Talla-Hartfell Wild Land Area Mapping Project

Wildland Research Limited

for

Southern Uplands Partnership Services Ltd (SUPS Ltd)

Contents

Executive Summary

This report develops a natural capital GIS database and mapping product for the Talla-Hartfell Wildland Project[1] on behalf of the Southern Uplands Partnership Services Ltd (SUPSLtd) and South of Scotland Enterprise (SoSE). It is intended that this work will be used to inform and stimulate debate amongst local stakeholders on how to maximise nature-based solutions and associated ecosystem service delivery.

The report provides a Natural Capital Assessment (NCA) of the Talla-Hartfell Wildland Project area, and associated SSSIs and SACs, focusing on non-monetary values of wildness, public access, woodland opportunity, ecological connectivity, and landscape character. We use a GIS-based desk study coupled to a participatory mapping exercise to survey public opinion and integrate this local knowledge with information on landscape characteristics with particular reference to patterns in biodiversity, hydrology and flood mitigation measures, peatlands and associated carbon storage. The report utilises publicly available datasets to prepare base maps and models of wildness, accessibility, opportunity for new native woodland, ecological connectivity, and landscape character. The study uses face-to-face map-based methods to capture spatial patterns regarding public opinion, local values, and landscape qualities and character.

We used this integrated approach to map opportunities for maximising nature-based solutions and ecosystem service delivery (biodiversity, native woodland, existing land use and wild land), assess future opportunities (public access, woodland planting schemes, biodiversity and flood mitigation) and produce value-added spatial analyses that can be used to inform and stimulate debate amongst local stakeholders.

The report identifies potential threats to wildness and landscape quality, including commercial forestry operations, land acquisition, and renewable energy developments. However, opportunities exist for continued native woodland planting and regeneration with associated benefits for landscape quality, recreation, flood mitigation and biodiversity. The report recommends further utilisation of woodland opportunity mapping, better provision of access paths and routes, careful monitoring of commercial forestry operations, sensitive planning of renewable energy developments, and expanding the approach of wild land NCA mapping and participation across other wild land areas in Scotland. The participatory mapping workshops suggest that local people want more from their landscape than just timber and renewable energy and see the current trend as a continuing process of local resource extraction, with the financial benefits exported outside the local area. They highlight the need in the long-term for a genuinely sustainable and more holistic approach to valuing, managing and restoring local natural resources.

[1] https://sup.org.uk/projects/talla-hartfell-wildland-project/

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1. Introduction

1.1 Natural Capital Assessment

Natural Capital Assessment (NCA) is a process that aims to measure the value of natural resources and ecosystems, and to ensure their sustainable management for the benefit of society. The Scottish Government recognizes the importance of natural capital and has made significant efforts to prioritize its assessment and management through the development of policies, strategies, and initiatives. The National Performance Framework for Scotland sets out the government's commitment to achieving sustainable economic growth while protecting and enhancing Scotland's natural capital. This framework recognizes the interdependence of the economy, environment, and society, and the need to balance economic development with environmental protection and social well-being. The assessment of natural capital in Scotland involves quantifying the economic, social, and environmental benefits that natural assets provide to society. It seeks to ensure that decision-makers have a better understanding of the impact of their actions on the natural environment and can make informed decisions that promote sustainable development.

The National Strategy for Economic Transformation highlights the need for a values-led, high-integrity market for responsible private investment in natural capital. This will build on Scotland's international reputation for its nature and supporting policy framework on land and sea, and emerging nature-based solutions. The First Minister endorsed the Leaders' Pledge for Nature at COP26, with an international commitment to reverse biodiversity loss and create a "nature-positive" world by 2030[2]. The pledge highlights the need to "transform and reform our economic and financial sectors" to safeguard the wellbeing of people and planet. The Scottish Government is committed to ensuring that local communities are empowered and benefit from investment in natural capital.

The South of Scotland is being positioned as the "Natural Capital Innovation Zone" to encourage and accelerate responsible investment across the region[3]. Aimed at promoting responsible investment, and centred on protecting nature and supporting economic transition for local communities.

Further to this, the Interim principles for responsible investment state reiterate that while this is largely focused on delivering wider carbon management goals it also supports a wide range of benefits including economic development (particularly in rural areas), biodiversity improvements, resilience of food supply and natural flood management[4].

[2] The National Strategy for Economic Transformation. retrieved from https://www.gov.scot/publications/scotlands-national-strategy-economic-transformation/

[3] Natural Capital Principles https://www.southofscotlandenterprise.com/news/naturalcapitalinvestment

[4] Interim principles for Responsible Investment in Natural capital. Retrieved from https://www.gov.scot/publications/ministerial-statement-on-interim-principles-for-responsible-investment-in-natural-capital/

The wider literature on NCA in Scotland highlights the importance of valuing and managing natural capital for sustainable economic growth, environmental protection, and social well-being, and provides insights into the challenges and opportunities associated with this process[5].

These resources provide a more in-depth analysis of the concept of natural capital and its assessment in Scotland. They highlight the importance of valuing and managing natural capital for sustainable economic growth, environmental protection, and social well-being.

There are, however, several difficulties and arguments surrounding the reliance on natural capital assessments:

- Measuring natural capital is challenging: There is no standard method for measuring natural capital, and different approaches can lead to different results. Measuring natural capital involves quantifying ecosystem services, which can be complex, difficult, and even impossible to value in monetary terms.
- Difficulties in assigning value: Assigning monetary value to natural capital can be controversial as it can be difficult to accurately quantify the value of ecosystem services. Assigning value can also be seen as placing a price tag on nature, which can be perceived as inappropriate by some people and in some situations.
- Limitations of the economic approach: Some argue that natural capital assessments rely too heavily on economic approaches and do not fully account for non-monetary values such as intrinsic, cultural, or spiritual values.
- Overreliance on technology: There is a risk of over-reliance on technology and engineering solutions to address natural capital problems, which can neglect the importance of natural processes and systems.

[5] Scottish Government. (2017). Scotland's Economic Strategy. Retrieved from https://www.gov.scot/publications/scotlands-economic-strategy/

Natural Capital Accounting: A Primer for Scotland. (2021). Scottish Forum on Natural Capital. Retrieved from https://www.naturalcapitalscotland.com/resources/natural-capital-accounting-primer-scotland

Aitkenhead, M., et al. (2018). Natural Capital Asset Index Report for Scotland. Scottish Natural Heritage Commissioned Report No. 1050. Retrieved from https://www.nature.scot/sites/default/files/2018-03/Commissioned%20Report%201050%20-%20Natural%20Capital%20Asset%20Index%20Report%20for%20Scotland.pdf

Bateman, I. J., et al. (2019). Economic Analysis for the UK National Ecosystem Assessment: Synthesis and Scenario Valuation of Changes in Ecosystem Services. Environmental and Resource Economics, 62(2), 247-275.

Haines-Young, R., et al. (2018). The Economic Value of Ecosystem Services in Scotland: A Review. Scottish Natural Heritage Commissioned Report No. 1052. Retrieved from https://www.nature.scot/sites/default/files/2018-03/Commissioned%20Report%201052%20-%20Economic%20value%20of%20ecosystem%20services%20in%20Scotland.pdf

Scottish Government. (2017). Scotland's Economic Strategy. Retrieved from https://www.gov.scot/publications/scotlands-economic-strategy/

- Lack of political will: The implementation of natural capital assessments requires political will and support, which may be lacking in some jurisdictions.
- Inadequate data: In many cases, there is a lack of adequate data on natural capital, which can limit the effectiveness of assessments and management strategies.

It is important to note that these challenges are not insurmountable and that efforts are being made to address them. Nevertheless, it is essential to recognize and address these challenges to ensure that natural capital assessments are conducted in a way that is transparent, scientifically sound, and socially just.

The use of GIS (Geographic Information Systems) is one approach that can be used to support natural capital assessments in several ways. Examples include:

- Mapping and visualization: GIS can be used to map and visualize natural capital assets, such as forests, wetlands, and water bodies. This enables decision-makers to see the spatial distribution of natural capital assets and identify areas that require protection or restoration.
- Data management: GIS can be used to manage and integrate large amounts of data on natural capital, such as biodiversity, landscape qualities, policy boundaries (e.g. protected areas) and land use. This helps to ensure that data is organized and readily available for analysis.
- Spatial analysis: GIS can be used to conduct spatial analysis to identify areas that are particularly important for natural capital, such as areas of high biodiversity or critical habitat for endangered species. This enables decision-makers to prioritize conservation and restoration efforts.
- Scenario planning: GIS can be used to model different scenarios for land use and management, allowing decision-makers to evaluate the potential impacts of different decisions on natural capital.
- Monitoring and evaluation: GIS can be used to monitor and evaluate the effectiveness of natural capital management strategies, such as the impact of habitat restoration on biodiversity.

While GIS can help decision-makers to make informed decisions about natural capital management by providing spatially explicit information and facilitating data-driven analysis, it does have certain limitations when it comes to incorporating local knowledge and public opinion.

- Lack of local knowledge: GIS relies on spatial data and modelling, which may not always capture the full complexity of local ecosystems and the ways in which they are used and valued by local communities. This can result in an incomplete or inaccurate picture of natural capital.
- Limited public input: GIS is often used by technical experts and may not adequately incorporate the perspectives and knowledge of local communities, stakeholders, and wider public. This can lead to a lack of understanding of the full range of values associated with natural capital.
- Standardized approaches: The use of standardized approaches and models in GIS may not account for the unique characteristics of local ecosystems and communities. This can result in a lack of specificity and relevance to local contexts.

- Biases and assumptions: The use of GIS and modelling can introduce biases and assumptions that may not reflect local knowledge and perspectives. This can result in a lack of trust and acceptance by local communities and stakeholders.
- Data availability: The use of GIS requires spatial data, which may not always be available or may be limited in scope. This can result in incomplete or inaccurate assessments of natural capital.

To address these limitations, it is important to incorporate local knowledge and public input into natural capital assessments through participatory processes, such as community mapping, citizen science, and stakeholder engagement. These approaches can help to ensure that assessments are more inclusive and reflect the diverse perspectives and values of local communities and stakeholders.

Participatory approaches, including participatory mapping workshops, can be used to improve the quality of natural capital assessments in several ways:

- Incorporating local knowledge: Participatory mapping workshops enable local communities, stakeholders, and wider public to share their knowledge and perspectives on natural capital assets and the ecosystem services they provide. This can help to ensure that assessments are more comprehensive and reflective of local values and needs.
- Building trust and engagement: Participatory approaches can help to build trust and engagement between technical experts and local communities, stakeholders, and Indigenous peoples. This can facilitate more collaborative and effective natural capital assessments and management strategies.
- Enhancing data quality: Participatory mapping workshops can help to improve the quality and accuracy of data on natural capital assets, ecosystem services, and their values. By engaging local communities in data collection and validation, assessments can be more robust and reliable.
- Identifying priorities and trade-offs: Participatory mapping workshops can help to identify local priorities and trade-offs related to natural capital management. This can enable decision-makers to prioritize conservation and restoration efforts in areas that are most important to local communities and stakeholders.
- Empowering local communities: Participatory approaches can empower local communities and stakeholders to participate in natural capital management decisions and advocate for their interests. This can lead to more equitable and sustainable management strategies.

Participatory approaches can help to ensure that natural capital assessments are more comprehensive, accurate, and reflective of local values and needs. By engaging local communities and stakeholders in the assessment process, and feeding back results for comment and further discussion, natural capital management strategies can be more effective and sustainable over the long-term.

1.2 Client brief

The proposed work addresses the brief to develop a natural capital GIS database and mapping product for the Talla-Hartfell Wildland Project[6] on behalf of the Southern Uplands Partnership Services Ltd (SUPSLtd) and South of Scotland Enterprise (SoSE). This will be used to inform and stimulate debate amongst local stakeholders on how to maximise nature-based solutions and associated ecosystem service delivery.

1.3 Consultant experience

This report has been prepared by the Wildland Research Limited (WRLtd) working for SUPSLtd. WRLtd is an independent consultancy with specialist knowledge in wilderness, geographical information systems (GIS) and landscape assessment.

Wildland Research Limited[7] is the consultancy arm of the Wildland Research Institute (WRi)[8] and specialises in providing specialist knowledge in wilderness, policy advice, mapping and landscape assessment.

WRLtd have detailed, in-depth knowledge of landscape mapping and with WRi are the originators of the original wildness methodology developed for the two Scottish National Parks[9] and have acted as technical advisors to the Scottish Government during their national wild land mapping process leading to the designation of Talla-Hartfell WLA[10]. WRi are co-authors of the EU Wildness Register and mapping programme (2013)[11] and developed the first map of naturalness potential for France, for IUCN France, Wild Europe and WWF France[12]. This map is now used in national level decision making on the French Protected Areas Strategy to 2030. We are currently working with NGOs in Iceland to map wilderness in the Central Highlands with the aim of informing government policy on protected area designation[13]. We are also working for Rewilding Britain on developing a UK-wide ecological connectivity map to inform strategic decisions on rewilding opportunities. In 2021 we produced a report on "The State of Wild Land in the Scottish Highlands" for Scottish Wild Land Group with Ian Kelly Planning Consultants Ltd.

1.4 Approach

The approach adopted was to focus on selected aspects of Natural Capital Assessment (NCA) that are most well represented in the Talla-Hartfell Wildland Project area. These include wildness (as defined by NatureScot and the National Planning Framework 4 under Policy 4g[14]), public access (both on foot and from private/public transport), woodland opportunity (recognising the existing efforts to re-establish native woodland within the study area), ecological connectivity (to

[6] https://sup.org.uk/projects/talla-hartfell-wildland-project/
[7] https://www.wildlandresearch.co.uk/
[8] https://www.wildlandresearch.org/
[9] Carver, S., Comber, A., McMorran, R. and Nutter, S., 2012. A GIS model for mapping spatial patterns and distribution of wild land in Scotland. Landscape and urban planning, 104(3-4), pp.395-409. https://doi.org/10.1016/j.landurbplan.2011.11.016
[10] https://www.nature.scot/guidance-mapping-scotlands-wildness-and-wild-land-non-technical-description-methodology
[11] https://ec.europa.eu/environment/nature/natura2000/wilderness/pdf/Wilderness_register_indicator.pdf
[12] https://uicn.fr/cartnat-premier-diagnostic-national-des-aires-a-fort-degre-de-naturalite/
[13] https://wildlandresearch.org/wp-content/uploads/sites/39/2022/03/Iceland-Wilderness-Report_FINAL_March16-3_compressed-med.pdf
[14] National Planning Framework 4 https://www.gov.scot/publications/national-planning-framework-4/

identify and fill gaps in local ecological networks), and wider landscape character. This is achieved using three key phases, a GIS-based desk study utilising existing spatial data and models, a participatory mapping exercise with input from local people, and a final deliberative phase which integrates the results of the desk-based and participatory mapping.

The report utilises the consultant's combined expertise on mapping, landscape ecology and participatory methods to develop a GIS database and mapping product focusing on natural capital assessments for the Talla-Hartfell Wildland Project area and its immediate environs. The aims of the work reported here are to:

- Utilise publicly available datasets to prepare base maps for use in local stakeholder mapping workshops to collect public opinion on key issues such as how best to realise the natural capital resources of the area while maintaining the wild and natural qualities of the Talla-Hartfell landscape for which the WLA was designated.
- Combine the georeferenced local knowledge with information on landscape character to map opportunities for maximising nature-based solutions and ecosystem service delivery within the Talla-Hartfell Wildland project area.
- Use additional spatial analyses on wild land and ecosystem connectivity to assess these opportunities and produce value-added map layers that can be used to inform and stimulate debate amongst local stakeholders.

Specifically, the report uses models of wildness, accessibility, woodland opportunity, ecological connectivity, and landscape character for the Talla-Hartfell Wildland Project area to add value to the base map GIS data layers and create a region-wide set of models concerning non-monetary aspects of natural capital across relevant themes including ecosystem service categories of provisioning, regulating, supporting and cultural services. The wildness mapping utilises the Phase 1 Wildness layers from the SNH/NatureScot wild land mapping exercise and highlights areas of potential change. The ecological connectivity mapping is based on the results of an Omniscape analysis which models spatial data on landcover from the GIS database of relevance to landscape permeability for a range of species, together with data on human barriers. The results presented identify potential core areas of high structural connectivity value for multiple species, as well as potential corridors or natural landscape linkages across the project area.

The GIS-based desk studies have several advantages for natural capital assessment, including:

- Access to comprehensive data: GIS technology enables access to large amounts of data from a variety of sources, including satellite imagery, remote sensing data, and environmental databases. This allows for a more comprehensive assessment of natural capital, including the identification of habitats, species, and ecosystem services, and their spatial distribution.
- Improved accuracy and precision: GIS technology allows for more accurate and precise mapping and analysis of natural capital, including the ability to identify and quantify changes in habitat or land cover over time. This enables more informed decision-making and planning and can help to identify areas that are at higher risk of degradation or loss.
- Efficient and cost-effective: GIS-based desk studies are generally more efficient and cost-effective than traditional field-based studies, as they do not require physical visits to the site. This can save time and resources, particularly for larger or remote areas that may be difficult to access.
- Facilitates collaboration and sharing of information: GIS technology enables the sharing of data and information across different organizations and stakeholders, facilitating

collaboration and coordination for natural capital assessments. This can help to ensure that all relevant data and information is included in the assessment and can lead to more informed and effective decision-making.

These studies nonetheless need to be backed up and supported by public-facing participatory mapping workshops to help capture the 'rich-picture' of local knowledge and opinion that cannot be adequately captured by desk-based studies alone. Participatory mapping workshops can complement desk-based GIS studies of natural capital assessment by incorporating local knowledge and perspectives to help provide a more comprehensive understanding of natural capital, increase stakeholder engagement, and improve decision-making, and identify potential solutions that are contextually appropriate and socially acceptable. There are several advantages to be gained from a participatory mapping element, including:

- Inclusion of local knowledge: Participatory mapping workshops provide an opportunity to incorporate local knowledge and perspectives that may not be captured in desk-based studies. Local people often have a deeper understanding of the local environment and its natural capital, including the location and condition of important habitats and species, and the benefits they provide to local communities. Incorporating this knowledge can help to provide a more complete picture of the natural capital of the area.
- Increased stakeholder engagement: Participatory mapping workshops provide an opportunity to engage with local people and stakeholders, building relationships and trust between the project team and local communities. This can help to build support for the project and ensure that local perspectives and needs are considered.
- Improved decision-making: Incorporating local knowledge and perspectives into natural capital assessments can help to improve decision-making, by ensuring that the assessment considers the social and cultural dimensions of natural capital. This can help to identify potential conflicts or trade-offs between different aspects of natural capital and local needs and preferences.
- Identification of potential solutions: Participatory mapping workshops can provide an opportunity for local people to identify potential solutions to issues or challenges related to natural capital. This can help to build local capacity and empowerment and ensure that solutions are contextually appropriate and socially acceptable.

Here we utilise existing models of stakeholder consultation, using face-to-face map-based methods (Paper2GIS)[15], that can capture spatial patterns in stakeholder opinion, value, and landscape meaning. Large scale paper maps are used in face-to-face workshops that bring people together in the same room, to discuss in detail the map product. The aim is that the printed map forms the starting point for a discussion of the key themes and allow us to capture detailed local knowledge of relevance to making robust and sustainable decisions. Stakeholder input of this kind is captured during the workshops by drawing on the maps and then using the Paper2GIS tool to digitise the stakeholder input in a spatially explicit way. This data is then integrated into the GIS as additional spatial layers. This work builds on existing work by members of the contractor team in Montana, Pyrenees, and Scotland. These data are recorded and integrated into the GIS database for interrogation and analysis.

[15] https://github.com/jonnyhuck/Paper2GIS

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2. Talla-Hartfell study area

2.1 Background

The Talla-Hartfell wild land area is a remote, and relatively undisturbed landscape in the Scottish Borders region of Scotland. While isolated and large within its local setting, it is relatively small in comparison to other wild land areas found north of the Highland Boundary Fault. The location of the Talla-Hartfell wild land area and surrounding landscape together with existing nature protections is shown in Figure 1. This covers an area of approximately 93km^2 and is located within the Southern Uplands, which are known for their rugged terrain, deep valleys, and extensive forests (see Photos 1-12). Talla-Hartfell area is characterized by a range of habitats, including heathland, blanket bog, native woodland, and upland grassland. These habitats support a diverse range of plant and animal species, including rare and endangered species such as hen harrier and black grouse. Large parts of the area are protected as Special Area of Conservation (SAC) and as a Site Special Scientific Interest (SSSI) as shown in Figure 1. The area is also important for its cultural heritage, with several historic sites and landmarks, including the Talla Reservoir and the ruins of a medieval castle, located within its boundaries. The area is used extensively for recreation, including hillwalking, mountain biking, and birdwatching[16].

The Talla-Hartfell wild land area is part of a larger conservation project, known as the Talla-Hartfell Wildland Project, which aims to restore and enhance the natural and cultural values of the area[17]. The project covers an area of roughly 472 km^2 and involves a range of activities, including habitat restoration, invasive species control, and community engagement. The Talla-Hartfell Wildland Project is a collaborative effort primarily involving Borders Forest Trust (BFT) but drawing input from several organizations with a shared interest in protecting and enhancing the natural and cultural values of the area, including:

- Scottish Wild Land Group (SWLG): a non-profit organization that works to promote and protect Scotland's wild land areas[18]. The SWLG is the lead organization for the Talla-Hartfell Wildland Project and is responsible for coordinating the project and its activities.
- Forestry and Land Scotland (FLS): a Scottish government agency responsible for managing Scotland's national forests and land. FLS is involved in the Talla-Hartfell Wildland Project through its role in managing the Talla Reservoir, which is located within the project area.
- NatureScot: a Scottish government agency responsible for protecting and enhancing Scotland's natural heritage[19]. NatureScot is involved in the Talla-Hartfell Wildland Project through its support for habitat restoration and monitoring activities.
- Private landowners: The Talla-Hartfell Wildland Project involves several private landowners who have agreed to participate in the project and allow their land to be used for habitat restoration and management activities.

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[16] https://www.nature.scot/sites/default/files/2021-06/Wild%20land%20Description%20Talla-Hart-fell-July-2016-02.pdf
[17] https://sup.org.uk/projects/talla-hartfell-wildland-project/
[18] https://swlg.org.uk/
[19] https://www.nature.scot/

2.2 NCA elements

Natural capital assessment (NCA) is an important component of the Talla-Hartfell Wildland Project, as it helps to inform and guide the project's habitat restoration and management activities. By assessing the natural capital of the area, the project team can identify the most valuable and ecologically important habitats and species, as well as the key ecosystem services provided by the landscape.

The natural capital assessment also helps to prioritize the project's conservation efforts and ensure that limited resources are allocated effectively. For example, if the assessment identifies a particular habitat or species that is at high risk of degradation or loss, the project team can potentially prioritize conservation efforts to address this threat and prevent further decline. The natural capital assessment can also help to engage and involve local communities and stakeholders in the project. By sharing the results of the assessment and involving local people in the decision-making process, the project team hope to co-develop sustainable planning ideas and build shared understanding for the importance of protecting and enhancing the natural values of the area.

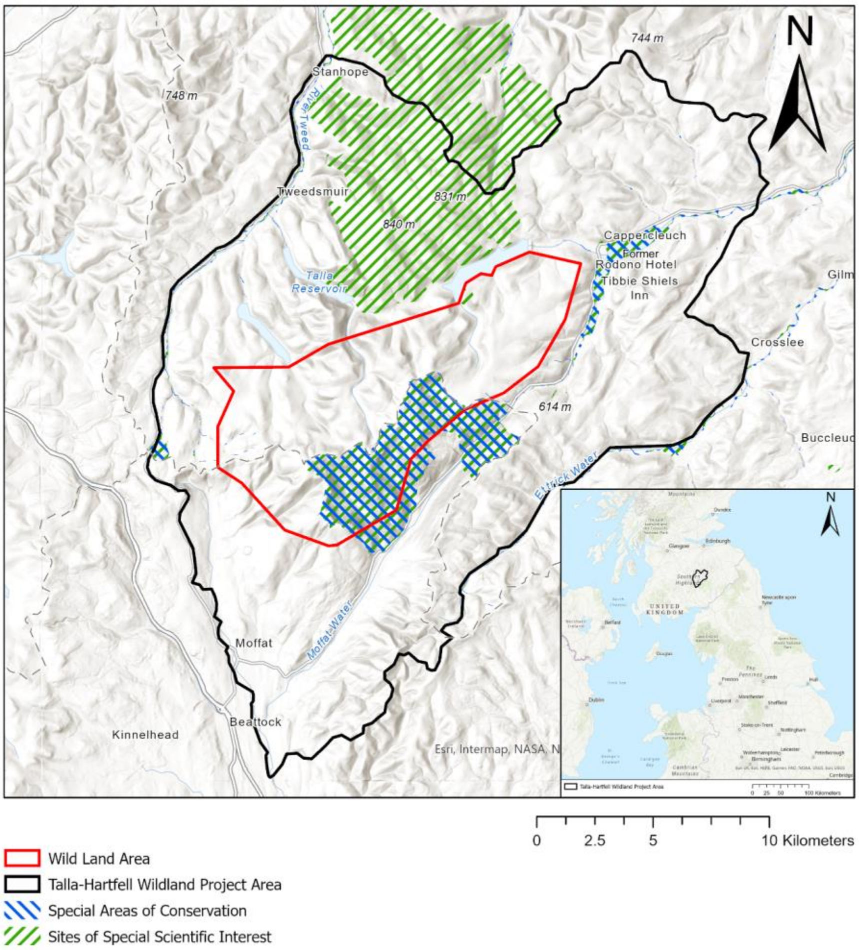

Figure 1. Location map of Talla-Hartfell Wildland Project

Photo 1. Moffat Water from Grey Mare's Tail

Photo 2. Loch Skeen

Photo 3. Looking down Carrifran valley

Photo 4. Moffat Water from Carrifran

Photo 5. Moffat Water from Carrifran Gans

Photo 6. Carrifran boundary, Saddle Yoke

Photo 7. View NW from White Coomb

Photo 8. Megget Water

Photo 9. Gameshope looking upstream

Photo 10. Gameshope looking towards Talla

Photo 11. Great Dodd

Photo 12. Craig Law

Photo 13. Carrifran in 1999

Photo 14. Carrifran in 2020

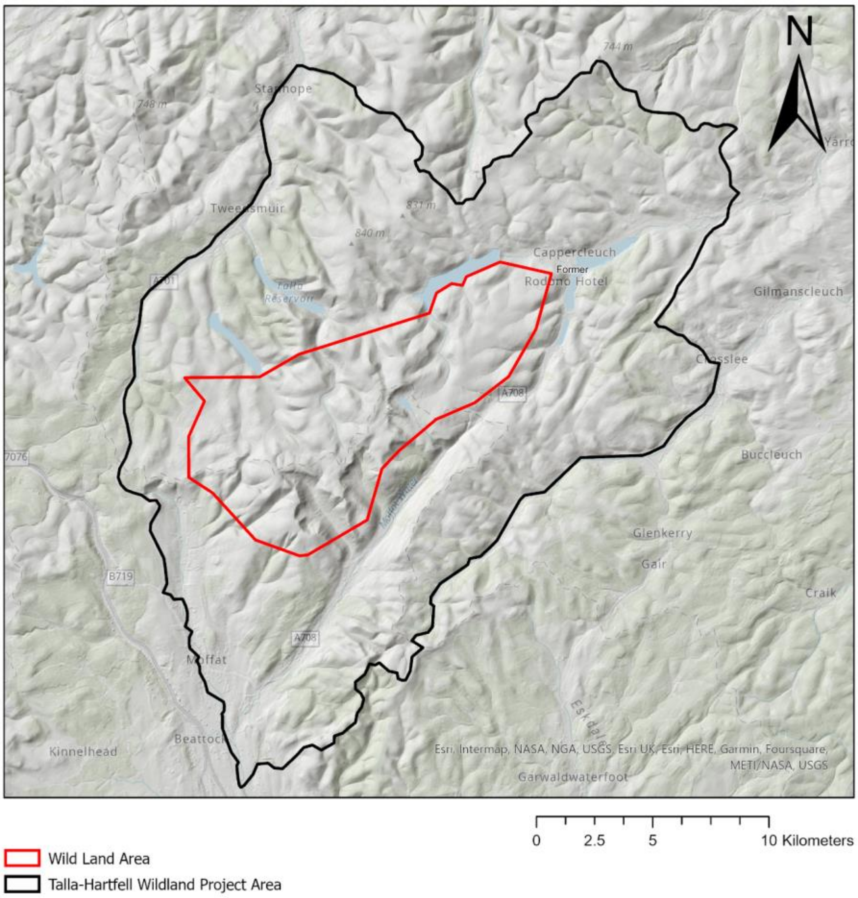

Figure 2. Talla-Hartfell Wildland Area and Project Area

3. Data

3.1 Data sources

All data required for the project are acquired from existing spatial datasets or are derived from the two participatory mapping workshops. Datasets are acquired/downloaded in digital formats and imported into GIS software for mapping and analysis.

3.2 Maps and tables

Data are presented in either map or table form. A list of principal datasets used in the report is provided in Table 1.

