precautionary approach would to be to code E2 as one of the priority habitats.
E	E4	Alpine and subalpine grasslands	g	g2b5	Grassland	Upland hay meadow	8	The closest habitat type to E4 in Ukhab is g2b5 alpine and subalpine calcareous grassland, no alpine or subalpine grasslands are however represented in the metric, on a precautionary basis we have therefore assumed that the habitats within the study area fits the criteria for one or more of the relevant Annex 1 subalpine grassland habitats and have coded it as an alternative Annex 1 grassland with highest level of distinctiveness of 8.
E	E5	Woodland fringes and clearings and tall forb stands	secondary code 16 and/or 165 g1 acid grassland g2 calcareous grassland g3 neutral grassland f2 fen marsh and swamp	g3	Grassland	Tall herb communities	6	E5 can represent a wide range of Ukhab habitats, g3 was chosen to differentiate it from areas more likely to be other grassland or wetland types. This could underestimate the biodiversity value of priority habitats that fall within these areas such as upland hay meadows if present. In the metric however this community appears to be better represented and we have coded it as tall herb communities.
F	F2	Arctic, alpine and subalpine scrub	h1c	h1c	Heathland and shrub	Mountain heath and willow scrub	8	Conversation to Ukhab and the metric is relatively straight forward here
F	F3	Temperate and mediterranean-montane scrub	h3a-f scrub blackthorn, hazel, sea buckthorn, bramble, gorse, hawthorn w2a5 Caledonian forest	h3e	Heathland and shrub	Gorse scrub	4	The majority of F3 habitats fall in to Ukhabs h3. In the metric these all have a distinctiveness of 4, with the exception of Annex 1 sea buckthorn habitats which are unlikely to represent the majority of this habitat type within the study area. Gose was selected as it is widespread in northwest Scotland and is not represent elsewhere in our habitat categorisations.
F	F4	Temperate shrub heathland	h1 dwarf shrub heath	h1b	Heathland and shrub	Upland heathland	6	The majority of heath within the study area is likely to be upland rather than lowland heath due to the mountainous terrain.
G	G1	Broadleaved deciduous woodland	w1 broadleaved, mixed and yew woodland	w1	Woodland	Upland birchwoods	6	We have assumed upland birch and oak are the dominant woodlands in this area so have coded woodland as such. These are high distinctiveness habitats and therefore this categorisation may overestimate the value of other, less distinctive woodland types.
G	G3	Coniferous woodland	w2 coniferous woodland	w2	Woodland	Default Other coniferous woodland - by exception with	2	We have assumed the majority of coniferous woodland is non-native plantation. This will greatly underestimate the value of any native pine

L1	EUNIS code	EUNIS name	UKhab to EUNIS conversation table	UKHab Selection where > 1 option	Metric 3. 1 Step 1 Broad Habitat	Metric 3. 1 Step 2 - Habitat Type (Assumed)	Habitat Distinctiveness	Classification notes
						data Native pine woodlands		woodland. To address this, we have used a separate data set to identify areas of Caledonian Scots pine woodland (see row below).
G	G3		w2 coniferous woodland	w2a5	Caledonian forest	Native pine woodlands	6	We have used a separate data set to identify areas of Caledonian Scots pine woodland. None were located within the study area.
G	G4	Mixed deciduous and coniferous woodland	w1h other woodland-mixed	w1h	Woodland	Other woodland mixed	4	Conversation to Ukhab and the metric is relatively straight forward here
G	G5	Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice	w woodland	w	Woodland	Other woodland mixed	4	There is insufficient information to further refine woodland type.
H	H2	Screes	s1a inland rock outcrop and scree habitat	s1a	Sparsely vegetated land	Inland rock outcrop and scree habitats	6	Conversation to Ukhab and the metric is relatively straight forward here
H	H3	Inland cliffs, rock pavements and outcrops	s1 inland rock outcrop and scree habitat	s1a	Sparsely vegetated land	Inland rock outcrop and scree habitats	6	Conversation to Ukhab and the metric is relatively straight forward here
I	I1	Arable land and market gardens	c1 arable and horticulture	c1	Cropland	Cereal crops	2	Conversation to Ukhab and the metric is relatively straight forward here. However, this categorisation will underestimate value of uncultivated areas e.g. field margins.
J	J	Constructed, industrial and other artificial habitats	u1b developed land sealed surface u1d suburban mosaic of developed/ natural surface u1e built linear features	u1	Urban	Developed land, sealed surface	0	Conversation to Ukhab and the metric is relatively straight forward here. We believe developed land with a sealed surface is likely to reflect the majority of these areas but will underestimate value of smaller areas with an unsealed surfaces etc. within these.
	O	Bare Earth	secondary code 73= bare ground	S	Sparsely vegetated land	Ruderal/ephemeral	2	Neither Ukhab nor the metric have a clear equivalent for bare earth. We have assumed that this is not ploughed areas although it may be bare peat, and that a few weeds etc are present so have coded as ruderal/ ephemeral. The distinctiveness of 2 is likely a reasonable representation of this habit's current biodiversity value.



Condition Value

A multi-step process was implemented to assign habitat condition, first utilising designation monitoring information for Special Protection Areas (SPAs), Special Areas of Conservation (SACs) and Sites of Special Scientific Interest (SSSIs); then analysis of deer density to infer potential degradation.

For habitats within the aforementioned designations, the habitat condition was assigned using existing monitoring information from the SiteLink Portal (NatureScot) where available. The following table was used to translate the feature site condition categories into an equivalent Metric 3.1 condition values. Where habitat-specific information was not available, habitats within the designations were assumed to be 'Good' condition.

For habitats outside of the ecological designations, deer density was used as an indicator for degraded habitats. Habitat condition was downgraded from assumed good to moderate in areas with deer densities were more than 5 deer per km^2 for woodland habitats and more than 7 deer per km^2 for open habitats [67]. This approach was based on (Putman et.al 2011[2]) and the UKhab habitat condition criteria of which grazing can influence a sufficient number (e.g. signs of browsing damage; diversity of tree age, height and structure; grassland species diversity), to downgrade habitats from good to moderate condition. Insufficient data were present to allow determination of whether any habitats may be considered in poor condition due to grazing alone. Deer Counts (Scottish Natural Heritage) were used in a Kernel Density Analysis to estimate the density of deer across the study area.

The Metric 3.1 provides the following default values for some habitats which were applied in this study as appropriate:

Broad Habitat	Habitat Type	Default Condition	Condition Score
Cropland	All types	Condition Assessment N/A - Poor	1
Grassland	Bracken	Condition Assessment N/A – Poor	1
Heathland and scrub	Bramble scrub	Condition Assessment N/A – Poor	1
	Rhododendron scrub	Condition Assessment N/A – Poor	1
	Sea buckthorn scrub (other)	Condition Assessment N/A – Poor	1
Urban	Artificial unvegetated, unsealed surface	N/A – Other	0
	Built linear features	N/A – Other	0
	Developed land, sealed surface	N/A – Other	0
	Ground level planters	Condition Assessment N/A – Poor	1
	Introduced shrub	Condition Assessment N/A – Poor	1
	Other green roof	Condition Assessment N/A – Poor	1

[67] Putman, R., Langbein, J., Green, P., and Watson P. 2011. Identifying thresholds densities for wild deer in the UK above which negative impacts may occur. Mammal Review

Broad Habitat	Habitat Type	Default Condition	Condition Score
	Actively worked sand pit, quarry or opencast mine	Condition Assessment N/A – Poor	1
	Un-vegetated garden	N/A – Other	0
Woodland	Felled	Good	3
Hedgerows and lines of trees*	Hedge ornamental non-native	Poor	1
Rivers and streams*	Culverts	Poor	1

* note linear feature included for comprehensiveness

Biodiversity Value

As detailed in the Metric 3.1, the relevant numerical values for distinctiveness and condition were assigned to each habitat parcel, then multiplied together to create the biodiversity value. This resulted in a value between 0-24. Although the Metric 3.1 incorporates habitat area into the biodiversity value, it was not included within this study as it could introduce bias, favouring large but biodiversity-poor habitat parcels.

