MOUNTAIN WOODLAND ACTION GROUP

Scrubbers' Bulletin 16

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The Bulletin of the Mountain Woodland Action Group,
a partnership of individuals supported by their organisations

Earlier issues of the Bulletin, along with other publications related to montane scrub and treelines can be found at www.msag.org.uk .

CONTENTS

As the cover shows, from tiny seeds new willows can grow and this issue of the Scrubbers' is packed with information about new research, data sources and, most optimistically, on the ground restoration projects and a recent willow-specific moth re-find.

We are very grateful to the authors for their articles, which remain their property as do the opinions and views presented.

Cover photo: Montane Willow planting at Corrour by Sarah H Watts

MWAG Scrubbers' Bulletin 2024 –Chair's Report by Sarah H. Watts

I'm delighted to showcase what a busy and productive 18 months it has been for the group since our last edition of Scrubbers' in spring 2023. We've seen restored mountain woodland continue to thrive, exciting new projects on the horizon, burgeoning research, and growing enthusiasm for the topic from policy makers, funding bodies, the media, and the wider public. It takes time and commitment to capitalise on such interest and potential (particularly when slow-growing montane plants are involved!), and I am hugely grateful for everyone contributing to our collaborative community striving to foster the conservation and revival of trees and shrubs in our mountains.

The Botanical Society of Britain and Ireland (BSBI) launched their Plant Atlas 2020 in March 2023; a monumental 20-year research project documenting changes in the British and Irish flora since the 1950s. The summary of the main findings of this survey highlights climate change and overgrazing as threats to mountain habitats and causes of declines in associated plant populations, with particular mention of montane willows. I was fortunate to be invited to the BSBI's Plant Atlas reception at the Scottish Parliament to champion the cause for protecting and enhancing mountain woodlands and scrub, for the benefit of people and wildlife.

Sarah at the BSBI Plant Atlas 2020 Scottish Parliament reception

Fortunately, this need has been recognised in recent national policy documents. Upland woodland and scrub is listed as a Key Botanical Asset for Conservation in Scotland in NatureScot's plan for Building a Plant Biodiversity Strategy for Scotland. Upland scrub also features in the Scottish Government's plan for "Tackling the Nature Emergency - Scottish biodiversity strategy to 2045" as a key habitat with a requirement for improved condition, extent, connectivity, and monitoring to sustain large-scale nature restoration.

The National Trust for Scotland has included montane willow scrub in their new Plan for Nature as one of six priority habitats for which the Trust feels it has special responsibility for, and a particular ability to make a positive impact. Pioneering habitat restoration and genetic rescue will continue at NTS flagship sites Ben Lawers and Mar Lodge, with feasibility studies in development to establish new populations in Glencoe and West Affric. Within other organisations, with representation on the MWAG, mountain woodland recovery carries on apace by the Borders Forest Trust, RSPB at Loch A'an, Trees for Life at West Affric, and at my own workplace on Corrour Estate. These actions are covered by the updated mapping data of relict and restored mountain woodland locations commissioned by NatureScot and detailed in my article on page 22.

We have also witnessed a budding public and media awareness of the plight of montane trees in Scotland through citizen science using the BSBI's data on altitudinal records, and the hashtag #HighMountainTrees on social media. My recent article in The Conversation highlights the role of biological recording for expanding knowledge of the environmental tolerances of plants, and the capacity for mountain woodland to flourish more widely while concurrently fighting the climate crisis.

Similarly, citizen science has been aiding Reforesting Scotland's Mountain Birch Project (with funding from Mossy Earth) aiming to reinstate mountain birch woodland in Scotland via population mapping, seed collecting, propagation and outreach. In conjunction with this innovative new initiative, a subgroup of us from the MWAG have formed the Mountain Birch Group (MBG), which comprises stakeholders with interest, knowledge, and experience of high-altitude birch, including conservation organisations, ecologists, plant scientists, geneticists, land managers, and tree growers. The MBG's purpose is to improve the understanding and conservation status of high-altitude birch and birchwoods in Scotland which are typically found above circa 600m. Key objectives including supporting survey and monitoring, conducting and disseminating research, and facilitating habitat restoration in appropriate places – read more about our first meeting on page 15.

The acquisition of Glen Prosen by Forestry and Land Scotland gives scope for mountain woodland and scrub to make a comeback on a former grouse moor in the Angus Glens. This site

MWAG members exploring the crags at Glen Prosen

hosted the MWAG's summer fieldtrip in 2024 and provided the opportunity for discussions on grazing management, habitat expansion from cliff ledge refugia, and the importance of tall herbs and open habitats that complement woodland within the altitudinal treeline mosaic.

Excitingly, there is increasing interest and engagement with the MWAG from private estates wishing to focus on ecological recovery in the uplands, including Dalnacardoch (bought privately and leased to Durrell Wildlife Conservation Trust), Glen Lochay (the location of our 2023 fieldtrip), and Glen Nevis. Such sites are a vital complement to the ongoing work of conservation charities and environmental NGOs in delivering mountain woodland restoration on landscape and national scales. Our suite of Best Practice Guides continues to be an invaluable resource for those seeking to embark on new projects, including information on site selection, land management, collection of seed and cuttings, and protection from grazing.

However, now is not the time to rest on our laurels. To ensure wider project uptake, connectivity, and restoration of the treeline across Scotland, there must be further support through national

Glen Lochay montane woodland

policy and funding to meet the needs of practitioners For example, mountain woodland is suita-

ble for integration within Scotland's 30 by 30 and Nature Networks frameworks, and there is a strong case for longer-term funding beyond current schemes such as the Nature Restoration Fund. A recent consultation on the Forestry Grant Scheme offered a chance to advocate for a more specific mountain woodland grant, including assistance with surveys, grazing management, monitoring, propagation and regeneration. The unique array of interconnected treeline habitat types and montane scrub mosaics may not fit neatly into a grant scheme or policy "box"; but rather than being a problem, this attribute should be one to celebrate as a vibrant and enriching feature of upland biodiversity.

As the planting of high-altitude provenance trees becomes more attractive and popular, it is critically important that we upscale their production to ensure a sufficient and ready supply to meet rising demand. A worthwhile follow-up GIS-based exercise would be the mapping of seed stands and tree nursery networks to identify sources of propagation material and gaps in the geographical range of planting stock. The ongoing seed collecting work of Trees for Life, Elsoms Trees and the Woodland Trust is proving instrumental to cultivating the montane trees and shrubs of the future. Furthermore, tree nurseries present a wonderful avenue for people to forge a special bond with mountain woodland. Cairngorms Connect are demonstrating just how profound this social link can be, as revealed on page 18. And in my own work and research, I am learning more and more that people, and our connections with each other, should be at the heart of nature recovery; through enhancing rural employment, volunteering, collaboration, knowledge exchange, inspiration, and positive interactions.

In November 2023 I was honoured to receive a Highly Commended in the Nature of Scotland Awards (see photo below) for my ongoing PhD research "Restoring Scotland's Mountain Woodlands". This achievement would not have been possible without the encouragement and guidance of the MWAG, and my colleagues at the University of Stirling and Corrour. I am eternally thankful for our longstanding members who continue to sit on the group and offer advice to mid and early career practitioners and researchers such as myself. It is also fantastic to welcome our new members and have input from talented students and young ecologists who will ensure that specialist knowledge and enthusiasm for mountain woodland continues in the decades to come. With that in mind, 2026 will be the 30th Anniversary of the MWAG and the group will be collecting ideas on how to celebrate all our wonderful progress so far; to be continued anon…!

***SARAH WATTS**, while in the final stages of completing her PhD, is employed as the Conservation Manager by the Corrour Estate and is the current Chair of the Mountain Woodland Action Group.*

Montane scrub woodlands in Eryri by Tristan Schroeder

A view from Snowdonia

Treeline ecotones, situated between the timberline and tree species line, are crucial transitional zones that provide high structural complexity and contribute to ecosystem function and biodiversity.

Globally, these areas can be degraded and face an uncertain future due to climatic changes. In Scotland, it is generally regarded that the treeline should consist of a diverse and structurally complex montane scrubland habitat that is found across Norway, Iceland, Greenland and elsewhere in the circumboreal zone. Studies of sediments in Wales also suggests that high altitude woodland scrub once existed, after the last glaciation, before anthropogenic activities increased. However, in the UK, the natural altitudinal treeline is highly fragmented due to historical land management of upland areas.

In 2023 the author undertook a study to fill the gap in knowledge regarding Eryri's (Snowdonia's) treeline ecotone, by collecting evidence on its current distribution and composition, to aid arctic alpine and tall herb plant and invertebrate restoration efforts. Data were collected through the Botanical Society of Britain and Ireland (BSBI) database as well as an online questionnaire. These data indicate that a more intact transitional boundary made up of trees and shrubs should exist below montane heathland habitats in Eryri.

The aim of the author's research was to understand whether high altitude trees and fragments of the missing treeline / scrub ecotone in Eryri still exist despite anthropogenic and climatic influence. It also set out to understand the composition of these communities in a Welsh context, to inform restoration initiatives.

Montane scrub woodland

Treeline ecotones and montane scrub woodland are important ecologically. They have far-reaching influence through their interactions with biotic and abiotic environmental factors. They represent a 'mosaic' habitat with high biodiversity due to their variability in structure and ecological niches[5]. Invertebrate diversity is known to be high within treelines, particularly for montane shrubs like willow (*Salix*) species, juniper (*Juniperus*) species, and Dwarf Birch *Betula nana*. The diversity of endemic ectomycorrhizal fungi has also been found to be high in the montane woodlands of Scotland. Diverse foraging opportunities are beneficial for small mammals, which support the wider ecosystem. Mountain scrub woodland also supports Ring Ouzel *Turdus torquatus* amongst many other bird species.

Most notably, mountain woodland habitat and willow scrub can provide protection against extreme weather for understorey tall herb and alpine plant communities, which would otherwise be exposed in higher environments. Montane treelines also play an important hydrological role, as the presence of trees and shrubs at high altitudes allow for greater stabilisation of steep slopes and increases in soil depth. Water absorption and retention, as well as control of evapotranspiration by the tree canopy, can help reduce surface runoff and increase drought resilience.

Unfortunately, montane woodlands across the globe are often degraded due to deforestation, over-grazing, climate change and nutrient loading[5]. Many treelines in Europe today are in fact 'anthropogenic treelines' which have been lowered from their original altitudinal range by human disturbance.

Wales' natural treeline in the past

The treeline in Wales once reached altitudes of 700-800m, migrating to these altitudes between 10,000 and 5,000 years ago. In Eryri, evidence from pollen cores shows woodland habitats fluctuated in composition in the uplands after the last glacial period, with species such as birches *Betula* spp., Alder *Alnus glutinosa*, Hazel *Corylus avellana*, limes *Tilia* spp., oaks *Quercus* spp.,

willows and many more extending their ranges into the uplands and eventually forming montane scrub at higher altitudes[3]. Juniper was an important facilitator of plant colonisation at this time, including at higher altitudes. Today, this high-altitude shrub is restricted to upland sites[3].

The gradual demise of Eryri's woodland treeline after this period is attributed to increased anthropogenic deforestation for timber and livestock grazing[3]. Evidence of burning, clearing, and grazing between 400-600m in Wales has also been found. This is consistent with the rest of the UK, where evidence of human interference is clear, even at high altitudes.

Coinciding with the beginning of the neolithic period was the sub-boreal period (5,000 years BP [Before Present]) where dryness increased significantly and heathland communities at higher altitudes expanded[3]. This suggests that climatic changes may also have been an important factor in the demise of mountain woodlands in Eryri[3].