Table 1. Data sources

Layer	Source Scale	Resolution	Link	Date
OS Terrain 50 DEM	1:50,000	50m	https://www.ordnancesurvey.co.uk/business-government/products/terrain-50	16/03/22
OS Terrain 5 DEM	1:10,000	5m	https://beta.ordnancesurvey.co.uk/products/os-terrain-5	04/04/22
CEH Land Cover Map 2020	N/A	10m	https://www.ceh.ac.uk/data/ukceh-land-cover-maps	2021
EUNIS	N/A	20m	https://spatialdata.gov.scot/geonetwork/srv/api/records/08d85469-bc12-4e67-819e-b41ae47b0392	25/11/14
National Archives Historic Path Data	1:10,560		https://maps.nls.uk/transcriptions/paths/	2023
Open Street Map	Variable		https://www.openstreetmap.org/	2023
OS Points of Interest: Wind Turbines	1:10,000	5m	https://beta.ordnancesurvey.co.uk/products/points-of-interest	05/12/22
Scottish Forestry woodland data	N/A		https://open-data-scottishforestry.hub.arcgis.com/datasets/6d27b064fcba471da50c8772ad0162d7_0/about	22/07/22
Borders Forest Trust planting shapefiles	N/A		https://bordersforesttrust.org/	2023
NatureScot wild land area mapping phase 1 attributes and composite	1:10,000	5m	https://cagmap.snh.gov.uk/natural-spaces/dataset.jsp?code=PHASE1	05/07/17
NBN Atlas	Variable		https://nbnatlas.org/	2023

4. Analyses

Desk-based analyses in this report are broken down into five broad categories: wildness, access, woodland opportunity, ecological connectivity, and landscape character. In this section, each are described in turn, how they fit within NCAs and how they are modelled and mapped for the purposes of this report and the Talla-Hartfell NCA.

4.1 Wildness

Wildness can be a significant factor in natural capital assessments due to its unique ecological and cultural value, its role as an indicator of ecosystem health and resilience, and its importance from a social and ethical perspective. Incorporating wildness into natural capital assessments can help to ensure that the full range of natural capital values are considered and can lead to more informed and effective decision-making.

Wildness represents a valuable and unique component of natural capital, with inherent ecological and cultural value and is particularly well represented, by definition, in wild land areas. Wild land areas can be defined as those areas that are relatively untouched by human activity and where natural processes are allowed to occur largely undisturbed. These areas can provide important ecological benefits, such as biodiversity conservation, carbon sequestration, and water regulation. They also have cultural and recreational value, providing opportunities for activities such as hiking, camping, and wildlife watching. NatureScot describe wild land as where “the wild character of the landscape, its related recreational value and potential for nature are such that these areas should be safeguarded against inappropriate development or land-use change”[20].

Wildness can also be an important indicator of the health and resilience of ecosystems. Wild areas are often less impacted by human activities such as agriculture, forestry, and urbanization, and can serve as reference areas to compare to more altered landscapes. Changes in the extent or quality of wild areas can therefore be an important indicator of the health and resilience of ecosystems and can help to identify areas that are at higher risk of degradation or loss of natural capital.

Finally, wildness can be an important consideration in natural capital assessments from a social and ethical perspective. Many people value wild areas for their intrinsic value, and as a symbol of the beauty and power of nature. Preserving and protecting wild areas can therefore be seen as a moral imperative and can be an important factor in decision-making related to natural capital.

4.1.1 Assessment of NatureScot Phase 1/2 wild land area mapping

The Scottish Natural Heritage (now NatureScot) wild land mapping was launched in 2014 and identified 42 wild land areas in Scotland, covering approximately 20% of Scotland's land area[21]. These areas were identified based on a set of criteria that included factors such as naturalness, ruggedness, remoteness, and absence of modern human structures. The mapping aimed to provide a consistent and transparent approach to identifying wild land, which could be used in policy and planning contexts. The methods and data used closely

[20] SNH (2002) Wildness in Scotland’s Countryside. Edinburgh, Scottish Natural Heritage
[21] https://www.nature.scot/doc/wild-land-areas-map-and-descriptions-2014

follow the methods developed by the consultants in mapping wildness in the two Scottish national parks[22].

The wild land mapping has been used in a range of policy and planning contexts, including the National Planning Framework 4, which seeks to protect and enhance Scotland's wild land areas. The mapping has also been used by developers and other stakeholders to inform decision-making and reduce the impact of development on wild land areas.

The Talla-Hartfell wild land area is one of the 42 wild land areas identified in the NatureScot mapping and is one of only three Wild Land Areas (WLAs) located to the south of the Highland Boundary Fault. It is an isolated and relatively small WLA, covering an area of roughly 93 km^2 in the southern uplands between the Scottish Borders and Dumfries and Galloway. Geographically, it forms an elongated triangle of rounded moorland hills, incised by several deep clefts and steep-sided glens (see Figure 2, Photos 1-12). The area offers striking views across the water from Talla, Fruid, and Megget reservoirs towards the moorland hills beyond. There are several established walking routes, including the horseshoe ridge walk to the Corbett of Hart Fell, and White Coomb and Lochcraig Head are also well-publicised destinations featuring rugged terrain. The Grey Mare's Tail waterfall and Loch Skeen are popular walking destinations owned and managed by The National Trust for Scotland. The landscape and scenic value of the area are recognized by both councils, lying within the Moffat Hills Regional Scenic Area (RSA) and Tweedsmuir Uplands Special Landscape Area (SLA). The SLA citation notes that this is a highly scenic area of dramatic landform with a significant degree of wildness.

Patterns of wildness based on the NatureScot Phase 1 and 2 wild land area mapping can be seen in Figure 3. This shows both Phase 1 Wildland Quality Index (WQI) on a scale of 0 (least wild) to 256 (most wild) in Figure 3a, and the derived Phase 2 areas based on the use of Jenks Natural Breaks classification in Figure 3b.

[22] Carver, S., Tricker, J. and Landres, P., 2013. Keeping it wild: Mapping wilderness character in the United States. Journal of environmental management, 131, pp.239-255. https://doi.org/10.1016/j.jenvman.2013.08.046

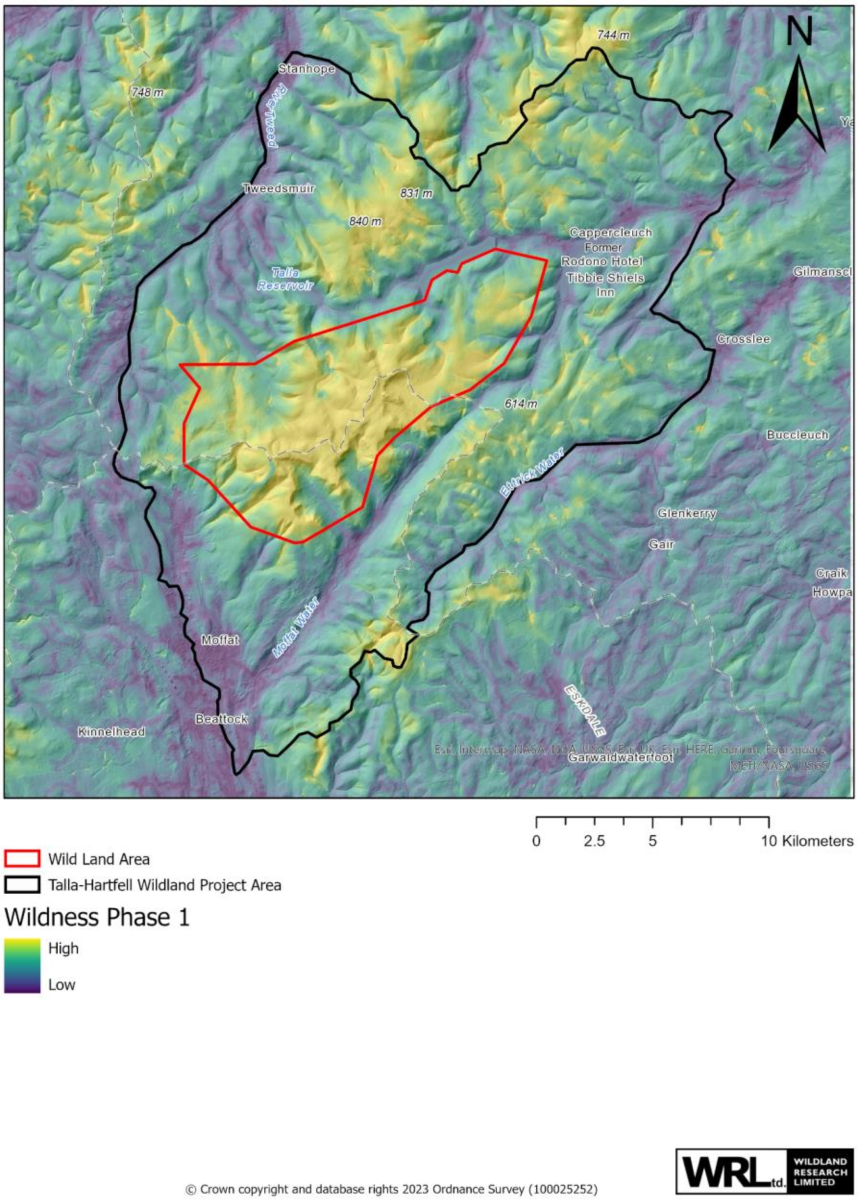

Figure 3a. Wild Land Area mapping: Phase 1 composite (After SNH, 2014)

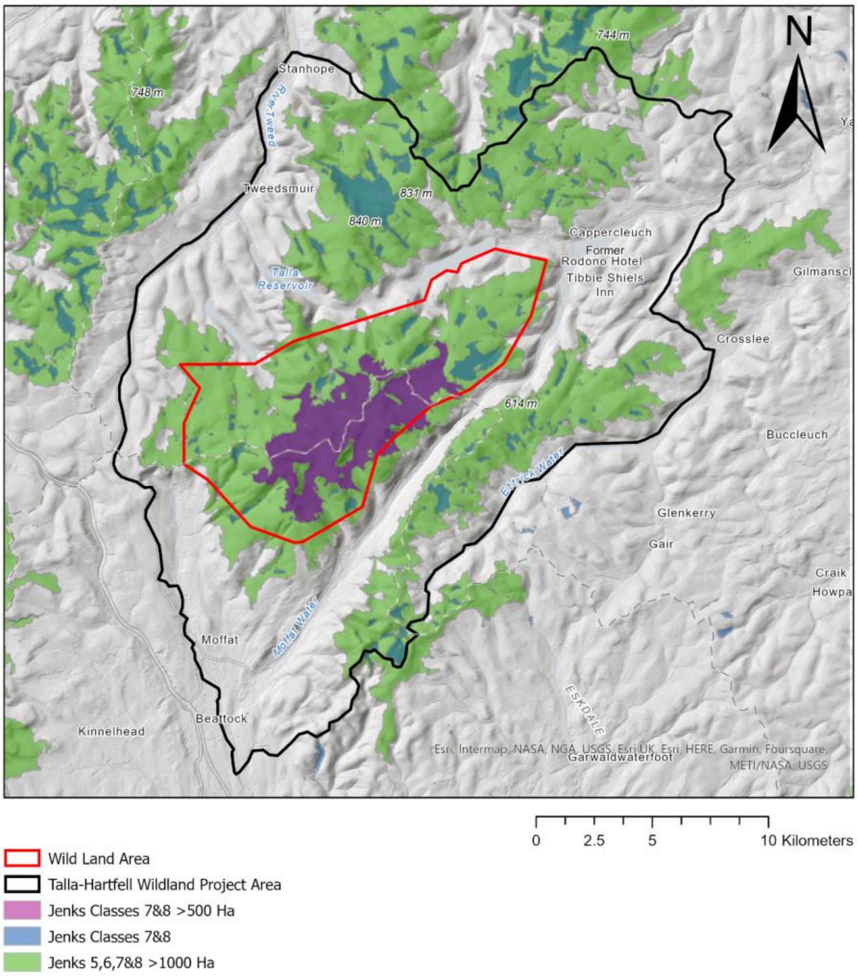

Figure 3b. Wild Land Area mapping: Phase 2 Jenks classes (After SNH, 2014)

4.1.2 Wild land typology

Figure 4 uses a reclassification of the four wildness input attributes (perceived naturalness of land cover, absence of modern human artefacts, remoteness from mechanised access, and rugged and challenging nature of the terrain) to create a simple wildness typology based loosely on the work of McMorran et al.[23] Here the four wildness attributes are reclassified into 5 wildness classes using the Jenks Natural Breaks classification and combined using a simple cross tabulation overlay to identify areas where all or nearly all four attributes exhibit high degree of wildness, which can then be compared against those areas where one of more attributes are compromised to differing degrees.

4.1.3 Biodiversity

Biological diversity – or biodiversity – is simply the variety of life seen in a habitat or ecosystem. It includes all living things all around us from the iconic or emblematic species to the smallest of insects, plants or bacteria. It is all life in our forests and mountains, our rivers and seas, our gardens and parks. Biodiversity and the species which make up this indicator have an intrinsic value to exist in their own right and for the benefit of other species on the planet. They also support our lives and are vital for our survival. It is therefore essential for our health and well-being that we protect our biodiversity and the services that it provides.

Scotland is renowned for its diversity of habitats and the sheer number of species – approximately 90,000 animal, plant and microbe species – which exist in a complex mosaic of habitats that make up a rich and varied landscape. Scotland is home to internationally important habitats many of which are protected areas, as well as many protected species.

In terms of protected areas, these include Sites of Special Scientific Interest (SSSI) and Special Areas of Conservation (SAC) which are those areas of land and water that NatureScot consider to best represent the natural heritage of Scotland - its diversity of plants, animals and habitats, rocks and landforms, or combinations of natural features of a particular type of habitat or landscape. They are the essential building blocks of Scotland's protected areas for nature conservation and several of these, covering over 14,500 hectares, are to be found in the upland parts of the Talla-Hartfell Area and as part of the river network running through the area (see Figure 1). These include the Tweedsmuir Hills (8898ha), the Moffat Hills (2890ha), the River Tweed and headwaters (2534ha) and Craigdilly (22.5ha). In the Tall-Hartfell Project area these protect key habitat types such as blanket bog, and specific types of grassland that are recognised by the Scottish Biodiversity List; a list of animals, plants and habitats that Scottish Ministers consider to be of principal importance for biodiversity conservation in Scotland. This list recognises several iconic species which are also to be found in the Talla-Hartfell area – Red deer (Cervus elaphus), Sika deer (Cervus nippon), Black Grouse (Tetrao tetrix), Golden Eagle (Aquila chrysaetos), Adder (Vipera berus) and Hen Harrier (Circus cyaneus). Distribution maps for selected species are shown in Figure 5a-c. the area is also home to some rare upland specialist plants such as Dwarf cornel (Cornus suecica) and Oblong woodsia (Woodsia ilvensis).

[23] Mc Morran, R., Price, M.F. and Warren, C.R., 2008. The call of different wilds: the importance of definition and perception in protecting and managing Scottish wild landscapes. Journal of Environmental Planning and Management, 51(2), pp.177-199. https://doi.org/10.1080/09640560701862955

Scotland's Wild Land Areas play a crucial role in supporting biodiversity and are significant for the conservation of various species and ecosystems. These areas are characterized by their relatively intact and undisturbed nature, offering habitats for a diverse range of flora and fauna. WLAs and Talla-Hartfell in particular are important for:

- Habitat Diversity: The Talla-Hartfell WLA encompass a wide range of habitats, including mountains, uplands, peatlands, forests, lakes, rivers and valleys. Each habitat provides unique ecological niches, supporting a rich diversity of species. These areas offer refuge to numerous native and sometimes rare or endangered species that may not be able to thrive in more modified landscapes.
- Species Richness: The Talla-Hartfell WLA is home to a multitude of species, including mammals, birds, reptiles, amphibians, insects, and plants. Iconic species such as black grouse, golden eagle, hen harrier and mountain hare are present or have been recorded in the area. There is also an important population of wild feral goats centred around the NTS site at the Grey Mare's Tail and Loch Skeen.
- Connectivity and Migration: Scotland's Wild Land Areas often serve as corridors for wildlife movement and migration, allowing species to disperse, find new territories, and maintain genetic diversity. These areas can act as steppingstones, linking different habitats and enabling wildlife populations to adapt to changing environmental conditions, such as climate change.
- Conservation Priority: The Talla-Hartfell WLA contains important designated protected areas, including the Tweedsmuir and Moffat Hills, and River Tweed SAC. These designations highlight their significance for biodiversity conservation. Protecting these areas is crucial for safeguarding vulnerable species, maintaining ecosystem processes, and preserving the overall resilience of Scotland's natural heritage.

By identifying the species and habitats that are of the highest priority for biodiversity conservation, the Scottish Biodiversity List helps public bodies apply their biodiversity duty and supports conservation action to protect these species for the future.

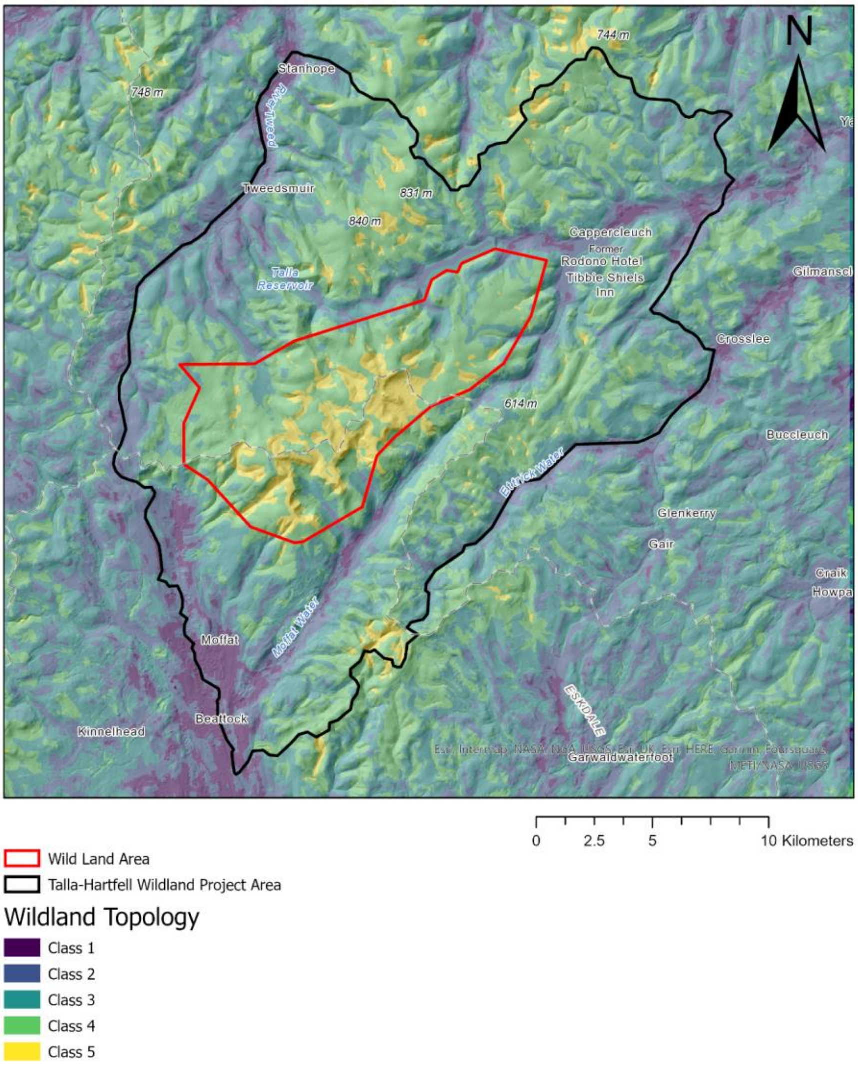

Figure 4. Wildland Typology

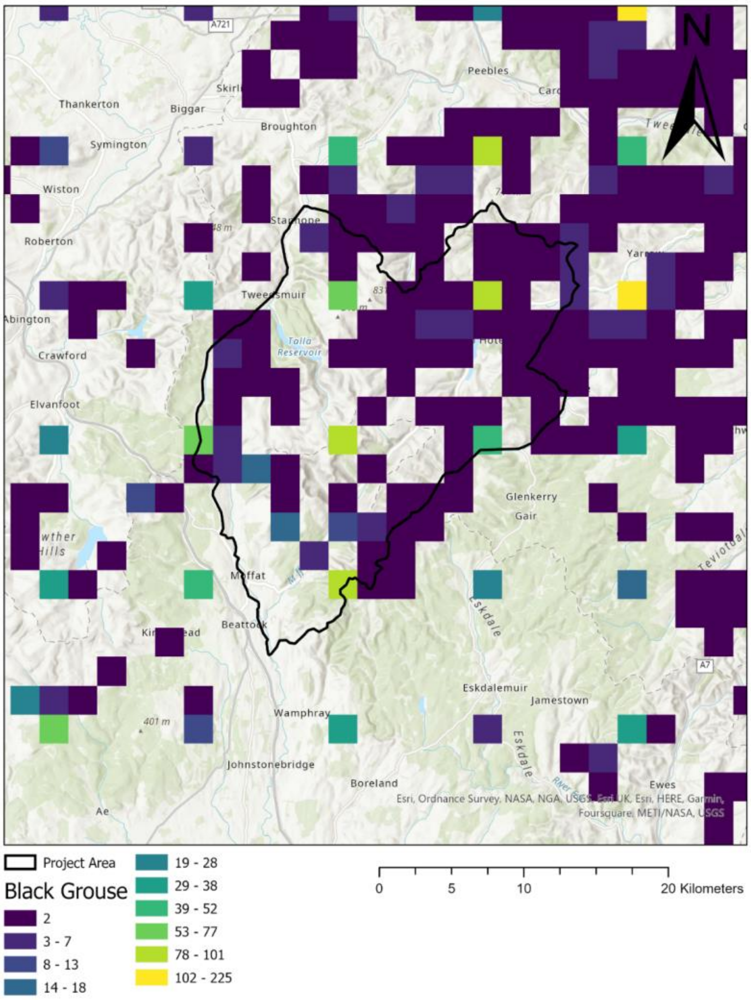

Figure 5a. Biodiversity indicators: Recorded observations of Black Grouse

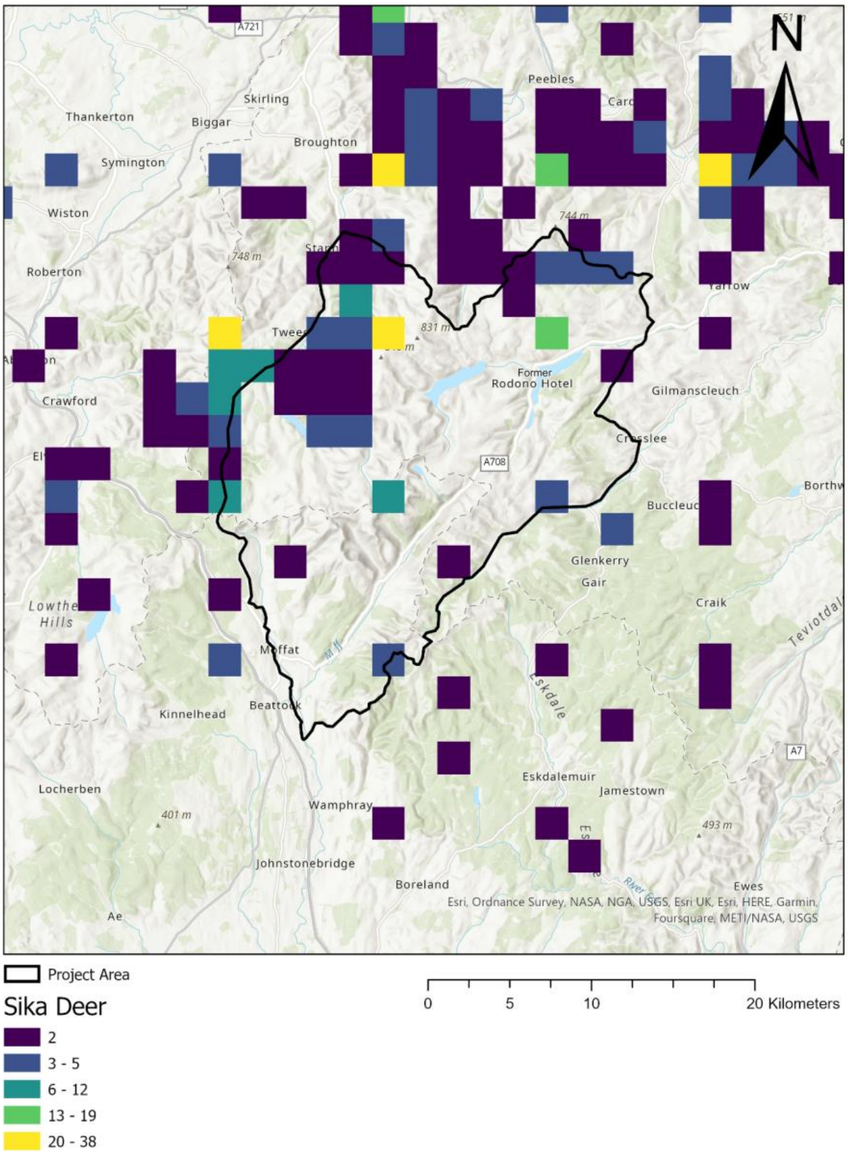

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Figure 5b. Biodiversity indicators: Recorded observations of Sika deer

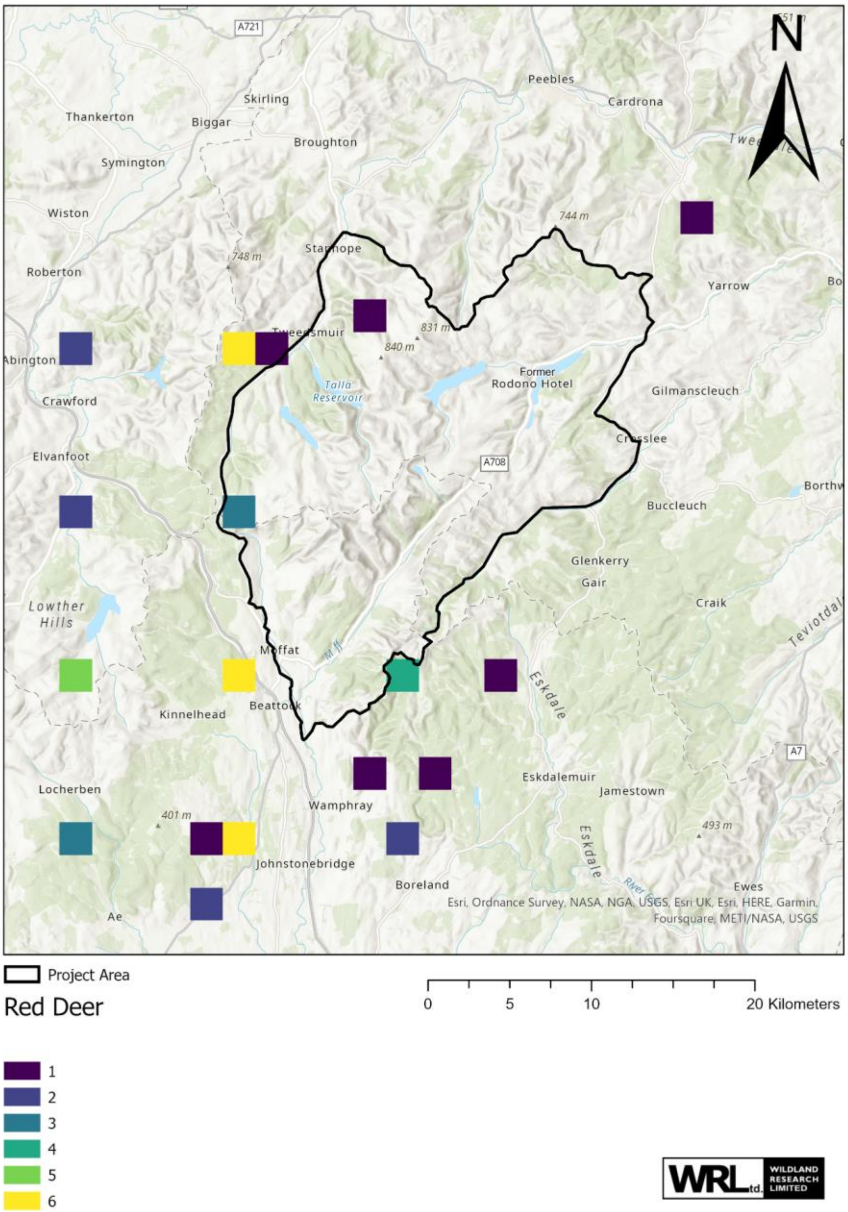

Figure 5c. Biodiversity indicators: Recorded observations of Red deer

4.1.4 Habitats

Peatlands in the Southern Uplands of Scotland play a vital role in the region's ecology and natural capital, particularly regarding carbon storage. These are characterized by the accumulation of partially decayed plant material which forms over centuries in waterlogged conditions. There are several key areas of importance:

- Carbon Storage: Peatlands are exceptional carbon sinks, sequestering and storing vast amounts of carbon dioxide from the atmosphere. The peat acts as a natural reservoir, locking away carbon and preventing its release into the atmosphere. Peatlands, therefore, contribute significantly to climate change mitigation by helping to reduce greenhouse gas emissions.
- Water Regulation: Peatlands function as natural sponges, playing a crucial role in regulating water flow. They have a remarkable capacity to retain rainwater, slowly releasing it over time. This function can help prevent flooding downstream during periods of heavy rainfall and ensures a steady supply of water during drier periods, supporting the overall hydrological balance of the region.
- Biodiversity Hotspots: Peatlands are home to a rich array of specialised plant and animal species, including several that are specifically adapted to the wet and acidic conditions found in these habitats. Rare and unique plant species such as bog mosses, heathers, and carnivorous plants, including sundews, thrive in these peatland ecosystems. These habitats also support a variety of bird species, including curlews, hen harriers, and short-eared owls, which rely on peatlands for nesting and foraging.
- Soil Formation and Nutrient Cycling: Peatlands are important contributors to soil formation and nutrient cycling. The decomposition of organic matter in peatlands releases essential nutrients, creating a fertile environment for plant growth. This nutrient-rich soil supports a diverse range of vegetation, contributing to the overall productivity and biodiversity of the region.
- Cultural and Historical Heritage: Peatlands in the Southern Uplands hold cultural and historical significance since they have been utilized by local communities for centuries for fuel, providing a traditional source of heating and cooking. The extraction of peat has also been an integral part of traditional practices, contributing to the unique cultural heritage of the region.