Carbon

Multiple existing datasets were used to understand distribution of carbon storage across study area:

- Woodland habitat types from the Asset Mapping Stage.
- Peat depth from 195 projects across Scotland as part of the Peatland Action project;
- Bare peat in Scotland from Sentinel-2 (taken in summer of 2018);
- Carbon and Peatland Map 2016, NatureScot. This shows the distribution of carbon and peatland across Scotland. This was created through analysis of historic soil information, land cover data (1988) and planning policy data.
- Topsoil Organic Carbon Concentration 2012, James Hutton Institute. This shows the estimated concentration of organic carbon in topsoil for Scotland. This was created through analysis of 1:250,000 soils maps and Scottish Soils Knowledge and Information Base

Further analysis was completed using the InVEST Carbon Model to estimate the carbon storage across the study area. This open-source software applied estimates of carbon storage for different habitat types to a given land cover dataset to calculate metric tonnes of carbon stored per 20m x 20m pixel. The outputs of the asset mapping were used in the model to represent landcover.

The below values were used for each habitat classification within the InVEST Carbon Model. These values are based on recent meta-analysis by the European Environment Agency[68]. This includes total carbon stocks for all terrestrial EUNIS habits (Level 3). For some habitats - notably blanket bogs, which we conservatively estimated to be an average of one metre in depth - estimates were also checked against Anderson (2021)[69] which provides UK-focussed estimates (summarised in Table 1 on page 6 of that paper).

[68] European Environment Agency (2020). "Carbon stocks and sequestration in terrestrial and marine ecosystems: a lever for nature restoration?" Authors are Kees Hendriks, Susan Gubbay, Eric Arets, John Janssen. Full information including the excel-based data can be found via the EEA website: https://www.eea.europa.eu/publications/carbon-stocks-and-sequestration-rates

[69] "Carbon and ecosystems: restoration and creation to capture carbon": https://cieem.net/resource/carbon-and-ecosystems-restoration-and-creation-to-capture-carbon/

EUNIS Classification from SLAM	Carbon Density (Metric Tonnes Per Hectare)
Inland surface standing and running waters	10
Raised and blanket bogs	576
Valley mires, poor fens and transition mires	150
Base-rich fens and calcareous spring mires	150
Dry grasslands	30
Mesic grasslands	80
Seasonally wet and wet grasslands	150
Alpine and subalpine grasslands	80
Woodland fringes and clearings and tall forb stands	100
Arctic, alpine and subalpine scrub	110
Temperate and mediterranean-montane scrub	110
Temperate shrub heathland	100
Broadleaved deciduous woodland	230
Coniferous woodland	175
Mixed deciduous and coniferous woodland	190
Young woodland	75
Screes	5
Cliffs and rock pavements	5
Arable land	55
Built-up	5
Bare field	5

Note that our analysis is limited to carbon stored in soils and vegetation. It does not include emissions from livestock, which are estimated to be 1.76 tCO2e per head of cattle (for sheep it's closer to 0.2 tCO2e per head).

Carbon sequestration data comes from the UK National Atmospheric Emission Inventory (NAEI) broken down further by The Department for Business, Energy and Industrial Strategy (BEIS) to enable estimation of changes in carbon stock in living biomass i.e. 'gross' sequestration. This is estimated at 3.17 million tCO2e and the annual monetary value is calculated by multiplying this number with the projected non-traded price of carbon which for the year in question was approximately £237 per tCO2e[70]. This results in an annual value of around £750 million. The overall asset value of £38bn is calculated by estimating sequestration into the future over the estimated life of the asset, which in this case is 100 years, multiplying by the non-traded price of carbon (which increases every year, for example by 2045 it is estimated as £351 per tCO2e), and 'discounting' these future cash flows.

[70] For an explanation of how the 'non-traded price of carbon' is calculated, including why it is far higher than traded carbon values, see https://www.gov.uk/recgovernment/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation.

Other ecosystem services

SLR have not analysed other ES in any detail, except for the MTS Community Council area. Interested readers are encouraged to refer to the 2017 open access book 'Mapping Ecosystem Services' edited by Benjamin Burkhard & Joachim Maes. For example, chapter 5.5 of the book explores why the different types of ES require very different approaches to mapping, including an explanation of why mapping 'cultural' ES is uniquely challenging and often requires a participatory GIS approach. It also includes specific ES examples that are outside the scope for this Project, but which NW2045 could chose to map in the future e.g. air quality regulation, drinking water, recreation

Participatory mapping (often referred to as Participatory GIS or PGIS) is a process whereby individual stakeholders with location-based knowledge contribute to the mapping of ES. PGIS data can be collected via face-to-face surveys, web-based surveys or from workshops and can be useful to understand what ES are possible, and to get a better understanding of socio-economic benefits. PGIS techniques are a form of direct measurement, but can also be integrated with other spatial datasets such as land-cover maps and/or be used in modelling. It is highly recommended that NW2045 use PGIS to map other ES, especially cultural ES such as education, recreation and spiritual values. For MTS, initial PGIS has been undertaken especially in relation to common grazings for the different crofting settlements.

APPENDIX 02

Dataset Review

Appendix 02 – Dataset Review

SLR reviewed around 250 datasets for use in the Project. Included in this appendix are a list of 200 spatially explicit datasets considered, including links to sources and notes. Those in **bold** are the datasets used most prominently for the mapping work in this project. Many were relevant but were unavailable for download (Web Map Service only) or SLR were not licenced to use, as there are restrictions on commercial use. Please contact SLR if you have questions or want further information on the datasets, such as attributions and whether there are open-source licences.

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
Habitat Map of Scotland	https://www.environment.gov.scot/our-environment/habitats-and-species/habitat-map-of-scotland/	24/04/2018	Using a different source
International and National Designations	https://sitelink.nature.scot/map	Various	
National soil map	https://soils.environment.gov.scot/maps/soil-maps/national-soil-map-of-scotland/	01/01/1981	Old data
Acid and nitrogen pollution - critical load	http://www.cldm.ceh.ac.uk/critical-loads/data	01/03/2011	
Carbon and peatland map	https://soils.environment.gov.scot/maps/thematic-maps/carbon-and-peatland-2016-map/	2016	
INNS (via NBN Atlas)	https://www.environment.gov.scot/our-environment/state-of-the-environment/ecosystem-health-indicators/resilience-indicators/indicator-11-invasive-non-native-species/	Various	Rhododendron American Mink
Renewables	https://data.gov.uk/dataset/12f3cd87-7a6b-4689-ae0d-4ff9bb6f8607/scottish-natural-heritage-renewables-wms	02/09/2014	
SEPA Hydrography Service	https://data.gov.uk/dataset/2814d7f6-c205-4ef7-b11c-c75f926b4ace/sepa-hydrography-service-wms	26/03/2012	
Scottish Wetland Inventory	https://data.gov.uk/dataset/e3cd6718-84f8-43b8-8f68-84dabb182e82/scottish-wetland-inventory	05/06/2014	
FGS1420 SMF Species Conservation	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/d58593c7-59aa-433d-8c8d-67fa5a0f544f	18/02/2022	
FGS1420 Woodland Creation - Options	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/f93ce0e3-e30e-4a09-86a0-589dd3f05107	18/02/2022	
FGS1424 WIG Habitats and Species - New Natural Regeneration - Options	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/69359cbe-ffe6-4d44-a596-1500bb561bd4	18/03/2022	
FGS Target Area - Small Native Woods in Crofting Counties	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/b574316a-d220-4bb6-acd3-0dcf2cc28aa9	04/04/2022	
Contaminated Land (Confirmed)	https://map-highland.opendata.arcgis.com/datasets/45c3003e7c724eba833832197459e86c_0/explore?location=57.691129%2C-4.629127%2C9.74&showTable=true	12/05/2022	None within NW2045 Study Area