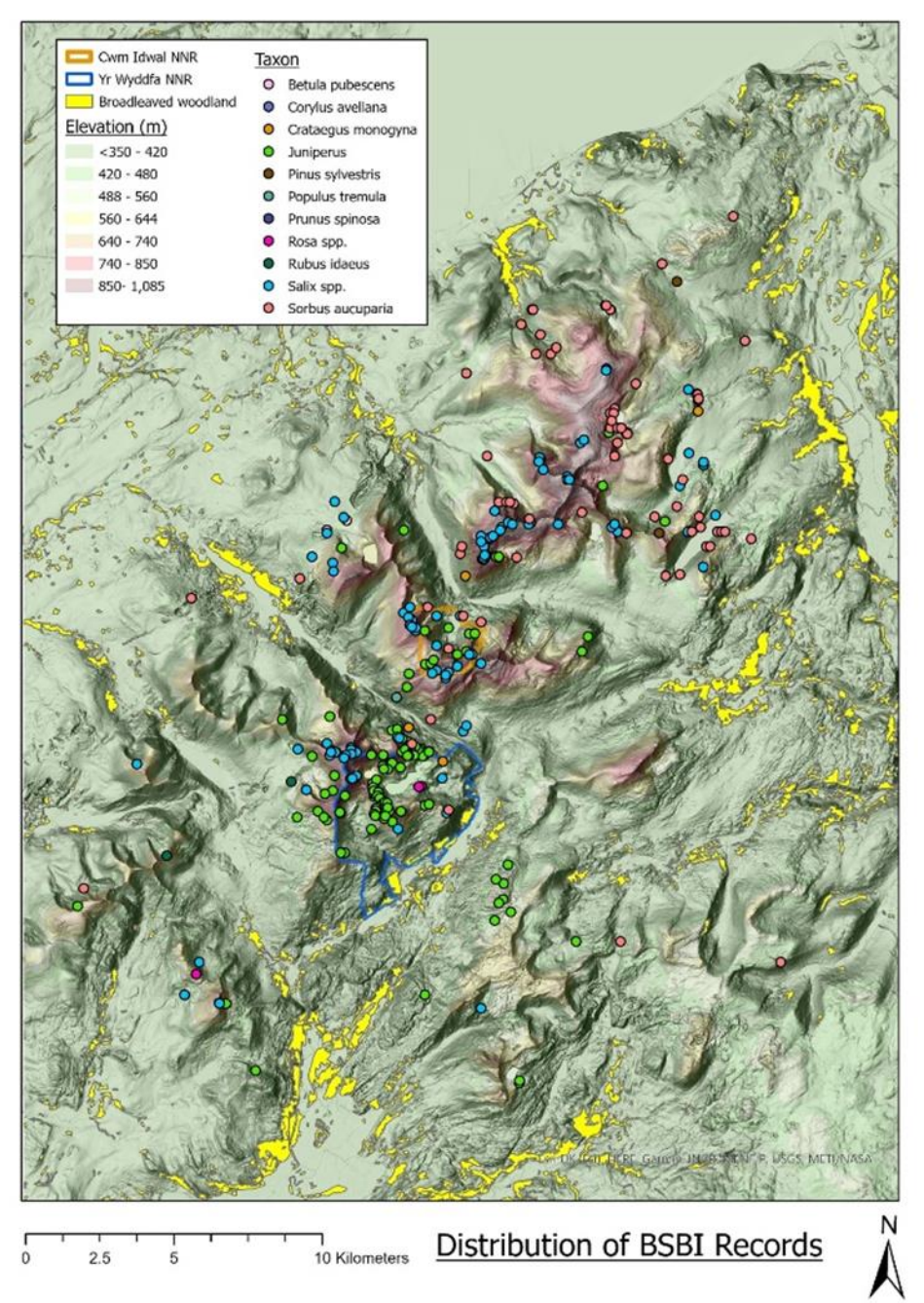
The current state of Eryri's treeline

There has been no extensive research into Eryri's current treeline distribution, although it is known that various forms of woodland scrub vegetation including various willows, Rowan *Sorbus aucuparia*, Hawthorn *Crataegus monogyna*, roses *Rosa* spp., and Raspberry *Rubus idaeus*, do occur at higher altitudes especially in areas out of reach from herbivores[4]. Several studies on Eryri's montane heathland communities exist; these communities grow at altitudes beyond the tree species line particularly on the Carneddau. Current knowledge on species typical of treelines and scrub communities existing at high altitudes elsewhere in Eryri, and the location, density, and extent of these, is limited. Beginning to fill this gap in knowledge may have important implications for the future of the restoration of this habitat, and the ecosystem services it can provide in Wales.

Montane trees survive at Eryri where they have escaped deforestation and grazing pressure

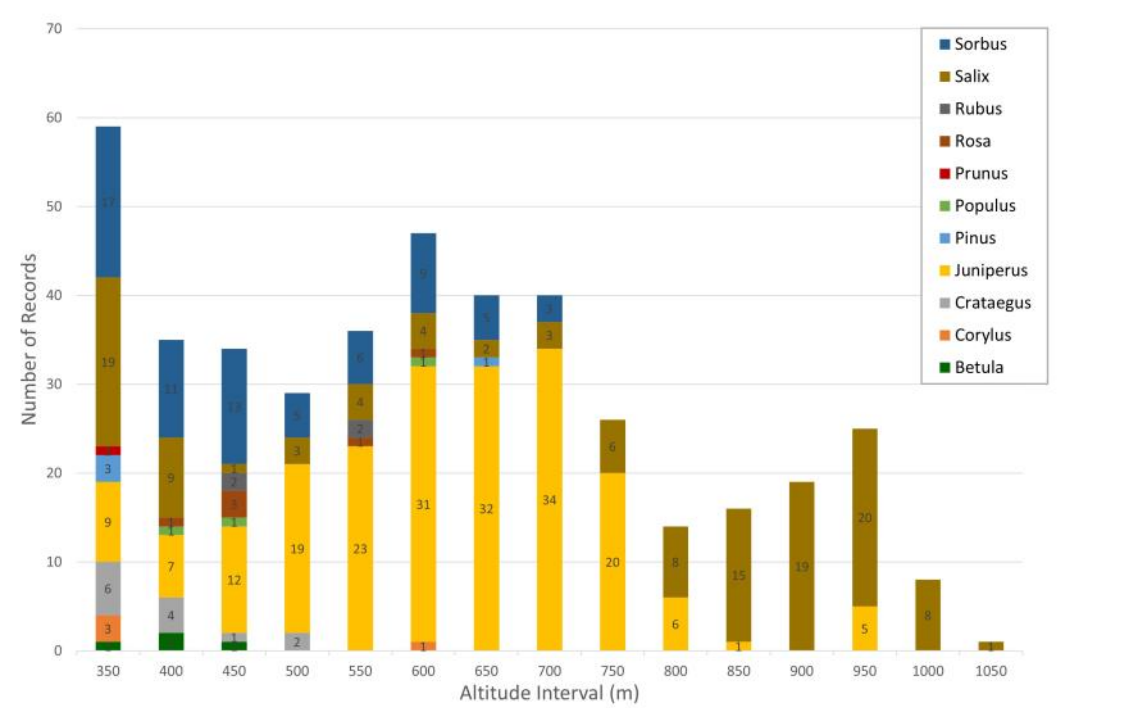
From analysis of data held by the BSBI it was found that the Glyderau, Carneddau and Yr Wyddfa mountain ranges in Eryri are hosts to many tree and shrub species at high altitudes. Most abundant were Dwarf Juniper *Juniperus communis* subsp. *nana*, and Dwarf Willow *Salix herbacea*, species that also form part of the montane heathland and have consequently been recorded extensively. Juniper *Juniperus communis'* average altitude seems consistent with historical evidence in Eryri, which suggested it to be a pioneer of open ground and capable of growing at high altitudes. Most of the juniper records are Dwarf Juniper, which forms part of montane heathland in Wales as well as other high-altitude areas in Scotland, England, and Norway[1,2]. The data also contained 43 records of *Juniperus communis*, which may also include the nominate subspecies, Common Juniper *J. communis* subsp. *communis*, which is indicative of Britain's natural treeline. Juniper was found to be the most abundant recorded tree species

between 500-750 metres in altitude. Dwarf Willow was the most abundant willow, and the second most abundant species. This species had the highest average altitude of any, and is also associated with montane heathland communities. Its mean altitudinal distribution may represent the approximate upper limit of the treeline ecotone, where the species line crosses into a sub-alpine habitat near 950 metres above sea level. Dwarf Willow was found to have a significantly different mean altitude when compared to other tree species.



Common Sallow *Salix cinerea* was the second most abundant willow, growing up to 550m. This, along with limited records of Creeping Willow *Salix repens*, Eared Willow *Salix aurita* and Goat Willow *Salix caprea*, is more typically associated with montane woodland or montane willow scrub habitats than heath, especially in Scotland. Dwarf Willow's presence at altitudes of 500-750m suggests it inhabits montane scrubland as well as montane heathland. Although Eryri lacks the rarer willows found in Scotland, such as Downy Willow *Salix lapponum* or Woolly Willow *Salix lanata*, the other species growing up to 550m would most likely form a mosaic treeline habitat if they were more widespread. They are significant, as they are rare in upland areas due to their palatability to herbivores.

The dataset evidence showed tree species like Hazel, birches, Hawthorn, Scots Pine *Pinus sylvestris*, Rowan and Aspen *Populus tremula* grow up to 600m or above, consistent with historical pollen records[3] and Scottish and Norwegian treeline habitats[1]. Raspberry and rose species also grow at 479-571m. From this, it can be suggested that we should have some form of biodiverse treeline habitat at higher altitudes in Eryri as a transitional zone between the timberline and tree species line, above which montane heathland occurs. This zone would likely include tree and shrub species such as Rowan, Hawthorn, birches, junipers, the four species of willows, Hazel, Raspberry, roses, Aspen and Scots Pine, as well as members of the hydrophilous tall herb community and a number of arctic alpine species currently only found on inaccessible ledges due to their sensitivity to grazing. At higher altitudes, the research found lower species richness, which further supports the treeline transitioning from high numbers of scrub and woodland species to fewer as altitude increases.



Bar graph showing species composition across altitude intervals of 50m. A noticeable decrease in species-richness with altitude is clearly visible.

In addition to the use of BSBI data a questionnaire was sent out to a range of organisations and individuals with knowledge of the montane environment in Eryri. The questionnaire sought to collect data on any sightings of high-altitude trees and shrubs in Eryri, with description of location, grid reference, species, quantity of individual plants and a date of last sighting. The species list previously used for the BSBI search was provided to give guidance on which species may be of interest.

Responses to the questions provided additional high altitude species locations. Data were limited to a sample size of five; with fourteen separate sightings in total. Information regarding the number of individuals, identification of species and date of sighting was provided inconsistently by respondents. However, responses did confirm the presence of *S. herbacea* on the Carneddau and Glyderau ranges and they supported historical assumptions of Corylus, Sorbus, Crataegus and Betula growing at higher altitudes[3]. Large population estimates of Corylus and Sorbus at Twll Du, Cwm Idwal suggest missing data in the BSBI records. Sorbus sightings near Pen Llitrig y Wrach also align with the BSBI dataset, but additional Crataegus and Betula sightings were missing from BSBI data for this site. The questionnaire results suggest the BSBI dataset is limited and does not reflect the true distribution of high attitude tree species in Eryri. Low precision for more than half of the questionnaire results suggested the need for further

investigation of exact locations. Despite this, in addition to the BSBI data, the questionnaire results do give some framework for future surveillance.

From this study, it is clear that several 'krummholz' species can grow up to 700m in Eryri, alongside Juniper and Dwarf Willow, which then extend higher up into montane heathland habitats. However, comparisons with the questionnaire data and the small sample sizes of most species in the BSBI dataset suggested much information is likely missing. This identifies a gap in knowledge of 'krummholz' species in Eryri which, if filled, might bring us closer to a stronger understanding of how intact the upper treeline in Eryri is. It was clear from distribution data that most trees and shrubs were isolated and distant from any broadleaved woodland. It is evident that the treeline in Eryri is highly fragmented and far reduced from its historical distribution.

More recording effort for trees across the mountains of Eryri will enable a much stronger picture of this important woodland habitat to be presented. Deliberate surveying would support and validate subsequent habitat restoration through planting or fenced exclosure.

The results of this research hypothesise the potential composition of Eryri's treeline ecotone. The upper montane scrub woodland and treeline ecotone in Eryri would certainly be composed of species such as Rowan *Sorbus aucuparia*, Hawthorn *Crataegus monogyna*, Downy Birch *Betula pubescens*, Juniper *Juniperus communis* subsp. *nana*, five species of willows (*Salix cinerea, S. herbacea, S. repens, S. aurita and S. caprea*), Hazel *Corylus avellana*, Raspberry *Rubus idaea*, Roses (*Rosa canina* agg. and *Rosa spinosissima*), Aspen *Populus tremula* and Scots Pine *Pinus sylvestris*. There would also be a mosaic of hydrophilous tall herb species and several arctic alpine species making use of the microclimatic niches created by the woody species. This confirmation of composition may allow upland restoration projects to make more informed decisions, bringing Wales one step closer to recovering this important habitat.

TRISTAN SCHROEDER *is a climber and mountaineer with an interest in ecology and conservation. Tristan's research into Eryri's trees formed his Bangor University undergraduate research dissertation.*

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MSc dissertation summary: An investigation into the influence of montane willow scrub restoration on soil organic carbon content at Ben Lawers NNR.

by Beth Scott

One of the main benefits generally associated with woodland creation is the sequestration of atmospheric carbon (Scottish Forestry, 2019; Fletcher *et al*., 2012). However, when the impacts of tree establishment on belowground soil carbon stocks are considered, afforestation does not necessarily lead to overall net carbon sequestration (Morrison *et al*., 2010; Friggens *et al*., 2020).

Montane willow scrub (MWS) habitat is one of the rarest habitats in the UK (JNCC, 2023) and multiple projects are now focusing on its conservation and restoration. Ben Lawers National Nature Reserve (NNR) has been the location of pioneering mountain woodland restoration work since the late 1980's, with particular emphasis on the restoration of MWS. Between 1989 and 2010, three fenced enclosures, known as Compartment 1, Exclosure 3 and Exclosure 4 were constructed on the NNR and planted extensively with MWS. The condition of these planted MWS populations has been monitored regularly since 1998 (Griffith, 1998; Mardon 2000; Sporleder 2004; Rickerby 2010; Watts 2013), and today Ben Lawers NNR hosts the best examples of this habitat type in the UK (National Trust for Scotland, 2023).