Preserving and restoring peatlands in the Southern Uplands is therefore of utmost importance for climate change mitigation, biodiversity conservation, water regulation, and cultural heritage. Efforts to protect and manage these unique ecosystems will ensure their continued benefits for both the environment and local communities in the years to come. Significant areas of deep peat (>40cm deep) are found in the Talla-Hartfell area, particularly in the east of the Talla-Hartfell WLA around Shielhope Hill and in the north-eastern hills of the Talla-Hartfell Project area around Black Law. The distribution of peatlands the Tall-Hartfell area is shown in Figure 6a. This is partially reflected in the distribution of land cover classes in the EUNIS (EUropean Nature Information System) data shown in Figure 6b. This is a Scotland raster based (10m) landcover made up of best available national data classified according to the EUNIS classifications which include raised and blanket bog communities represented in the peatland data in Figure 6a. The main purpose of the EUNIS landcover data is to provide well-known, nationally consistent information for SNH's national habitat network models.

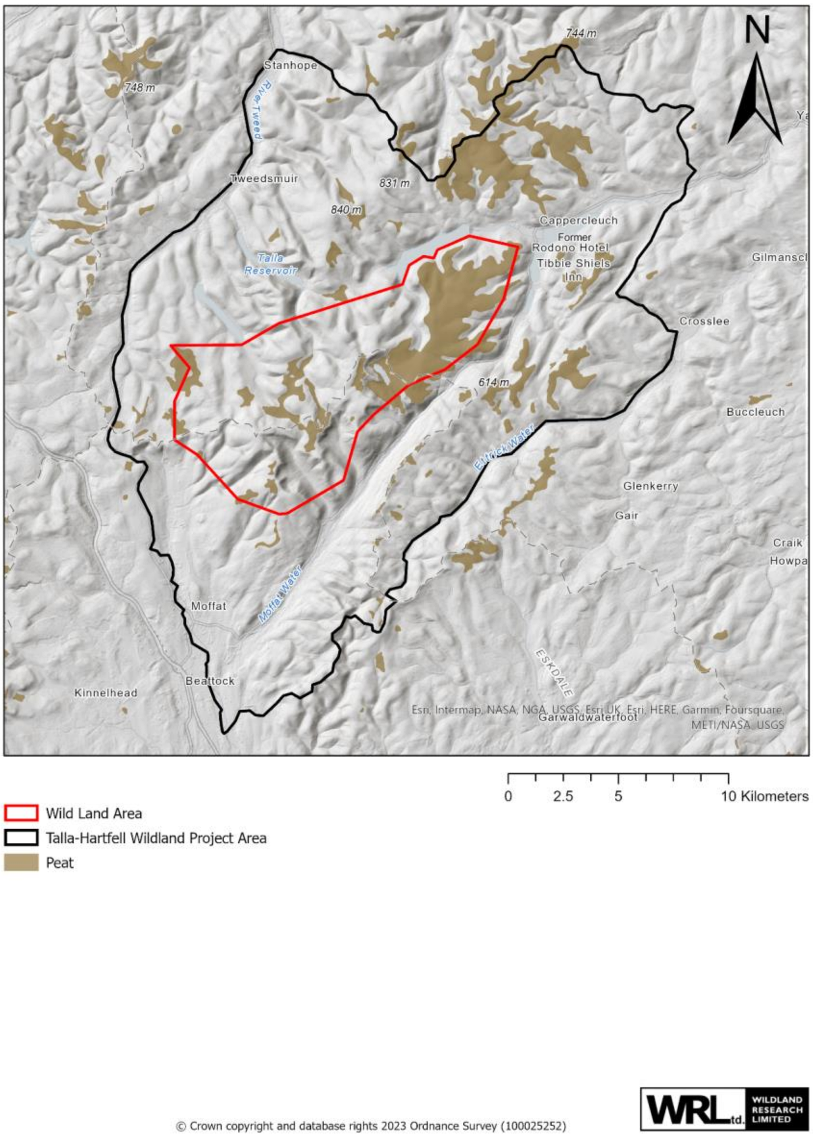

Figure 6a. Habitat indicators: Peatland

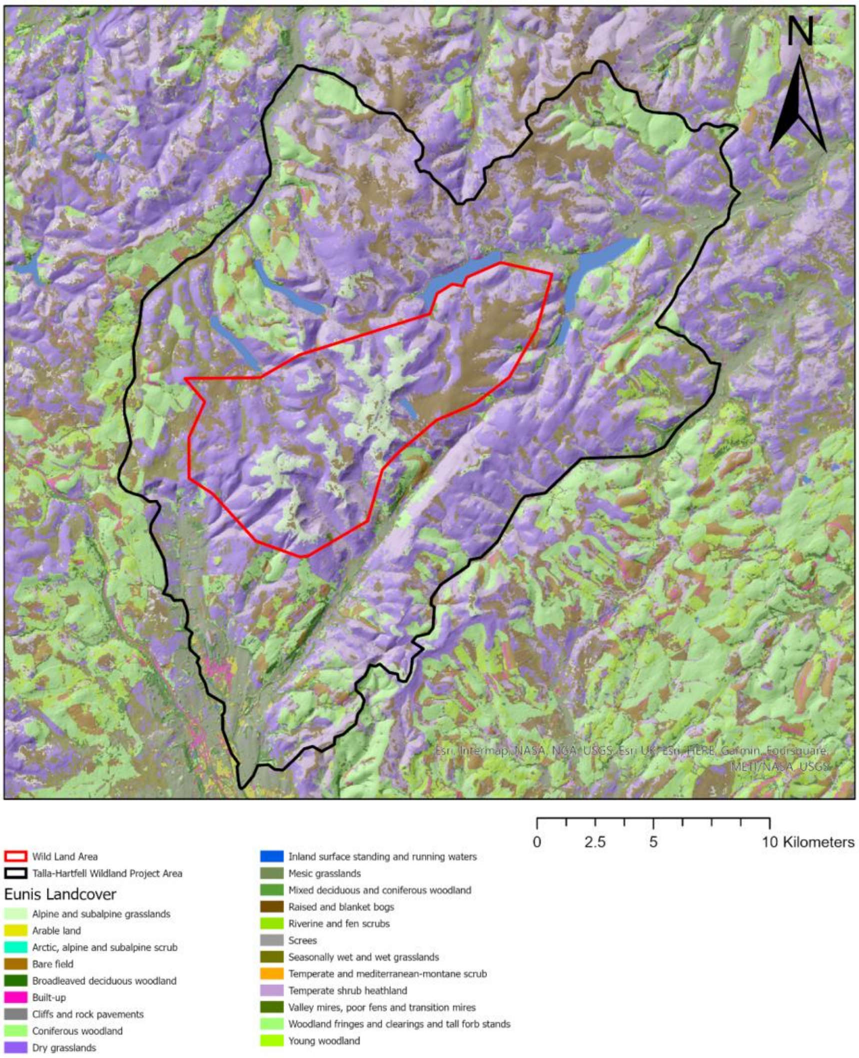

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Figure 6b. Habitat indicators: EUNIS landcover

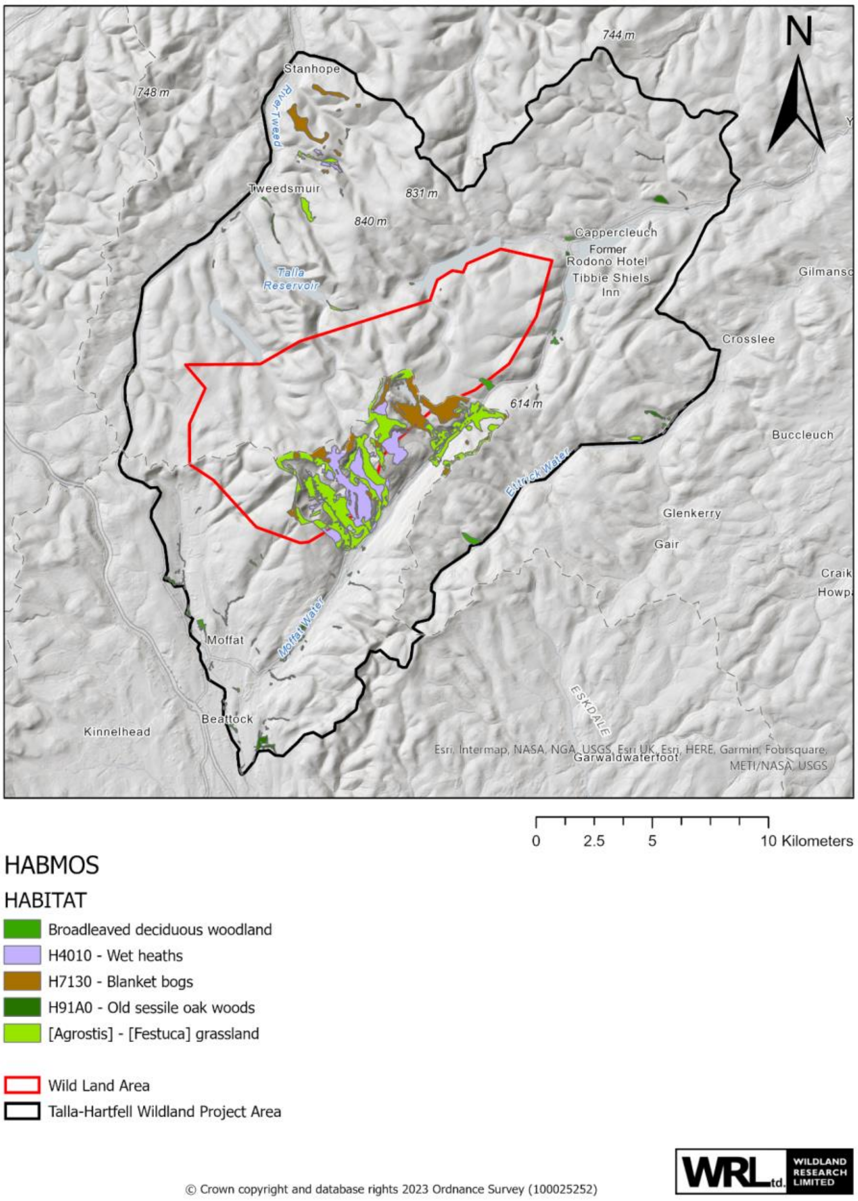

Figure 6c. Habitat indicators: HabMoS Habitat categories

The Habitat Map of Scotland (HabMoS) extends the EUNIS landcover map to provide a standard habitat classification system for terrestrial habitat data and mapping across Scotland. This interprets and adapts EUNIS for use in Scotland and correlates EUNIS habitats with habitat types listed in Annex I of the EU Habitats Directive. Correspondence tables are available to help support translation between EUNIS and the main national habitat classifications and lists. These include the National Vegetation Classification (NVC), UK Biodiversity Action Plan (BAP) priority habitat types, Phase 1 categories, and habitat features on Sites of Special Scientific Interest. This is an ongoing project and not all of Scotland has been completed. Figure 6c shows the HabMoS data and associated NVC habitat types for the Talla-Hartfell as of 2023 highlighting key habitats. It should be note that significant gaps still remain in these data, though these should be filled in due course as surveys progress.

4.2 Access

Public access can be a significant factor in natural capital assessments due to the important recreational and cultural benefits it provides, its potential for education and outreach, its significance from a social and ethical perspective, and its role in decision-making related to natural capital. Incorporating public access into natural capital assessments can help to ensure that the full range of natural capital values are considered and can lead to more informed and effective decision-making.

Access to natural areas can provide important recreational and cultural benefits with people visiting natural areas for activities such as hiking, camping, fishing, and wildlife watching, providing opportunities for physical exercise, relaxation, and connection to nature. These benefits can contribute to individual health and well-being and can also provide economic benefits through tourism and related industries.

Public access can also provide important opportunities for education and outreach. Visitors to natural areas can learn about the ecological and cultural values of these areas and can develop a deeper understanding of the importance of natural capital. This can lead to increased public awareness and support for conservation efforts and can help to build a sense of stewardship and responsibility towards natural resources.

Public access can also be an important consideration in natural capital assessments from a social and ethical perspective. Many people value the opportunity to access and enjoy natural areas and be protective about such areas as a public resource. Ensuring public access can therefore be seen as a matter of social justice and equity and can help to promote the idea that natural resources should be managed for the benefit of all.

Public access can also be an important factor in decision-making related to natural capital. Limiting public access to natural areas, for example through restrictions on recreational activities, may be necessary to protect sensitive ecosystems or endangered species in some circumstances. However, such restrictions may also be controversial, and may need to be carefully balanced against other natural capital values such as recreation and cultural benefits.

4.2.1 Core paths and permissive routes

Figure 7 shows the core paths and walking routes that are within and cross the Talla-Hartfell Wildland Project area. These include the recently available historic paths data from the National

Library of Scotland[24] many of which are no longer visible or in use but are included here to show how the area has been traversed in the past.

Scotland's Freedom to Roam laws, also known as the Right to Access, are unique in the world and grant everyone the legal right to access most of the country's land and inland water for outdoor recreation, such as hiking, cycling, wild camping, and fishing. The law was introduced in 2003 and is based on the traditional Scottish principle of "the right to roam," which dates back many centuries. The law has made Scotland a popular destination for outdoor enthusiasts and has helped to promote responsible and sustainable use of the country's natural resources[25].

While this allows people to wander at will outside of private homes, gardens and cropland, most people prefer to walk along establish tracks and paths, both for safety and ease of access. For this reason, the mapping of access routes and accessibility from various access points around the Talla-Hartfell Wildland Project area is both informative and important for the NCA[26].

The approach adopted here after mapping the existing access tracks and paths network (Figure 7) is to model remoteness using the same methods developed for the national parks and used in the NatureScot wild land mapping, but from selected local access points. These models utilise anisotropic distance models within GIS to model Naismith's Rule[27] taking terrain (altitude, slope and aspect), land cover (trafficability) and barrier features (e.g. open water and very steep ground) into account. Three models are produced based on a) access directly from urban areas with residential areas/streets (assuming walking directly from home in principal settlements such as Moffat, Biggar, Eskdalemuir and Broughton), b) access from established car parks and bus stops (as marked on OS 1:50,000 scale maps assuming walking from private car or public service bus), and c) access from any point along the public road within and surrounding the study area. These three models are shown as remoteness surfaces in 15, 30, 60, 120, 180, 240 and 300+ minute intervals (see Figure 8a-c).

[24] https://data.nls.uk/data/map-spatial-data/historic-footpaths/
[25] https://www.nature.scot/enjoying-outdoors/your-access-rights#:~:text=Scotland's%20access%20rights%20are%20yours,and%20other%20non%2Dmotorised%20activities.
[26] https://sup.org.uk/projects/equestrian-tourism-ride-scottish-borders-scotlands-horse-country/
[27] https://en.wikipedia.org/wiki/Naismith%27s_rule

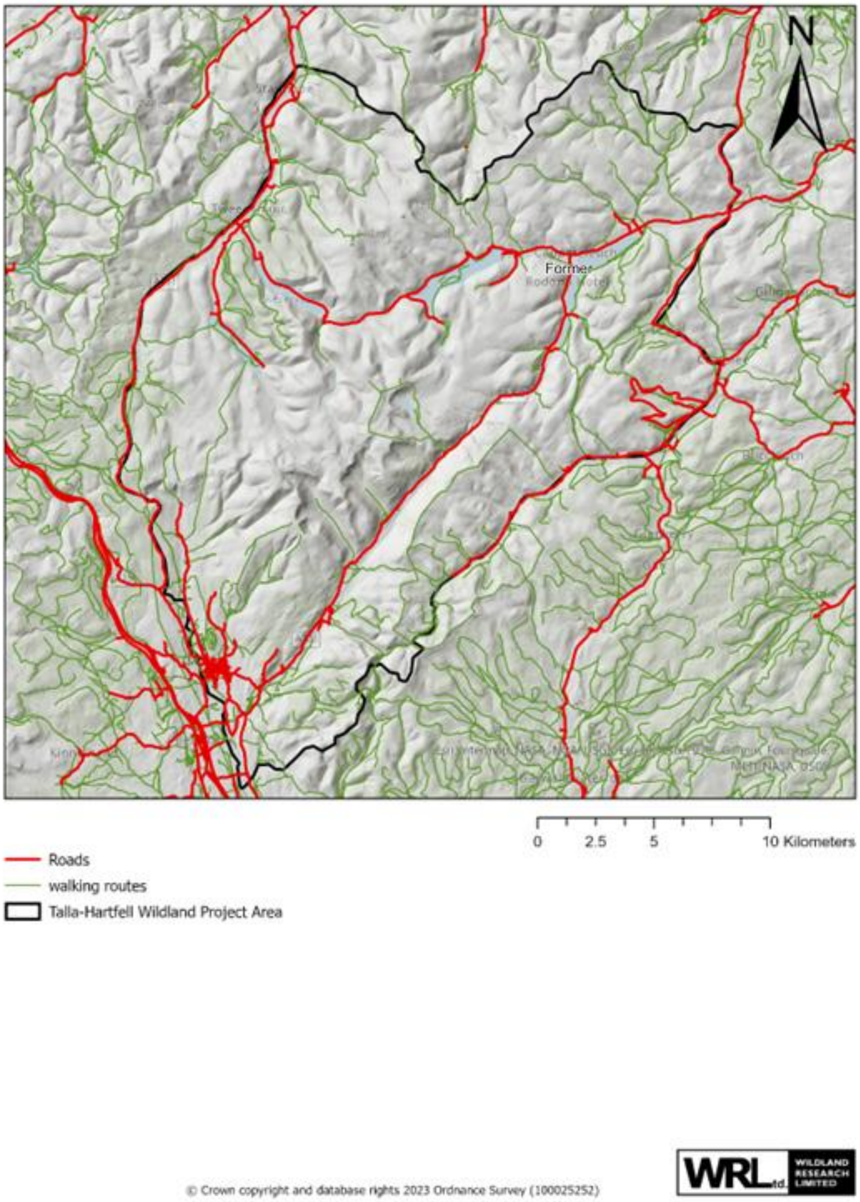

Figure 7. Walking paths and routes

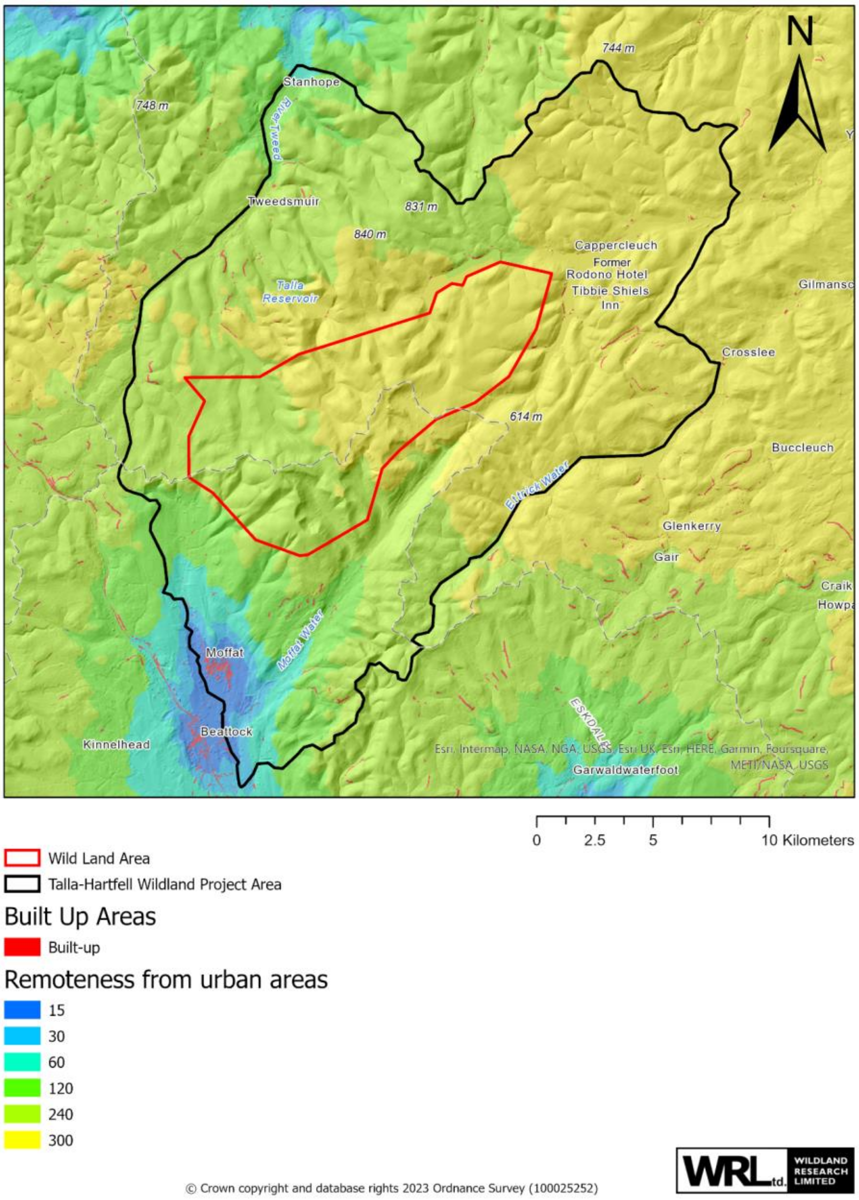

Figure 8a. Remoteness: from principal settlements

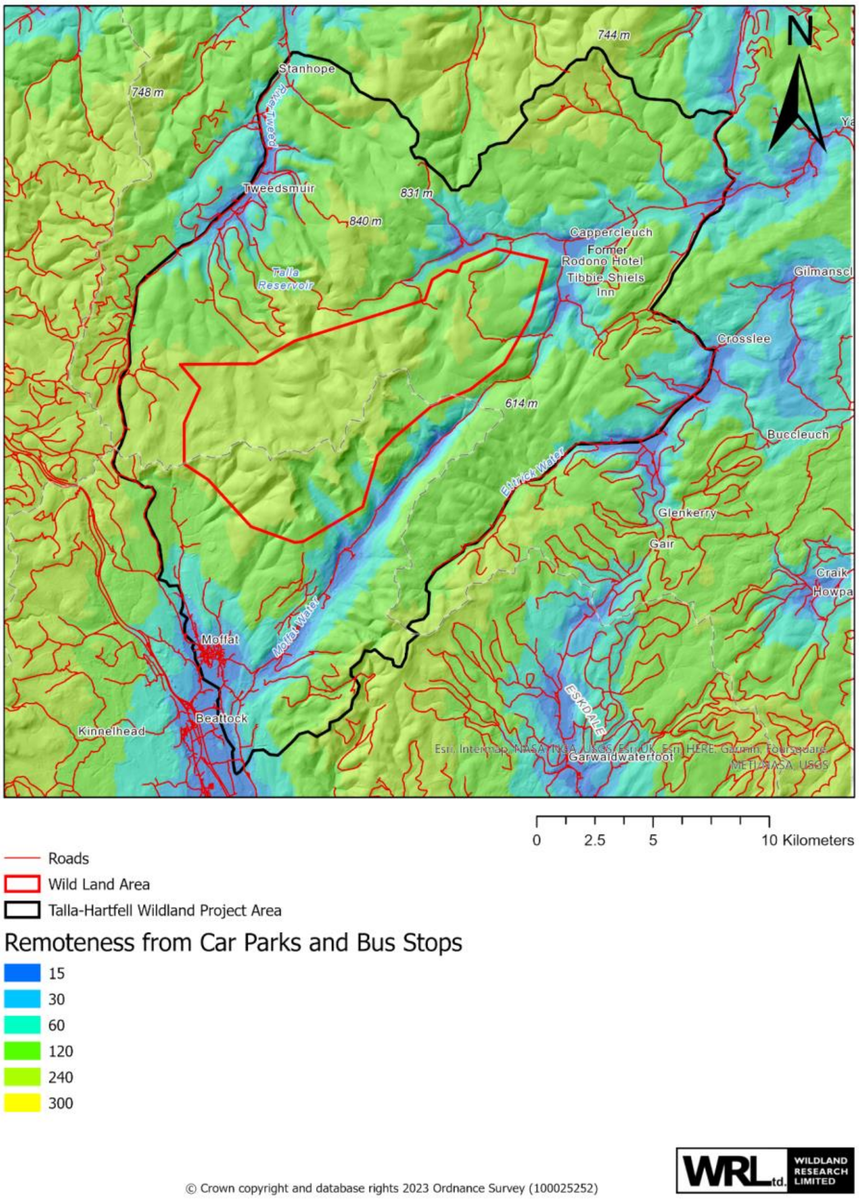

Figure 8b. Remoteness: from car parks and bus stops

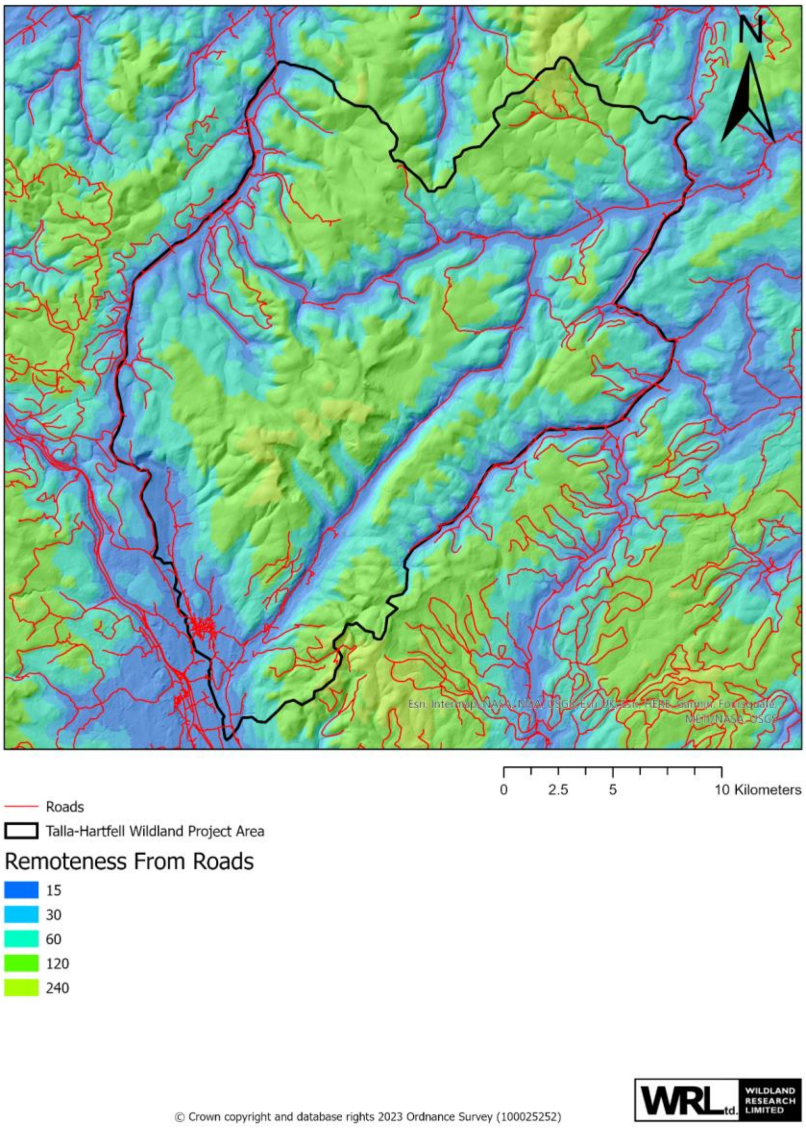

Figure 8c. Remoteness: from any public road

4.2.2 Recreational Opportunity Spectrum

The Recreation Opportunity Spectrum (ROS) is a framework used to classify outdoor recreational activities and settings based on their characteristics and the experiences they offer to visitors[28]. The ROS considers various factors such as the degree of development, accessibility, visitor use levels, and naturalness of the environment to identify six different types of outdoor recreation opportunities: primitive, semi-primitive non-motorized, semi-primitive motorized, roaded natural, rural, and urban. This classification system helps land managers and planners to better understand the needs and preferences of outdoor recreationists and develop management strategies that balance recreational use with environmental protection.