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
Local Nature Reserves	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/beda9339-b030-4641-9d0b-29aba8791192	11/08/2020	
SNH Landscape Character Assessment 2019	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/4A6F52B4-11DD-47E1-B90A-A8D51500E136	04/05/2021	
National Forest Inventory Woodland Map 2019 (GB)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/65e7f292-4070-4822-8617-defe4f0e1c86	30/04/2021	
Bare peat in Scotland from Sentinel 2	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/92ebd99b-d4da-4dcc-b18d-839d782c921b	13/04/2020	
Scottish Cultural Protected Sites	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/2a9b09a4-1705-404c-b247-ff968cfc96d8	05/02/2020	
Less Favoured Areas	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/f4e358c1-df06-4107-bfd2-03f7581ecb07	01/12/2020	
Watercourses	https://osdatahub.os.uk/downloads/open/OpenRivers	2022/04	
Roads	https://osdatahub.os.uk/downloads/open/OpenRoads	2022/04	
Powerlines	OSM	2022/04	
Corepaths	https://map-highland.opendata.arcgis.com/datasets/Highland::core-paths/explore?location=58.376648%2C-4.177542%2C9.07	2022/04	
Community Councils	https://map-highland.opendata.arcgis.com/datasets/community-councils	2022/04	
Deer Locations	https://cagmap.snh.gov.uk/natural-spaces/dataset.jsp?code=DCP	05/05/2022	
CodePoint (Post Code Data)	https://osdatahub.os.uk/downloads/open/CodePointOpen	2022-05	
UPRN (Unique Property Reference Numers)	https://osdatahub.os.uk/downloads/open/OpenUPRN	2022-06	
Peatland ACTION - Peat depth	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/82e2ad6e-b97e-4f4c-80b7-679e15c55d25	03/12/2020	
Deer Vehicle Collisions	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/44ab0f27-fedf-4dac-95c6-6d815055c5c1	06/06/2019	

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
National Forest Estate Subcompartments Scotland 2019	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/4ea30596-8d2c-4be7-a5c3-ecd4fc580a3b	31/03/2019	
Local Development Plans - Scotland	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/8e13ad58-41f2-4308-a3a8-5ffe8593e731	30/04/2019	Not clear how often updated
Conservation Areas	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/61e70ae1-bbfa-40f7-a72c-2b782a63f81c	18/12/2019	
FGS Target Area - Highland Native Woodlands	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/b3db93a4-3ae7-43ef-b56d-4756c0a404a4	10/01/2018	
Deer Management Group boundaries	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/5fdc1379-80a7-40ca-a21a-2f8596875936	10/01/2018	Study area has two groups
Habitat Impact Assessment (upland protected areas)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/15798e01-a246-468e-bacd-43f99cf6b70d	08/02/2018	Spatially limited and limited to certain habitats
SPRI_Waste_Water_Release	Scottish Pollution Release Inventory (sepa.org.uk)	09/09/2019	
Woodland Carbon Code Projects	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/00b1df16-8451-4635-9e8b-f4c15c711be4	20/09/2017	
Highland Council Community Partnerships	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/55254015-cf99-4021-a9be-cdc3c9b40358	01/03/2017	Sutherland Community Partnership area
Wind Turbine Spatial Framework - Scotland	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=4B154800B46F5190AD7AA8F1E6393F59#/metadata/50c53bbf-c1bf-4819-bd86-3c5adad65900	11/05/2022	Not licensed to use
Mapping selected bio-physical aspects of Aesthetics	https://openscience.hutton.ac.uk/dataset/mapping-aesthetics-in-scotland-based-on-10-metrics#	30/03/2022	Could be useful for Cultural ES
Land Capability Maps	https://openscience.hutton.ac.uk/dataset/land-capability-maps	02/03/2022	
Thematic Soil Maps	https://openscience.hutton.ac.uk/dataset/thematic-soil-maps	28/02/2022	Used Topsoil Organic Carbon
Soil profile depth, bulk density and carbon stock	https://openscience.hutton.ac.uk/dataset/soil-profile-depth-bulk-density-and-carbon-stock-of-scotland	28/02/2022	Used peat depth info

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
Land cover	https://openscience.hutton.ac.uk/dataset/land-cover	28/02/2022	Using other map
Soil Risk Maps	https://openscience.hutton.ac.uk/dataset/soil-risk-maps-partial-cover	05/03/2019	
National Soils of Scotland	https://openscience.hutton.ac.uk/dataset/national-soils-of-scotland	08/10/2021	
AECS Spatial Targeting - Beetle Banks	https://openscience.hutton.ac.uk/dataset/aecs-beetle-banks	29/09/2021	
Species richness	https://openscience.hutton.ac.uk/dataset/species-richness	29/09/2021	
Scotland's Epiphyte Diversity Climate Change Risk	https://openscience.hutton.ac.uk/dataset/scotland-s-epiphyte-diversity-climate-change-risk	29/09/2021	
National Waters Inventory	https://openscience.hutton.ac.uk/dataset/national-waters-inventory-for-scotland-part-of-data-used-on-the-project	29/09/2021	
Daily streamflow from gauge stations on main rivers	https://openscience.hutton.ac.uk/dataset/daily-flow-data-from-gauging-stations-on-main-rivers-of-scotland-1947-2017	29/09/2021	
Cultural Heritage: Entertainment	https://openscience.hutton.ac.uk/dataset/cultural-heritage-entertainment	29/09/2021	Of some use for cultural ES
Cultural Heritage: Class Indicator	https://openscience.hutton.ac.uk/dataset/cultural-heritage-class-indicator	29/09/2021	Of some use for cultural ES
Surface water isotope spatial patterns	https://openscience.hutton.ac.uk/dataset/characterization-of-surface-water-isotope-spatial-patterns-of-scotland	29/09/2021	
Biodiversity - bees	https://openscience.hutton.ac.uk/dataset/biodiversity	29/09/2021	Useful for pollination ES
Available Water Capacity	https://openscience.hutton.ac.uk/dataset/available-water-capacity	29/09/2021	
AECS - Retention Of Winter Stubbles For Wildlife & Water Quality	https://openscience.hutton.ac.uk/dataset/aecs-retention-of-winter-stubbles-for-wildlife-water-quality	20/09/2021	
AECS - Wader & Wildlife Mown Grassland	https://openscience.hutton.ac.uk/dataset/aecs-wader-wildlife-mown-grassland	20/09/2021	
Unharvested Conservation Headlands For Wildlife	https://openscience.hutton.ac.uk/dataset/aecs-unharvested-conservation-headlands-for-wildlife	20/09/2021	
AECS Spatial Targeting - Wader Grazed Grassland	https://openscience.hutton.ac.uk/dataset/aecs-wader-grazed-grassland	20/09/2021	
AECS Spatial Targeting - Creation of Hedgerows	https://openscience.hutton.ac.uk/dataset/aecs-creation-of-hedgerows	20/09/2021	