While there are many known benefits to MWS restoration, there is still uncertainty surrounding the carbon sequestration potential of montane willow species, and the impact of planting them on soil carbon content is not yet fully understood (Watts & Jump, 2022). With Ben Lawers NNR as the study site, this project aimed to 1) evaluate the success of MWS restoration at Ben Lawers NNR, and 2) investigate the influence of the MWS species *Salix lapponum* (downy willow) restoration on soil organic carbon (SOC) content.

Figure 1. Restored *Salix lapponum* thriving at Ben Lawers NNR

1) Evaluating the success of MWS restoration at Ben Lawers.

Assessing the success of a habitat restoration project can be complex, as there are various indicators of success to consider based on the project's goals. These indicators may include the extent of the target feature, population size, feature connectivity, and the reproductive viability of the population, among others. For the purposes of this project, successful MWS restoration at Ben Lawers NNR was defined as a significant increase in the overall percentage coverage and

volume of willow shrubs between 2013 and 2023, drawing on Griffith's definition of success (Griffith, 1998).

The data required to evaluate the success of MWS restoration was collected while undertaking the repeat monitoring and site condition monitoring of the MWS at Ben Lawers. Following the established monitoring protocols (Shaw, 2008; Rickerby, 2010; Watts, 2013), each of the 39 previously established permanent monitoring willow plots were visited and surveyed in June of 2023. These plots were spread across the three fenced exclosures at Ben Lawers NNR and included all species of montane willows present at Ben Lawers. The data required to calculate the percentage coverage and volume of willow shrubs was then extracted from the extensive repeat monitoring dataset and analysed against the data collected in 2013 by Watts.

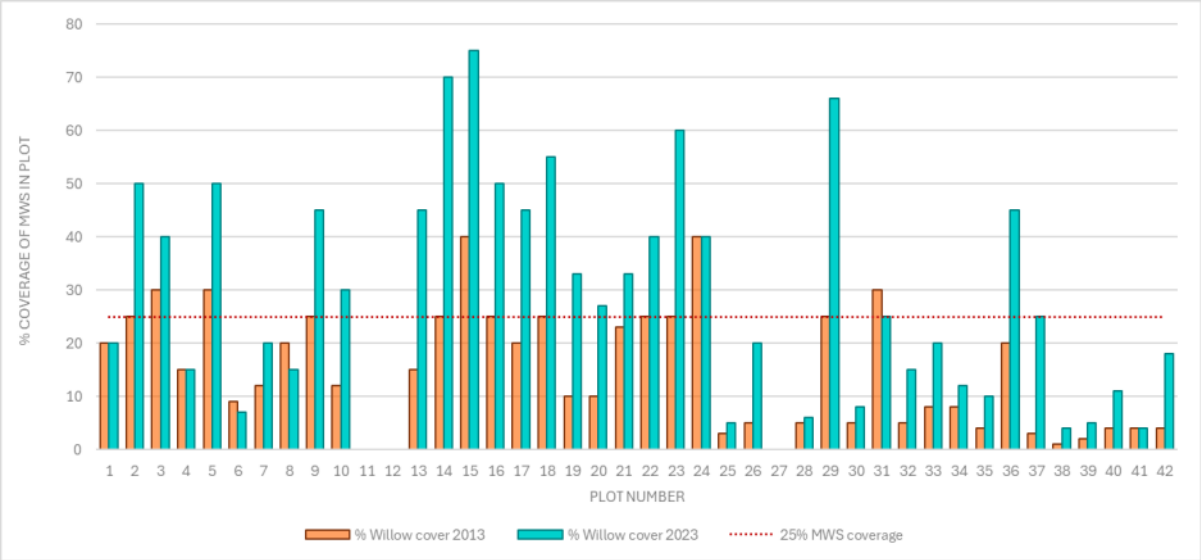

Figure 2. Graph the illustrating change in percentage coverage of MWS (of a mix of MWS species) in permanent repeat monitoring plots at Ben Lawers NNR between 2013 and 2023. These 42 plots are spread across all three fenced exclosures. The dotted line indicates 25% MWS coverage, one of the condition targets of site condition monitoring. Plots 11, 12 and 27 show no data as these are juniper plots which were not included in this study.

This study found that, at Ben Lawers NNR, both the percentage coverage of willow shrubs and the volume of individual willow plants had increased significantly between 2013 and 2023 across all three fenced exclosures planted with MWS. In 2023, 21 out of 39 permanent plots had at least 25% willow coverage, meeting this condition target of site condition monitoring. This was an increase of 8 plots from 2013 when only 13 out of 39 plots had at least 25% willow coverage, see Figure 2. Overall, the trends in willow shrub percentage coverage and volume indicate that the MWS restoration project at Ben Lawers continues to be successful.

2) Investigating the influence of Salix lapponum restoration on soil organic carbon (SOC) content

To assess the influence of the planting and establishment of the MWS species *Salix lapponum* on SOC content, soil samples were collected from 20 plots within areas with *S. lapponum* willow coverage and 20 plots in areas without willow coverage, all within the fenced exclosures. These soil samples were then taken to the lab where they were processed and soil organic carbon (SOC) content, soil moisture content, and soil bulk density were measured. Due to time constraints, *S. lapponum* was the only MWS species included in this aspect of this study.

As soil type is known to affect SOC development and the underlying soil type differs across Ben Lawers NNR (Soil Survey of Scotland Staff, 1981), the study design was stratified by soil type. Three soil types were considered, each located within a different fenced exclosure - peaty gley soils in Compartment 1, montane soils in Exclosure 3, and mineral podzols in Exclosure 4.

The presence of *S. lapponum* coverage resulted in a significant decrease in soil organic carbon content and soil moisture content of peaty gley soils, relative to areas with no willow coverage.

On mineral podzol soils, *S. lapponum* coverage resulted in a significant increase in soil bulk density, however no significant change in soil organic carbon content or soil moisture content was observed. *S. lapponum* coverage had no significant effect on montane soil, however more comprehensive sampling is required to verify this result. The relations between soil organic carbon, soil moisture and soil bulk density showed significant correlation across all soil types.

Peaty soils, such as peaty gley soils, can begin emitting carbon in the form of CO_2 into the atmosphere as they dry. This is due to soil decomposition and respiration rates increasing as soil moisture decreases and oxygen availability consequently increases. As soils emit more CO_2 into the atmosphere, the SOC content decreases (Natural Resources Wales, n.d.; Waddinton *et al*., 2010). The results of this study suggest that the MWS species *S. lapponum* may dry out the peaty gley soils as it establishes, leading to an increase in soil respiration, and consequently a decrease in SOC content as carbon was emitted to the atmosphere. Whether the amount of carbon released from the soil is more or less than the carbon taken in by *S. lapponum* in the form of above-ground biomass as it grows will require further research.

Figure 3. From scrambling around under willows out on the hill at Ben Lawers NNR to processing soil samples back in the lab at Bangor University.

This study's results highlight the ongoing success of the MWS restoration project at Ben Lawers NNR, and finds that, while MWS restoration presents many benefits (Scott, 2000; Watts & Jump, 2022), more research is required to determine how MWS restoration affects the ecosystem carbon balance and if it offers a means of carbon sequestration.

Detailed findings from the MWS repeat monitoring undertaken for this project will be recorded in a report for the NTS team at Ben Lawers, and full details of the soil analysis and results are currently available in a dissertation format.

BETH SCOTT *recently graduated from Bangor University where she studied an MSc in Environmental Forestry and completed her dissertation on montane willows, on which this article is based. She has a keen interest in ecology and native woodland restoration and is currently an Assistant Environment Forest Manager with Scottish Woodland.*

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An Unofficial Montane Birch Symposium, Mar Lodge, December 2023 by Andrew Painting

It is heartening, walking in the hills, to find substantial pockets of montane woodland returning to Scotland. Pine and juniper woodland is reaching its altitudinal limits once more in a great ring around the Cairngorms. Montane willow conservation has gone from strength to strength, building on deep roots put down in the last few decades, not least by members of the Mountain Woodland Action Group. Knowledge of montane woodland is growing, with altitudinal records for everything from grey willow *Salix cinerea* to Sitka spruce *Picea sitchensis* smashed in 2023. But what of birch? Is this a forgotten part of Scotland's montane woodland?

Downy birch *Betula pubescens* forms an extremely important and biodiverse element of montane woodland in Scandinavia, but even by the standards of Scotland's depauperate montane woodland stock, it appears to be particularly poorly represented in our high hills. Downy birch in the montane zone is a tricky customer: taxonomically and genetically complicated; morphologically all over the place; and, there's no getting around it, remarkably rare. New records are coming in every year, but the number of mature, seed-bearing birches above 600m altitude can be counted in the very low hundreds. Montane birch restoration appears to be stymied by a complicated array of factors which go beyond herbivore impacts. Previous attempts to plant the species in the uplands have had mixed results. It says something that it remains unclear to what extent a montane 'birch belt' was present in Scotland, though we do know for certain that in the past there was more birch in our mountains than is currently the case, and that our remaining high altitude birch stands are, essentially, endangered.

With interest in montane birch growing in Scotland, and an awareness that practitioners across Scotland are striking out on their own in its conservation, in December 2023 National Trust for Scotland's Shaila Rao convened an unofficial 'montane birch symposium' at Mar Lodge. This brought together expertise from across Scotland, with twenty individuals attending, representing fourteen organisations. This enthusiastic attendance is testament to the interest that currently swirls around montane birch. There was a hugely impressive amount of experience in the room, and the symposium proved to be a unique opportunity for attendees to learn from one another's experience with birch.

Isolated mountain birch at Mar Lodge (Sarah Watts)

The purpose of the meeting was to share knowledge about the species and its complicated taxonomy and genetic status; share information on what is currently being done for montane birch; better understand the 'official' NatureScot position on montane birch; and find a collaborative way forward to improve the fortunes of upland and montane birch in Scotland.

Betula x *intermedia* at Pol Bhat, Mar Lodge (Sarah Watts)

The symposium started with five talks. Following the publication of his paper in British and Irish Botany, Andy Amphlett kicked things off with a talk on the thorny issue of downy birch taxonomy in Scotland. Amphlett talked the group through his paper, noting that Scotland's 'normal' upland downy birch, *Betula pubescens,* var. *fragrans*, appears to be endemic. Hybridisation and subsequent introgression with dwarf birch *Betula nana* was also discussed. This was of particular interest, as the 'birch-belt' of Southwest Norway comprises *Betula pubsecens* var. *pumila,* a heavily introgressed tetraploid which seems particularly well adapted to cold and altitude. This taxon (or rather, its Scottish equivalent), remains 'unconfirmed' in Scotland, with around ten putative records of the taxon from Hoy to the Cairngorms. Gus Routledge kept us abreast of the grassroots, citizen science led Mountain Birch Project, and pointed out the biodiversity benefits of montane birch. This project is recording high altitude birch, taking seed, and may well lead to experimental planting in the fulness of time. So far the project has found around 100 mature (seed-producing) birches above 600m altitude, with more to be found. Dr Aline Finger shared current genetic research on birch in the UK and Scandinavia, including fascinating observations on the genetic makeup of downy birch in Britain, and the impact of genetics on growth form in Scandinavia. Ian MacDonald shared the NatureScot perspective on birch ('NatureScot likes birch!'), noting the current rules around planting in designated sites and how these might change in the future. Finally, Ellie Dimambro-Denson discussed comparisons between the 'birch-belt' in Southwest Norway and Scotland's almost total lack of this habitat. Her talk was richly illustrated, and noted both the similarities and differences in Scotland and Norway's history, geology, climate and ecology. Of particular note was the insight that many species of conservation concern in Scotland, from twinflower *Linnaea borealis* and Alpine sow-thistle *Cicerbita alpina* to ring ouzel *Turdus torquatus*, are faring extremely well in Norway's birch belt!

Following the talks, practitioners discussed work which is already underway for birch in Scotland. It was extremely impressive to hear of the work that is already underway right across Scotland. After this update, there was a broad general discussion, taking in taxonomy and genetics; limits

to birch in the montane zone and challenges for its restoration; the importance of herbivore densities and seed rain; the potential impact of mycorrhizal fungi on re-establishment; geological and ecological conditions and limits; the practicalities of seed establishment in nurseries and wider practicalities regarding birch restoration; and working within NatureScot guidelines. Comparisons with Southwest Norway and other parts of Europe were discussed. Examples of projects which has worked well and poorly were shared. Attendees certainly went home with lots of food for thought!