In the context of the Talla-Hartfell Wildland Project area and the remoteness/accessibility modelling described above, ROS is perhaps best considered in terms of opportunity for off-road walking activities. The above classification of remoteness surfaces into quarter, half, one hour, two-hour, three-hour and four-hour+ intervals is done to reflect various walking-based ROS classes: walking the dog, short, longer, half-day, full-day, long-day and overnight walks, respectively. These assume (with the possible exception of overnight walks involving a wild camp) that walks are two-way, returning to the point of origin/departure, thus doubling the time taken (e.g. for a 'dog walk' the outward walk is set at 15mins, meaning a 30min walk overall returning either to home or the car). Figure 9 shows a combination of all three remoteness models into five overall remoteness classes (1-5), identifying those areas that provide the greatest opportunity for a remote ROS experience regardless of means of access. These highlight areas in classes 1 and 2 where 'primitive' and 'semi-primitive non-motorised' recreational activities may best be experienced. Classes 3 and 4 indicated areas which are more open to 'roaded natural' and 'rural' activities. While class 5 identifies more 'urban/developed' areas.

These maps could be modified for a combination of cycling and walking, or indeed any feasible combination of modes of transport. Walking provides the widest possible sphere of access based on Right to Roam laws and ability to go "off path". Cycling and horse riding, however, require definite access routes in the form of bridleways. These are limited in extent throughout the Talla-Hartfell area to existing roads and tracks.

[28] https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm9_027593.pdf

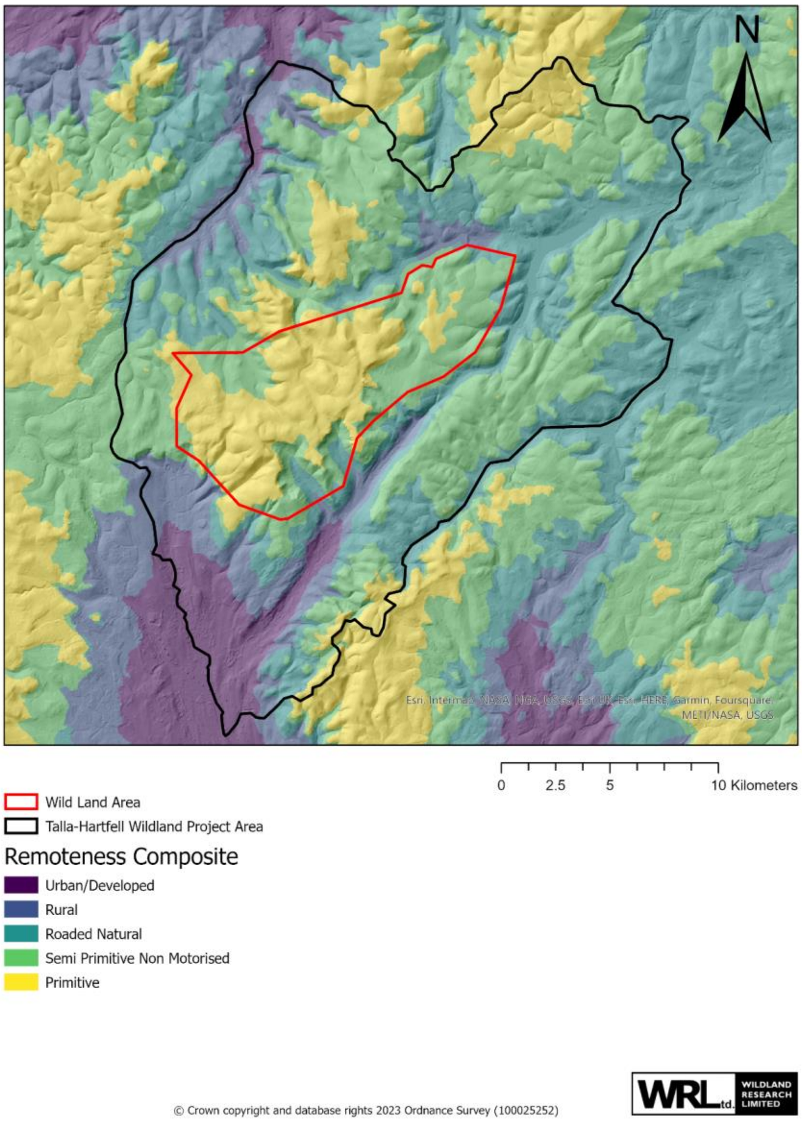

Figure 9. Combined remoteness

4.3 Woodland opportunity

Native woodland opportunity mapping can be a useful tool in identifying key natural capital areas. This is due to the important ecological and cultural values of native woodland, which make it a key focus for any conservation restoration or habitat creation project. Furthermore, its importance as culturally valued landscape means that it has potential to engage stakeholders and the public, and as such support conservation and restoration efforts. Incorporating native woodland opportunity maps into natural capital assessments can help to ensure that the full range of natural capital values are considered and can lead to more informed and effective decision-making.

In ecological terms native woodland is a valuable component of natural capital as it can provide important habitat for wildlife, help to regulate water and nutrient cycles, and sequester carbon from the atmosphere. Native woodland can also have cultural and recreational value, providing opportunities for activities such as hiking, wildlife watching, and gathering of wild foods.

Native woodland opportunity maps can help to identify areas where the restoration or creation of native woodland would provide the greatest overall benefit in terms of natural capital. By using a range of data sources on existing woodland, as well as on soil type, climate, and topography, opportunity maps can identify areas that are most suitable for native woodland establishment or expansion. This information can be used as a departure point for discussions with local people and potentially guide land use planning, and to prioritize areas for conservation or restoration.

Woodland opportunity maps can also help to engage stakeholders and the public in natural capital assessments. By providing visual representations of potential native woodland opportunities, opportunity maps can help to communicate the potential benefits of native woodland restoration or creation to a range of audiences. As the basis of discussion with local people they can also be used to capture local information that is not available via remote sensing approaches. This can both improve the maps and build support for conservation efforts to promote natural resources management of benefit for all.

Finally in the longer-term, woodland opportunity maps can be an important tool for monitoring and evaluating the effectiveness of conservation and restoration efforts. By comparing predicted native woodland distribution to actual distribution, opportunity maps can help to assess the success of restoration or creation efforts and to identify areas where further action may be needed.

4.3.1 Native woodland planting

Scotland has much less woodland cover than other countries in Europe, although this has increased during the 20th century, as in 1900, only about 5% of Scotland's land area was wooded. Large-scale afforestation had increased this figure to about 17% by the early 21st century, although a large percentage of this is non-native plantation woodland. The Scottish Government's Draft Climate Change Plan, published in January 2017, proposes specific targets for future woodland expansion to cover 21% of Scotland by 2032[29]. To deliver this, the draft plan proposes that the rate of new afforestation rises to 15-18,000 hectares per year by 2024.

[29] https://www.gov.scot/publications/securing-green-recovery-path-net-zero-update-climate-change-plan-20182032/

Nature Scot highlight that appropriate woodland expansion will bring more of the benefits that woodlands can provide such as richer and more diverse habitats, enhanced landscapes, carbon sequestration and storage, timber, wood fuel and other woodland products, as well as ecosystem services such as clean water, mitigation of diffuse agricultural pollution, and reduced flood risk[30]. Whilst non-native plantation woodland can achieve some of these benefits, native woodland planting brings the full range of these benefits as well as being a key component of habitat networks for a diverse range of species. As such native woodland planting is a key part of the Scottish Government schemes to support increased forest cover in Scotland. The current scheme is the Forestry Grant Scheme (FGS) which has two key aims; (1) Support the creation of new woodlands – contributing towards the Scottish Government target of 18,000 hectares of new woodlands per year from 2024/25, and (2) the sustainable management of existing woodlands[31].

Within the Talla-Hartfell area the Borders Forest Trust (BFT) is working on native woodland planting at the landscape scale (Figure 10). Large parts of the Talla-Hartfell WLA are within the montane scrub zone and so are more suited to planting and reestablishment of tree species such as montane birch and willow. This is supported by a mix of funding sources including grants from the FGS to plant new areas of native woodland at three key areas: Carrifran Wildwood, Talla & Gameshope and Corehead and the Devil's Beef Tub. The combined land area covers 3,100ha, which will make a significant contribution to the national afforestation targets.

4.3.2 Cleuch woodland

Gills, locally known as “cleuchs”, are small, steep-sided valleys formed by the erosion of soil and rock by water. They are an important part of the landscape and provide a unique habitat for a variety of plant and animal species. However, cleuchs are also prone by their nature to soil erosion, especially in areas where land has been degraded due to human activities such as overgrazing, deforestation and forestry operations.

Active woodland regeneration along cleuchs is a process that aims to restore the ecosystem's natural functions by reintroducing native tree species and improving soil conditions and hydrology. The regeneration process involves careful planning and management to ensure the successful establishment of new trees that can stabilize the soil and prevent further erosion. The restoration of cleuchs through woodland regeneration is a critical process for maintaining the health and resilience of the ecosystem and ensuring its sustainability for future generations. This requires the collaboration and efforts of scientists, land managers, and local communities to achieve a healthy and sustainable ecosystem that benefits both people and the environment.

The steep slopes in cleuch areas also represent a risk to grazing animals and as such they are often fenced off by farmers to protect livestock. This process has over time led to extensive natural regeneration of native woodland species in cleuch areas across Scotland. The enclosure of these areas to protect livestock inevitable leads to a reduction in grazing pressure which allows any naturally regenerating saplings to take hold, reach a sufficient size and produce seed. Over time this contributes to woodland expansion within cleuch areas. The cleuch model is developed here to identifies the location and spatial extent of gills using a combination of proximity to small mountain streams (or “burns”), and topography (steep slopes). These are

[30] https://www.nature.scot/professional-advice/land-and-sea-management/managing-land/forests-and-woodlands/woodland-expansion-across-scotland
[31] https://forestry.gov.scot/support-regulations/forestry-grants

mapped in Figure 11. Such areas may also provide opportunity areas for riparian woodland under the new Forestry Grant Scheme and provide benefits that support river management, water quality, flood mitigation and/or fisheries [32].

[32] Forestry Grant Scheme https://www.ruralpayments.org/topics/all-schemes/forestry-grant-scheme/woodland-creation/

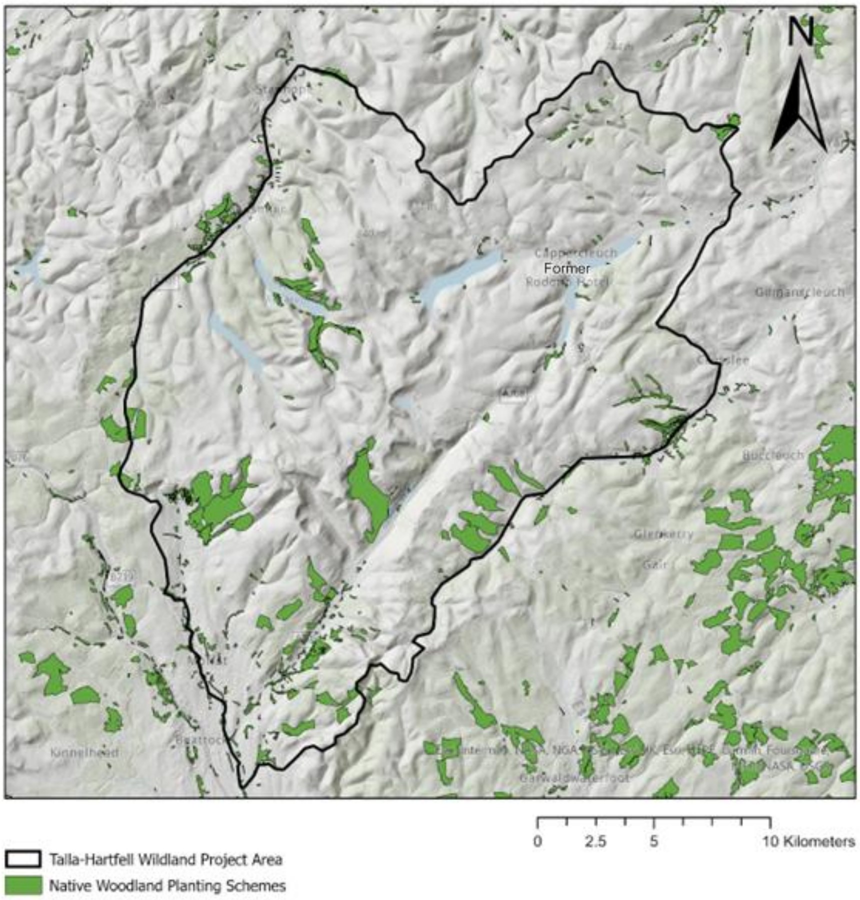

Figure 10. Native woodland and FGS creation schemes
(Data source Forestry Commission Scotland)

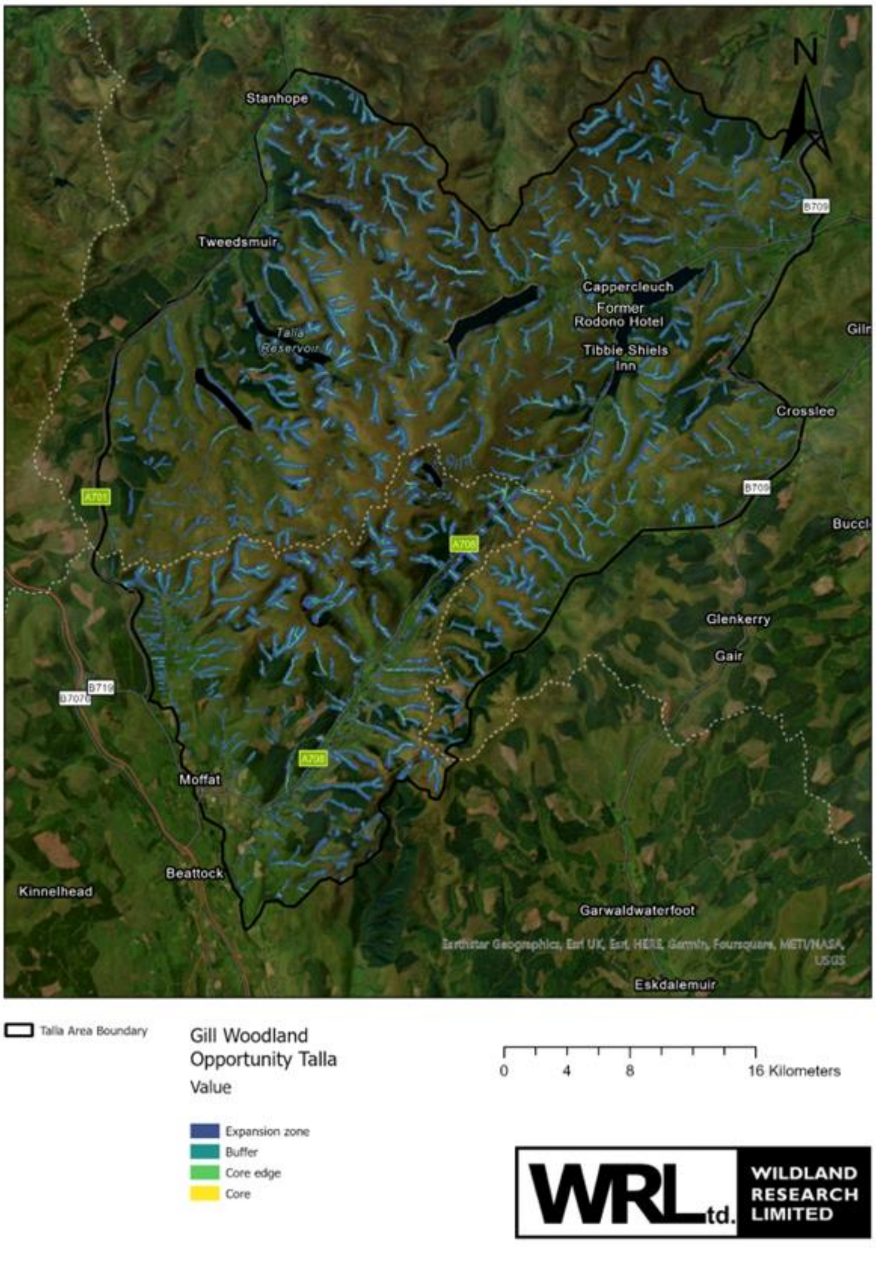

Figure 11. Gill ("Cleuch") woodland opportunity

4.3.3 Flood mitigation

Much has been written on the possible value of woodland regeneration, particularly in upland areas and flood plains, for flood mitigation. Work by Marshall et al. (2014) in the experimental catchment at Pontbren, Wales has demonstrated the effects of reducing grazing pressure and planting trees has on infiltration and runoff. In experiment plots with different treatments, infiltration increased 67-fold and runoff was reduced by between 47 and 78% after five years in plots with no grazing and planted with trees when compared to control plots under normal sheep grazing, this demonstrating possible benefits of tree regeneration for flood mitigation measures[33]. Similarly promising figures have been recorded for floodplain woodland with reductions in flow velocity, increase in flood storage by 15-70% and increased peak travel time between 30 and 140 minutes across a 2km river reach[34].

It is suggested that combinations of gill/cleuch woodland and floodplain woodland could help mitigate downstream flooding by increasing interception and infiltration, increasing surface roughness, and slowing flow velocities with resulting reduction in flow volumes and increased time to peak 'lag-times'. This is generally known as "slowing the flow".

Topographic controls on soil moisture and associated hydraulic connectivity are key to understanding hydrological response to rainfall inputs. Saturated soils immediately adjacent to stream channels produce the fastest runoff response in the river network since rainfall cannot infiltrate into saturated soils and so runs off directly into the adjacent stream. These patterns can be modelled and mapped as a Topographic Wetness Index (TWI) using high resolution terrain models. A 5m DEM is used here together with the D-Infinity flow direction model to plot flow paths and possible saturated soils adjacent to river channels (see Figure 12a). These are then integrated with the gill/cleuch woodland model from Figure 11 to highlight where woodland regeneration could provide maximum benefit for flood mitigation by increasing infiltration and reducing runoff rates through increased surface roughness. These are shown in Figure 12b. One caveat here is that wet flushes are often protected from disturbance, including tree planting as has been the case in Carrifran, due to protected habitats and associated plant assemblages.

Examination of floodplains and riparian corridors along the Rivers Yarrow, Moffat Water, Annan and Tweed reveal quiet extensive tree cover along the riverbanks but within a limited ripearian buffer, often just a single tree deep. Flood alleviation schemes along the lower reaches of the Annan above Threewater Foot has channelised the river. Opportunities for further development of floodplain woodland is perhaps limited through much of the flat floodplain areas being the best grade agricultural land used for grazing and hay meadows. Further mapping of ecological connectivity (see section 4.3.5) reveals significant flows in and along some these floodplain woodland areas. Regional projects are currently underway, including work led by the Tweed Forum in Eddleston water and Langhope Rig[35].

[33] Marshall, M.R., Ballard, C.E., Frogbrook, Z.L., Solloway, I., McIntyre, N., Reynolds, B. and Wheater, H.S., 2014. The impact of rural land management changes on soil hydraulic properties and runoff processes: results from experimental plots in upland UK. Hydrological Processes, 28(4), pp.2617-2629.
[34] Thomas, H. and Nisbet, T.R., 2007. An assessment of the impact of floodplain woodland on flood flows. Water and Environment Journal, 21(2), pp.114-126.
[35] https://tweedforum.org/our-work/current-projects/

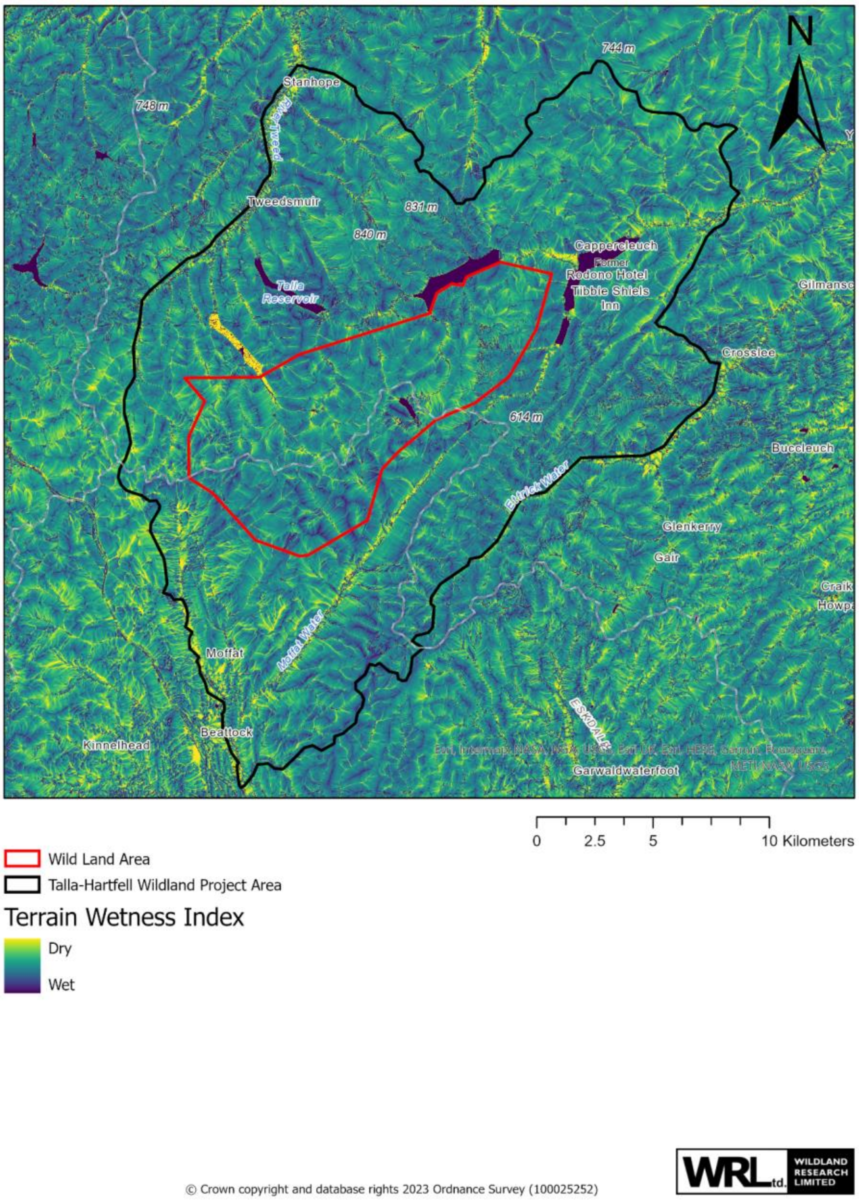
N
744 m
748 m
Stanhope
Tweedsmuir
831 m
840 m
Talla Reservoir
Cappercleuch
Former Rodono Hotel
Tibbie Shiels Inn
Gilmanse
Crosslee
614 m
Buccleuch
Ettrick Water
Glenkerry
Gair
Craik
Howpa
Moffat
Moffat Water
Beattock
Kinnelhead
Garwaldwaterfoot
0
2.5
5
10 Kilometers
Wild Land Area
Talla-Hartfell Wildland Project Area
Terrain Wetness Index
Dry
Wet
© Crown copyright and database rights 2023 Ordnance Survey (100025252)

Figure 12a. Terrain Wetness Index

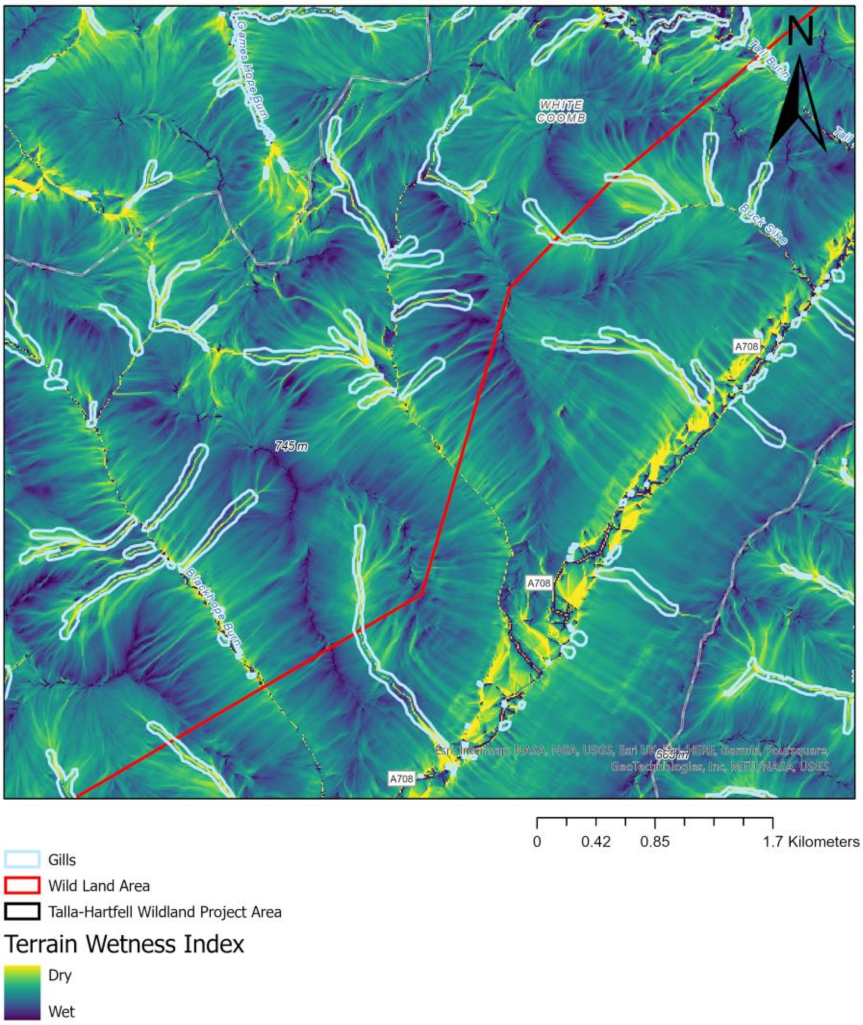

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Figure 12b. Terrain Wetness Index with Gill outlines (Carrifran zoom only shown for clarity)

4.3.4 Woodland connectivity

Woodland connectivity refers to the degree to which forested areas are connected to each other both via continuous woodland features as well as through other natural corridors which can both support seed transport as well as the movement of animal and insect species. These natural corridors can consist of streams, rivers, and other natural features such as hedgerows which together form ecological networks. Functional connectivity is important for maintaining the health and resilience of forest ecosystems, as well as for the survival of many plant and animal species. In recent years, there has been growing recognition of the importance of native woodland connectivity, and efforts have been made to protect and enhance the connectivity of those areas that remain and develop new native woodland areas to restore what has been lost.

One of the primary reasons why native woodland connectivity is important is that it helps to maintain biodiversity. Connected forested areas provide a larger and more varied habitat for many species, allowing them to move between areas and maintain healthy populations. Isolated woodland areas, on the other hand, can become fragmented and may not provide sufficient habitat for certain species to survive. Native woodland connectivity helps to protect and preserve biodiversity, which is crucial for maintaining the ecological balance of forested ecosystems.

In addition to maintaining biodiversity, native woodland connectivity can also provide other benefits such as climate change mitigation. Forests play a critical role in sequestering carbon dioxide from the atmosphere, and connected forested areas represent larger and more effective carbon sinks. By preserving and enhancing native woodland connectivity, we can help to mitigate the effects of climate change by reducing the amount of carbon dioxide in the atmosphere.

Finally, native woodland connectivity can also provide recreational and economic benefits for local communities. Forested areas can provide opportunities for hiking, camping, and other outdoor activities, as well as a source of timber and other forest products. By maintaining and enhancing native woodland connectivity, we can help to ensure that these benefits are available to current and future generations. By recognizing its importance and taking steps to protect and enhance it, we can help to preserve biodiversity, mitigate the effects of climate change, and provide economic and recreational opportunities for local communities.

Increasing woodland cover in Scottish upland areas can have several potential disadvantages, however, which may vary depending on the specific context and management practices. Some of these disadvantages include:

- Changes to traditional land uses: Upland areas in Scotland have historically been used for grazing livestock and game hunting. Increasing woodland cover may limit these traditional land uses, potentially impacting local livelihoods and cultural practices, especially regarding sheep farming.
- Increased competition for resources: Woodland cover by competing with other land uses, such as grazing and commercial forestry, impacts the productivity of neighbouring farmland and potentially lead to conflicts over resource allocation.
- Impact on wildlife: While increasing woodland cover can provide habitat for certain species, it may also impact other wildlife that rely on open habitats, particularly ground

nesting birds. This includes upland species, such as grouse and curlew, which require heather moorland and/or rough grassland habitats for breeding and feeding.

- Management challenges: Woodland management in upland areas can be challenging due to factors such as harsh weather conditions, limited access, and steep terrain. This can make it difficult to implement effective management practices and ensure the long-term success of woodland establishment. Nevertheless, the work of the Borders Forest Trust and Carrifran Wildwood demonstrates that it remains possible to plant native woodland across the full range of altitudinal gradients. Non-intervention management strategies are of course well suited in the longer term to native woodland schemes operating in remote areas.