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
AECS - Forage Brassica Crops for Farmland Birds	https://openscience.hutton.ac.uk/dataset/aecs-forage-brassica-crops-for-farmland-birds	20/09/2021	
Grass Strips in Arable Fields	https://openscience.hutton.ac.uk/dataset/aecs-grass-strips-in-arable-fields	20/09/2021	
AECS - Wild Bird Seed For Farmland Birds	https://openscience.hutton.ac.uk/dataset/aecs-wild-bird-seed-for-farmland-birds	20/09/2021	
AECS - Management or Restoration of Hedgerows	https://openscience.hutton.ac.uk/dataset/management-or-restoration-of-hedgerows	20/09/2021	
Stubbles Followed By Green Manure In Arable Rotation	https://openscience.hutton.ac.uk/dataset/aecs-stubbles-followed-by-green-manure-in-an-arable-rotation	20/09/2021	
Wader Zonal Map	https://dataforestry.opendata.arcgis.com/datasets/a77be003a20748fcbb7b8a484305dc06_0/explore?location=55.207158%2C-3.248120%2C6.89	16/03/2022	
FGS Tree Health Options	https://open-data-scottishforestry.hub.arcgis.com/datasets/07d5be286e3a4312888390eaf3451ea2_0/explore?location=56.366696%2C-4.710936%2C8.69	13/02/2022	Not licensed to use
Caledonian Pinewood Inventory	https://opendatascottishforestry.hub.arcgis.com/datasets/d3cf37378ae546c6b074257054d12a38_0/explore?location=57.933282%2C-4.339411%2C9.00	24/01/2020	Not in Project Area
Native Woodland Survey of Scotland	https://opendatascottishforestry.hub.arcgis.com/datasets/6d27b064fcba471da50c8772ad0162d7_0/explore?location=58.290508%2C-4.490370%2C9.00	17/01/2020	Not in Project Area
Land Capability for Agriculture	https://www.hutton.ac.uk/learning/natural-resource-datasets/landcover/land-capability-agriculture	Various	Outdated (from 1981)
LiDAR for Scotland	https://remotesensingdata.gov.scot/data#/map	Various	Limited Coverage
Historic Environment Scotland (WFS)	https://data.gov.uk/dataset/7aca90a5-9859-49d8-a38a-afd70180aa8e/historic-environment-scotland-wfs	24/09/2020	Unusable Format
Aquaculture sites	http://aquaculture.scotland.gov.uk/map/map.aspx	Various	Mainly marine
SEPA data	https://www.sepa.org.uk/environment/environmental-data/	Various	
Highland wind turbines	https://data.spatialhub.scot/dataset/renewable_energy_sites-hi	31/03/2022	Excel format
Local Landscape Areas	https://data.spatialhub.scot/dataset/local_landscape_areas-is	12/05/2022	
Site Condition Monitoring	NatureScot	Various	Not spatial, but used for biodiversity mapping
NPF Data Atlas	https://scotgov.maps.arcgis.com/apps/webappviewer/index.html?id=b9172e82226c46c281c777317f584b3c&showLayers=Environmental_6678	Various	

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
Available Water Capacity (AWC)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=775598CB8E44F6E9445E55DD4A36D21D#/metadata/71e38c05-cf6c-4732-b966-7c202e146cc4	27/03/2019	Not relevent to services selected for assessment
Map of runoff risk (partial cover)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/ab89fb3c-14fa-4ec1-8cd2-f9811a61713d	19/04/2018	Partial coverage of study area
Map of soil leaching potential (partial cover)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/ab89fb3c-14fa-4ec1-8cd2-f9811a61713d	19/04/2018	Partial coverage of study area
Nitrate Vulnerable Zones	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/ab89fb3c-14fa-4ec1-8cd2-f9811a61713d	07/01/2002	Partial coverage of study area
Highland Region Land Classification Grid Square	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/%7B4755b665-c853-4b49-a22d-b7012afc0f39%7D	17/08/1987	
Map of subsoil compaction risk (partial cover)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=775598CB8E44F6E9445E55DD4A36D21D#/metadata/4b2d3298-29bf-4217-8e00-3291695713c6	19/04/2018	
Prime Agricultural Land	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/906d451b-f7ec-4e70-b928-25b89d8db8c8	01/01/1998	Not in Project Area
BGS soil property data layers (OGC WxS INSPIRE)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=775598CB8E44F6E9445E55DD4A36D21D#/metadata/c42c40be-da99-45ce-e044-0003ba9b0d98	01/01/2012	
Special Areas of Hill Land Farming	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/bd311c01-f795-40b8-a67a-cb8210bc727b	01/01/1998	
Agricultural Area Office Boundaries	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=775598CB8E44F6E9445E55DD4A36D21D#/metadata/cabf24b4-4c55-4e7a-98e4-c968a5ee2fe5	17/02/2003	
Agricultural Parishes	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=775598CB8E44F6E9445E55DD4A36D21D#/metadata/c1d34a5d-28a7-4944-9892-196ca6b3be0c	01/01/1997	
Environmentally Sensitive Areas	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=775598CB8E44F6E9445E55DD4A36D21D#/metadata/89a2f20f-8592-4e8c-b6ad-34cf2d4fad06	01/01/1996	
FCS Admin Boundaries (WMS)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/dc628f2b-bb1c-4cee-a347-855a7c9e46b0	20/09/2017	
FCS Inventories and Surveys (WMS)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/e1bea8b8-3b74-4694-88b2-408f9b66d6d9	20/09/2017	

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
Felling Licence Applications (1998-2011)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=775598CB8E44F6E9445E55DD4A36D21D#/metadata/1E63FF74-41FB-47D9-8DBA-3BCA19C5B5DB	09/01/1997	
Felling Licence Applications (2012 onwards)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search;jsessionid=775598CB8E44F6E9445E55DD4A36D21D#/metadata/10BBDA20-5A46-4EA2-9048-8D1CDCCE99D6	01/01/2012	
FGS1420 Agro-forestry	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/6c4f9281-728a-4067-8482-99f6bb3597db	20/11/2015	
FGS1420 Long Term Forest Plan	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/35ee5480-2af3-47b9-82d8-b476a68a70f0	11/01/2015	
Native Woodland Survey of Scotland (NWSS)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/BB223316-8746-4338-9056-5D9A2F0D2824	11/01/2009	
FGS1420 SMF Livestock Exclusion	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/cc61c4a3-ec83-4eba-ab5c-924242718021	20/11/2015	
FGS1420 SMF Low Impact Silvicultural Systems (LISS)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/a76d3850-3001-4c2c-8917-0bb094aa4625	20/11/2015	
FGS1420 SMF Native Woodlands	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/1e82fb10-98ca-42ca-b18d-0fe8459b353a	21/11/2015	
FGS1420 SMF Public Access - Rural	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/eea25b93-ae38-4315-af73-40f9497b6ac6	20/11/2015	Not in Project Area
FGS1420 SMF Public Access - WIAT	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/85dc5dd7-868d-42c5-97cd-11512c94d788	20/11/2015	Not in Project Area
FGS1420 Tree Health - Claims	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/9726534d-aa83-4271-b4ba-ddb58e9ed36c	20/11/2015	Not in Project Area
FGS1420 WIG WIAT Footpaths	FGS WIG WIAT Footpaths | FGS WIG WIAT Footpaths | Scottish Forestry Open Data (arcgis.com)	20/11/2015	Not in Project Area
FGS1420 WIG Woodland Grazing Plan	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/a7c052de-49d6-4d49-8916-8eabd4a4183d	21/11/2015	Not in Project Area
FGS1420 Woodland Creation - Options	FGS Woodland Creation Options | FGS Woodland Creation Options | Scottish Forestry Open Data (arcgis.com)	22/11/2015	
FGS1420 WIG WIAT Urban Management Plans	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/d72f52f6-007f-4143-b983-3a1f43fae8ca	11/01/2015	Not in Project Area