Collecting birch seed at Loch na Lap, Corrour (Mark Hamblin)

The strength of the symposium was that it brought together people with many decades of experience and diverse perspectives. Discussions were collaborative and constructive, and if there were disagreements between attendees, then they were discussed agreeably! Undoubtedly, work already underway will be refined in the light of this discussion. Significant collaborative plans have been proposed for both research and restoration. There was a consensus within the group that this meeting be the first step towards a coherent and cooperative approach towards upland and montane birch conservation and restoration projects in Scotland. As such, the meeting finished with the development of a series of research questions to be answered, and proposed actions for meeting participants were mooted, which are listed below.

There is clearly plenty of appetite for working both harder and smarter for Scotland's montane birch. The next few years may yet prove to be a renaissance for montane birch. This impromptu, grassroots symposium may prove to be a significant milestone in our knowledge of our mysterious montane birches, and potentially even their restoration in the wider landscape.

Research Questions

- What is the current status of *B. pubescens var pumila* and other heavily introgressed *pubescens/nana* birches in Scotland?
- Given its endemic status, what steps should be taken to conserve *B. pubescens* var *fragrans* in Scotland?
- What was the historic status of the birch belt in Scotland?
- To what extent do genetics and altitude/climate determine morphological differences in birches in Scotland?
- What is the importance of obligate mycorrhizal associations to birch re-establishment?

- To what extent does seed provenance impact birch establishment, and is it the case that more local generally = better success?
- What best practice guidelines can be used for the establishment of upland birchwoods, taking into account seed provenance, genetic diversity, risk mitigation for tree disease, etc.

Actions agreed on by participants of the birch symposium

- Consolidate survey data and information gathering about high altitude birch stands.
- Develop a standardised methodology for recording mature birch in the uplands, particularly in the montane zone.
- Develop a revised methodology and centralised database for seed collection, including seed viability tests.
- Develop an inventory of birch seed collected from high altitude areas in Scotland.
- Conduct a genetic study of high-altitude birch stands in the Cairngorms, possibly as a partnership between Cairngorms Connect, RGBE, and NTS. This includes the possibility of a similar west coast study as well.
- Conduct peat-core studies of high-altitude sites using macro-fossil analysis to help determine the historic status of birch in the montane zone.
- Develop a montane birch subgroup within the Mountain Woodland Action Group.
- Devise a field trip in the summer for interested stakeholders.

ANDREW PAINTING *is an Ecologist working on the Mar Lodge Estate for National Trust for Scotland*

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For the love of trees – bringing people on our journey to restore mountain woodlands by Lynn Cassels

The birth of the Tree Nursery

Cairngorms Connect is a partnership of neighbouring land managers, committed to a bold and ambitious 200-year vision to enhance habitats, species and ecological processes across a vast area within the Cairngorms National Park. When Cairngorms Connect received funding, one of the targets was the development of the small Tree Nursery in RSPB Scotland Abernethy. This had been started back in 2015 as a result of a real grass roots effort led by the Friends of Abernethy, a group of interested locals who wanted to grow trees for planting in the RSPB Scotland Abernethy Reserve. But after an initial push, the project somewhat lost its way. There was little money or staff time available and the interest from the volunteers waned due to a lack of organisation and direction.

With the support of the Endangered Landscapes and Seascapes Programme through Cairngorms Connect in 2019 came funding to recruit a part time manager David Blair, later to be joined in 2022 by a part time assistant Lynn Cassells. Today, our overarching aims at the Cairngorms Connect Tree Nursery are twofold; firstly, to grow trees for planting out across the partnership area and secondly, to engage and work with our local community to help us achieve that.

The Tree Nursery (Scotland the Big Picture)

The need to share

In the practical field of conservation and ecological restoration, the success of interventions such as tree planting can be measured in any number of ways such as monitoring species increase or decrease, mapping habitats expand or contract, or achieving goals and targets set in management plans. But the real long-term success relies heavily on how well we bring others along with us through education, engagement and direct involvement.

And working within these fields, it can be easy to stay within the confines of our safe zones, communicating primarily with those around us on what we are interested in but rarely stepping outside of our immediate sphere of influence. During a recent webinar on Rewilding, Anna Gilchrist from the University of Manchester talked about the importance of ‘taking rewilding out of the ivory towers of academia’, acknowledging the limitations that discussion and research alone can have on long term achievement and delivery of nature focussed agendas, in somewhat siloed spheres, if we don’t engage with others.

The power of volunteers

During a relatively short period of time from the Tree Nursery's original inception, the number of trees grown has increased from 100s per year to 1,000s per year where the lion's share of the work is delivered by an ever-expanding volunteer base. From September 2022 to September 2023, we recorded 1,500 volunteer hours, a number which will likely increase. So what is it about the Tree Nursery that is growing a new army of mountain woodland advocates?

Building back biodiversity

The first reason seems to be driven by the need to counter the many negative impacts that our modern-day living is having on the rest of nature. Coming to volunteer in the Tree Nursery is a practical and very positive contribution to building back biodiversity into our landscape. In their own words…

"Why do I volunteer at the Tree Nursery? Well, I guess it's because I enjoy working in nature, nurturing the new trees as they grow, and doing something for nature as a whole. A real highlight is when we get to plant the young trees out on the mountain and seeing previous ones not just surviving but thriving!"

"Quite honestly, the primary driving force for me to go to the Tree Nursery is undoubtedly "guilt". Guilt for a life spent using precious planet resources. As well as that, for me, the Tree Nursery is a place of magic, seeds are sown, shoots appear, little trees are planted and a forest will, in time, be created."

"We all need to do our bit and helping to grow trees is one thing I resolve to do."

"I've often found myself on a hill climb anticipating epics views only to find barren landscape as far as you can see and the only trees to be found being the bog wood. Therefore, I feel privileged to be part of an awesome team of volunteers contributing to the process of regenerating the woodland, both lower down and higher up into the mountains, from seed collection to planting out and lots of weeding in between!"

For many, this need to get out and do something is important and links in strongly with the second reason why our volunteer numbers are only ever increasing.

Eared-willow cuttings, strapped to the backs of volunteers, make their way through the landscape to their new homes (Lizzie Brotherston)

Landscape healing with social connection

We live in a world at the mercy of endless crises, epidemics and pandemics where a constant choose to 'heat or eat' and where many are paralysed by the overwhelm of what we actually *can*

do to make a real, positive change. The healing power of nature and community is getting increasing attention from our National Health Service, evidenced in the recent formation of NHS Forest 'an alliance of health sites working to transform their green space to realise it's full potential for health, wellbeing and biodiversity, and to encourage engagement with nature.' Some doctors have started prescribing social and physical activities, the effectiveness of which are now starting to be backed up with scientific research. A 2022 review of relevant literature by UCL presented evidence for various health improvements from these 'prescriptions' that include improved quality of life and wellbeing, improvements in anxiety and depression and even a reduction in the number of visits to a GP.

So how does that fit in with the motivations of some of our volunteers? Again, in their own words;

"I started going along to the Tree Nursery because I wanted to do something useful for nature conservation that was within my physical capability. Not only did it turn out to be a great social occasion with like-minded people, but as a mental health sufferer, it turned out to be a much-needed weekly therapy session!"

"For me, the Tree Nursery is a place of magic, seeds are sown, shoots appear, little trees are planted and a forest will, in time, be created. For that reason, even when I'm not physically there, the Tree Nursery remains a special place in my mind that I can visit whenever I need to."

"I believe the Tree Nursery is a very special place for all of us in different ways but in the end it is the reason for being there that binds us….. the trees. The essence of life and our roots."

Healing in

David, from the Tree Nursery hold willow seedlings as staff & volunteers fill their packs (© Caringorm Connect, Lizzie Brotherston)

The core theme that seems to unite all our volunteers is the want or need to heal. This can be personally through the connection with the soil and plants and other volunteers. Or it can be practically through their work growing trees that when planted, help to heal a wounded landscape. Many of our regulars give up hours of their lives every week to weed beds, collect seed, prick out seedlings, plant trees, turn compost, the list goes on. These people bring the place alive, they are part of the biodiversity of the place.

Branching out

It's not just the local community who want to be a part of what we do. We're seeing increasing engagement with posts about the Tree Nursery work through our Cairngorms Connect social

media pages. This is contributing to a rise in volunteer sign ups that of late, we are seeing come through on a weekly basis. And our work was recently featured in the BBC Saving our Wild Isles episode where the now famous 'Willow Walk' was featured. This is an annual event whereby staff and volunteers come together to walk thousands of saplings into the Loch A'an basin for planting. These include montane scrub species such as Downy Willow *Salix lapponum*, Whortle Leaved Willow *Salix myrsinites* and Dwarf Birch *Betula nana*. To observe or be part of such an event is like watching or riding a wave of mountain woodland expansion in real time.

The Tree Nursery work sits at the epicentre of everything that we are trying to do at Cairngorms Connect where beneath the many thousands of baby trees, grows an understory of hope of a community where people come together to do good things as an integral part of nature. Not people and nature. People as part of nature, playing a role no less or more important than the rest of life we share this beautiful planet with. It's here where the true sustainable, regenerative and resilient future of mountain woodland restoration lies.

Stay up to date with news from the Tree Nursery and the wider Cairngorms Connect Partnership, by signing up to our newsletter:

https://bit.ly/Cairngorms-Connections

LYNN CASSELS *has worked part-time for Cairngorms Connect as the Tree Nursery Assistant since November 2022.*

Mapping relict and restored mountain woodland across Scotland by Sarah H. Watts

Introduction

In Winter 2022/23, NatureScot commissioned the creation of a new dataset of mountain woodland locations across Scotland; to be used to inform landscape-scale ecological restoration, 30x30 goals, Nature Networks, UK and European Reporting and Area based casework, and training data for habitat mapping. The project was also designed to highlight wild, relict sites of mountain trees which could provide sources of propagation material for upscaling conservation work across the country, as well as the fragmented, remnant populations potentially in need of supplementary planting and genetic rescue. These data will enable the identification of suitable restoration sites to help create wider landscape connectivity across Scotland between existing habitat patches, and showcase the exciting range of projects that are currently ongoing to facilitate the recovery of our mountain treeline ecotone.

There are two outputs from this mapping exercise:

1. Point locations (grid references) of wild mountain woodland species (also known as relict or remnant mountain woodland); created as a .csv file

2. Spatial polygons of mountain woodland restoration sites; created as a .shp file that is compatible with ArcGIS (ESRI) and QGIS, with the associated attribute table also given in a .csv file

Part of the requirement of this work was to define the limits of what records of mountain woodland should be included, building on a previous dataset created by the Mountain Woodland Action Group (MWAG); hereafter referred to as the Original Montane Scrub Dataset (OMSD). The project benefits from information gathered and retained by the MWAG over 25 years of habitat restoration and collaborative knowledge exchange. To create these data, it was also necessary

to contact organisations, land managers and private estates who have surveyed and planted mountain woodland as part of a nature restoration plan; their invaluable input is acknowledged below.

This article provides online data download weblinks, a summary of the breadth and type of data available, a step-by-step guide to its creation, and a brief discussion of future applications. These data are up to date as of March 2023.

Download links

These data are available on the NatureScot website as Open Data under an Open Government Licence.

Output 1 interactive map:

https://opendata.nature.scot/maps/habmos-mountain-woodland-2023-wild-relict-or-remnant

Output 1 download:

https://spatialdata.gov.scot/geonetwork/srv/eng/catalog.search#/metadata/3c165034-238b-4d01-94b3-79802c874e98

Output 2 interactive map:

https://opendata.nature.scot/maps/habmos-mountain-woodland-2023-restoration-sites

Output 2 download:

Hab-Mos-Mountain Woodland Restoration Projects

Overall summary of the data

Output 1:

- A total of 18,538 point records have been compiled across 24 tree and shrub taxa that feature in mountain woodland habitats in Scotland;
- From these records, there are a total of 324 that qualify for EU Habitat Directive Annex 1 type H4080 (Sub-Arctic *Salix* spp. scrub), and a total of 210 that qualify for Annex 1 type H5130 (*Juniperus communis* formations on heaths or calcareous grasslands);
- Some geographical areas (e.g the Cairngorms) have had higher recording effort than others;
- The BSBI Distribution Database will be the primary source of information for future updates.