Forest Research have developed an approach for mapping areas suitable for woodland creation to improve water quality and reduce flood risk[36]. This uses a wide range of spatial datasets to generate maps showing priority areas for planting. The results provide a strong basis for developing and refining regional strategies, initiatives and plans to deliver new woodlands where they can best contribute to flood risk management (FRM) and Water Framework Directive (WFD) targets. Woodland creation, however, is not without risks and care will be required in site selection to ensure that planting does not increase flood risk by synchronising, rather than desynchronising downstream flood flows. Example woodland creation and opportunity maps are shown in Figure 13 for the Carrifran/Moffat Water area.

[36] Native Woodland Targets and Forest Habitat Networks in Scotland (2008) https://forestry.gov.scot/publications/forests-and-the-environment/biodiversity/native-woodlands/native-woodland-targets-and-habitat-network

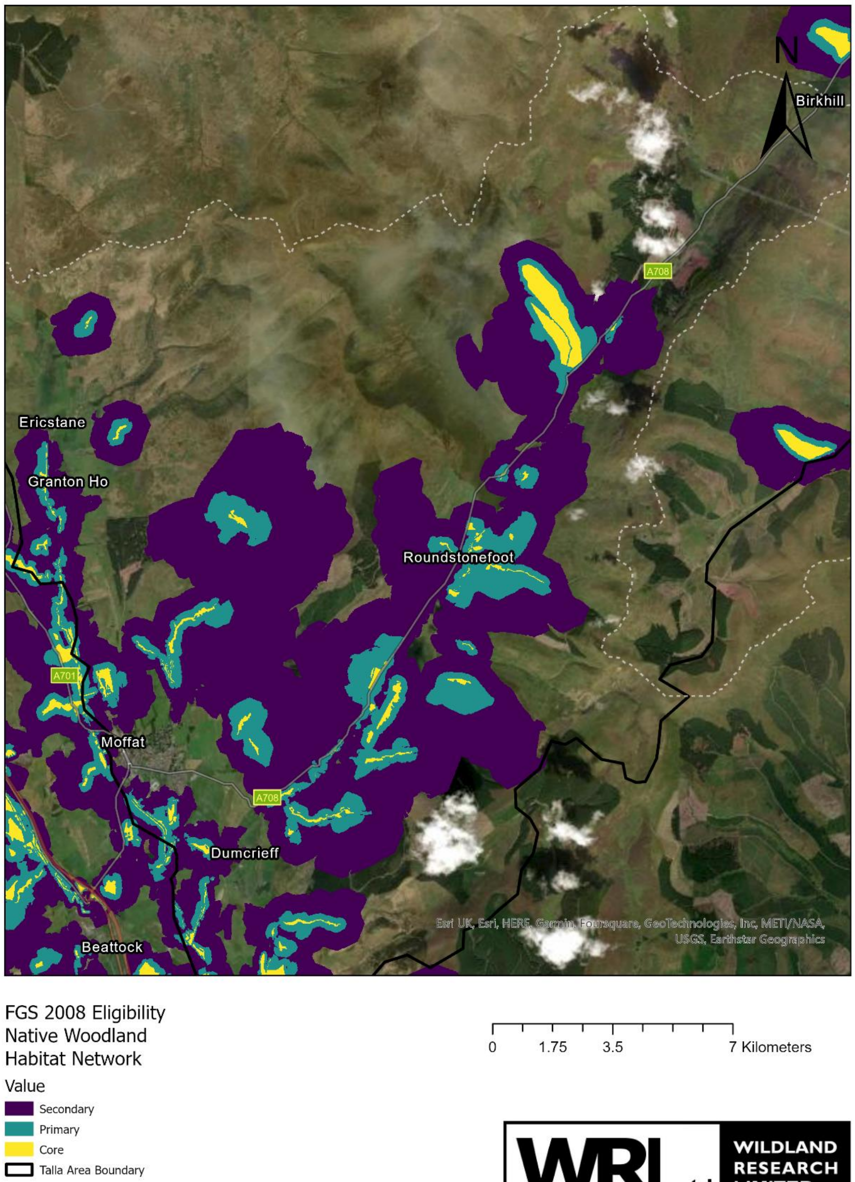

Figure 13. Forestry Grant Scheme woodland opportunity map produced by Forestry Commission Scotland. (Moffat Water zoom only shown for clarity)

4.3.5 Connectivity modelling approaches

Multiple approaches exist for modelling landscape connectivity. Recent research has found that connectivity modelling is a useful tool to support decision making on landscape scale conservation and protected areas strategy. When modelling structural landscape connectivity across large landscapes, an approach based on what is known as 'circuit theory' has been shown to correlate with analyses testing gene flow in key species groups over time. Evidence is also growing that connectivity modelling can produce results that accurately reflect the functional behaviour of species in the landscape. Models of landscape connectivity using spatial data on human influence and landscape naturalness have also been shown to identify similar areas to modelling based on species specific approaches.

One additional advantage of this circuit-based approach when modelling structural connectivity such as woodland networks - within which multiple other species also move - is that it avoids making assumptions about where species will start and end their journey as they move through the landscape (see Section 4.4).

Omniscape is a specific modelling tool based on circuit theory and has been widely used to identify intact natural areas of high permeability in the landscape as well as areas of high ecological integrity for multiple species that will be resilient to future climate change (see for example McRae et al. 2016; Brennan et al. 2020)[37].

Omniscape works by passing a moving window of a specific radius over the whole of the resistance surface and attempts to connect the most natural pixels within that window. In our model the moving window has a radius of 5km and attempts to connect the top 30% of natural pixels within that moving window. See Figure 14.

[37] McRae, B.H., Shah, V. and Edelman, A., 2016. Circuitscape: modeling landscape connectivity to promote conservation and human health. The Nature Conservancy, 14, pp.1-14.
Brennan, A., Beytell, P., Aschenborn, O., Du Preez, P., Funston, P.J., Hanssen, L., Kilian, J.W., Stuart-Hill, G., Taylor, R.D. and Naidoo, R., 2020. Characterizing multispecies connectivity across a transfrontier conservation landscape. Journal of Applied Ecology, 57(9), pp.1700-1710.

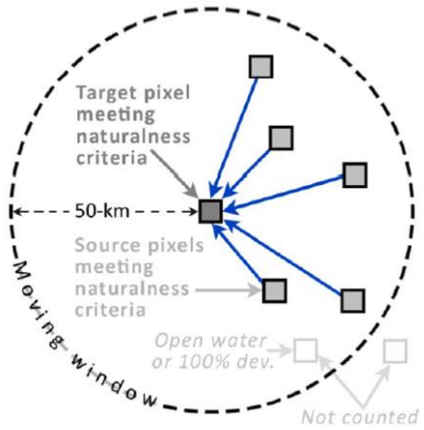

Figure 14. Illustration of moving window circuit theory methods such as Omniscape (reproduced from McRae et al. 2016). *In the simplest case a moving window is passed over the input spatial layers centring on each pixel in turn. If the centre pixel meets the naturalness criteria for being a destination for movement, it is treated as a target for movement. All pixels within the moving window radius that meet the same criteria are considered sources. Current flows from all source pixels to the target pixel, with more current flowing to more natural pixels.*

Areas with highest current flow tend to be those where natural or artificial barriers channel and concentrate flow. This is particularly evident in agricultural areas where linear stretches of natural land (such as woodland) form corridors conducive to movement for multiple species. To model woodland connectivity, we built a spatial layer which mapped where key areas of native woodland were already present. This layer consisted of data from the Native Woodland Survey for Scotland, recent native woodland planting schemes under the Forestry Grant Scheme (FGS), the FGS Woodland Network model, and the gill woodland model (see 4.3.2). These areas were given different weight in the model with existing established native woodland given a higher weight considering their potential as seeds sources for woodland expansion. The other areas were weighted based on their future potential to develop into native woodland (such as the FGS planting schemes) or their potential as areas where new woodland can easily take hold (such as the gill areas).

The Omniscape software tool was then used to analyse this woodland 'source' layer in conjunction with a general landscape habitat resistance model (see 4.4). The results highlight existing connected native woodland areas as well as highlighting those areas which have the potential to become established native woodland areas in the future. The resulting woodland opportunity connectivity model is show alongside the ecological connectivity model in section 4.4, figures 15c and 15d.

4.4 Ecological connectivity

Ecological connectivity refers to the ability of ecosystems to maintain functional and biological relationships across space and time, allowing for the movement of organisms, genetic information, and ecological processes. It is a significant consideration in natural capital assessments due to its importance for maintaining biodiversity and ecosystem health, providing ecosystem services that benefit human wellbeing, and guiding land use planning and management decisions. Incorporating ecological connectivity into natural capital assessments can help to ensure that ecosystems are managed and conserved in a way that maximizes their full range of benefits and supports long-term sustainability. Ecological connectivity is important in natural capital assessments for several reasons.

First, ecological connectivity is crucial for maintaining biodiversity and ecosystem health. Isolated habitats can lead to genetic isolation, inbreeding, and a loss of genetic diversity, which can increase the risk of extinction and reduce ecosystem resilience. In contrast, connected habitats can support a greater diversity of species and can allow for the movement of species in response to environmental change, helping to maintain ecosystem function and adaptability.

Second, ecological connectivity can provide a range of ecosystem services that benefit human wellbeing. For example, connected habitats can support pollination, pest control, and water purification services, which can contribute to food security, crop yields, and water quality. Connected habitats can also provide recreational opportunities and cultural value, supporting activities such as hiking, wildlife watching, and spiritual connection to nature.

Third, ecological connectivity can be a valuable tool in land use planning and management. By identifying areas of high ecological connectivity, natural capital assessments can help to guide land use decisions that support ecosystem health and resilience, while avoiding or mitigating the negative impacts of development or fragmentation. This can lead to more sustainable land use practices and more effective conservation efforts.

We used a landscape scale connectivity analysis, which focuses on identifying areas likely to facilitate ecological flow—particularly movement, dispersal, gene flow, and distributional range shifts for terrestrial plants and animals. Whilst the analysis is conducted at the scale of the Talla-Hartfell Wildland Project area, using a standardised modelling approach, the modelling is calculated at the local scale. This local-scale permeability analysis is not species-specific. Rather, it focuses on structural connectivity of natural lands to identify areas well-connected within a 5-km radius. This avoids making assumptions about how species move but rather identifies areas likely to be more favourable for movement for multiple species during daily foraging behaviour, dispersal for breeding and over multiple life cycles. As such the results identify broad, intact areas where movement of multiple terrestrial and freshwater aquatic organisms is largely unrestricted by human modifications to the landscape. It also identifies constricted areas where fragmentation or barriers have reduced movement options and further habitat loss could isolate remaining natural lands. The modelling outputs highlight potential areas of interest and represent a first step in an iterative process that will then take account of local scale ecological data and other social considerations.

Landcover data from Nature Scot and the Centre for Ecology and Hydrology were used to produce a thematic spatial layer for the Talla-Hartfell Wildland Project area which classifies the landscape in terms of naturalness on a relative scale. Areas of higher potential naturalness such as broadleaf woodland or alpine heath are given a higher score than areas of lower potential naturalness such as urban areas. Areas classified as ancient woodland are given an additional value as are areas on steep slopes which are less likely to have been grazed or intensively managed via agro-forestry activities.

This layer was integrated with a second layer designed to reinforce the barrier effect of the road network, with different weightings given to roads to reflect the volume of traffic that passes along them and the fragmentation effect of this on connectivity.

These two layers are then reclassified so that high scores represent high resistance to movement, a 'resistance surface'. This final spatial layer is produced at a resolution of 20m x 20m pixels where each pixel is attributed a resistance value on a scale of 1-1000.

The results of the modelling show potential ecological connectivity using a metric known as 'normalised cumulative current flow'. See Figures 15a and 15b. Current flow in the model results from the interaction of three factors: resistance, and the amount and configuration of natural pixels available to connect within the specified search radius. Current flow will avoid areas with strong movement barriers, concentrating where flow is channelled through pinch-points, and will be diffuse in highly intact/highly permeable areas Flow can be channelled around both artificial and 'natural' barriers where resistance is higher. Low flow will be seen in areas where there are relatively few natural landscape areas to connect. This layer shows:

- Areas of higher 'permeability' or connectivity between large well-connected areas with higher potential naturalness.
- Bottlenecks to movement where permeability/flow is impeded and current accumulates.

Normalised Cumulative Current Flow is calculated as raw current flow divided by flow potential which can help to differentiate the mechanisms behind different flow rates (e.g. barrier effects on impeding or channelizing flow; diffusion of current across large natural areas). Helps to highlight the mechanisms behind different flow rates, and better distinguishes broadly natural areas with diffuse flow from areas where barriers are blocking flow or channelling flow through pinch-points. If flow is lower than would be expected without barriers – as shown in the flow potential layer – then barriers are blocking flow from the area. This is often evident in urban centres, which have low scores. If flow is higher than would be expected without barriers – current flow is high relative to the flow potential layer – then barriers are channelling flow into the area and potentially creating pinch-points. This layer potentially highlights:

- Areas where the best movement options still exist in fragmented landscapes.[38]

[38] McRae, B.H., K. Popper, A. Jones, M. Schindel, S. Buttrick, K. Hall, R.S. Unnasch, and J. Platt. 2016. Conserving Nature's Stage: Mapping Omnidirectional Connectivity for Resilient Terrestrial Landscapes in the Pacific Northwest. The Nature Conservancy, Portland Oregon. 47 pp. Available online at: https://conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/oregon/science/Pages/Resilient-Landscapes.aspx October 23rd 2022.

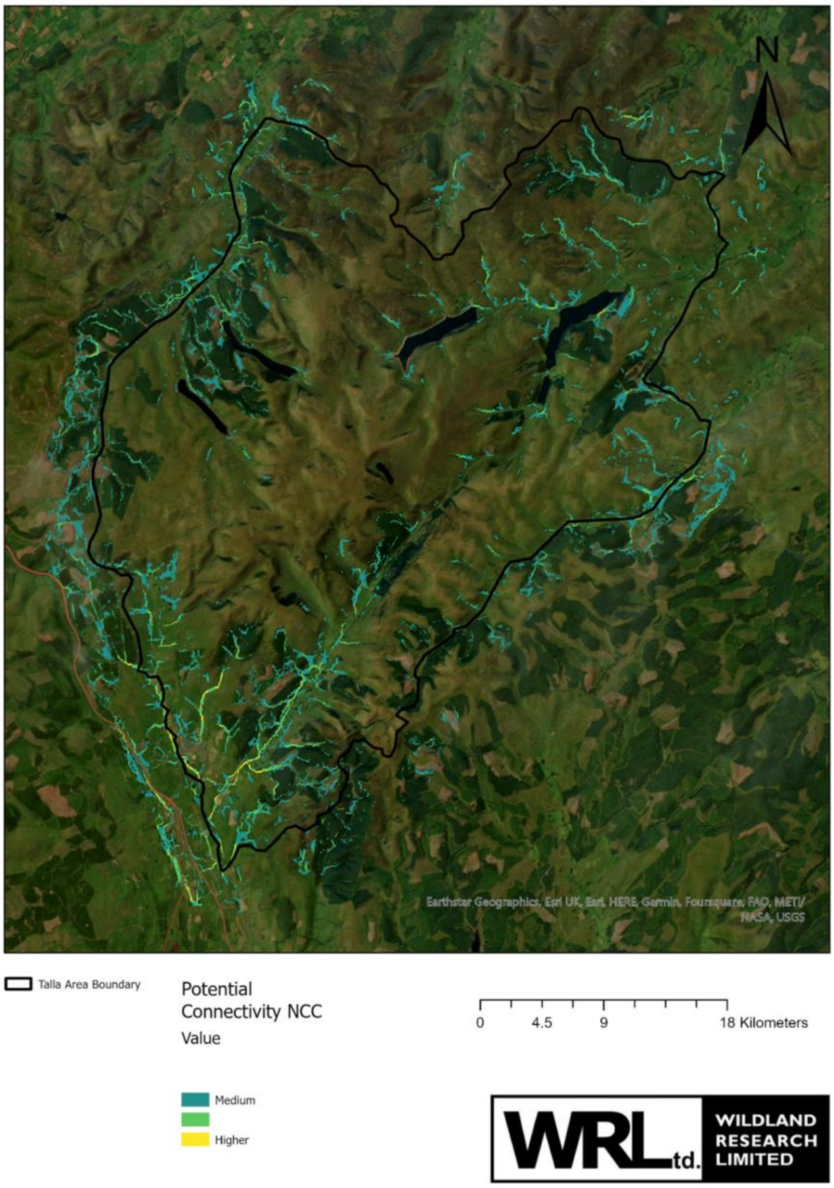

Figure 15a. Ecological connectivity: normalized cumulative current flow. Coloured areas, especially those areas in yellow are areas where there is higher potential ecological flow in the model. This is usually linked to areas or linear elements of intact natural habitats that form natural landscape linkages. These are often channelled into corridors by surrounding intensive land use practices or built infrastructure.

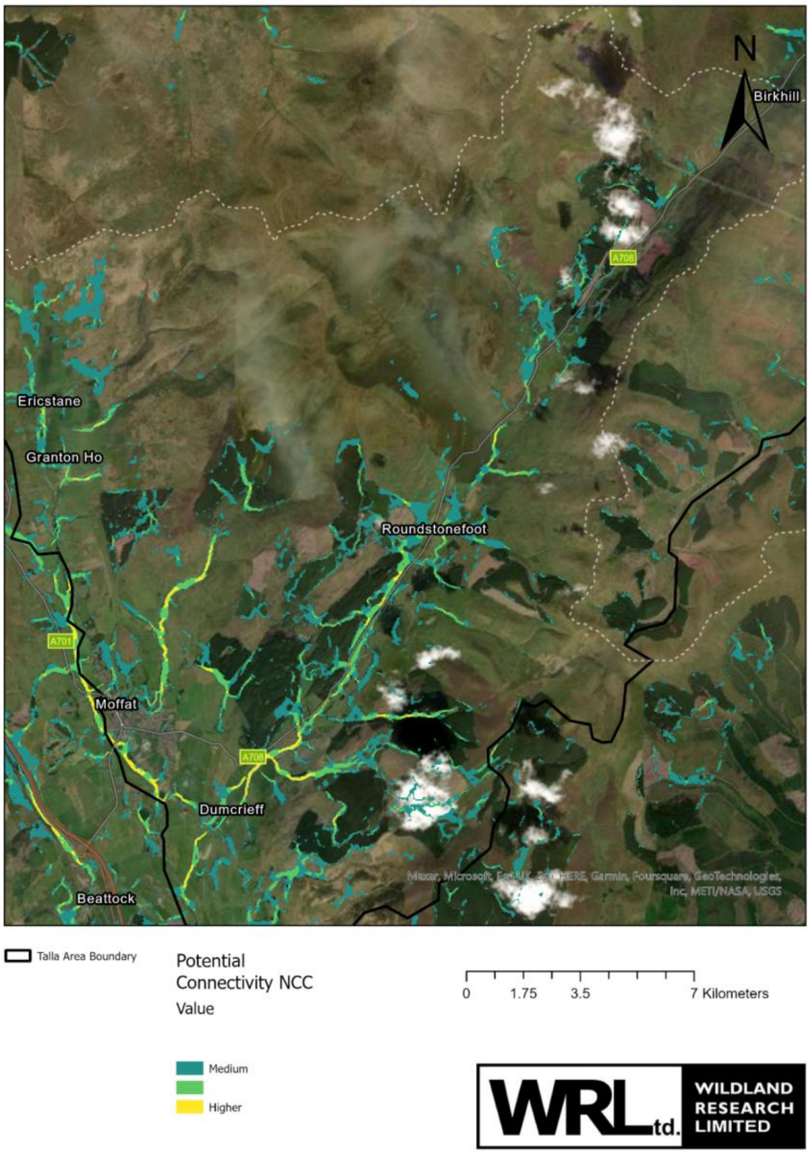

Figure 15b. Ecological connectivity: normalized cumulative current flow (focus on Moffat Water). Coloured areas, especially those areas in yellow are areas where there is higher potential ecological flow in the model. This is usually linked to areas or linear elements of intact natural habitats that form natural landscape linkages. These are often channelled into corridors by surrounding intensive land use practices or built infrastructure.

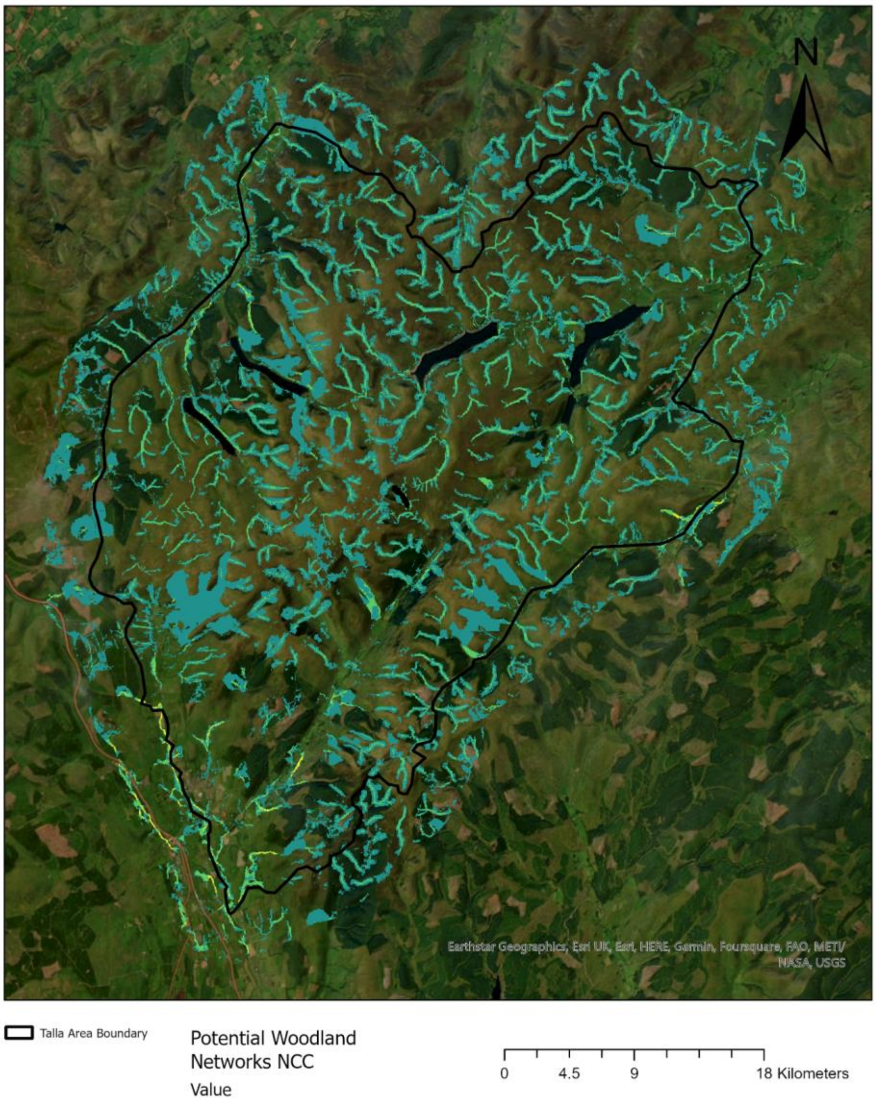

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Figure 15c. Potential woodland networks: normalized cumulative current flow. Coloured areas indicate source areas and potential expansion corridors for woodland afforestation via multiple mechanisms (see section 6.1.3 for more details).

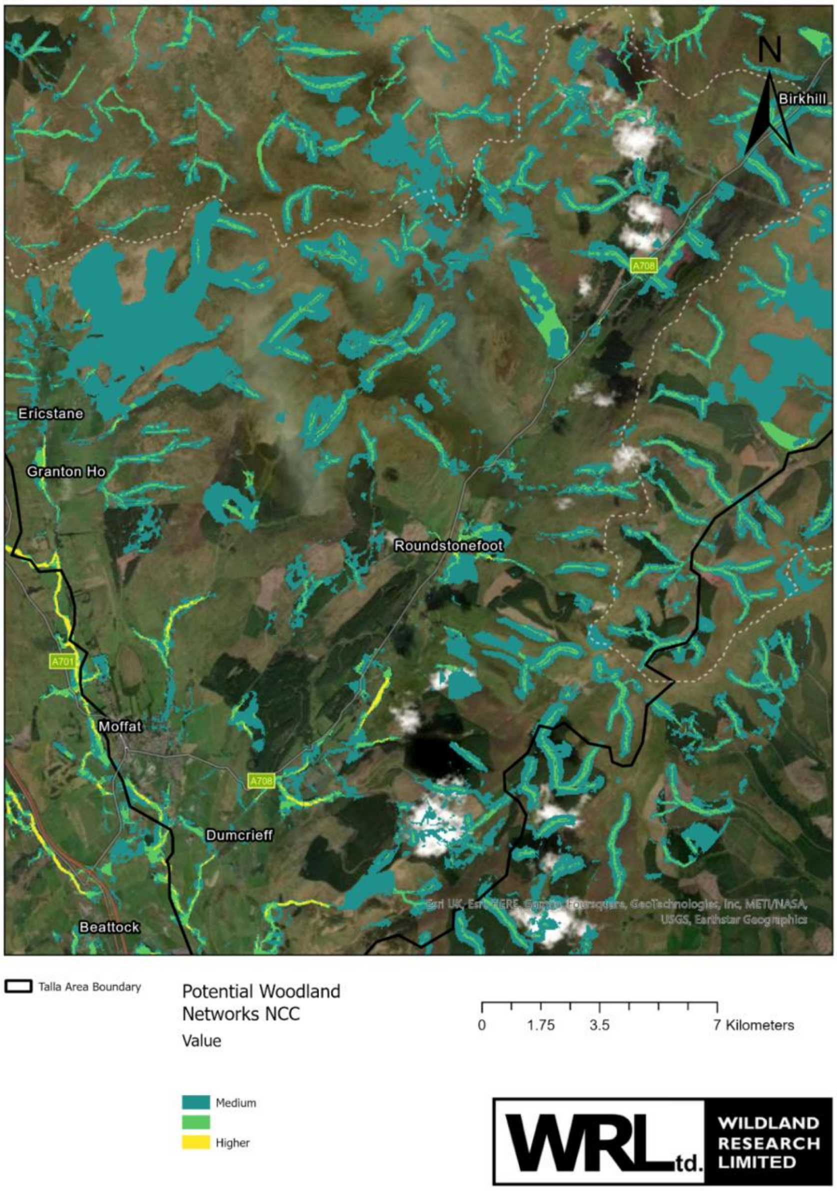


Figure 15d. Potential woodland networks: normalized cumulative current flow (focus on Moffat Water). Coloured areas indicate source areas and potential expansion corridors for woodland afforestation via multiple mechanisms (see section 6.1.3 for more details).

4.5 Landscape character

Landscape Character Assessment (LCA) is a method used to identify and map the unique features and qualities that make up a landscape. It provides a framework for understanding the visual, cultural, and ecological components of a landscape, and can be used to inform land use planning and decision-making[39]. In natural capital assessments, LCA can help to identify areas of high natural capital value, identify potential conflicts between land uses and natural capital, and engage local communities and stakeholders in the assessment process. By incorporating LCA into natural capital assessments, it is possible to ensure that land use planning and decision-making is informed by a comprehensive understanding of the unique features and qualities of a landscape and supports the sustainable management and conservation of natural capital.

LCA can help to identify and map areas of high natural capital value within a landscape. By understanding the unique features and qualities of a landscape, it is possible to identify areas that are particularly important for supporting biodiversity, providing ecosystem services, or delivering other benefits to society. These areas can then be targeted for conservation or management measures to protect their natural capital value.

LCA can also help to identify potential conflicts between land uses and the natural capital value of a landscape. By understanding the different components of a landscape and their importance, it is possible to identify where certain land uses may have negative impacts on natural capital, and where there may be opportunities to achieve multiple benefits through integrated land use planning.

Finally, LCA can help to engage local communities and stakeholders in the natural capital assessment process. By involving local people in the identification and mapping of landscape features and qualities, it is possible to capture local knowledge and values and incorporate them into natural capital assessments. This can help to ensure that the assessment reflects the perspectives and priorities of local people and can support more effective communication and decision-making.

4.5.1 Landscape characteristics of the Talla-Hartfell wildland area

The Talla-Hartfell Wildland Project area is characterized by a rugged landscape with a mix of upland heath, blanket bog, and scattered woodland (see Photos 1-12). It is an area of high rainfall and cold temperatures, and its distinctive landforms include steep-sided hills, crags, and scree slopes. The area is largely undeveloped and remote, with few settlements and a low human population density. The natural features of the Talla-Hartfell wild land area make it an important habitat for a range of flora and fauna, including upland birds, mammals such as red deer and mountain hare, and a variety of plant species adapted to the harsh upland environment.

Human land use has had a significant impact on the landscape character of the Talla-Hartfell Wildland Project area. Historically, the area was heavily used for sheep grazing, and this has led to a patchwork of vegetation types, including heathland, grassland, and scrub. The area also

[39] https://digital.nls.uk/pubs/e-monographs/2020/216649977.23.pdf

contains several archaeological sites, such as cairns, stone circles and sheep folds, which were built by historic communities.

There are also many water supply schemes in the area, including the Talla, Megget and Fruid Reservoirs, which have had a significant impact on the landscape character. These reservoirs are large, artificial bodies of water that have flooded valleys and altered the natural flow of rivers.

Recently, commercial forestry has been a major land use in the area, and this has resulted in large areas of conifer plantation. These plantations are generally monocultures of densely planted Sitka spruce and other non-native tree species, which can have a significant impact on biodiversity and the visual character of the landscape.