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
FGS Climatic Site Suitability - Broadleaves	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/41bd7524-534a-44a1-acc0-5ced0e0f16a8	23/11/2015	
FGS Climatic Site Suitability - Conifer (Sitka Spruce)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/f06e4bec-34c5-486b-8c39-72357728c058	24/11/2015	
FGS Climatic Site Suitability - Diverse Conifer - Douglas Fir	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/e1b271e1-641f-4bb6-a525-b412e87c5eee	25/11/2015	
FGS Site Suitability - Diverse Conifer - Norway Spruce	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/34e99a63-d92b-4cb5-8dcd-5fff70664b21	26/11/2015	
FGS Climatic Site Suitability - Diverse Conifer - Scots Pine	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/5ba2aa99-0c5f-4b49-a8d5-a30b5d99220f	27/11/2015	
FGS Climatic Site Suitability - Native Broadleaves (W10)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/2e8276ee-548a-4c52-9808-ff40bf86ea87	12/05/2014	
FGS Climatic Site Suitability - Native Broadleaves (W11)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/86c9a9c8-dc26-4c02-aae9-c6f9ea02bbdd	12/05/2014	
FGS Climatic Site Suitability - Native Broadleaves (W16)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/b0995677-1650-4f56-abcc-c4bf0924d94c	12/05/2014	
FGS Climatic Site Suitability - Native Broadleaves (W17)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/a67c039f-3fd3-4228-ae38-116a3f3827bb	12/05/2014	
FGS Climatic Site Suitability - Native Broadleaves (W6)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/5a5884a3-5e2d-4b63-b1ce-23857271968b	12/05/2014	
FGS Climatic Site Suitability - Native Broadleaves (W7)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/a1cb5498-b44b-49a3-9556-afda30770f14	12/05/2014	
FGS Climatic Site Suitability - Native Broadleaves (W8)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/fcb2693b-f93e-47ab-8612-80508b70a0a1	12/05/2014	
FGS Climatic Site Suitability - Native Broadleaves (W9)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/b27c28ef-786b-4440-8ccd-1b71840de5a8	12/05/2014	
FGS Climatic Site Suitability - Native Scots Pine (W18)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/efd87250-430e-4f66-bc4f-1be1feeb667c	12/06/2014	
FGS Climatic Site Suitability - Native Upland Birch (W4)	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/e024c196-dffb-480d-8c46-bc536eed6b33	12/06/2014	

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
FGS Native Woodland - Integrated Habitat Network	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/565bf020-e438-48bc-92ee-6b4d3a28b773	20/01/2015	
FGS Species Conservation - Grey Squirrel Control	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/565bf020-e438-48bc-92ee-6b4d3a28b773	20/07/2015	
FGS Target Area - CSGN Additional Contribution Area	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/bf909a71-c031-4860-b300-cdbf00ef75db	13/01/2015	Not in Project Area
FGS Target Area - Deer Fence High Cost Area	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/fdd11557-f234-46bf-a4b5-2bd93a5f9fe3	23/10/2016	Grid squares not appropriate for analysis.
FGS Target Area - Predator Control for Black Grouse	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/42b73840-6dcc-4b68-afb9-d646810d9ce3	04/10/2015	
FGS Target Area - Predator Control for Capercaillie	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/42b73840-6dcc-4b68-afb9-d646810d9ce3	04/10/2015	Not in Project Area
FGS Target Area - Rhododendron Control	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/5f2e86de-7dd7-4334-8963-4de9f68e035c	07/11/2017	Not in Project Area
Forest Reproductive Material Sites	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/CFA88B77-1667-48BB-8235-59E8461A6726	14/08/2006	Not in Project Area
EUNIS Land Cover Scotland	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/08d85469-bc12-4e67-819e-b41ae47b0392	25/11/2014	
Management Plans	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/5CC00C17-762F-4731-8888-467082808402	04/01/2010	
SFGS Forest Plans	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/9C518129-D1F2-4D19-9A2D-7448FE71E824	10/01/1999	Not in Project Area
RDC Forest Plans	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/5FB84A8B-D618-4CD6-9E0B-7E903CEFE27B	04/01/2010	
RDC - Woodland Creation Boundary	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/A41DFDAE-5ACD-44EE-B851-D07C03D388FF	25/05/2011	
RDC - Woodland Creation Options	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/A41DFDAE-5ACD-44EE-B851-D07C03D388FF	25/05/2011	
SFGS Deer Fence Lines	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/7D1BA42E-723E-46D6-9F99-F3ABB0D8B995	06/01/2003	

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
Scottish Forestry Conservancy Boundaries	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/B8A22DF4-B0DC-4F0B-A713-0CF5F8784A28	06/06/2004	
National Forest Estate Legal Boundary Scotland 2019	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/cb43b17d-9127-4b1d-9d17-d58ce1ab122b	31/03/2019	
National Forest Estate Ownership Scotland 2019	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/e7005559-4463-4584-97c5-11a50b503752	27/12/2012	
National Forest Estate Recreation Areas GB	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/e7005559-4463-4584-97c5-11a50b503752	27/12/2012	
National Forest Estate Recreation Points GB	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/05ea1a4f-76fc-45e1-82f4-5a0d197c00b0	31/03/2016	
National Forest Estate Recreation Routes GB	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/b130b605-290f-4f71-80ef-0a6407b6a4e3	31/03/2016	
Employment Land Audit 2019	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/9083f3cc-5560-4a23-9e56-e91b997becf6	18/06/2020	Not in Project Area
Employment Land Supply - Scotland	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/3e6fd0cf-e363-42f1-b8ad-e2db04f3ad35	10/08/2020	
Aquaculture - Finfish and shellfish farms	https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/Marine_Scotland_FishDAC_1249	12/08/2016	
Flood Hazard and Risk Maps	https://map.sepa.org.uk/floodmap/map.htm	Various	
Flood risk management strategies	https://www2.sepa.org.uk/frmstrategies/	14/12/2015	
Flood Disadvantage - Scotland	4. Results - Mapping flood disadvantage in Scotland 2015: report - gov.scot (www.gov.scot)	23/12/2015	
Flood maps	https://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/#LiDAR	Various	
Surface water flood forecasting	https://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/#LiDAR	Various	
Flood Reports	https://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/#LiDAR	Various	
Natural Flood Management	https://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/#LiDAR	Various	
National Flood Risk Assessment	https://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge/#National_Flood_Risk_Assessment	Various	
Rainfall data for Scotland	https://www2.sepa.org.uk/rainfall	Various	

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
Archived Rainfall data	https://www2.sepa.org.uk/rainfall	Various	
Scottish River flow data via the National River Flow Archive	Data Types and Formats | National River Flow Archive (ceh.ac.uk)	Various	
Archived River Flow data	Data Types and Formats | National River Flow Archive (ceh.ac.uk)	Various	
WB inter catchments	https://www.sepa.org.uk/environment/environmental-data/	08/08/2018	
Groundwater classifications	https://www.sepa.org.uk/environment/environmental-data/	08/08/2018	
Estuaries classifications	https://www.sepa.org.uk/environment/environmental-data/	08/08/2018	
Coastal classifications	https://www.sepa.org.uk/environment/environmental-data/	08/08/2018	
Loch classifications	https://www.sepa.org.uk/environment/environmental-data/	08/08/2018	
River classifications	https://www.sepa.org.uk/environment/environmental-data/	08/08/2018	
Obstacles to Fish Passage	https://www.sepa.org.uk/environment/environmental-data/	08/08/2018	
Water Framework Directive River Basin Districts	https://www.sepa.org.uk/environment/environmental-data/	08/09/2018	
Water Framework Directive Sub-Basin Units	https://www.sepa.org.uk/environment/environmental-data/	08/10/2018	
Baseline water body intercatchments	https://www.sepa.org.uk/environment/environmental-data/	08/11/2018	
River and loch waterbody nested catchments	https://www.sepa.org.uk/environment/environmental-data/	08/12/2018	
Baseline Confluence Inter Catchments	https://www.sepa.org.uk/environment/environmental-data/	13/08/2018	
Baseline Confluences Nested Catchments	https://www.sepa.org.uk/environment/environmental-data/	14/08/2018	
Main river and coastal catchments	https://www.sepa.org.uk/environment/environmental-data/	15/08/2018	
Bathing water catchments	https://data.gov.uk/dataset/b6b62c2e-7fd5-4d3c-8b72-636763c0a178/bathing-waters-zoi-catchments	10/12/2021	
Private Water Supplies - Scotland	https://data.gov.uk/dataset/d7c912c7-639f-492a-a066-ba9672c46281/private-water-supply-scotland	08/12/2021	
(GeoIndex) water wells with water level measurements	https://data.gov.uk/dataset/94378248-46c9-4e63-bc9c-a36e9df42044/map-based-index-geoindex-water-wells-with-water-level-measurements	26/06/2017	
SPRI Water Releases	SpatialData.gov.scot	08/08/2018	