Output 2:

- A total of 128 mountain woodland restoration sites have been compiled across Scotland, covering a total gross area of 10,844 ha;
- There are a total of 57 sites which contain a component targeting EU Habitat Directive Annex 1 type H4080 (Sub-Arctic *Salix* spp. scrub), four sites which contain a component targeting Annex 1 type H5130 (*Juniperus communis* formations on heaths or calcareous grasslands), and eight sites which target both habitats;
- Contributing organisations have participated in a purely voluntary capacity and the dataset will therefore not be an absolute list of all restoration work across Scotland

Output1: Collation of "wild, relict or remnant" mountain woodland point records in Scotland

Criteria for including records in Output 1:

- At any altitude:
  - Nationally Rare or Scarce arctic-alpine willows and scrub specialists (*Salix lanata*, *Salix lapponum*, *Salix myrsinites*, *Salix arbuscula*, *Salix reticulata*, *Salix caprea* subsp. *sphacelata*, *Sorbus rupicola*, *Betula nana*)
  - Records listed as "Treeline scrub" in the OMSD
- At ≥ 400m altitude:
  - Sub-montane willows (*Salix phylicifolia*, *Salix myrsinifolia*)
  - Secondary montane/sub-montane trees or shrubs (*Populus tremula*, *Corylus avellana*, *Prunus padus*, *Prunus avium*, *Pinus sylvestris*, *Salix repens*, *Salix aurita*, *Salix cinerea*, *Salix caprea*)
  - *Juniperus communis*
- At ≥ 600m altitude:
  - Mountain broadleaves (*Sorbus aucuparia*, *Betula pubescens*, *Betula pendula*)
- Date is post-1950 (i.e. remove historical/out-of-date records)
- Precision is at 1km or better (but remove any 1km records where more precise records also exist for that square; unless assigned an EU Habitat Directive Annex 1 type in the OMSD)
- Remove any planting/deliberate introductions that are not part of habitat restoration work (e.g. garden/roadside planting)
- Remove records of *Salix herbacea* and "Coastal scrub" from the OMSD

Workflow for Output 1:

1. Download records from Botanical Society of Britain and Ireland Distribution Database (BSBI DDb) and filter duplicates;
2. Cross reference and integrate with the OMSD;
3. Gather and integrate additional records from external organisations and individuals;
4. Remove any 1km precision records where more precise records also exist within that particular 1km square;
5. Visual checking and verification of record distribution in QGIS using 1:50,000 OS back-drop mapping obtained from Digimap;
6. Assign EU Habitat Directive Annex 1 types using the criteria given by Sullivan (2015).

The number of records compiled by taxon, species group and Annex 1 Habitat types are given in Tables 1 and 2, along with a comparison with the most recent version of the OMSD. There is a total of 18,538 point records across 24 tree and shrub taxa, which is over three times as many records than in the OMSD. Arctic-alpine specialist willows comprise a total of 3602 records (Figure 1).

Some geographical areas, particularly within the Cairngorms, have had a higher recording effort than other locations in Scotland. Any downstream analysis involving Output 1 should therefore account for geographical bias in recording effort, as well as the constraints imposed on the new dataset by the choice of altitudinal limits outlined above. For example, mountain woodland habitats can have potential to occur at altitudes lower than 400m in the North-West of Scotland. Also, records of species which are commoner at lower altitudes (i.e. the secondary montane/sub-montane trees or shrubs) are not expected to be all-inclusive of every occurrence, but will nevertheless provide an overview of their distribution in mountain areas.

Table 1: Number of records of each taxon and species group given in Output 1, in comparison to the Original Montane Scrub Dataset (OMSD).

Taxon	OMSD	New database	Date BSBI DDb records downloaded
Arctic-alpine specialist willows			
Salix lanata Woolly willow	60	270	07/11/2022
Salix lapponum Downy willow	420	1582	11/11/2022
Salix myrsinites Whortle-leaved willow	226	748	11/11/2022
Salix arbuscula Mountain willow	138	522	11/11/2022
Salix reticulata Net-leaved willow	99	480	11/11/2022
Total	**943**	**3602**	
Sub-montane willows			
Salix myrsinifolia Dark-leaved willow	131	242	01/01/2023
Salix phylicifolia Tea-leaved willow	93	289	31/12/2022
Total	**224**	**531**	
Scrub specialists			
Salix caprea subsp. *Sphacelate* High altitude Goat willow	n/a	102	11/11/2022
Sorbus rupicola Rock Whitebeam	63	210	11/11/2022
Betula nana Dwarf birch	326	2590	11/02/2023
Total	**389**	**2902**	
Secondary montane/sub-montane trees or shrubs			
Pinus sylvestris Scots' pine	n/a	1776	24/02/2023
Prunus avium Gean	n/a	7	30/12/2022
Prunus padus Bird cherry	n/a	27	30/12/2022
Populus tremula Aspen	n/a	234	03/02/2023
Corylus avellana Hazel	n/a	57	03/02/2023
Salix repens Creeping willow	7	707	03/02/2023
Salix aurita Eared-willow	6	1276	03/02/2023
Salix caprea Goat willow	n/a	161	03/02/2023
Salix cinerea Grey willow	n/a	98	03/02/2023
Total	**13**	**4343**	
Juniperus communis Juniper	1547	6346	04/03/2023
Mountain broadleaves			
Betula pubescens Downy birch	n/a	103	18/02/2023
Betula pendula Silver birch	n/a	8	18/02/2023
Sorbus aucuparia Rowan	n/a	561	18/02/2023
Total		**672**	
Other records			
Treeline scrub	142	142	
Not included in new database			
Salix hybrids	85	n/a	
Salix herbacea Least willow	184	n/a	
Coastal scrub	310	n/a	
Total	**579**	n/a	
Overall total number of records	**5406**	**18538**	

Table 2: Number of records in Output 1 assigned to EU Habitat Directive Annex 1 Habitat types using the criteria given in Sullivan (2015).

Annex 1 Habitat	OMSD	New database
H4080	90	324
Potential H4080	90	393
H5130	160	210
Potential H5130	154	145

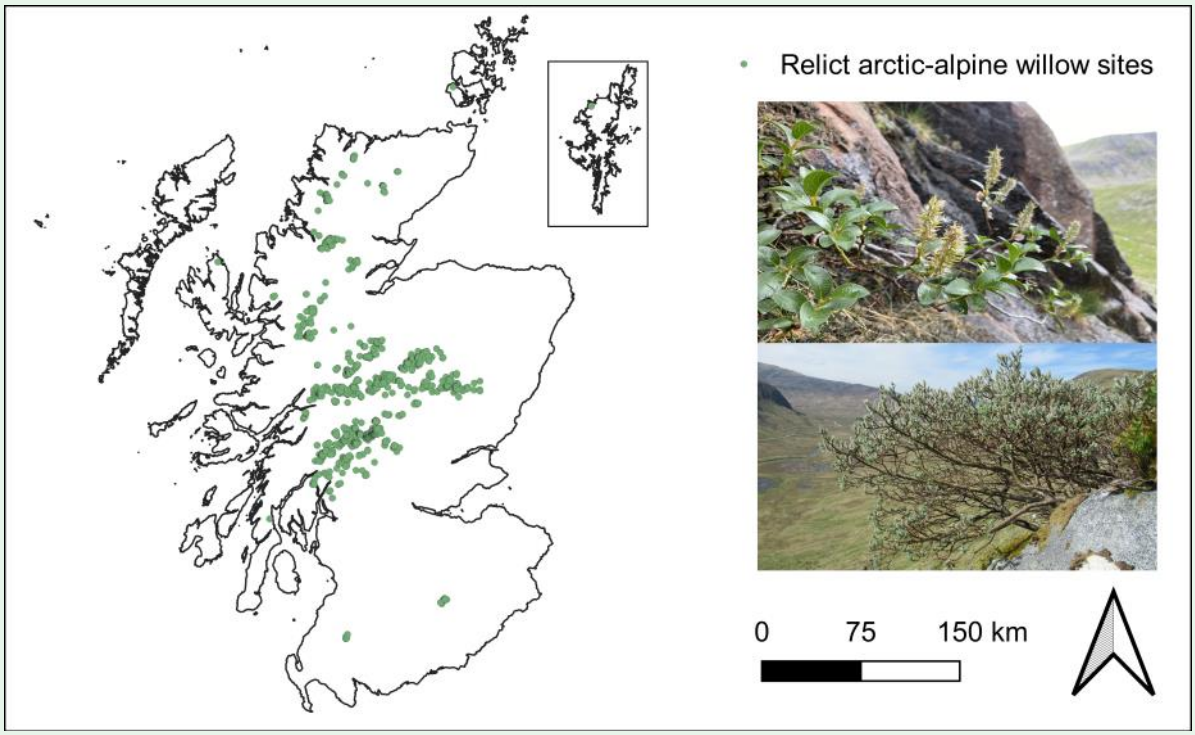

Figure 1: The broad distribution of relict arctic-alpine specialist willow population point data contained in Output 1, combined for *Salix lanata*, *Salix lapponum*, *Salix myrsinites*, *Salix arbuscula*, *Salix reticulata*.

Records have been assigned EU Habitat Directive Annex 1 types based on the criteria given in Sullivan (2015). There were a total of 324 that qualify for H4080 (Sub-Arctic *Salix* spp. scrub), and a total of 210 that qualify for H5130 (*Juniperus communis* formations on heaths or calcareous grasslands). However this process was not exhaustive; selection did not account for records with low numbers of qualifying plants present that could be assigned an Annex 1 type because they are located geographically very closely to records with higher numbers of qualifying plants. Similarly, the selection process did not account for multiple highly localised records (with high geographical precision and within 100m of each other) that when combined would give enough numbers of qualifying plants to be assigned an Annex 1 type. There are fewer records assigned to "Potential H5130" in the new dataset in comparison to the OMSD, this is because the latter included any records of *Juniperus communis* regardless of altitude.

Within the scope of this project, it was not possible to simply add up counts of plants from multiple records within 100m of each other because to do so would potentially duplicate separate counts of the same population made over time, and/or by multiple recorders. In addition, not all records contain full details of the numbers or abundances of plants present. Nevertheless, the records with Annex 1 types already assigned should provide a useful understanding of the overall distribution of sites with H4080/H5130 present, and the likely locations of potential areas where protection of the habitat or its restoration could improve the condition in the future. To assign

Annex 1 types in more detail would require careful scrutiny of each individual record and its location with respect to others mapped within GIS.

It is recommended that this new dataset is updated every three years, or annually for the Nationally Rare/Scarce arctic-alpine willows and scrub specialist species. The BSBI DDb will form the primary source of information for updates; however in order to align the Output 1 dataset with the BSBI DDb, it is advised that any records not sourced from BSBI should be sent for inclusion in their database too.

Output 2: Mountain woodland restoration polygons

Criteria for including records in Output 2:

- Locations in Scotland where conservation action has taken place specifically for the purpose of mountain woodland restoration, and/or montane scrub restoration, including:
    - Current/ongoing restoration projects;
    - Proposed restoration projects that are imminently due to start and in the final stages of planning;
    - Older restoration projects that can be accurately mapped;
    - Projects at ≥ 400m altitude; except EU Habitat Directive Annex 1 types H4080 and H5130 which are mapped at any altitude. Projects with a major component ≥ 400m can include areas that fall below the 400m contour;
- Relevant conservation action for mountain woodland restoration:
    - Tree planting of native species that form a component of mountain woodland habitats
    - Management to improve habitat condition e.g. use of fencing or reducing overgrazing pressure by controlling larger herbivores
    - Management to facilitate natural regeneration

Workflow for Output 2:

1. Literature review of MWAG bulletins and discussion with MWAG members to compile a list of potential projects to include in the mapping
2. Contact relevant organisations to request data and related information for restoration projects that meet the criteria listed above
3. Collate and edit the shapefiles in QGIS using 1:50,000 OS backdrop mapping obtained from Digimap
4. If organisations do not have GIS data, then new polygons are created using annotated maps
5. Create associated attribute table in Microsoft Excel; assign habitat types based on expert knowledge and the information provided by contributing organisations
6. Join attribute table to shapefile

A total of 128 mountain woodland restoration sites have been compiled across Scotland for inclusion in this dataset (Figure 2). The polygons represent a total gross area of 10,844 ha, ranging in individual size from 0.081 ha to 1341 ha. Polygons were mapped at appropriate spatial scales depending on the data provided by contributing organisations. For example, while some polygons show fence lines around whole sites, other areas map the focus of smaller restoration works within larger fenced areas. This variety of information is captured within the attribute table.

Polygons were drawn so that they did not overlap, except for some sites at Mar Lodge where several habitat types were the focus of restoration work over large areas producing some small overlap across polygons. A decision was made to retain these mapped overlaps to capture the breadth of information kindly contributed by the National Trust for Scotland.