The installation of wind turbines has been a more recent addition to the area's human land use, with several large industrial wind farms now present on the surrounding hillsides. Although outside of the Talla-Hartfell Wildland Project area, these are visible from within over large areas interior hills. While they have the potential to provide renewable energy, their presence therefore has an impact on the visual and sensory experience of the landscape for visitors and residents.

Recent native woodland planting and regeneration schemes (e.g. Carrifran Wildwood and Borders Forest Trust) is likely to have a significant impact on the landscape character of the Talla-Hartfell wild land area as time progresses and woodland becomes more established. This will introduce a new element to the landscape, and over time, native woodland will become a prominent feature of the area and increase biodiversity and create habitats for wildlife, providing food and shelter. The presence of more trees will also help to stabilize slopes and prevent soil erosion, reducing the impact of heavy rain on the landscape.

In terms of visual impact, native woodland planting and regeneration can soften the appearance of the landscape and add a more natural and diverse character to the area. It can also provide a contrast to the surrounding open moorland and heathland, creating a more varied and interesting landscape for visitors.

While planting and regeneration of native woodland can take many years to establish and may not have an immediate impact on the landscape character of the Talla-Hartfell Wildland Project area, it is encouraging just how much has been achieved by Carrifran Wildwood and BFT where planting has taken place. It is easy to contrast these areas with the commercial forestry and bare hillsides of traditional sheep grazed hills. The longer-term success of these efforts will ultimately depend on factors such as the location, species selection, and management practices used.

4.5.2 Measures of landscape character

As a structured approach, Landscape character assessment (LCA), uses distinct measures to identify and describe the unique character of a landscape. This involves the identification of distinctive landscape types, mapping of landscape features, and analysis of the relationship between different landscape elements. Some of the measures used in LCA include:

- Landscape Typology: Landscape typology is the classification of landscapes into distinct categories based on their physical, ecological, cultural, and historical characteristics. It provides a framework for the assessment of the landscape character and helps identify key landscape elements that contribute to the character of a particular landscape.

- Landscape Features: Landscape features are the physical elements that make up the landscape, such as landforms, water features, vegetation, and buildings. These features can be mapped, and their spatial relationships analyzed to identify patterns and trends in the landscape.
- Visual Quality: Visual quality measures the aesthetic and scenic value of the landscape. It includes the assessment of views and viewpoints, visual complexity, and the impact of changes in the landscape on the visual character.
- Ecological Value: Ecological value measures the biodiversity and ecosystem services provided by the landscape. It includes the assessment of habitats, species diversity, and the quality of ecological systems.
- Cultural Heritage: Cultural heritage measures the historic, archaeological, and cultural value of the landscape. It includes the assessment of heritage assets such as historic buildings, structures, and cultural landscapes.
- Sensitivity and Capacity: Sensitivity measures the degree to which the landscape is susceptible to change, while capacity measures the ability of the landscape to absorb change without significant impact on its character.
- Landscape Character Indicators: Landscape character indicators are quantitative measures used to assess the overall condition and health of the landscape. They include measures of landscape diversity, connectivity, and fragmentation, as well as indicators of ecological and cultural value.

Here we focus on those measures that best help understand variations in natural capital across the Talla-Hartfell Wildland Project area including landscape topography and features, visual quality and impact. Combined with the work on wildness, access, woodland opportunity and ecological connectivity described in previous sections of this report, these data help understand the assess the natural capital of the Talla-Hartfell area.

Topography is recorded and measured here using high resolution digital elevation models (DEM). GIS tools can be used to show basic terrain features including altitude and common derivatives, slope and aspect (Figure 16a-d). More advanced tools can be used to derive information of more interest in terms of LCA such as openness, sky/terrain view, total area visible and ruggedness. These are shown in Figures 17-21. A key aspect of landscape character in the Talla-Hartfell area is its openness and wide vistas. However, these characteristics are spatially variable depending on where you are in the landscape. Maps of positive and negative topographic openness describe the dominance (positive) or enclosure (negative) of a landscape location in relation to how wide a landscape can be viewed from any position (Figure 17a and b). Related indices of terrain and sky view factors describe how much land or sky can be seen from any location within the landscape. It follows that your view tends to be dominated by land when stood in the bottom of a valley as surrounding hillside obscure much of the horizon. Conversely, stood on the top of a hill means that a wider horizon and more sky is visible. These are shown in Figures 18 and 19. The “size” of the view can be measured as the total land area visible from any point. Figure 20 gives an idea of the expansiveness of the view from any point in the study area. Finally, terrain ruggedness shows the variability of the landscape in terms of variation of slope (see Figure 21). This attribute was used by NatureScot in modelling wildness.

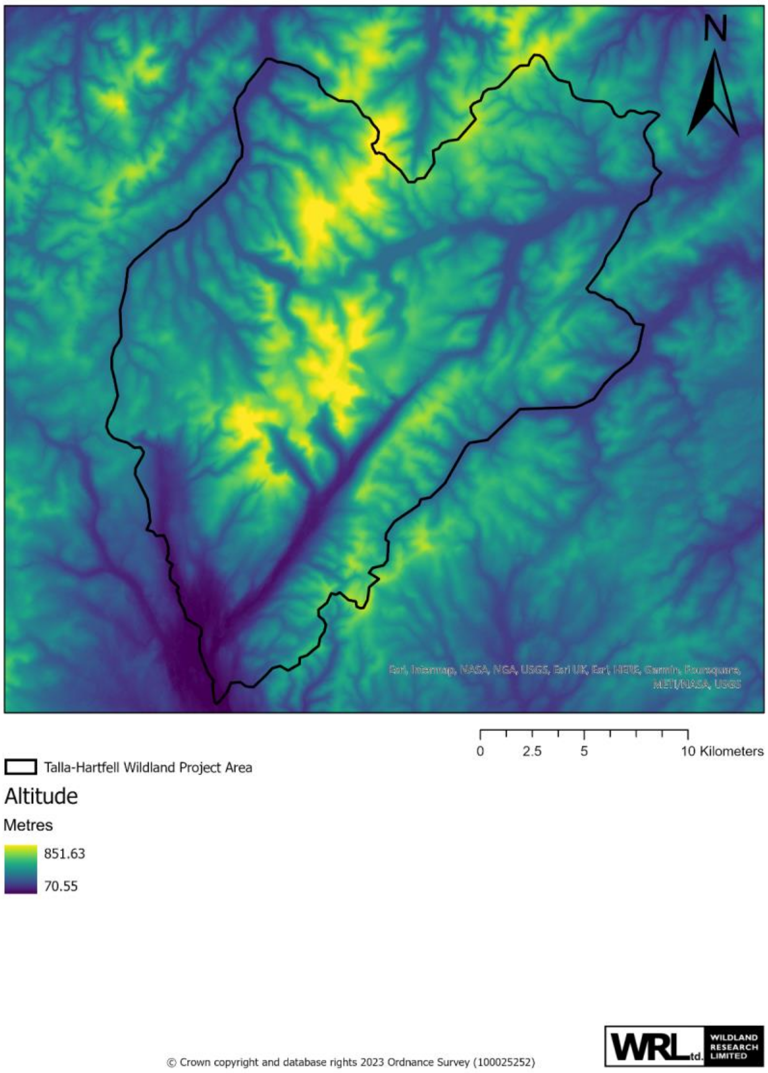


Figure 16a. Topography: altitude

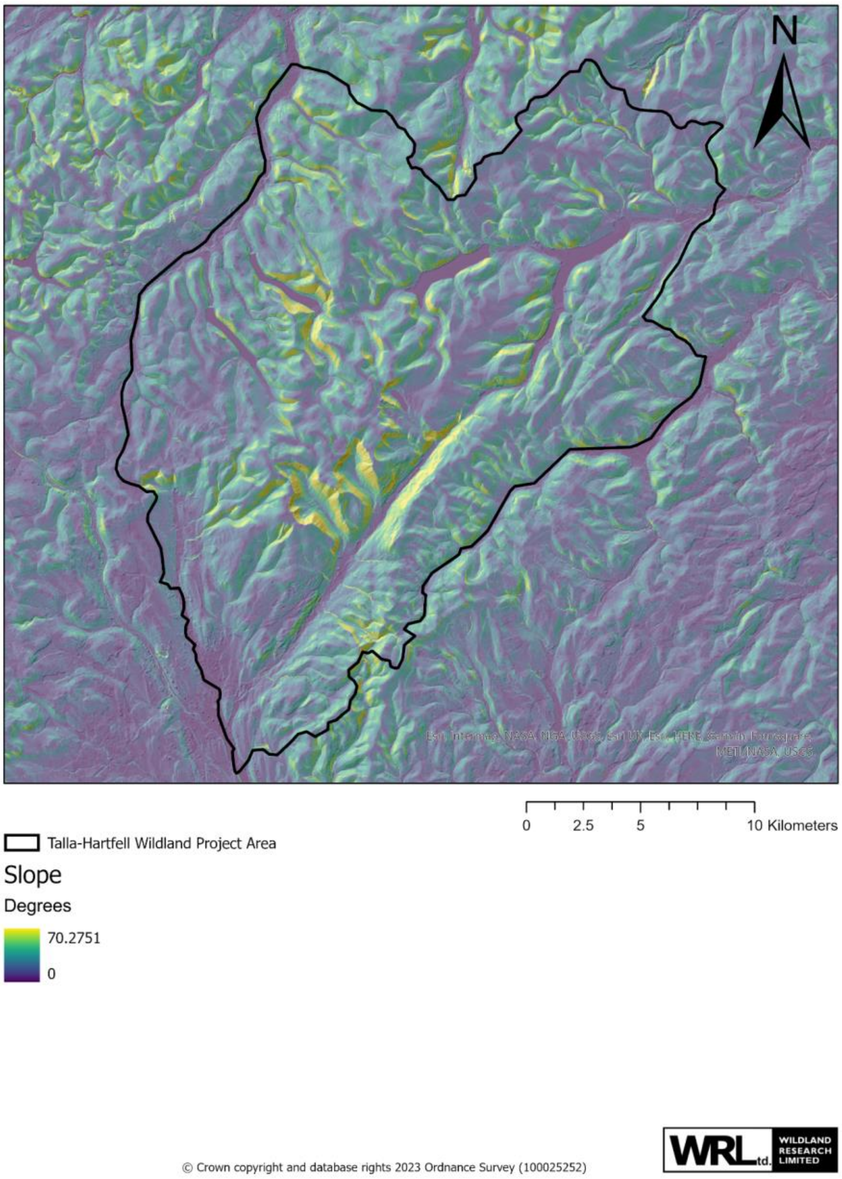


Figure 16b. Topography: slope

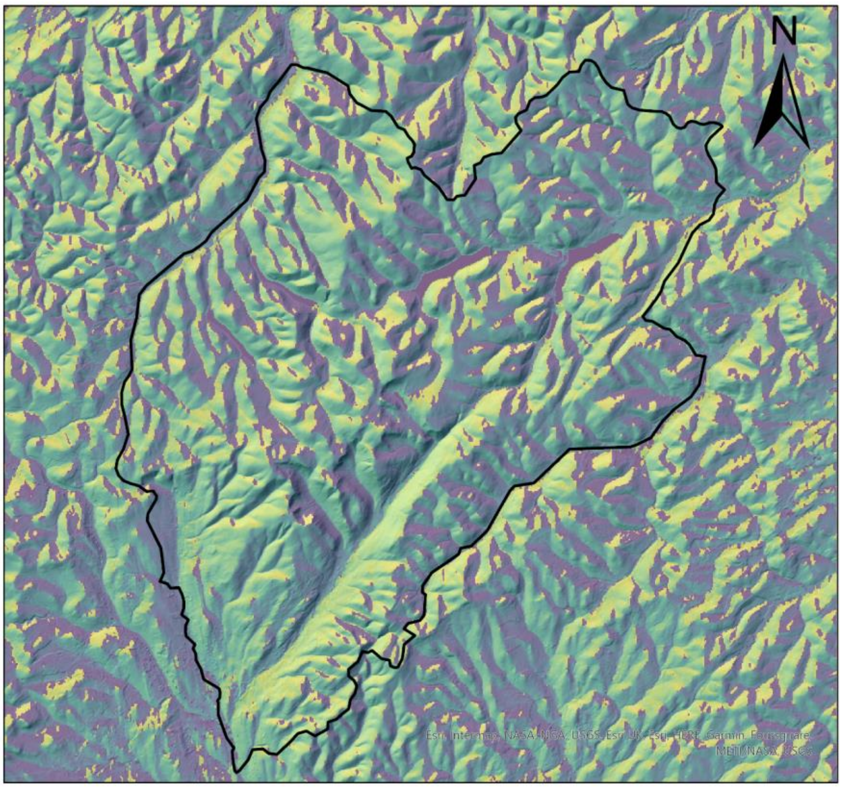


Figure 16c. Topography: aspect

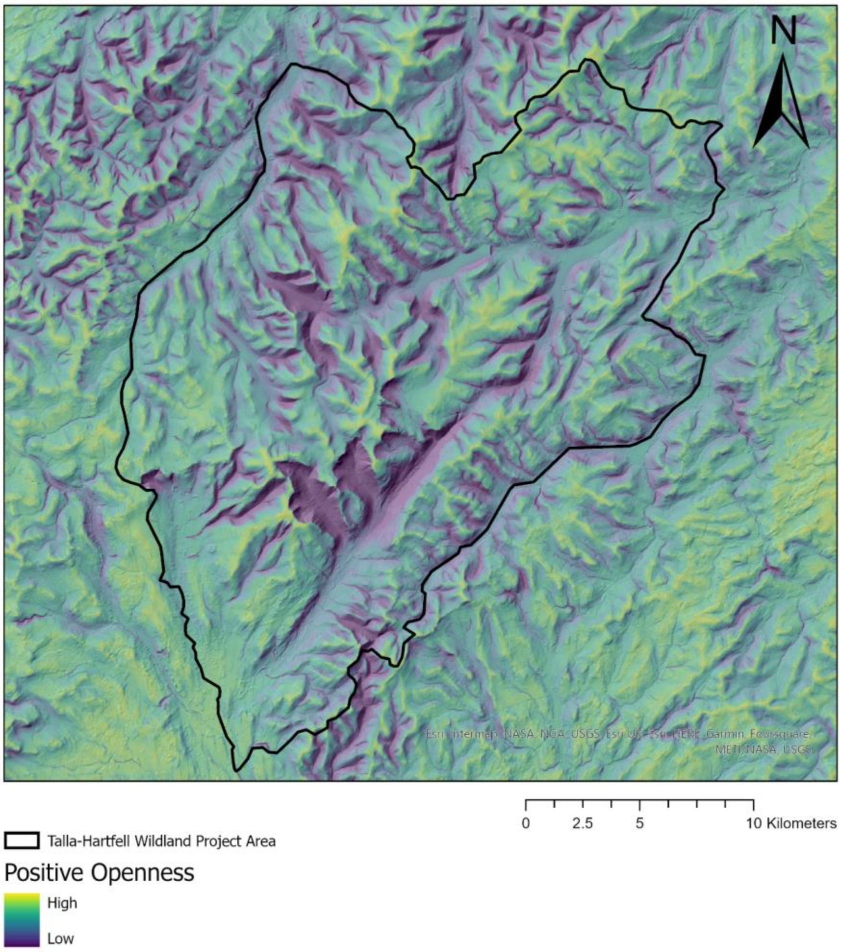


Figure 17a. Openness: positive

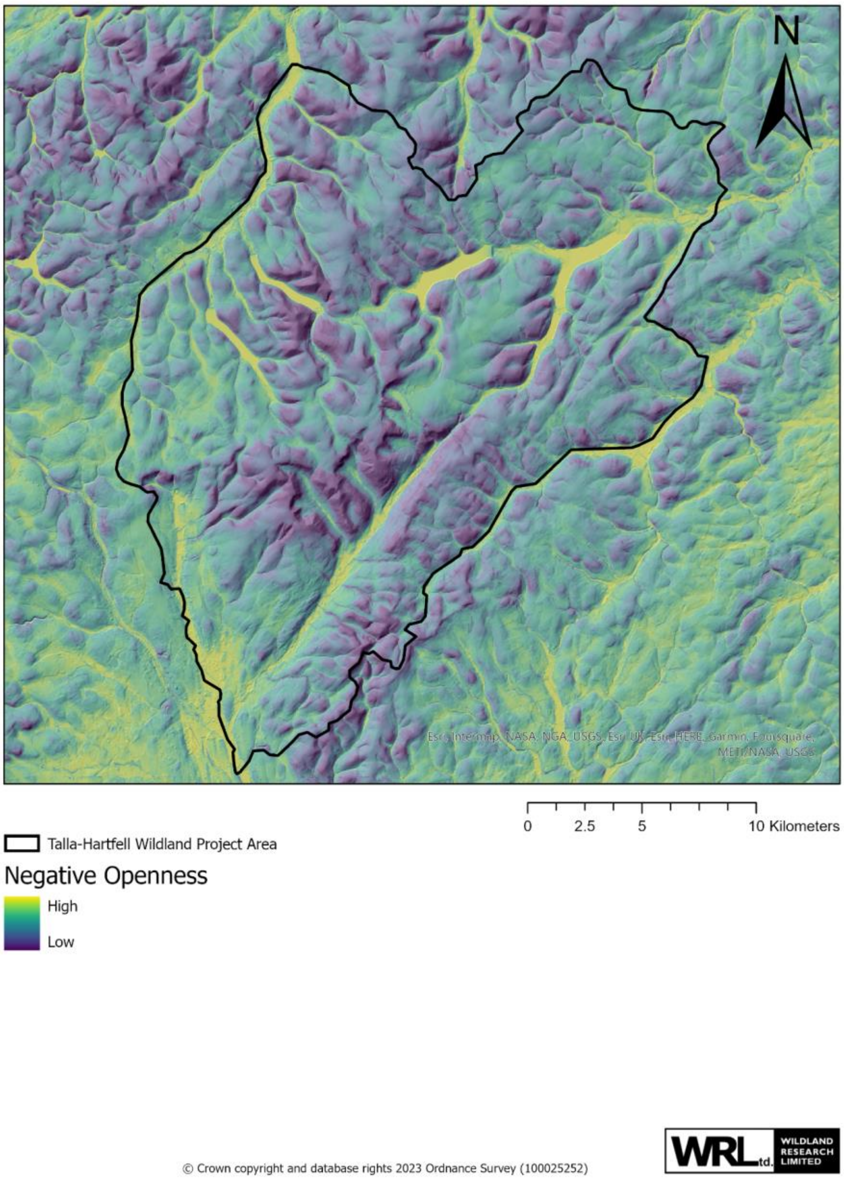


Figure 17b. Openness: negative

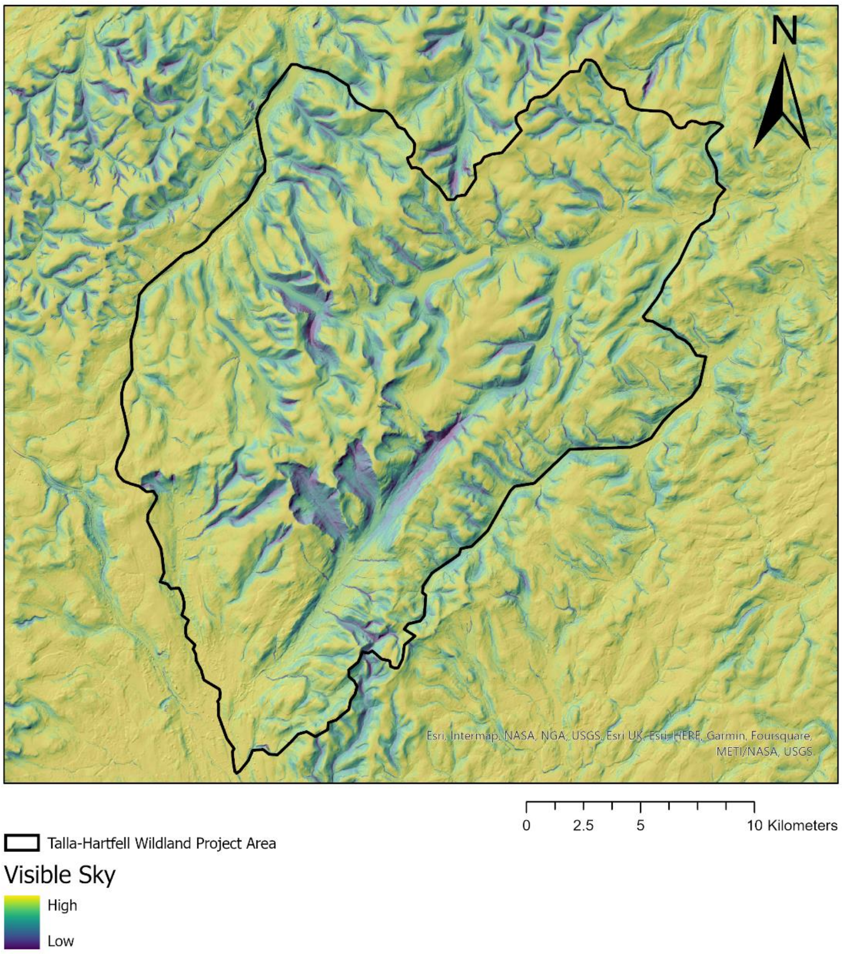


Figure 18. Sky view

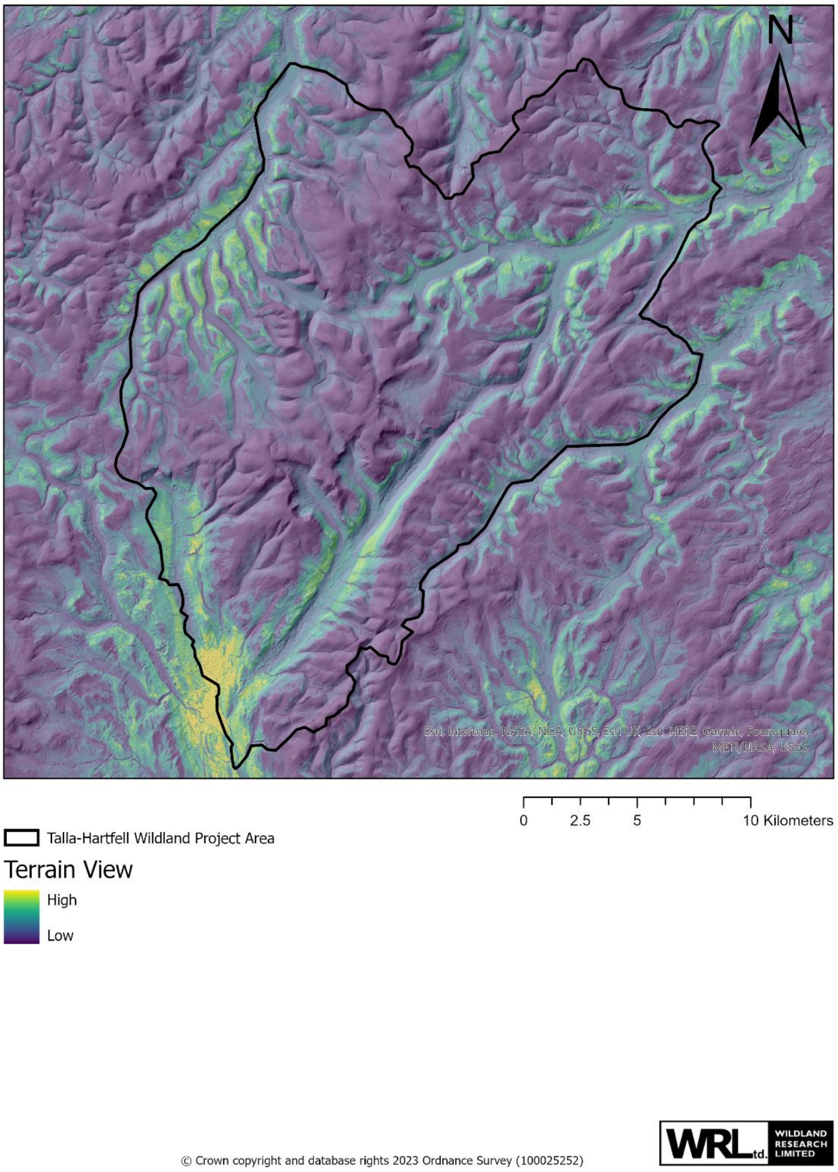


Figure 19. Terrain view

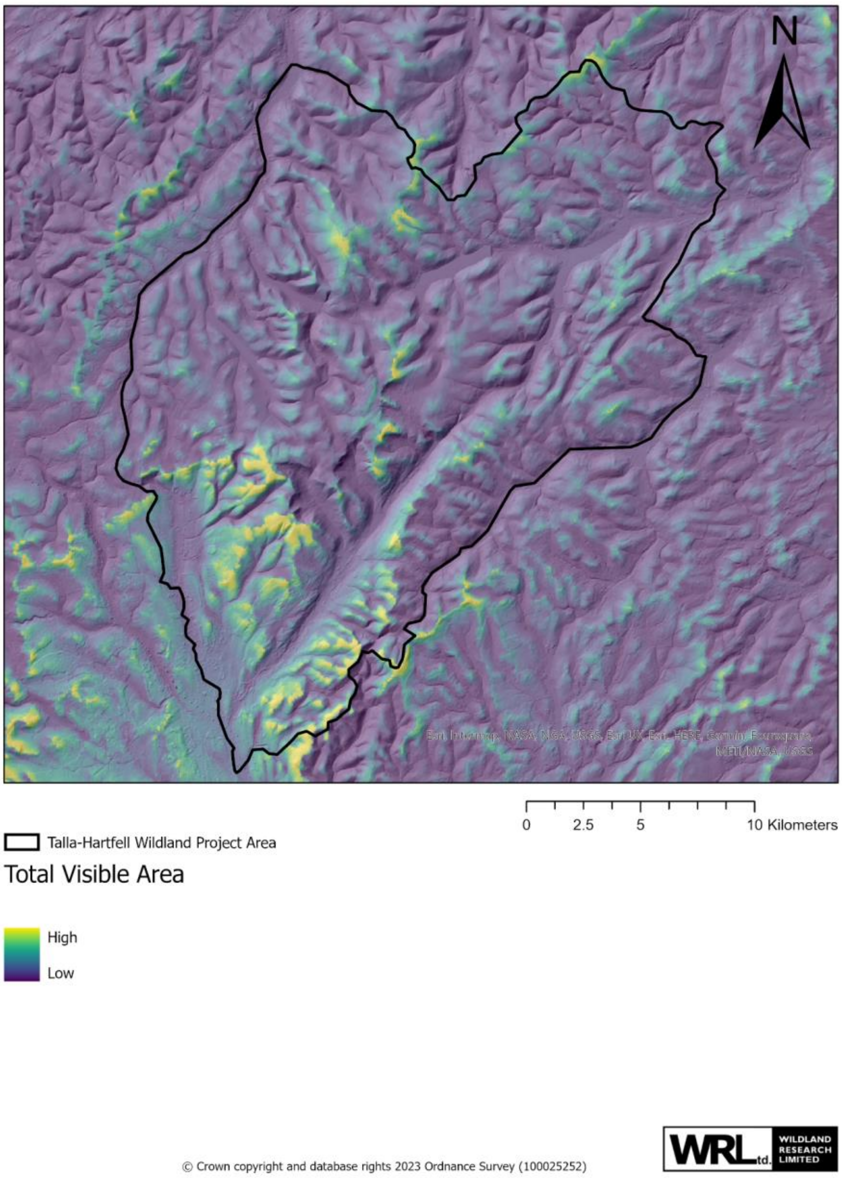


Figure 20. Total visible area

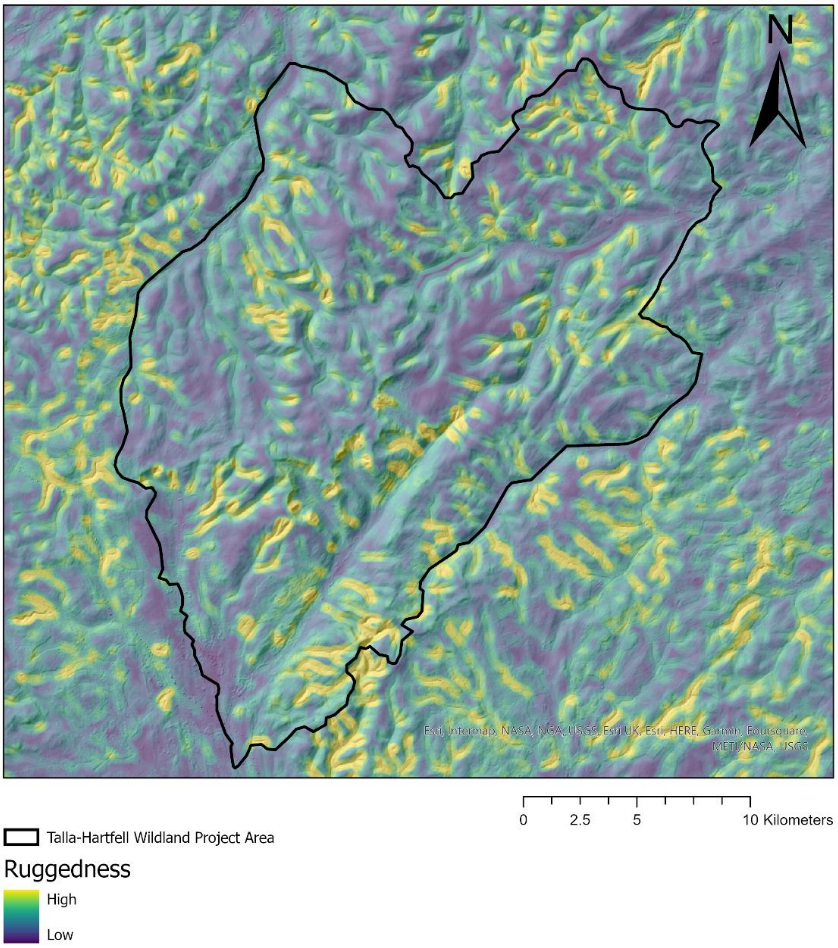


Figure 21. Ruggedness

Topography also exerts strong control over visibility of human features and infrastructure along with distance decay effects. Three visibility indices are included here, one showing the number wind turbines visible, and their relative impacts based on partial visibility and distance decay effects, a second showing the relative dominance of broad land cover types visible across the Talla-Hartfell Wildland Project area, and another (derived from the NatureScot wildness mapping) showing the total visual impact from all human features in the area. These are shown in Figures 22-24. These are calculated using a custom viewshed tool (Viewshed Explorer) that takes area visible, partial visibility and distance decay into account and is the same as used in the NatureScot Wild Land Area mapping and earlier feasibility studies[40].