Dataset	Source	Date of last data update	Notes (e.g. could it be useful for NW2045?)
SPRI Air Releases	SpatialData.gov.scot	08/08/2018	
Scottish Pollutant Release Inventory Waste Transfers	SpatialData.gov.scot	30/01/2020	
Effluent_Monitoring_Sites	https://data.gov.uk/dataset/7d98d9ce-b726-49b1-a157-11e58a4ca0c1/effluent_monitoring_sites	21/07/2021	
Biosphere Reserves	SpatialData.gov.scot	16/06/2016	
Scottish Crop Map 2019	https://www.gov.scot/publications/scottish-crop-map-2019/pages/6/	27/05/2021	
Met Office	https://www.metoffice.gov.uk/public/weather/climate	Various	
Slope	http://mapapps2.bgs.ac.uk/ukso/home.html	Various	
Soil Drainage	http://www.landis.org.uk/soilscapes/	Various	
Soil Erodibility	http://www.landis.org.uk/soilscapes/	Various	
Highland Council Local Dev Plan 1	https://www.highland.gov.uk/downloads/file/19712/caslplan_adopted	31/08/2018	
Highland Council Local Dev Plan 2	https://www.highland.gov.uk/downloads/file/21199/westplan_adopted_september_2019	01/09/2019	
Local community plans	https://www.highlandcpp.org.uk/community-plans.html	Various	
UK Ecological status	Ecological Status (ceh.ac.uk)	23/05/2016	
Mink Distribution	The Mammal Society	2020-12-18	
Rhododendron x21	Botanical Society of Britain & Ireland	2020-12-18	
Japanese Knot weeds	Botanical Society of Britain & Ireland	2020-12-18	
Himalyan balsam	Botanical Society of Britain & Ireland	2020-12-18	
Crofting Records	https://www.crofts.ros.gov.uk/register/search	Various	Not good data
Spaceport	https://wam.highland.gov.uk/wam/applicationDetails.do?activeTab=documents&keyVal=Q5CD2AIHKTF00	Various	Good localised information
Indicators of Ecosystem Services in Scotland	https://www.arcgis.com/apps/MapSeries/index.html?appid=a1c9afe0f8594c3da68654f8124632fa	Various	Useful collection across various ES
Habitat and Land Cover Map of Scotland 2020	https://data.gov.uk/dataset/911c87c4-a0d3-4bb8-9089-f7657980113e/scotland-habitat-and-land-cover-map-2020#licence-info	25/10/2021	

APPENDIX 03

Community Engagement Events

See Storymap. Until at least the end of 2022, this will be hosted by SLR at [What Does the Land Do for You? (arcgis.com)]

APPENDIX 04

Drivers of Habitat Change

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Appendix 04 – Drivers of Habitat Change

The table below sets out what are considered likely to be key drivers of habitat change within the study area. They relate to changes to habitat in the sense of vegetation type and condition from a biodiversity perspective and do not take into account drivers of change that may predominantly influence fauna such as recreational disturbance of birds or the spread of American mink on water voles or social factors such as connectivity and housing

Driver	Market / policy responses	State (condition or type)	Supporting statements from NFP4: The area's natural capital will play a vital role in locking in carbon and building our resilience by providing valuable ecosystem services.	Potential Sources of Mapped Data
Land use change- conversation to forestry – conifer	Carbon and timber markets & Scot.Gov policy	Type	A programme of investment in forestry, woodland creation, native woodlands and peatland restoration will play a key role in reducing our national emissions, providing investment opportunities, supporting ecosystems and biodiversity and benefiting current and future generations.	Planning Applications - Proposed Woodlands.
Land use change- conversation to forestry – broadleaved	Carbon, biodiversity and timber markets & Scot.Gov policy	Type		Planning Applications - Proposed Woodlands.
Land use change- bog restoration	Carbon and biodiversity markets & Scot.Gov policy Water & fisheries interests	Condition		Highland Council or Stakeholders.
Land use change- river restoration	Scot.Gov policy; Water & fisheries interests; Flood mitigation	Condition	The area's rivers are also strategic assets that will continue to benefit from aligned land use, climate adaptation and biodiversity enhancement.	Highland Council or Stakeholders.
Land use change- conversation to agriculture	Probably not a big concern in this area Scot.Gov policy	Type	Food and drink is a key sector, with aquaculture, distilleries, commercial fishing, and seaweed farming providing a crucial and growing source of employment for many local communities. This sector is of national significance, with whisky generating an estimated £5 billion to the UK economy and salmon accounting for more than 40% of total food exports. Food miles can be reduced over time with the help of local community-led food growing networks, by supporting locally driven public procurement and, from a land use perspective, protecting higher quality agricultural land.	Highland Council or Stakeholders.
Land use change- urban/ industrial development inc. Strategic renewable energy generation and transmission infrastructure	Probably not a big concern in this area or impact direction/ magnitude unclear due to biodiversity enhancement requirements under NPF4	Type	This area also makes an important contribution to our climate change targets by supporting renewable energy generation. Repowering and extending existing wind farms will optimise their productivity and capitalise on the area's significant natural energy resources, and there is potential to increase offshore wind energy capacity. Planning permission has been granted for a spaceport at Melness in Sutherland, making use of its location away from populated areas to provide a vertical launch facility that could link with wider opportunities for manufacturing, research and development across Scotland.	Highland Council or Stakeholders.
Land use management – muriburn	Scot.Gov policy Grouse industry	Condition	Wider but closely related priorities include continuing conservation at a landscape-scale, to develop resilient nature networks, deer and moorland management	Highland Council or Stakeholders.
Land use management - deer	Scot.Gov policy Stalking industry			Highland Council or Stakeholders.
Land use management – grazing/ crofting	Scot.Gov policy Rural depopulation	Condition/ Type	Greater efforts to ensure young people have more influence in decisions that affect their future places could support this, as well as helping more people access land and crofts and the reuse of abandoned sites where appropriate.	Highland Council or Stakeholders.

	Reduced interest from younger generation 2nd homes / house prices etc. reducing affordability for local population			
Climate change – temperature (averages and extreme event frequency and severity)	Climate change Scot.Gov policy	Condition/ Type	Climate change risks include changing levels of rainfall, increased storm events, temperature rise, flood risk, rising sea levels and associated erosion.	Met Office.
Climate change – precipitation (averages and extreme event frequency and severity)	Climate change Scot.Gov policy	Condition/ Type		SEPA/Met Office
Climate change wind (averages and extreme event frequency and severity)	Climate change Scot.Gov policy	Condition/ Type		Maybe from: (https://globalwindatlas.info/download/gis-files)?
Climate change – sea level rise	Climate change Scot.Gov policy	Condition/ Type	Of particular concern are the impacts on vulnerable low-lying coastal zones and infrastructure, potentially wide-ranging effects from biodiversity loss to sea level rise, coastal erosion, flooding and landslips.	Commercial data sets available. High-level assessment could be completed through analysis of DTM.
Cultural heritage designations	Potential restrictions on development/ changes in landscape	Condition/ Type	The Highlands of Scotland, together with Moray and parts of mainland Argyll, are world renowned for their stunning landscapes, rich biodiversity and cultural heritage… there is currently a proposal to make the Flow Country a UNESCO World Heritage Site.	Historic Environment Scotland or Stakeholders

APPENDIX 05

Place-Based Approach to Land Use and Pressures

Appendix 05 - Place-Based Approach to Land Use and Pressures

SLR and NW2045 together gathered information and land use, pressures and education for the Melness-Tongue-Skerray Community Council area, as a test case study to facilitate decision-making (e.g. more explicit review of trade-offs and synergies between ES; specific development information) at a more local level. For transparency, the information requested is included in this Appendix.