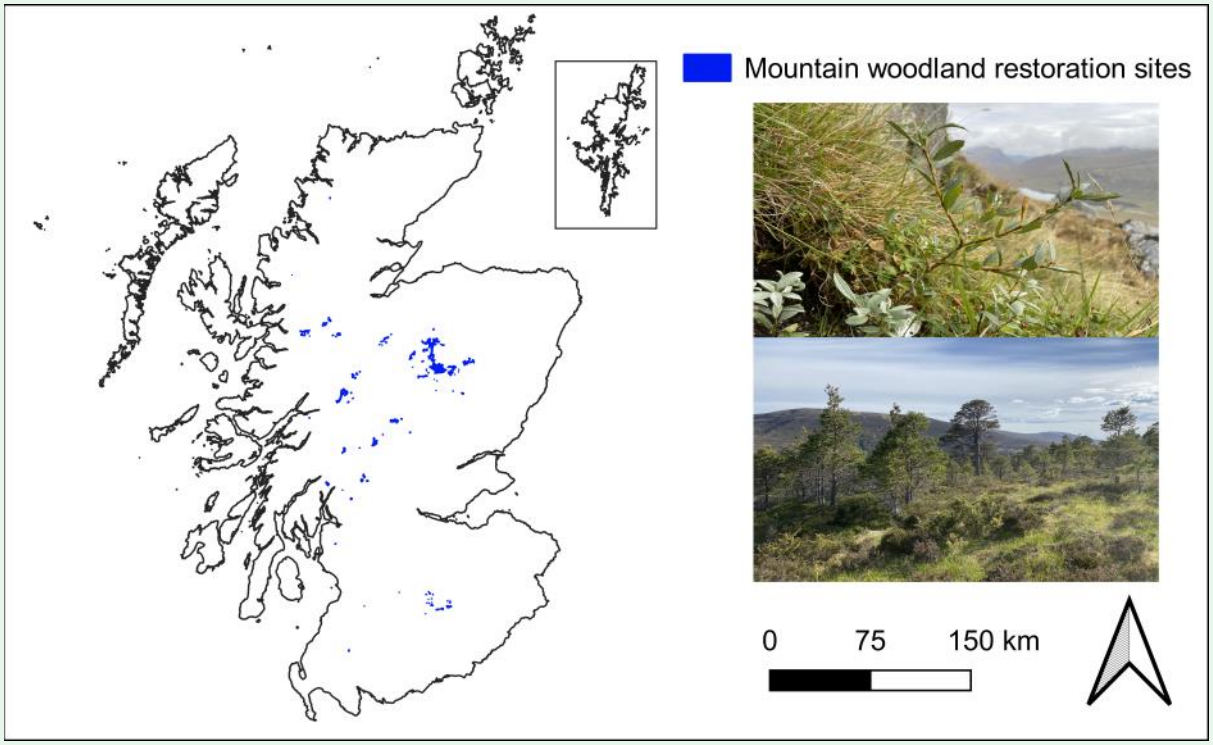

Figure 2: The broad Scotland-wide distribution of mountain woodland restoration sites mapped in Output 2.

Table 3: The number of mountain woodland restoration sites included in Output 2 (out of a total of 128) which target EU Habitat Directive Annex 1 Habitat types.

Annex 1 Habitat	Number of restoration sites
H4080	43
H4080 (only as a minor constituent of the woodland or as a mosaic with other habitat types)	13
H4080 and H6430	1
H4080 and H5130	8
H5130	4
H6430	1
H91C0	12

Data were gathered as much as possible on planting numbers; focusing on Nationally Rare and Scarce specialist arctic-alpine willows or montane scrub species. Comprehensive information on the precise planting numbers of more common tree species was not always available, particularly for older restoration projects. There are a total of 57 sites which contain a component targeting EU Habitat Directive Annex 1 type H4080 (Sub-Arctic *Salix* spp. scrub), four sites which contain a component targeting Annex 1 type H5130 (*Juniperus communis* formations on heaths or calcareous grasslands), and eight sites which target both habitats (Table 3).

Contributing organisations have participated in a purely voluntary capacity and the resulting dataset will therefore not be an absolute list of all restoration work taking place across Scotland. One organisation that was contacted declined to contribute data towards the project, and several others who would be willing to participate were still to create detailed enough plans for projects yet to start. It is therefore recommended that the dataset provided in Output 2 is updated every three to five years, to account for future progress in new and ongoing habitat restoration.

Action for the future

The distribution of relict arctic-alpine willow populations (Figure 1) and mountain woodland restoration sites (Figure 2) highlight gaps within the geographical range of Scotland's montane willows where conservation work could be expanded, including in Lochaber, the Angus Glens and the North-West Highlands. Opportunity mapping using national data on geology, soil type, topography, altitude, climate and land use, in conjunction with the data presented here should be undertaken to identify priority locations for restoration.

As well as focusing on sites of high nature conservation concern, future action could harness the capacity for nature recovery on land previously managed intensively for sport shooting (e.g. deer stalking and grouse moors), which often host relict populations of montane willows in need of rescue and enhancement.

The ecological prospects for much more of upland Scotland are evidenced by the extensive montane scrub re-established over decades by the National Trust for Scotland at Ben Lawers, and recent planting success in large-scale restoration projects in the Cairngorms (e.g. Mar Lodge and Loch A'an) and on private estates (e.g. Corrour and Coignafearn). Mountain woodland is rapidly gaining recognition for its importance to biodiversity and climate change mitigation (Watts & Jump 2022). To ensure these benefits are delivered, there must be sufficient support through national policy and funding to meet the needs of practitioners. A network of native tree nurseries and seed stands is also needed across the country to be ready to meet rising demand for montane planting stock for the full range of local provenances.

Acknowledgements

This work was commissioned by Philippa Vigano at NatureScot. The wealth of records included in Output 1 would not have been possible without the Distribution Database of the Botanical Society of Britain and Ireland (BSBI DDb). The MWAG gave advice on the species and criteria required for inclusion in Output 1, and provided knowledge on past, current and planned restoration projects and the organisations/individuals to contact for more information regarding Output 2. Richard Marriott and Heather McHaffie facilitated access to the Woolly Willow Steering Group Archive.

The following organisations contributed data: Balmoral Estate, Borders Forest Trust, BSBI, Cashel Forest Trust, Coignafearn Estate, Corrour Estate, Eadha Enterprises, Forestry and Land Scotland, Highland Perthshire Communities Land Trust, Invercauld Estate, John Muir Trust, National Trust for Scotland, NatureScot, RSPB, SRUC, SSE, Tillhill, Trees for Life, Woodland Trust.

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***SARAH WATTS**, while in the final stages of completing her PhD, is employed as the Conservation Manager by the Corrour Estate and is the current Chair of the Mountain Woodland Action Group.*

The Scope For Mountain Woodland Restoration: A New Approach
by Innes Manders

Introduction

How much land is suitable for mountain woodland restoration? This question, posed to the MWAG was passed onto me in early 2023 when I was developing plans for my undergraduate dissertation at the University of St Andrews. Before laying out my small contribution to answering it, I should set out what I understand it to mean:

Suitable land: land capable of supporting mountain woodland.

Mountain woodland: tree and shrub communities occurring above 400m altitude.

Restoration: Following Holl and Smith (2007), I understand restoration as the return of ecosystems to an ecologically functioning state (though not necessarily one which existed in the past).

Combining Peterken's definitions of naturalness (1996) with rewilding principles, I have found an additional concept useful here:

Possible natural: the state which could prevail in the near future if missing ecosystem components are restored to ecologically viable populations and human influence is otherwise removed.

Existing Approaches

At present, there are two core lines of evidence informing understandings of how much land is suitable for mountain woodland: paleoecology and the native woodland model (NWM).

Paleoecology

Based on the original conception of ecological restoration as returning environments to a past state, palaeoecologists have attempted to address the evidence deficit by understanding the past extent of mountain woodland. This line of research has contributed greatly to understandings of the past distribution of woodlands across Scotland and remains an important line of evidence for landscape-scale restoration.

However, palaeoecological studies of mountain woodland environments are difficult. Because pollen can be blown considerable distances, palynological studies of treeline position must be very cautiously interpreted unless there is an abundance of macrofossils (Birks and Bjune, 2010). I believe the only Scottish treeline where this has been attempted is Creag Fhiachlach (Nagy et al., 2013). Palaeoecological evidence of montane and subalpine scrub communities is even more limited (Tipping, 1997),

This absence of evidence is not evidence of absence, but in the words of Thompson and Horsfield (1997), we simply "do not know what the former natural upland habitats really looked like". What we can say for certain is that refugia habitats offer no long-term security (Marden, 2003) and if populations were not historically more widespread, most Scottish populations of species such as *Salix lanata* would not have been viable into the present time.

The Native Woodland Model (NWM)

The second approach involves computer modelling, of which the most commonly employed model is the NWM (Towers et al., 2004). Applying the model to predict woodland cover in the Cairngorms, Amphlett (2022) found 75% of terrestrial habitats above 600 m could support some degree of cover by trees or shrubs.

However, Towers et al. (2004) recognise uncertainties around the potential distribution of montane scrub. Furthermore, the ability of trees to grow at a location does not mean they would occur there in a functioning ecosystem. For lowland habitats it has been possible to verify the model by comparing the outputs to existing native woodland (Towers et al., 2004); however, this is not possible for a habitat which is almost entirely absent. Therefore, to test the validity of the

model in upland areas another approach is needed.

Comparisons with Southwest Norway

Comparisons with Norway have informed understandings of the potential cover of mountain woodland in Scotland since Poore and McVean's landmark paper in 1957, A New Approach to Scottish Mountain Vegetation. Recently the most prominent advocate of this comparison has been Duncan Halley. There are strong foundations for this comparison (Halley, SB 9, 2011), although limitations do exist. The strengths and weaknesses of comparisons with upland areas of Southwest Norway are also summarised in my dissertation.

Methodology

The method developed here is based on the principle that if climate, species and geology are sufficiently similar, then browsing pressures can be treated as the over-riding factor controlling mountain woodland distribution. Building on this premise, studying a comparable area of South-western Norway could inform understandings of a 'possible natural' state of the Scottish Highlands.

For this purpose, Corrour Estate was selected as the Scottish case study. Corrour was selected due to its active efforts to restore mountain woodland, and long-term commitment to reducing herbivore numbers to a level which would enable landscape-scale woodland regeneration. By selecting a site in the Western Highlands, I also hoped to address the geographical imbalance in research on mountain woodland, which has thus far been focussed mostly on the Cairngorms.

In Southwest Norway the timberline varies from 300-500 m in Fjordland to 1200-1300 m in Jotunheim (Holtmeier, 2009, p.50); therefore, selecting a comparable field site was crucial to the applicability of this method. Possible sites were identified through a multiple criteria elevation (MCE) using QGIS. Further consideration of bioclimatic variables, massif size, the extent of woodland areas, where a range of aspects and slope could be found in a comparatively small area, and of practical considerations led to the selection of Kjerringafjellet, Vestland as a suitable field site (Figure 1). A climatic comparison of the study areas, and the limitations of this comparison are summarised in my dissertation. The main limitation is that Kjerringafjellet has a slightly more continental climate than Corrour, and may be more comparable to the climate of the Cairngorms.

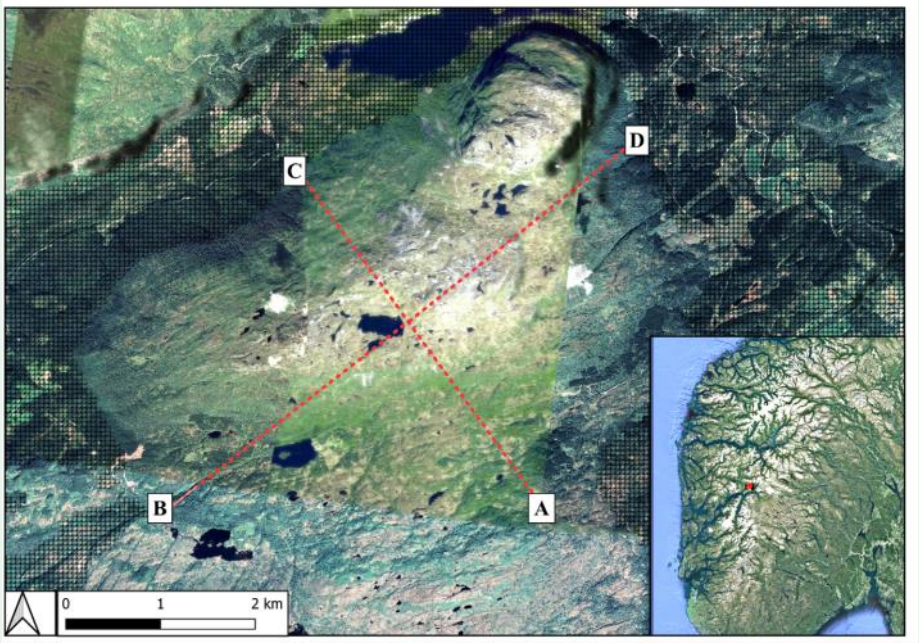

Figure 1. Location of transects at field study area, Kjerringafjellet, and location of area in SW Norway.

Empirical data was collected through a three-week field study. The four transects (Figure 1.) were walked in full and vegetation boundaries recorded. Within each area of vegetation >50m

the vegetation was sampled using 30x30m tree and shrub quadrats and 4x4m quadrats of the field layer. Additional information was also collected on tree and shrub characteristics, but I won't go into that here.

Composition and Distribution of Vegetation Clusters

First, I used cluster analysis to organise the data into clusters of plots with similar vegetation. The three larger clusters were found to correspond generally to bog vegetation, alpine vegetation, and mountain woodland. The abundance of tree and shrub species in each cluster are shown in Figure 2. Although mountain woodland represented the largest cluster of plots with the most apparent variability, subdividing it based on the entire vegetation composition did not seem to yield informative results.