Wind turbines exert a significant impact on landscapes in which they are sighted since they are both large and mobile, with spin blades and associated effects of blade flicker, and contrast starkly with the surrounding landscape in rural locations. Measures of wind turbine impacts are usually performed using viewshed or visibility analyses and simple buffer operations. Here, the Viewshed Explorer tool is used to calculate the visual impact of wind turbines in the vicinity of the Talla-Hartfell area based on terrain data, turbine height and location. This takes both partial visibility and distance decay effects into account depending on intervening terrain and location or turbine, its height and observer location. The resulting impact model is shown in Figure 22.

Landscape character is also affected by landcover. The model shown in Figure 23 shows the pattern of dominant landcover type that is visible across the study area taking terrain and distance decay effects into account. The model is broken down into six broad landcover types: urban (built up areas), agricultural land (arable crops and improved pasture), plantation forestry, upland (mainly rough grassland and montane vegetation), deciduous woodland, and open water.

Figure 24 shows the visual impact of all modern human features in the landscape. This is based on the wildness attribute “absence of modern human artefacts” used by NatureScot in mapping wildness, and includes all buildings, roads, railways, tracks, dams, pylons and wind turbines. This gives an overall impression of how landscape character is impacted by visible human features and where one can get an enhanced sense of remoteness and wildness where no such features can be observed.

[40] Carver, S., Comber, A., McMorran, R. and Nutter, S., 2012. A GIS model for mapping spatial patterns and distribution of wild land in Scotland. Landscape and urban planning, 104(3-4), pp.395-409. https://doi.org/10.1016/j.landurbplan.2011.11.016

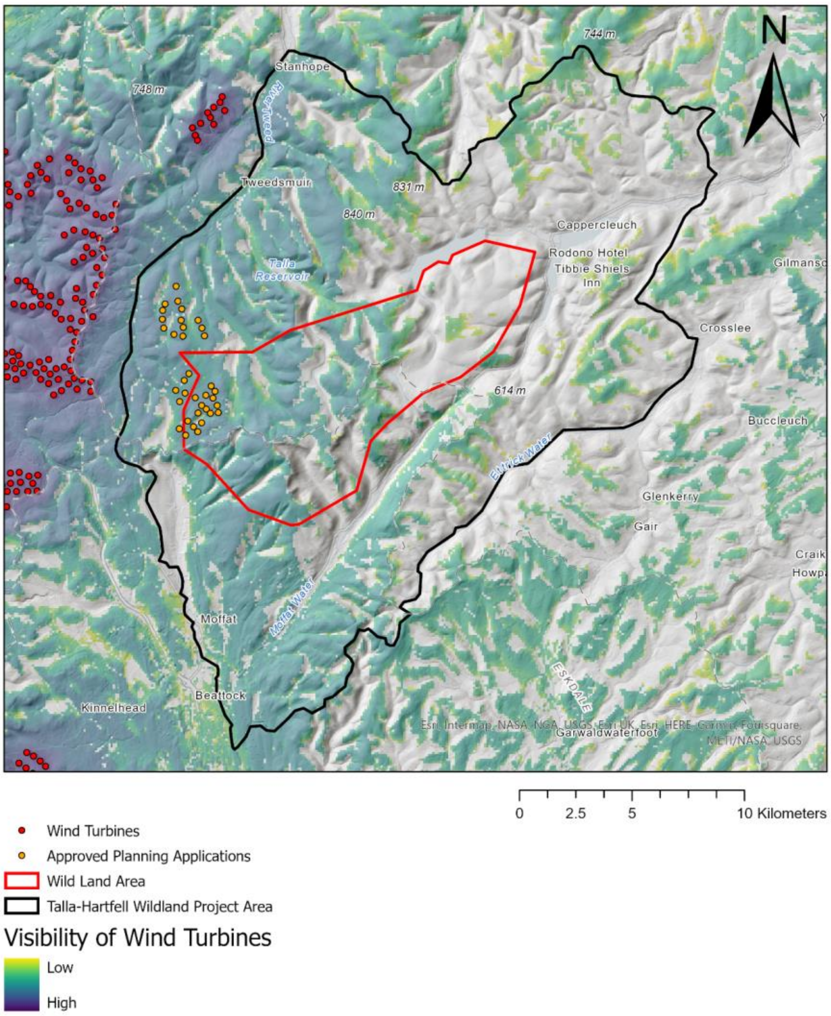


Figure 22. Visual impact from windfarms

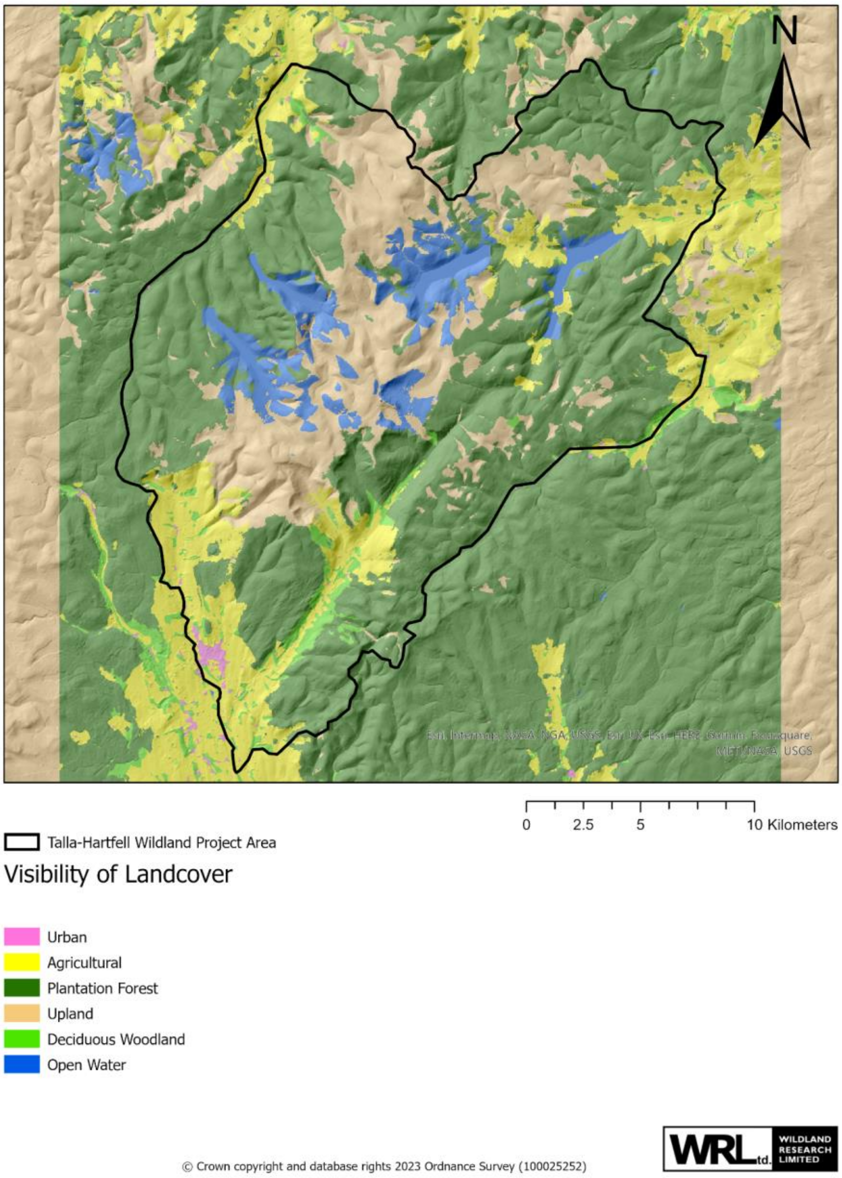


Figure 23. Dominant land cover

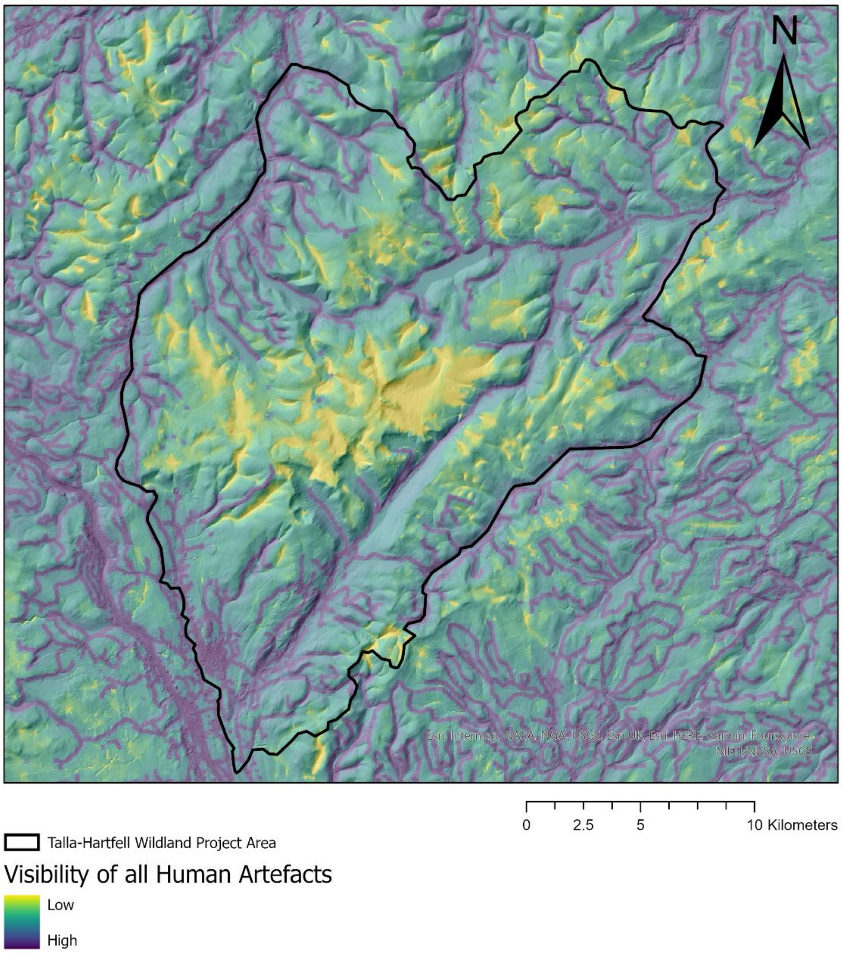


Figure 24. Absence of modern human artefacts

5. Stakeholder workshops

Desk-based studies using GIS and associated spatial data are an excellent way of summarising and visualising the patterns and interactions between different elements of NCAs. They are, however, despite being a valuable tool in enabling the processing and analysis of large amounts of spatial data to produce detailed maps and models of natural capital assets and flows, they are limited in relying on off-the-shelf spatial data (which may not always be an accurate reflection of up-to-date local conditions), often lack inputs as regards qualitative local knowledge and opinion.

Participatory mapping is a process of collaborative map-making that involves local communities, stakeholders, and experts in identifying and representing spatial information. It is a powerful tool for engaging communities in decision-making processes, promoting local knowledge and perspectives, and enhancing spatial awareness and communication. Participatory mapping approaches can be used to address a wide range of issues, including land-use planning, natural resource management, disaster risk reduction, and social and environmental justice. The process typically involves a series of workshops or meetings where participants use a variety of techniques and tools, such as paper maps, digital mapping software, or geographic information systems (GIS), to collect and represent data, share information, and develop strategies and solutions. Participatory mapping can help to bridge the gap between technical expertise and local knowledge and can lead to more inclusive and effective decision-making processes that reflect the needs and priorities of diverse communities.

5.1 Participatory mapping approach

Two participatory mapping workshops were held with local residents in late March 2023; one in Tweedsmuir Village Hall, and the other in Kirkhope Parish Hall in Ettrickbridge. Each event was attended by between approximately 15-20 people with mixed gender and ranging ages from late 20s to retirees. The attendees included people working on the land (specifically foresters and farmers) as well as residents in local villages.

After a short introduction to the project and its aims and objectives, participants were asked to discuss each of four groups of topical questions and use paper base maps to record their knowledge and opinions about these. The four question groups and associated prompts or sub-questions were as follows:

- Which land, in your opinion, should continue to be agriculture, forestry, archaeology and any others?'
- Where, in your opinion, are the best places to establish new native woodland?
  - Do you favour planting or natural regeneration?
  - Are there any areas where tree planting shouldn't take place?
- Which areas, in your opinion, are the wildest parts of the area?
  - Why do you consider these areas to be wild?
  - Do you think they require further protection (beyond the existing Wild Land Area)?
- Where would it be good to have more walking/cycling/riding access on either core paths or permissive paths?

- Are there any paths that it would be good to join up?

Participants were asked to record the results of their group discussions on the base maps and write any additional comments and discussion on separate pieces of paper. These we then attached to the appropriate maps on completion of the workshops.

The Paper2GIS software was used to convert the mark up on the paper base maps to GIS-readable shapefiles. The written comments were scanned and converted to text files and linked to their appropriate GIS layers. Figure 25 Shows an example marked up base map and the resulting shapefile.

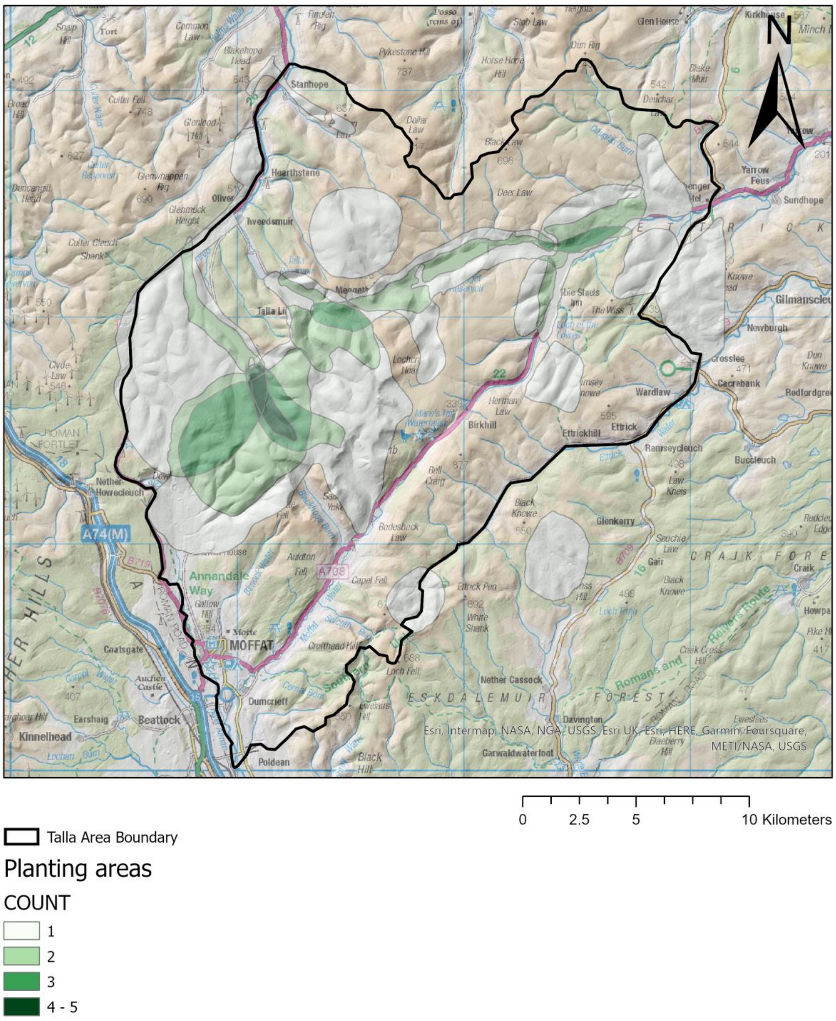
Figure 25. Example marked up base map

5.2 Results

Results from the participatory mapping workshops are summarised in section 6.2 and full text included in Appendix 1. Figures 26-28 Show the combined outputs from the participatory mapping grouped into principal themes: woodland, access, and wildness.

5.3 Integration with desk-based mapping

Participatory mapping outputs shown in Figures 26-28 are georeferenced and converted to GIS-readable formats using the Paper2GIS software. This allows the overlay of these data with standard desk-based mapping for scrutiny and consideration. While the participatory mapping data is not considered to be precise (in the same way that GIS datasets derived from topographic maps and other sources may be), they are important sources of locally grounded information on public knowledge and opinion (see section 1.1). Overlays with other GIS data and model outputs are therefore geographically approximate but illustrative of potentially useful and interesting patterns.



WRL ltd. WILDLAND RESEARCH LIMITED

Figure 26. Participatory mapping: woodland

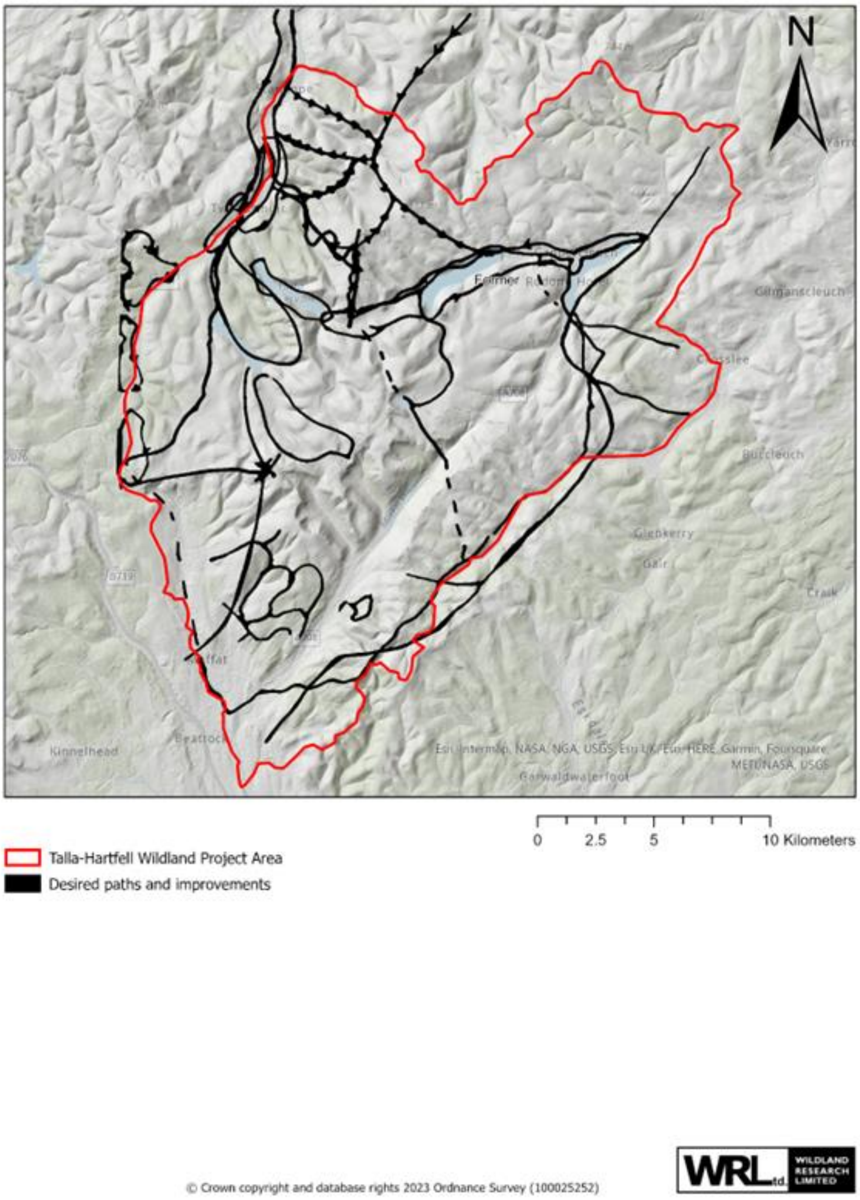
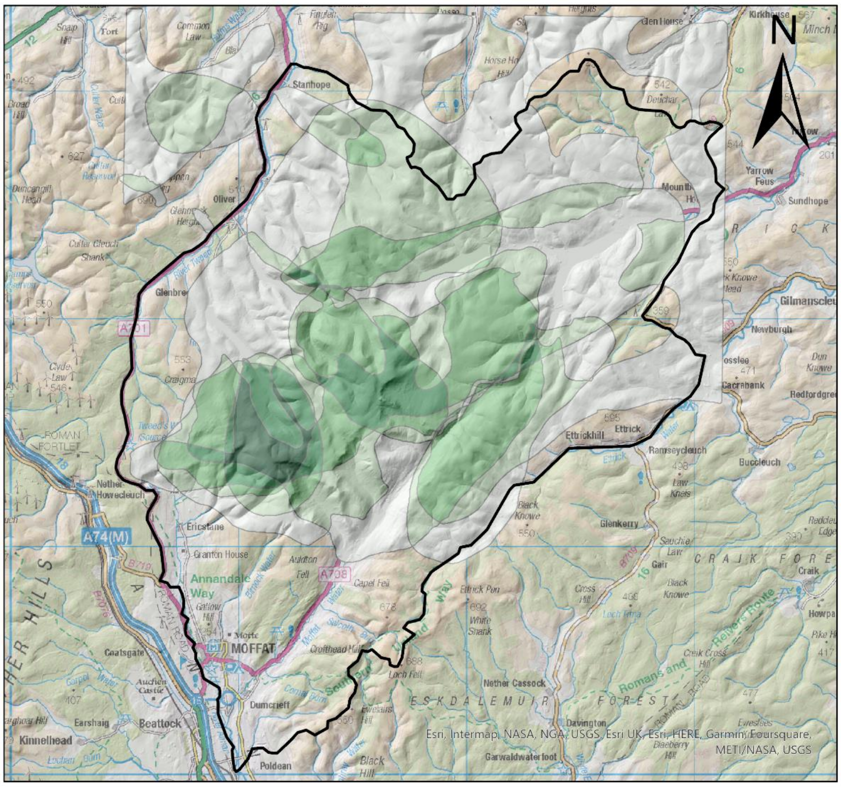


Figure 27. Participatory mapping: access



0 2.5 5 10 Kilometers

Talla Area Boundary

Wildest Areas

COUNT

- 1
- 2
- 3
- 4
- 5

WRL ltd. WILDLAND RESEARCH LIMITED

Figure 28. Participatory mapping: wildness

6. Discussion

6.1 NCA desk-based mapping

The results of the desk-based mapping are presented as a series of mapped outputs. Some are simply maps of the spatial datasets used in the analysis (e.g. altitude and paths data), others are derived variables (e.g. slope and aspect derived from altitude data), while many are value-added layers derived from advanced spatial modelling involving one or more input layers and complex spatial modelling approaches (e.g. ecological connectivity) and associated interpretation and post-processing. These are reported under five principal themes: wildness, access, woodland opportunity, ecological connectivity, and landscape character.

6.1.1 Wildness

Patterns of wildness across the Talla-Hartfell Wildland Project area, as shown in Figure 3, are determined by the interaction of topography and human land use. Arguably, topography is the single most important driver as this affects all four of the attributes of wildness used by NatureScot in mapping variations in wild land quality (Phase 1 mapping) and the resulting wild land areas. Variations in topography (altitude, slope, and aspect) are shown in Figure 16. Here, topography affects land use (determining as it does land capability through slope gradients affecting mechanisation for agriculture and forestry, soil moisture, nutrients, runoff, and erosion as well as climate through temperature and precipitation). As described in section 2, the Talla-Hartfell Wildland Project area is characterised by rugged upland landscapes dissected by deep, steep-sided valleys. This limits land use to upland hill farming (principally sheep on the hill and cattle at lower elevations), commercial forestry, water supply and renewable energy (see Photos 7-10).

Topography also greatly affects remoteness by limiting access to the core interior areas by road or track, and steep slopes make walking difficult. Whilst “as the crow flies” distances may be small compared to other wild land areas in the Highlands of Scotland, steep topography, and barrier features (cliffs and large areas of open water) combine to create long walk times for anyone wishing to climb any of the hills or cross from one side to the other. Patterns of remoteness depend on both origin and destination as illustrated in Figure 8, with Figure 9 showing the overall combined pattern of remoteness. This can affect recreational opportunity by limiting certain activities to areas depending on origin. The general lack of walking paths and routes in and across the study area clearly affects accessibility and is an issue raised by participants in the mapping workshops (see section 6.2).

Visual impact of human features and land use is also greatly affected by topography (see Figures 22 and 24). Steep valleys and slopes can act as a visual shield against visibility of roads, buildings and other human structures giving the interior of the study area a distinctively wild feel. This said, the tops of the hills are generally rounded and offer distant views of large industrial windfarms, while their flanks present views of water supply reservoirs such as Talla, Fruid and Megget as well as the many large blocks of non-native conifer plantations. Figure 22 shows the visual impact from wind farms to the west of the project area and how they are principally visible from summits and ridges as well as upper slopes with a westerly aspect. Figure 23 shows the dominant visible land cover and demonstrates how reservoirs and plantation forest tends to dominate the look and feel across large areas of the Talla-Hartfell landscape.

Finally, ruggedness is driven wholly by topography with steep and varied terrain creating a rugged feel to much of the upland landscape (Figure 21).

Bringing all four attributes of wildness together into one composite indicator of wildness quality (Phase 1 map) shows distinct patterns in overall wildness, with a marked gradient from valley bottoms to interior summits and deep valley heads as shown in Figure 3a. The Resulting Phase 2 map in Figure 3b is defined by reclassifying the Phase 1 map into eight classes using a Jenks Natural Breaks classifier and is used by Nature Scot to define the Talla-Hartfell Wild Land Area boundary in Figure 2.

Patterns in biodiversity and habitats are somewhat difficult to discern with any certainty due to paucity of data. Figures 5 and 6 show distribution of selected indicator species and habitats. While the data may be either poor (NBN Atlas) or incomplete (HabMoS) it is clear that the area is important for upland species and habitats, though impacted by human land use such as sheep grazing and commercial forestry operations.

6.1.2 Access

While the Talla-Hartfell Wildland Project area is apparently criss-crossed by a series of paths and tracks (both current and historical as illustrated in Figure 7), many of these are, according to workshop participants, poorly maintained and signposted, meaning that many routes are seldom used and don't receive much footfall. The same can be said of the two principal roads crossing and entering the area. These are both very minor roads (Cappercleuch to Tweedsmuir, and the dead-end road from Peebles to Langhaugh) and so tend to see very little traffic compared to the main thoroughfares such as the A701 and A708. While this may further enhance the feeling of wildness of the area, it does mean that access can be limited to those people willing to go off-path and explore the wider landscape and opportunities it provides.

Accessibility also depends on both point of access (origin) and time available. As described above, remoteness across the area is determined by topography but also where a journey starts. Three maps are provided to illustrate accessibility of the study area depending on origin (Figure 8). The first of these (Figure 8a) shows time taken to walk from residential areas assuming a walk begins at home, while the second and third maps (Figures 8b and 8c) assume mechanised transport (car or bus) is used to get either to car park or bus stop, or any point along the public highway, where a walk can start. Very different accessibility patterns naturally result from such origins but can be combined into an overall remoteness map as shown in Figure 9. Hartfell, Firthhope Rig, White Combe and Muckle Knees stand out as particularly remote areas in this analysis.

While not a complete picture, the Strava Global Heatmap tool[41] does provide a snapshot of recreational use of the area for walking, running, cycling, canoeing/sailing, and skiing. The heatmap for the Talla-Hartfell area is shown in Figure 29. This indicates that while many of the principal hills in the study area along with certain honeypot attractions (such as Grey Mare's Tail and Loch Skeen) are destinations for walkers (with many hills being classified and listed as Corbetts and Grahams) and tracks in certain plantation forests (e.g. the Silver Jubilee Road situated between Talla and Fruid reservoirs) are popular for walkers, runners and cyclists, many parts of the Talla-Hartfell Wildland Project area remain lightly used due to their remoteness and

[41] https://www.strava.com/heatmap#11.58/-3.40603/55.45786/hot/run

lack of established paths/routes. Examples include the hills and valleys around Craigmaid in the west and (despite the presence of access tracks) the Kirkstead Burn and Black Law in the east.