Land Use

Dataset / information request	How the information will be used	Notes e.g. preferred format
Ownership / tenure boundary	Map the extent of ownership / tenure (e.g. crofting townships), and compare it to other mapped boundaries (administrative, designations etc.)	Preferably in GIS format (ESRI Shapefile). Alternatively can be Ordnance Survey/Aerial Photography map with boundaries drawn on
[Information from Part 1 , Q1.1 (I and II) of the Grazings Census]	Comparison with and improvement of existing habitat maps prepared by SLR	This question is for grazing committees only
[Information from Part 1 , Q1.2 (all) of the Grazings Census]	Essential to understand how the crofts are being used, including diversification	This question is for grazing committees only
Do any education activities take place on the land?	Contribute to the education / tourism ecosystem service mapping, and to ground-truth broader work around natural capital stocks.	This could include school visits, volunteering, university research activities, studio workshops etc. For grazing committees, ideally we will get information for however many crofts are being used for other purposes per Q1.2 (III) of the Grazings Census
Do any tourism activities take place on the land?		Please note in particular if any aspects of nature/education-based tourism
Is land used for any other purpose not already described?	Ground-truth broader work around natural capital stocks, and ensure that we include all relevant land use in analysis	This could include food processing, renewable energy, crafting, animal feed etc.

Land Pressures

Dataset / information request	How the information will be used	Notes e.g. preferred format
Are invasive species an issue (e.g. bracken, whin, rhododendron)?	All of this information would help us to get a better picture of threats and opportunities	
Is muirburn used as a management operation?		
Is predation (either avian or mammalian) a significant issue for livestock?		
Is there significant deer damage and/or is fencing used to exclude deer from certain areas?		
Approximately how many cattle and sheep graze on the land (e.g. in the township)?	To get a better understanding of grazing management / pressures	

Education / Education-Related Tourism

At the moment, we have mapped information about relevant designated sites (e.g. SSSIs), along with locations of schools and historical monuments. We could also analyse and add cultural heritage information. But community expertise is needed.

Dataset / information request	How the information will be used	Notes e.g. preferred format
Locations for education-related facilities / sites of historic importance	Map all potential nature-related education facilities / information centres / visitor centres etc.	This can include things without clear connection to nature or education (e.g. gift shop, war memorial, statue, Coastguard HQ). An address / postcode or point map would be sufficient.
Locations / landscapes used in educational media (TV, books etc.)	Might not be possible to formally map, but insights can be added to our final report	SNH mapped the cultural association to landscapes, and this included an area south of Strathy, but nothing else.
Visitor numbers for education-related facilities	Might not be possible to formally map, but insights can be added to our final report	If Strathnaver Museum is included in our study, we have figures for this (2019-20 it was 6,309). Could include NC500 users.
Geopark Boundary	Even if mainly outside of the Community Council area(s) of interest, it's an integral attraction for education	Preferably in GIS format (ESRI Shapefile). Alternatively can be Ordnance Survey/Aerial Photography map with boundary drawn.
Local Landscape Areas from the Highland Council	To discuss whether to map these areas, and the extent to which they relate to education	Preferably in GIS format (ESRI Shapefile).
Important visitor locations	Help to build a picture of opportunities for education (e.g. campsite could add educational materials)	An address / postcode or point map would be sufficient. Could include campsites / areas for sports activities (hiking, mountain biking, rafting etc.)
Volunteer Organisations / Community Hubs	Help to identify examples where nature-based volunteer activities and/or education occur	An address / postcode or point map would be sufficient. Could include Scout / Guide / Church groups etc.

APPENDIX 06

Glossary

Appendix 06 - Glossary

Most terms are taken from Burkhard and Maes (2017).

Abiotic:	Referring to the physical (non-living) environment, for example, temperature, moisture and light, or natural mineral substances.
Abundance:	The total number of individuals of a taxon or taxa in an area, population, or community. Relative abundance refers to the total number of individuals of one taxon compared with the total number of individuals of all other taxa in an area, volume, or community.
Afforestation:	Planting of forests on land that has historically not contained forests (as opposed to Reforestation).
Assessment:	A social process whereby researchers and policy makers come together to review the available evidence and information with a view to identifying the status and trends in some system of interest, and in order to identify appropriate response options. In contrast to pure research, assessments aim to communicate existing knowledge, so that it is made relevant and helpful to an inexpert decision maker.
Benefits:	The direct and indirect outputs from ecosystems that have been turned into goods or experiences that are no longer functionally connected to the systems from which they were derived. Benefits are things that can be valued either in monetary or social terms.
Biodiversity:	The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Biodiversity is a contraction of 'biological diversity'.
Biomass:	The mass of tissues in living organisms in a population, ecosystem, or spatial unit derived by the fixation of energy though organic processes.
Biophysical Structure:	The architecture of an ecosystem that results from the interaction between the abiotic, physical environment and organisms or whole biotic communities.
Capital:	A resource used / available for use in the production of goods and services. There are five types of capital: Natural capital – that part of nature which directly or indirectly underpins value to people, including ecosystems, species, freshwater, soils, minerals, the air and oceans, as well as natural processes and functions. In combination with other types of capital, natural capital forms part of our wealth; that is, our ability to produce actual or potential goods and services into the future to support our well-being; manufactured capital (for example, machinery and buildings); financial capital (for example, shares and banknotes); human capital (for example, knowledge and skills); and social capital (for example, levels of trust and connections amongst people).
Carbon sequestration:	The process of increasing the carbon content of a reservoir other than the atmosphere.
Community (Ecological):	An assemblage of species occurring in the same space or time, often linked by biotic interactions such as competition or predation.

Community (Human):	A group of people who have something in common. A local community is a fairly small group of people who share a common place of residence and a set of institutions.
Cost-Benefit Analysis:	A technique designed to determine the economic feasibility of a project or plan by quantifying its economic costs and benefits.
Cultural Ecosystem Services:	All the non-material, and normally non-consumptive, outputs of ecosystems that affect physical and mental states of people. CES are primarily regarded as the physical settings, locations or situations that give rise to changes in the physical or mental states of people, and whose character are fundamentally dependent on living processes; they can involve individual species, habitats and whole ecosystems. The settings can be semi-natural as well as natural settings (i.e. can include cultural landscapes) providing they are dependent on in situ living processes. In the classification we make the distinction between settings that support interactions that are used for physical activities such as hiking and angling, and intellectual or mental interactions involving analytical, symbolic and representational activities. Spiritual and religious settings are also recognised
Defra Metric 3.1:	A method used to assess biodiversity baseline value and change following intervention. It largely applies to England where Natural England will be recommending to the Secretary of State that the Biodiversity Metric 3.1 forms the basis of the statutory biodiversity metric used to underpin future mandatory biodiversity net gain as set out in the Environment Act 2021.
Drivers of Change:	Any natural or human-induced factor that directly or indirectly causes a change in the structure or function of an ecosystem. A direct driver of change unequivocally influences ecosystem structure or processes and can therefore be identified and measured to differing degrees of accuracy. An indirect driver operates by altering the strength of impact of one or more direct drivers.
Ecosystem:	Dynamic complex of plant, animal, and microorganisms communities and their non-living environment interacting as a functional unit. Humans may be an integral part of an ecosystem, although 'socio-ecological system' is sometimes used to denote situations in which people play a significant role, or where the character of the ecosystem is heavily influenced by human action.
Ecosystem Service Flows:	The current flow of ecosystem services provided by natural capital stocks and the systems within which they are embedded. These yield the welfare-bearing goods and services which provide actual or potential benefits to humans.
Ecosystem Service Mapping:	The process of creating a cartographic representation of (quantified) ecosystem service indicators in geographic space and time.
Ecosystem Service Potential:	This describes the natural contributions to ES generation. It measures the amount of ES that can be provided or used in a sustainable way in a certain region. This potential should be assessed over a sufficiently long period of time.
Equity:	Fairness of rights, distribution, and access. Depending on context, this can refer to resources, services or power.