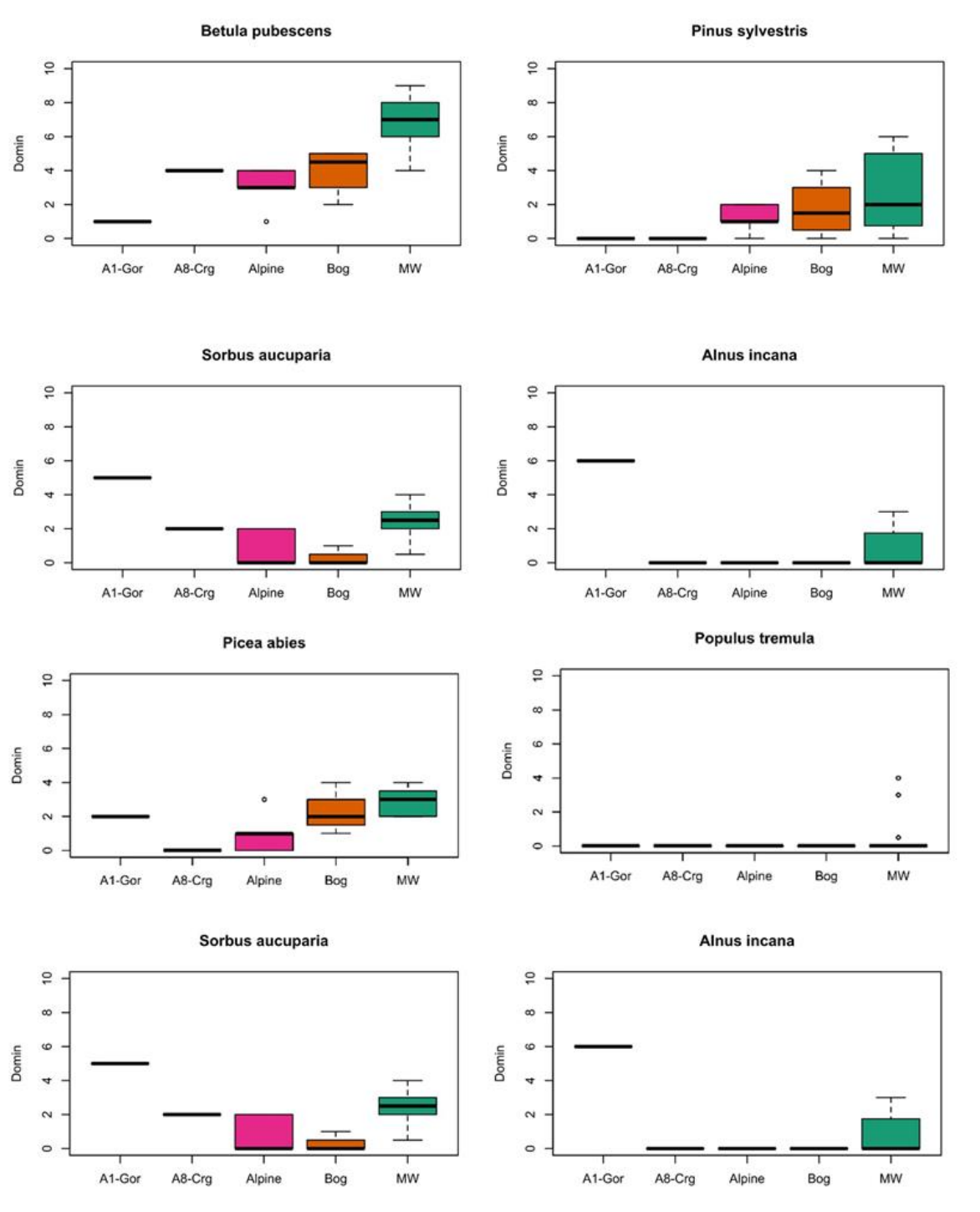

Figure 2A. Abundance of tree species by vegetation cluster.

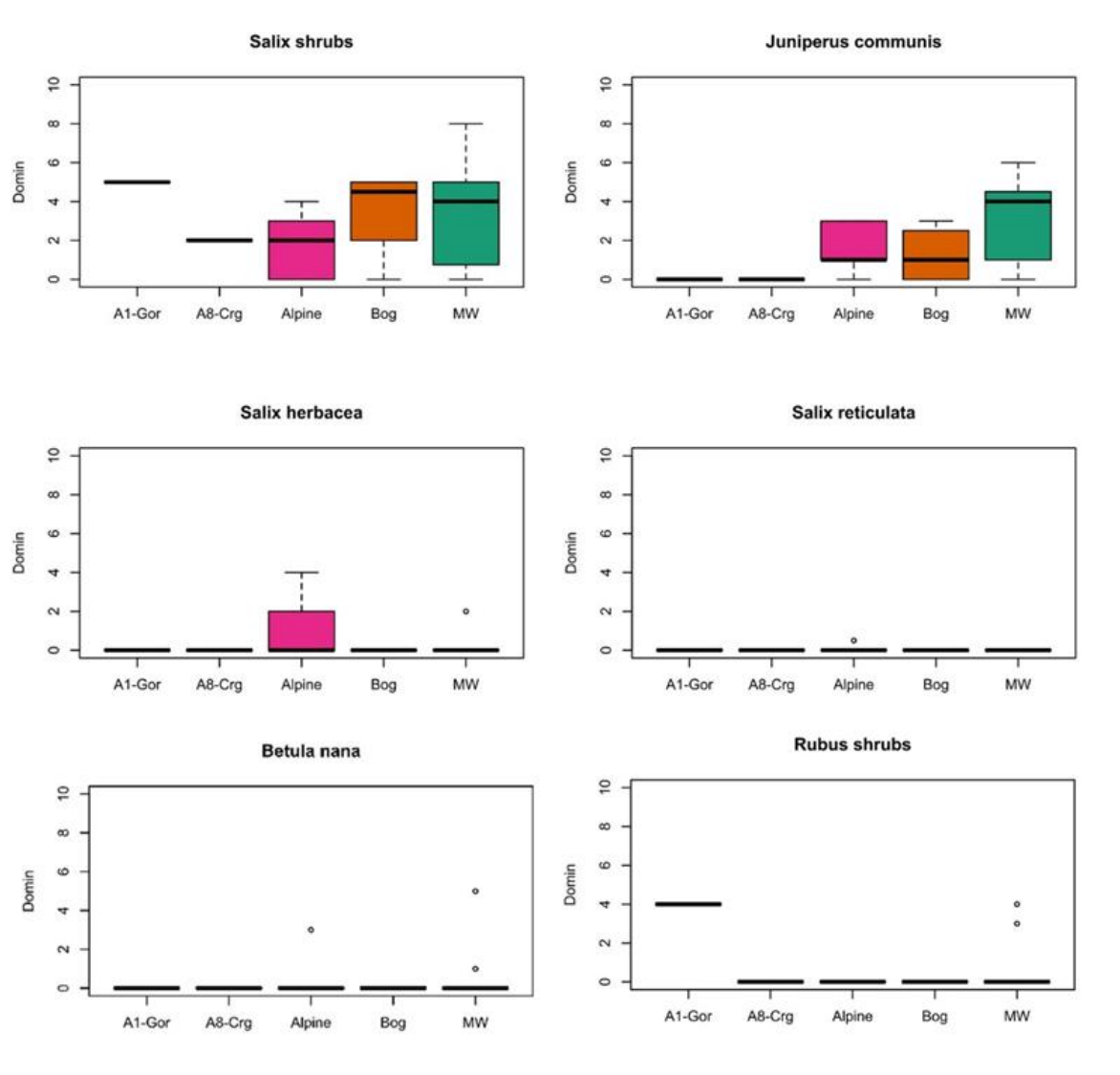

Figure 2B. Abundance of shrub species by vegetation cluster.

Therefore, the next step was to investigate which environmental variables could explain the distribution of mountain woodland as a whole. This was achieved through Canonical Correspondence Analysis (CCA), followed by investigation of individual variables. I identified deep peat (here considered ≥20cm) as a necessary and sufficient condition for bog vegetation. The distribution of mountain woodland and alpine plots could be explained by the interacting factors of altitude and slope, with the maximum altitude of woodland higher on steeper ground.

Next, I returned to the problem of variability within mountain woodland by subdividing the mountain woodland cluster according to whether or not there was >25% cover of tree-form *P. sylvestris,* and/or >25% cover of *B. pubescens*. In the remaining clusters, the dominant plants were *Salix* shrubs and *Juniperus communis*. All plots where *P. sylvestris* cover was >25% occurred at 545m or below. For birch krummholz, the threshold altitude was 870m.

The Rule-Based Model

Model Creation

Translating the data from Kjerringafjellet to Corrour Estate posed a new issue. The size of the dataset prevented the employment of numerical biogeographical approaches such as transfer functions, or traditional bioclimatic envelope modelling. Therefore, a simple rule-based model was developed in order to classify vegetation (Figure 3). The model was applied to Corrour Estate using QGIS.

This approach is most similar to the rule-based envelope method employed by Hemsing and Bryn (2012) to model the expansion of potential natural vegetation in Norwegian mountain woodlands. As Hemsing and Bryn noted, there are disadvantages to this approach; however, their transparency and adaptability makes rule-based GIS models well suited to this scale of study.

I developed a rule-based model based on the controlling factors of slope, altitude and the presence/absence of deep peat. Variations in climate were not considered when transferring data across using the model. Therefore, the model relies upon as close a climatic similarity as possible. Larger datasets could allow such differences to be considered by additional rules.

When tested on Kjerringafjellet, the model set out a realistic scenario similar to existing vegetation. So, working with a Digital Elevation Model, and map of deep peat at Corrour, I applied the rules derived from my analysis of Kjerringafjellet to Corrour. A schematic of the model logic is shown in Figure 3.

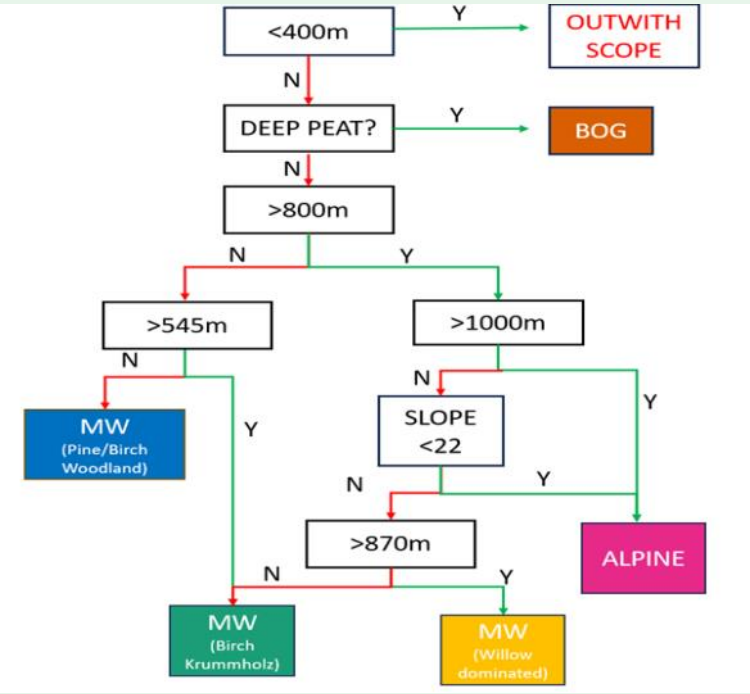

Figure 3. Simple rule-based envelope model for land at Kjerringafjellet and Corrour Estate. The application of the model is derived from Kjerringafjellet and applied to Corrour based on the assumption of biogeographical and climatic similarities. NB. Mountain woodland dominated by either pine or birch may occur below 545 m.