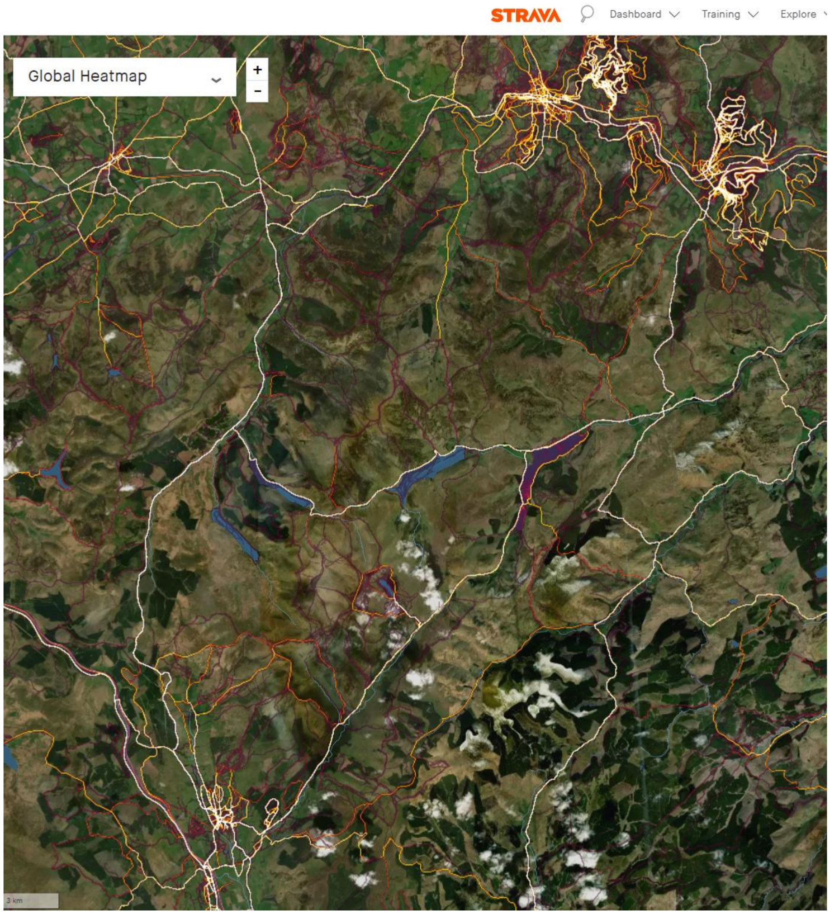


Figure 25. Strava heatmap

6.1.3 Woodland opportunity

The analysis used spatial data on native woodland, recent planting schemes and gill areas to explore woodland opportunity areas (see Figures 15c and 15d. The results highlight the fact that key sources of woodland expansion - native woodland areas that are larger, more intact, well established and well connected – are limited in number in the Talla-Hartfell area and they remain relatively isolated. Their isolation in the mapped outputs is partly a reflection of the dispersal distance used for modelling connectivity which was set at 1km radius based on the recommendations in the existing literature[42]. Nevertheless, the key conclusion remains that for now whilst extensive native woodland planting is underway in the area, even those areas that have already been planted while take a significant amount of time to establish. The main difference, that is clear in the woodland network compared to the general connectivity model (see Figure 15a and 15b), is the potential of the gill areas to act as a kind of 'green infrastructure' to support woodland expansion over time. These have clear advantages as areas that often protect young trees from grazing pressure and can shelter them from extreme weather. Gill areas shown in Figure 11 extend over a range of altitudes and as such offer a range of climatic conditions that are suited to multiple species. A key challenge with mapping of this type is the availability of spatial data on woodland planting and natural regeneration. As a result, there are some areas which are now regenerating which could already act as source areas, but which are not clearly captured by the current model. This limitation can of course be addressed by re-running the models as improved source data becomes available.

This is an initial assessment of woodland opportunity and, as outlined in section 4.3, uses an approach based on nativeness of trees rather than on specific tree species types. This kind of 'generic focal species' approach has been conducted previously although the modelling approach used in the 2008 study (see Figure 13) was based more on a simple 'buffering' analysis rather than a circuit model which attempts to pick out corridors for tree expansion along specific landscape features which will facilitate this 'flow' over time. It is recommended that a follow up analysis uses the same modelling approach and looks more specifically at individual trees species networks. This could look for example at oakwood networks and connect the dispersal patterns not just to native planting schemes but to key vectors in natural dispersal. Dispersal agents depend on the tree species, but seeds can be dispersed by gravity, mammals, birds or wind[43]. Birds for example can disperse seed by digesting berries and excreting the seed (e.g. rowan), or by carrying and burying seed for future consumption, such as the behaviour of the jay in supporting oak woodland expansion. In this way seed can be transported over long distances and can be encouraged by measures to encourage the birds in question such as the addition of perches, brash piles or by the development of scrub as it colonises new habitats. For species that rely on wind to disperse their seed (e.g. birch), new woodland sites will need to be down-wind of parent trees according to the prevailing wind direction during the months of seed dispersal. Developing specific individual species based sub-models (IBMs) for key target tree species such as Caledonian Pine, birch, oak, rowan and willow, would allow strategic planting of woodland seed sources so that they take maximum advantage of natural dispersal factors and how these will impact woodland expansion over time.

6.1.4 Ecological connectivity

The analysis used spatial data on land cover and human built infrastructure to identify areas important for connectivity for a range of species (see Section 4.4 and Figures 15a and 15b). Non-species-specific models which focus on the naturalness of habitats have been shown to identify important areas for a range of species and the results highlight the fact that currently the main

[42] Moseley, Darren, Duncan Ray, Kevin Watts, and Jonathan Humphrey. "Forest habitat networks Scotland." Contract report to Forestry Commission Scotland, Forestry Commission GB and Scottish Natural Heritage. Forest Research, Alice Holt (2008).

[43] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1030526/FC_Natural_Colonisation_Report_HP_1_Nov.pdf

areas of potential connectivity for a broad range of species are concentrated in the valley floor areas. This is not surprising given that there is a greater diversity of habitats to be found in these areas and that the climatic conditions are often more favourable in these areas as well. Areas with highest 'flow' in the model – the areas in yellow - tend to be those where natural or artificial barriers channel and concentrate this flow. This is particularly evident in agricultural areas where linear stretches of natural land (such as woodland or hedgerows) form corridors conducive to movement. Similarly, natural, linear features that are surrounded by man-made development form conduits – such as road margins – also concentrating flow.

A central tenet of landscape conservation planning is that natural communities can be supported by a connected landscape network that supports many species and habitat types[44]. The critical importance of landscape connectivity to both habitat specialists and generalist species has long been established[45], and disruption of movement for feeding, dispersal and migration can lead to population declines, loss of genetic variation, and potentially species extinction. Equally recent studies to develop forest naturalness indicator for Europe found that connectivity, along with basic measures of tree species type and accessibility, was a key predictor of the naturalness of forest habitats[46]. Whilst gaps in knowledge remain, ecological connectivity has been found to be of critical importance to natural ecosystems not just in terms of biodiversity but as suppliers of a wide range of critical ecosystem services such as pollination and pest regulation[47].

Given the focus on the naturalness of the landscape the modelling is constrained by the availability of datasets and whilst there is good data in the study area on ancient woodland areas there is no equivalent data highlighting areas of undisturbed scrub or grassland. Detailed data on the ecological integrity of water bodies and rivers is also limited, and so whilst they feature clearly in the woodland opportunity map, they have been given a more neutral weighting in the general connectivity model. Nevertheless, river networks often emerge as linear corridor elements connecting intact terrestrial habitats.

In addition to developing the connectivity mapping via improved data sources, several other options exist going forward to improve the mapping. Given the local focus of the mapping within a clearly defined area, and the precedent set for participatory mapping within this report, a participatory ground truthing exercise could be a useful way to check the results of these preliminary analyses and add rich local expert spatially explicit data into the models that is not currently available via remote sensing approaches. In quantitative terms the outputs of the model runs can also be further analysed using a graph theory to provide a series of metrics which statistically describe the relative importance of areas of high ecological flow in a network of such areas, as well as the relative importance of the key corridors or connecting landscape linkages between these patches of high flow. In more detailed terms the advantages of this subsequent additional analysis step is that it allows us to provide a more structured way of both interpreting and presenting the results. A Network graph analysis of this kind can for example

[44] Jennings, M. K., Zeller, K. A., & Lewison, R. L. (2020). Supporting adaptive connectivity in dynamic landscapes. *Land*, *9*(9), 295.
[45] Lindborg, R., & Eriksson, O. (2004). Historical landscape connectivity affects present plant species diversity. *Ecology*, *85*(7), 1840-1845.
With, K. A., Gardner, R. H., & Turner, M. G. (1997). Landscape connectivity and population distributions in heterogeneous environments. *Oikos*, 151-169.
[46] EA - European Environment Agency (2014). Developing a forest naturalness indicator for Europe: concept and methodology for a high nature value (HNV) forest indicator. Luxembourg, Publications Office, 60 p.
[47] Mitchell, M. G., Bennett, E. M., & Gonzalez, A. (2013). Linking landscape connectivity and ecosystem service provision: current knowledge and research gaps. Ecosystems, 16(5), 894-908.

quantify how individual landscape patches and corridors can contribute to overall habitat connectivity and availability in the landscape, including steppingstone effects.

6.1.5 Landscape character

The report uses mapped outputs and models to describe variations in landscape character across the Talla-Hartfell Wildland Project area. These are shown in Figures 16-24 and revolve around mapping topography (and associated indices) and measures of intervisibility.

Altitude in the form of a Digital Elevation Model (DEM) is the basic starting point for any topographic landscape assessment (Figure 16a) and is used to calculate all other indices starting with slope and aspect (Figures 16b and 16c). These, together, show the basic lie of the land and how the study area consists of a broad upland area of rounded summits dissected by steep glaciated valleys such as Moffat Water, Blackhope and Carrifran. The Devil's Beef Tub in the west adjacent to the A701 is a remarkable feature and stands out well on these maps.

Openness is modelled from the DEM and is related to how wide an area of landscape can be viewed from any position (Figure 17) either looking up (positive openness) or looking down (negative openness) from the point of observation. High positive openness tends to emphasise the higher vantage afforded by peaks and ridges, while negative openness tends to emphasise the wide flat open spaces in the lower elevations. Steep valleys like Blackhope and Carrifran, and steep cliffs and valley sides exhibit low positive and negative openness, respectively.

Sky view and terrain view factors describe the amount of sky or land visible above the horizontal for any position in the landscape. Consequently, valleys tend to exhibit low sky view and high terrain view, while ridges and summits are the opposite. Together these maps (Figures 18 and 19) give a further indication of the degree of enclosure or expansiveness in the landscape depending on relative position of the observer.

One of the principal characteristics of the Talla-Hartfell landscape is the expansive views that can be seen from the hills in the area. While measures of openness and sky/terrain view described above can provide spatial indicators of openness and enclosure, a measure of total land area visible can be used to provide a further impression of just how large the view is from some these hills. Patterns of total area visible in Figure 20 demonstrate how summits and their upper slopes provide wide 360-degree views of the surrounding landscape. Hart Fell, Swatte Fell, White Combe (Photo 7), Broad Law, Dollar Law and Pykestone Hill all present particularly expansive views. Such large views can, however, be something of a double-edged sword when it comes to landscape quality and character, as while they provide an impressive vista, they also open the prospect to potentially negative views of wind farms and commercial plantation forestry. The map in Figure 22 shows how the turbines of the Clyde and Glenkerie wind farms are visible from large swathes of the Talla-Hartfell Wildland Project out to the west of the area. Figure 19 shows how views of commercial forestry plantations and associated operations dominate views over large areas of the Talla-Hartfell Wildland Project area, particularly around Moffat Water, the Talla and Fruid valleys and Douglas Burn. Other patterns in the dominant visible landcover show the effects of the water supply reservoirs (Talla, Fruid and Megget) as well as agricultural fields, urban areas and deciduous woodland in the lower Annan and Moffat Water valleys. It is worth noting that the dominance of native woodland will increase as existing woodland planting/regeneration schemes mature. This is arguably already the case in Carrifran where native woodland planting has transformed this valley over the past 23 years (see Photos 13 & 14)[48].

Overall visual impact from all human features was assessed as part of the NatureScot wild land area Phase 1 mapping. Figure 24 shows the absence of modern human artefacts attribute that models the visual impact from all modern human features (roads, railways, buildings, pylons, masts, wind turbines, and other structures) across the landscape. The enclosed nature of the deeply incised upland valleys 'protects' these areas from visibility of most human features. Of note in this regard are Loch Skeen and the Midlaw Burn, Winterhope Burn, upper Gameshope, Fingland, Hawkshaw, Kirkstead and Glengaber valleys where surround steep hillsides block the view from most or all human artefacts. It is worth noting that while plantation forestry was included in this visual impact assessment in development work for these methods[49], it was subsequently removed from the analysis by NatureScot (then SNH) and so is not included in the patterns shown in Figure 24.

6.2 Participatory mapping

The participatory mapping workshops have revealed some interesting patterns as shown in Table 2. Participants in the mapping workshops expressed varied responses to the geographical and contextual questions posed. Robust discussion between participants reached some agreement on a number of common concerns and hopes for the future of the area.

Figures 26-28 show the overlap between the group responses to the other questions asked in the workshop. These figures show those areas most marked as being the wildest, those areas deemed best for new planting of native tree species, and which areas should remain agricultural land or commercial forestry. One of the most common responses to the questions was a general desire for better accessibility through both improved quality and quantity of footpath provision throughout the Talla-Hartfell area, especially around the Lochs and connecting smaller settlements. Figure 27 shows the most marked routes, with thicker lines indicating routes which were most common throughout the mapping workshop.

There was general agreement that existing routes like the Southern Upland Way and the path from Fruid to Moffat via Crown of Scotland need better protection and improvement. Desired new routes include a path on the west side of A701 from Tweedsmuir to Broughton Crook with a series of connections within existing forestry and windfarm tracks for circular routes and multiuse (foot, cycle, horse) paths. There is a general need to maintain access to various places, including Logar, Oliver Castle, Hawkshaw Castle, Crown of Scotland, Talla railway, Gameshope Castle (church and graveyard), standing stones, Postman's monument, Crook Inn, and riverside areas. The paths to and around Crown of Scotland, Silver Jubilee, and Polmood need protection and maintenance.

In terms of forestry, there was a general agreement over the broader and further need to reintroduce native trees and re-establish native woodland across the Talla-Hartfell Wildland Project area, with a desire to see breaks in commercial forestry to establish native woodland, improve aesthetics, biodiversity, and opportunity for wildlife. There was a stated need to ensure that planted trees survive and become adult trees (although some mortality is to be expected).

[48] https://bordersforesttrust.org/wild-heart/carrifran-wildwood/carrifran-photo-gallery/annual-change

[49] Carver, S., Comber, A., McMorran, R. and Nutter, S., 2012. A GIS model for mapping spatial patterns and distribution of wild land in Scotland. Landscape and urban planning, 104(3-4), pp.395-409.

Some participants expressed a desire to avoid planting in grassland and heath to preserve carbon sequestration, while preserving flatter areas (particularly in valley bottoms) for agriculture and productive land for sheep farming. Some people stated a preference for avoiding obscuring views with tree planting and to replace dense commercial forestry plantings with better spacing and more open native woodland. Areas for native planting include St. Mary's Loch as well as along burns and valleys. There was a general dislike among some participants for commercial forestry and a desire to reduce it on less steep areas, leaving it open for sheep farming.

As regards wildness, there was general for support native woodland since this feels wilder than plantation forestry, but also support for open upland areas as these also have a distinctive wild feel about them. Many participants felt that the wild land area needs further protection against planting on better hill ground. Paths are needed for accessibility to the wilder parts of the area, and focus should be given to walking and Southern Upland Way. Several participants suggested that wildness does not preclude livestock production, indicating continued support for hill farming in the area.

Other themes that were raised included concern that commercial forestry is displacing traditional agriculture, and there are no local timber processing facilities or walking access into planted areas. Some participants suggested the need to develop a higher carbon code and generate revenue to sustain rural populations and enable new projects.

Table 2. Summary of workshop participants' comments

Category	Comments
Wildness	Native woodland feels wild. Upland Hill areas are wild. Wildland areas need further protection against planting on better hill ground. Paths are needed for accessibility, and a focus should be given to walking and Southern Upland Way. Wildness does not preclude livestock production.
Paths	Existing routes like Southern Upland Way need improvement. Historical routes, the Thief's Road and Captain's Path should be protected/improved. Desired routes include a path on the west side of A701 from Tweedsmuir to Broughton Crook. Connections within existing forestry and windfarms for circular routes, multiuse paths. Path from Fruid to Moffat via Crown of Scotland needs protection and access improvement. Need to maintain access to various places, including Logar, Oliver Castle, Hawshaw Castle, Crown of Scotland, Talla railway, Gameshope Castle, church and graveyard, standing stones, Postman's monument, Crook Inn, and riverside areas. Crown of Scotland, Silver Jubilee, and Polmood need protection and maintenance.
Tree Planting	Need to reintroduce native trees and establish native woodland. Breaks in forestry to establish native woodland, improve aesthetics, bio-diversity, and wildlife. Need to ensure that planted trees survive and become adult trees. Avoid planting in grassland and heath to preserve carbon sequestration. Preserve flat areas for agriculture and productive land for sheep farming. Avoid obscured views and replace commercial forestry with better spacing and woodland. Areas for native planting include St Mary's Loch and burns/valleys. Dislike for commercial forestry and a desire to reduce it on less steep areas, leaving it for sheep farming.
Other	Agroforestry is displacing traditional agriculture, and there are no processing facilities or walking access. Need to develop a higher carbon code and generate revenue to sustain rural populations and enable new projects.

7. Conclusions and recommendations

This report recognises NCA as the process of quantifying the value of natural resources and ecosystems in largely monetary terms. As such it is a framework used to evaluate the benefits that ecosystems provide to humans, such as clean water, air, and soil, as well as the value of natural resources, such as timber, fish, and minerals. While natural capital assessment can provide valuable insights into the economic value of nature and the environment, some critical aspects are worth considering.

Firstly, the process of quantifying the value of natural resources and ecosystems in monetary terms is complex and can be subjective. Assigning a monetary value to natural capital requires several assumptions, such as how much people are willing to pay for ecosystem services, and how much it would cost to replace the services provided by nature with human-made technologies. These assumptions can vary widely and can lead to different valuations of the same natural resource or ecosystem.

Secondly, natural capital assessment can be criticized for promoting the commodification of nature. Assigning a monetary value to nature can make it appear as if nature is only valuable if it has a price tag attached to it. This can undermine efforts to protect nature for its intrinsic value such as protecting scenic landscapes and biodiversity. Furthermore, the concept of natural capital can be used to justify further exploitation of natural resources, if the economic benefits are deemed to outweigh the costs.

Natural capital assessment can also overlook the social and cultural values of nature. Ecosystems provide a range of benefits to people beyond their economic value, including cultural and spiritual values, aesthetic benefits, and recreational opportunities. These non-economic values are often not considered in natural capital assessment, which can result in a limited understanding of the full value of nature. This has implications for how local people and communities view and value the natural capital of their local area and can lead to conflict and a sense of unease when benefactors from natural capital exploitation are largely external actors, such as is largely the case in terms of commercial forestry and renewable energy developments. This is especially the case when developments take place at the expense of traditional land use, as with commercial forestry displacing upland sheep farms, or landscape quality as is the case with large-scale wind energy developments.

This report outlines work undertaken to provide a desk-based Natural Capital Assessment (NCA) utilising spatial data and GIS mapping backed up and supported by participatory workshops with local people. The NCA focuses on five key areas of relevance to the Talla-Hartfell Wildland Project: wildness, access, woodland opportunity, ecological connectivity and landscape character. Maps and analyses are provided for each of these five thematic areas. These stress the geographical variations in the patterns of these five key landscape qualities rather than attempt a monetary valuation. These are further supplemented by maps and commentary from two participatory mapping workshops as a means of 'grounding' the analyses with local knowledge and critical opinion.

The general findings reported here can be seen as reinforcing the NatureScot wild land assessment showing distinctive patterns in wildness across the Talla-Hartfell Wildland Project area that are driven by landscape characteristics of topography, land use, access, and visual impacts. A number of potential threats to wildness and landscape quality are identified including the expansion of commercial forestry operations and land acquisition, conflicts with sheep grazing, and renewable energy developments (particularly large-scale wind). These need to be balanced against opportunities in the area for continued native woodland planting and regeneration with associated benefits for landscape quality, recreation, biodiversity, other non-monetary ecosystem service values. It is interesting that while the threats are largely driven by external commercial interests extracting monetary value from the landscape, the opportunities are largely local and non-monetary in nature, providing wider benefits to local communities and visitors through enhancements to landscape quality and non-extractive ecosystem services (i.e. supporting, regulating and cultural).

These observations are born out through the results of the participatory mapping workshops which suggest that local people want more from their landscape than just timber and renewable energy. There were strong representations at these workshops for better paths and walking routes, more native woodland, a slowdown of commercial forestry (especially where it is seen as taking over hill farms as the only viable economic alternative), and appreciation of wildness which doesn't necessarily preclude sheep farming. A recurring theme in these workshops was that local people see commercial forestry simply as resource extraction with other people profiting.

The report makes the following recommendations:

- Further development and utilisation of woodland opportunity mapping and ecological connectivity models to better target woodland planting and ensure resilient networks benefitting biodiversity and ecosystem services.
- Better provision of access paths and routes within and across the Talla-Hartfell Wildland Project area for people to enjoy (and therefore value) the area.
- Careful monitoring and control of commercial forestry operations to protect wild land qualities/character.
- Development of a consultation with local landowners to explore a range of economically viable and ecologically sustainable long-term land use options, beyond just selling the land to external investors.
- Sensitive planning/siting of new renewable generating capacity.
- Expanding the approach/process of wild land NCA mapping and participation across other wild land areas in Scotland, creating network of local community groups able to share experiences, values, and sustain ongoing monitoring of threats and opportunities.
- Identifying opportunities for responsible investment in natural capital to deliver wider benefits and opportunities for improved community benefits.

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Appendices

Appendix 1. Transcription of all workshop participants' comments

Paths:
Existing routes - Southern Upland Way.
Round St. Marys Loch. Peebles Blackhouse, needs improvement at top of Blackhouse to join Thieves Road. Silver Jubilee Rd. Broadlaw to Stanhope.
DESIRED Route west side of A701 from Tweedsmuir Broughton Crook - west side to -> Crossroads, Tweedsmuir.
Connections within existing forestry + windfarms, circular routes. Multiuse paths.
Path Fruid to Moffat via Crown of Scotland protected and access improved.
Great to have a path up Ettrick and yarrow valley.
Paths round Moffat.
Alongside roads from Ettrickbridge up/westward.
Gordon arms towards yarrow/Selkirk.
Disability access to forest tracks.
Captain's Path – Look at accessibility.
The pilgrims path ancient footpath in Cartershope Glen carted the wool to market. (Maybe some of this info is accurate.
Path called the pilgrims way – runs along Fruid reservoir going towards the Devil's Beef Tub steeped in history, would be good to reinstate this.
Historical interest covenanters hid here and had secret meetings/services.
Logar, Oliver castle, Hawshaw castle, Crown of Scotland, Talla railway, Gameshope castle, Church + graveyard, Standing stones, Path to Grey Mare's Tail, Postman's monument, Crook Inn.
Riverside areas should be outside planting plans to maintain for agriculture, etc.
Crown of Scotland needs protection.
Xa visual – need to protect unique view (see route Fruid to Moffat).
Silver Jubilee – to protect and maintain.
Polmood – regenerated area.
Grey Mare's Tail.
DESIRABLE nature area west of A701.
Stanhope Glen.
Connections across landscape eg. between reservoirs - along Megget Water to St Mary's Loch.
Courses. Gameshope.
Paths need adequate width to be maintained as plants/trees grow.
Windfarm access improved.
Feel welcomed.
Quality paths.
Signage – routes stopes.
Wooden posts waymarkers QR codes.
Positive messaging.
Circular routes and paths.
Require associated infrastructure – toilets – car parks.
Linking routes to the destination tweed walk / path so extra bits needed for extensions / other walks
Safe walk to the crook from village.

Commercial access.
Newer woodlands are more accessible with self-closing gates.
Styles over deer fencing is very challenging (older forestry).
Keeping access signs current and changing.
Multiuse paths Horses bikes etc.
Diversion signs.
Using up to date access routes.
Deer stalking lists.
Linking to Annandale Way.
Linking to Southern Upland Way.
Route from Meggat to manor.
Right of servitude.
Path at Patervan.
Thieves Road – Drummelier back of Stanhope down to Glenrath.
Potential drove road from Mosstennan to Biggar .
Moffat at the back of Tweedshaws Ealshaw .
Some paths but want to leave lots of the walks natural / wild walks.

Native woodland:
Breaks in forestry to establish native woodland - improve aesthetic, biodiversity, wildlife.
Planting vs regeneration - may not be practical, depending upon existing land use.
Reintroduce native trees/woodland.
Need to ensure that planted trees survive - significant % of loss - don't become adult trees.
Enough but not the right kind- No oak.
Areas not suitable for sheep.
Valleys/ Sykes.
Plant up Syke's.
No economic benefit, wildlife benefit.
Flooding caused by plantation.
Avoid obscured views.
Replace commercial forestry.
Second time is done better.
Increase Spacing.
Increase Woodland.
Favour native woodland with both planting and natural regeneration.
Increase in woodland throughout Ettrick and & yarrow valley to benefit wildlife especially salmon population.
Help flood prevention.
Fenced off to protect from deer and wildlife.
Tree guards removed when no longer needed.
Retain best agricultural land for arable/ grazing.
Include specified areas of imported grassland for livestock to move to in winter/spring.
Planting preferred over natural regen due to high deer levels deer fencing will be required.
Potential for agroforestry to be examined.
Agrofrestry is displacing traditional agriculture in this community. no employment in forestry.
No processing facilities - saw mills We just have huge lomies + ferced in monoculture forests. - so no walking access either.

It is felt with in our communities that these areas are being used as the place to place all these monocultures.
We are so few in number (small community) that our voices are few in opposition.
Keenness to connect already planted native woodland.
Breadlaw hill has very much a tundra environment which should be kept. (arctic hares).
We all felt that we need more native trees and connection up, making corridors is the best way forwards leaving the bare hill tops.
Ettrick side we feel is much more commercially planted so not much opportunity for native planting Ettrick community with know more about this.
Any planting would need to be deer fenced.
Chat about lynx: 1 person keen, 1 person not unkeen but felt that the habitat needed to be there for the lynx first which hopefully would create less problems for farmers and livestock.
Do other countries that have lynx and wolves have these problems?
Stanhope & Broadlaw are remote however they are managed (grouse shooting etc) is this wild we don't really think.
Wild places in terms of used by used by wildlife are the steep gulley's in between the commercial planting. fungi etc Could these steep gullies be planted with trees?
Is sort of wild has sheep though.
Broadlaw SSSI – no change to current land use.
Planting native woodland along the edge of A701 – previously commercial forestry to the road – now planting must be further back – specified distance.

Wildland:
A Cultural Centre possibly approved around St Mary's Loch, mural skills, dykeing, possible repurposed they're closing down I of the 3 in Eey.
Native planting around 3 Laws & burns/river.
Money has to be available if further protection is required.
Farms have to be valued for forestry not agriculture.
An annual payment to rewild, just leave it alone.
Track over to Bodesbeck could be by key entry.
Maintain old Rights of way sheep trods.
SUP, cycling mountain bikes routes, solar charging stations?
Concentrate on walking. Southern Upland Way Interconnected forestry roads, WELL MARKED & checked.
Wild land areas: Should it be a national park?
Moorland, windswept, heather.
Trees / valleys where trees have survived /avoided heavy grazing, chemical sprays, poaching.
Not moorland because it's burned regularly & grazed heavily managed for game birds.
Groups of Some small copses trees left.
Wildness by this definition does not preclude livestock production.
Wild Definition: Can't hear traffic, Remote feeling, Reduced infrastructure, takes an effort to get there, feels natural, Don't meet other people / feeling of isolation, and feels "unmanaged".

Agriculture:
Continue to be good agricultural land- ground falling to Moffat, low lying ground that doesn't flood.
History of the valleys- Authors James Hogg, Sir Walter Scott, Robert Burns.
Archaeology has to be proved not just re: historical fairy tales which sterilise development on ground.

To reduce commercial forestry on less steep areas, leave for sheep farming, with protection against planting on better hill ground. Should not have more commercial forest.
Preserve flat areas for agriculture.
Productive land sheep farming.
Grassland and heath should be preserved for carbon sequestration.
There needs to be a higher carbon code developed in line with the woodland carbon code.
This should be an important source of needed revenue which would sustain the rural population enabling new projects.
Windfarms are also beginning to monopolise.
Farms for sale generate more income Sale wise for forestry than anything else where the government subsidies are that's the way things will go.
Government policy needs changing.
We still use for agriculture.
Sheep farms all go – people all go.
Forestry employment is within wider area, doesn't impact local communities.
Generally do not bring families.
Change of farm accommodation now being used as holiday lets / air bnb lots of potential residential space no longer available.