Exchange Value:	Relates to obtaining valuations of ecosystem services and assets that are consistent with values that would have been obtained if a market for the ecosystem services or assets had existed. (Contrasts with Welfare Value.)
Externality:	A consequence of an action that affects someone other than the agent undertaking that action and for which the agent is neither compensated nor penalized through the markets. Externalities can be positive or negative.
Geographic Information System (GIS):	A computer-based system for the storage, analysis and display of spatially referenced data.
Habitat:	The physical location or type of environment in which an organism or biological population lives or occurs. Terrestrial or aquatic areas distinguished by geographical, abiotic and biotic features, whether entirely natural or semi-natural.
Human Well-being:	A state that is "intrinsically and not just instrumentally valuable" (or good) for a person or a societal group. Components of human well-being have been classified into: basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience.
Impact:	Negative or positive effect on individuals, society and/or environmental resources resulting from environmental change
Indicator:	An indicator in policy is a metric of a policy-relevant phenomenon used to set environmental goals and evaluate their fulfilment. An indicator in science is a quantifiable metric which reflects a phenomenon of interest.
InVEST Tool:	This is the Integrated Valuation of Ecosystem Services and Tradeoffs suite of models. It was developed by Stanford University and is free to use and open-source. It has been used in this project, notably the carbon model.
Land Cover:	The physical coverage of land, usually expressed in terms of vegetation cover or lack of it (habitats). Related to, but not synonymous with, land use
Land Use:	The human use of a piece of land for a certain purpose such as irrigated agriculture or recreation. Influenced by, but not synonymous with, land cover.
Market Failure:	The inability of a market to capture the full value of ecosystem services and/or the costs of their loss/degradation.
Metric:	A system or standard of measurement that enables the measurement of a trend over time. For example, measurements and estimates of greenhouse gas emissions.
Monetary Valuation:	The process whereby people express the importance or preference they have for the service or benefits that ecosystems provide in monetary terms.
Natural Capital:	The elements of nature that directly or indirectly produce value for people, including ecosystems, species, freshwater, land, minerals, air and oceans, as well as natural processes and functions.
Natural Capital Accounting:	A way of organising information about natural capital so that the state and trends in natural assets can be documented and assessed in a systematic way by decision makers.
Natural Capital Asset Maintenance:	Capital maintenance is an accounting concept based on the principle that income is only recognised after a full recovery of costs has been achieved or capital has been maintained. In a natural capital asset context, this concerns the cost/investment required to maintain its condition. For

	example, the cost this year of conserving natural capital in the state that it was last year, taking measures such as repairing or replacing key components that have eroded. These maintenance provisions can therefore be thought of as a measure of the money that needs to be spent in order to maintain natural capital intact through time
Natural Capital Baseline:	The starting measurement point of natural capital assets - changes relative to the baseline over time provide a measure of progress or decline. A natural capital asset baseline is essential for any proper, robust evaluation of national and corporate environmental performance.
Natural Capital Stock:	The tangible biotic and abiotic structures that make up the natural world and which support processes and functions that can contribute to human well-being. Stocks can be represented in various ways, but are more often measured in terms of the areas, volumes or numbers.
Non-Monetary Valuation:	The process whereby people express the importance or preference they have for the service or benefits that ecosystems provide in terms other than money.
Opportunity Costs:	The benefits forgone by undertaking one activity instead of another
Participatory Approach:	Family of approaches and methods to enable (rural) people to share, enhance, and analyse their knowledge of life and conditions, to plan and to act, to monitor and evaluate.
Provisioning Services:	Those material and energetic outputs from ecosystems that contribute to human well-being.
Quality (or Condition):	Refers to the underlying condition of natural capital assets and their ability to maintain flows of services.
Quantity (or Extent):	Refers to the extent, volume or amount of an asset, benefit or a good.
Regulating Services:	All the ways in which ecosystems and living organisms can mediate or moderate the ambient environment so that human well-being is enhanced. It therefore covers the degradation of wastes and toxic substances by exploiting living processes.
Socio-Economic System:	A system consisting of individuals, groups and organizations and their economic and social interactions.
Stakeholder:	Any group, organisation or individual who can affect or is affected by the ecosystem's services.
Synergies:	Ecosystem service synergies arise when multiple services are enhanced simultaneously.
Trade-Off:	Situations in which one service increases and another one decreases. This may be due to simultaneous response to the same driver or due to true interactions among services.
Valuation:	The process whereby people express the importance or preference they have for the service or benefits that ecosystems provide. Importance Value can be expressed in monetary or nonmonetary terms.
Welfare Value:	Relates to obtaining valuations that measure the change in the overall costs and benefits associated with ecosystem services and assets. (Contrasts with Exchange Value.)

APPENDIX 07

References

Appendix 07 - References

Included throughout this report are references in footnotes and source links. Below are the six main references behind our methodological approach and analysis.

- Burkhard, B., & Maes, J. (Eds.) (2017). *Mapping Ecosystem Services.* Pensoft Publishers. https://doi.org/10.3897/ab.e12837

  This open access book (downloadable as a PDF) contains a wealth of information across its 350-plus pages. This includes chapters about quantifying and mapping ecosystem services, uncertainties around mapping, as well as potential applications.

- Helm, D. (2022). Natural capital, carbon offsetting and land use: A discussion paper. Prepared for the Scottish Land Commission.

  https://www.landcommission.gov.scot/downloads/628de8eb9c11a_Land%20Lines%20Natural%20capital-carbon%20offsetting%20and%20land%20use.pdf

  Dieter Helm is Professor of Economic Policy at the University of Oxford. He was the Chair of England's Natural Capital Committee (2012-20), providing advice to the government on the sustainable use of natural capital. His paper argues that natural capital should generally be regarded as a public good, and is a call for the Scottish Government to properly ensure that natural capital assets are maximised.

- The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2022). Values Assessment - Decisions Based on Narrow Set of Market Values of Nature Underpin the Global Biodiversity Crisis.

  https://ipbes.net/media_release/Values_Assessment_Published

  IPBES are an independent intergovernmental body established to strengthen the science-policy interface for biodiversity and ecosystem services for the conservation and sustainable use of biodiversity. In 2022, they released an assessment demonstrating that the way nature is valued in political and economic decisions (using market values) is a key driver of the global biodiversity crisis, and provided over 50 valuation approaches to help make visible nature's multiple values.

- McMorran, R., Glendinning, J., & Glass, J. (2022). *Rural Land Markets Insights Report*. Prepared for the Scottish Land Commission. https://www.landcommission.gov.scot/downloads/62543b9498bb1_Rural%20Land%20Market%20Insights%20Report%20April%202022.pdf

  This report demonstrates that increased demand for natural capital investment is driving activity in the land market.

- Robbie, J., Jokubauskaite, G. (2022). *Carbon Markets, Public Interest and Landownership in Scotland: A discussion paper*. Prepared for the Scottish Land Commission

  https://www.landcommission.gov.scot/downloads/628dea082d087_Land%20Lines%20Nat%20Cap-Carbon%20Markets,%20Public%20Interest%20and%20Landownership%20in%20Scotland.pdf

  This paper investigates the consequences of the carbon markets in Scotland, including exacerbating unequal land ownership and exclusion from decision-making. It considers possible models of regulation for the public interest.

- Reed, M.S., Waylen, K., Glass, J., Glendinning, J., McMorran, R., Peskett, L., Rudman, H., Stevens, B., Williams, A. (2022). *Land Use Partnerships using a Natural Capital Approach: Lessons for Scotland*. ClimateXChange.

  https://www.climatexchange.org.uk/media/5298/cxc-regional-land-use-partnerships-and-the-natural-capital-approach-march-22.pdf

  This report examined evidence from the UK and Europe for the use of the natural capital approach in successful partnership-working across multiple sectors and landownership boundaries. It focused on outcomes for climate change, biodiversity and benefits to local communities. It is a very useful source for NW2045 and other RLUPs as they produce a Regional Land Use Framework.

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