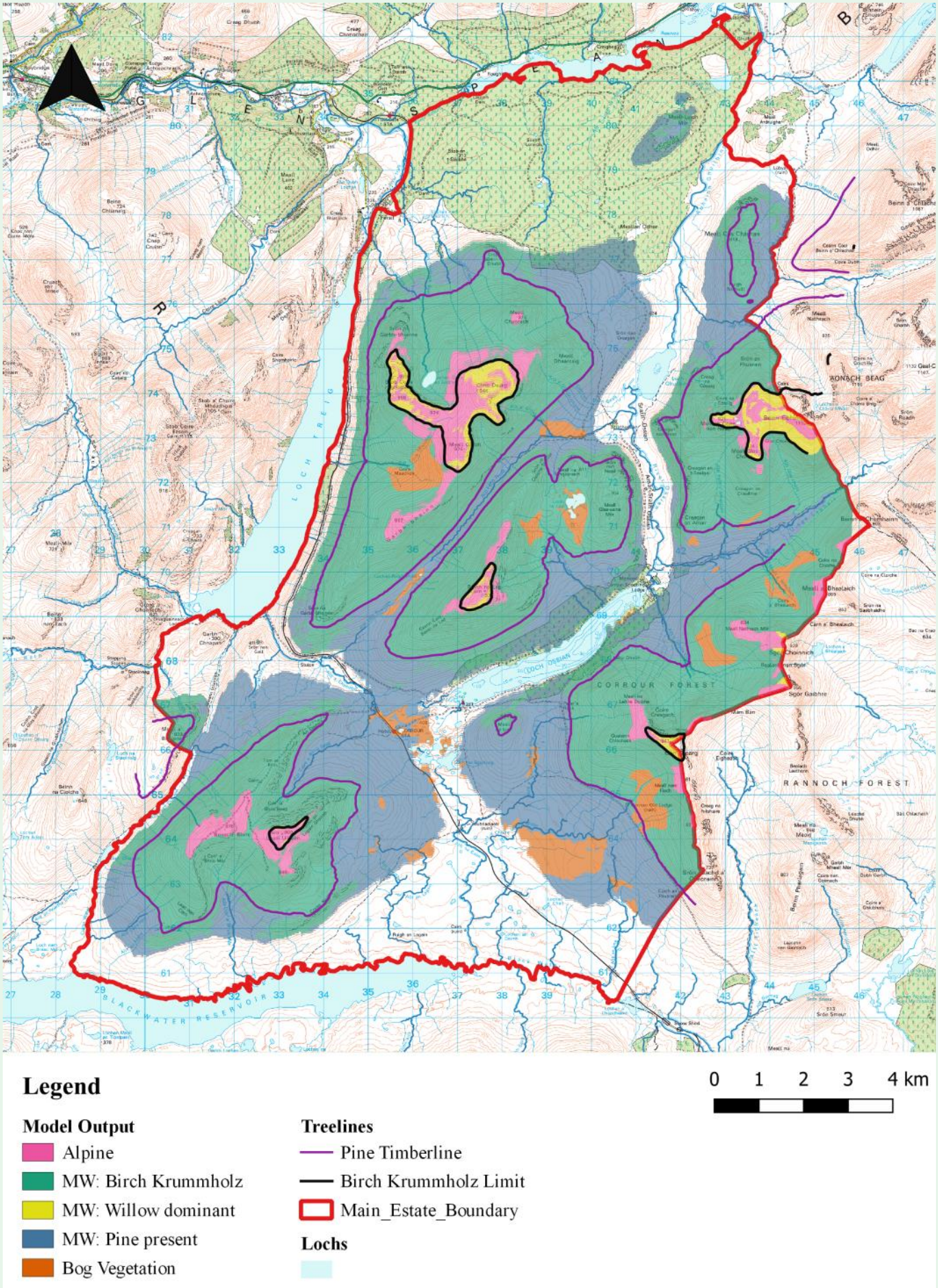

Figure 4. Modelled possible natural vegetation of Corrour Estate. Model only predicts possible natural vegetation of terrestrial habitats above 400 m. Communities are split to show the likelihood of krummholz birch or tree-form pines based on the maximum altitude at which these occurred with Domin > 5. Therefore, the 550 m contour line (blue) corresponds generally to the pine timberline and the 870 m contour (black) to the upper limit of the birch krummholz belt.

Results

The model outputs suggest over two thirds of the area above 400m at Corrour Estate could support mountain woodland communities (Figure 4). Of this area, half would constitute birch krummholz, with extensive areas below 550m supporting a mixture of tall pine and birch woodland. Scattered areas of willow and juniper scrub would occur primarily above, but also within, the birch krummholz zone (Figure 4).

Comparison with the NWM

Despite the differing approaches, there is significant agreement between the outputs of the NWM and my rule-based model. Both suggest the capacity for extensive areas of mountain woodland across Corrour, with typically pine, birch and willow-dominated communities all present to varying degrees. The outputs of the NWM allow more detailed breakdown of vegetation composition as categories are based on variation in the entire community rather than the dominant species. However, this study enables new understandings of the characteristics of mountain woodland (e.g., widespread krummholz forms) and of the distribution of specific species. For example, the absence of *Quercus petraea*, *Quercus robur* and *Betula pendula* in this study suggests that modelled areas of W11 woodland above c. 400 m at Corrour Estate would be dominated by *Betula pubescens*. The absence of *Corylus avellana* and *Alnus glutinosa* suggests that although they have been recorded above 400 m in Central and Eastern Scotland (Dines and Pearman, 2020; Stroh and Dines, 2020) these species may naturally be restricted to low altitudes at Corrour Estate.

Diversity

The possible vegetation maps produced by this model appear to suggest a large degree of homogeneity across the landscape (Figure 4), more so than the NWM. However, this is largely a result of the broad groupings employed herein due to the limited sample size. A crucial finding from my fieldwork is that greater variety in composition and structure exists within Norwegian mountain woodlands. This diversity of habitat is not represented by remnant areas of mountain woodland across Scotland. Evidence of processes such as avalanche damage creating dense, near-horizontal birch scrub supporting *Populus tremula*, *Sorbus aucuparia* and *Alnus incana*, also demonstrate the dynamic nature of mountain woodland habitat.

	Maximum Recorded Altitude (m)			
Species	**Timber-line**	**Krummholz**	**Tree**	**Species Limit**
Pinus sylvestris	**545**	Domin <5	**810**	**≥1020**
Betula pubescens	**735**	**870**	**810**	**≥1020**
Sorbus aucuparia	Domin <5	NA	**735**	**925***
Picea abies	Domin <5	Domin <5	**510***	**925**
Alnus incana	Domin <5	**735**	**480**	**735**
Populus tremula	Domin <5	NA	**600**	**600**
Prunus padus	Domin <5	NA	**450**	**450**
Salix caprea	Domin <5	NA	**805**	**805**
Salix shrub spp.	NA	NA	NA	**925**
Juniperus communis	NA	NA	NA	**≥1020**
Betula nana	NA	NA	NA	**925**

Table 1. Maximum recorded altitude of trees and key shrub species in surveyed plots. Timberlines and krummholz belt shown only for plots where species Domin > 5. A tree is defined as an individual with a height >2m.
*Recorded at higher elevations at the field site, outside plots.

Figure 5. High-altitude trees at Kjerringafjellet. Left: *Sorbus aucuparia* sapling 1050 m asl. at the summit of Kvasshovden. Right: Highest tree forms of *Betula pubescens* and *Pinus sylvestris*, 810 m asl at plot D1.

Montane Shrubs

At the field site willow species occurr across the full spectrum of the broad mountain woodland category, as well as in bog and alpine plots. Along with *J. communis*, montane willows (including *S. lanata* and *S. lapponum*) occurred in mixed communities *with B. pubescens* and even *Picea abies.* This suggests the poor representation of montane willows in NVC communities may not be a product of their having a particularly restricted niche, but simply due to the very limited fragments found in the Highlands. With a larger seed source and reduced browsing pressure new communities may develop across the Scottish Highlands which challenge our expectations of where these species can thrive.

The restricted distribution of *B. nana* at the field site (present in 3/27 plots) is in accordance with claims that it is less widespread in oceanic climates (Horsfield and Thompson, 1997). However, *B. nana* was not recorded in bog vegetation on deep peat. This provides further evidence that blanket bogs constitute a refuge for the species, and it may be better adapted to growth on mineral soils (Gilbert, 2011).

One surprising finding is that in the possible natural scenario, several tree and shrub species would be expected to occur above the upper limit of montane shrub-dominated vegetation (Figure 5). At Kjerringafjellet, not only *J. communis*, *S. reticulata* and *S. herbacea* but also *B. pubescens, P. sylvestris, Picea abies* and *Sorbus aucuparia* were all recorded above 900 m asl. Both *B. pubescens* (1020 m) and *Salix caprea* (805 m) occurred at higher altitudes than had been recorded in the UK until 2022 (Figure 5; Watts, 2023). This suggests reducing browsing pressures could make small, high-altitude trees more common in alpine habitats across the Western Highlands.

Conclusion

This study draws on comparisons with Western Norway to inform understandings of the "possible natural" state of mountain woodlands in the Western Highlands under sustained reductions in browsing pressure. Through the application of a new rule-based modelling approach based on empirical data from a climatic analogue in Norway, this study outlines a possible natural scenario for Corrour Estate. As the potential for mountain woodland restoration gains traction across the Scottish Highlands, this research could provide a new line of evidence to guide restoration efforts.

Future research should develop this approach with a larger dataset derived from multiple areas of Southwest Norway, including areas exposed to a windier and more oceanic climate. With the

development of more robust rules and a statistical approach to model validation this approach could be used to map the potential distribution of mountain woodland across the entire Western Highlands. In the meantime, I hope it's a useful illustration of the alternative 'possible natural' landscape which could develop under reduced grazing pressure.

This research would not have been possible without funding from the Henrietta Hutton Research Grant, BSBI Plant Study Grant and fieldwork assistance from Julia Stewart. Dissertation supervisor, Dr. Ian Lawson, University of St Andrews.

INNES MANDERS *recently, successfully, completed this research at the University of St. Andrews. He is now pursuing work surveying montane willow populations and hopes to return to research on mountain woodland. His full dissertation A Possible Natural Scenario for Mountain Woodland in the Western Highlands is available at: https://universityofstandrews907-my.sharepoint.com/:b:/g/personal/im206_st-andrews_ac_uk/EZ6NcSRFKK1Mu7XObdAszJsBJBQ-OPdD4YhpJP6GODEGuQ?e=HZ06g6*

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The SUPERB Project: Upscaling Forest Restoration

by Daniele Ferarreto, Tom Locatelli and Bruce Nicoll

SUPERB (Systemic solutions for upscaling of urgent ecosystem restoration for forest-related biodiversity and ecosystem services) is a European forest restoration project funded by the EU Horizon 2020 Research and Innovation Programme to restore thousands of hectares of forest landscapes across Europe.

SUPERB will build on the vast but scattered practical knowledge and lessons learned from successful and unsuccessful forest restoration and adaptation activities and synthesise them for future action. The project features 12 large-scale demos in 12 countries, representing various challenges and stressors on European forests and a wide range of necessary restoration actions. The overall aim of the project is to implement country-specific restoration activities in partnership with local communities, landowners, and other partners.

Queen Elizabeth Forest Park (QEFP) in the Loch Lomond and Trossachs National Park was chosen as the demo area for Scotland. QEFP is owned by the Scottish Government and managed by Forestry and Land Scotland (FLS), an associate partner in SUPERB and acting as the sub-contractor chosen to carry out three different restoration actions in the DEMO area:

1) expansion of continuous cover forestry to promote higher species and structural diversity in conifer stands that were originally managed as clearfell – replant silvicultural systems;
2) development of a natural flood management area, where conifer species are removed from riparian zones, and native broadleaf species are planted and established, in addition to various timber engineering solutions to slow peak stream flow (leaky dams and timber bunds built with timber sourced in situ).
3) high elevation planting: expanding the forest above the current treeline with native broadleaf and montane tree and shrub species to enhance biodiversity and reduce soil erosion and landslide risk.

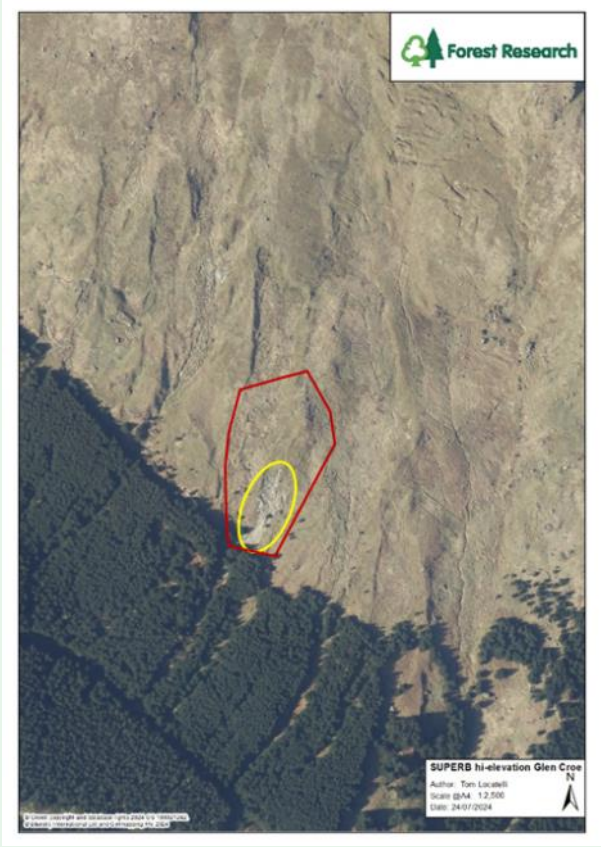

Figure 1. High elevation planting area (red polygon) and landslide area (circled in yellow).

Figure 2. View from SUPERB project high elevation planting site in Glen Croe.

The objectives of SUPERB extend beyond showing the potential of these restoration activities through the demo area. The project aims to define the potential for upscaling these restoration actions to suitable areas across Scotland.

High elevation planting plan at QEFP

The SUPERB high elevation planting site is located on a hillside in Glen Croe, above the A83 trunk road, approximately 3 kilometres west of Arrochar, Argyll (Figure 1). The site is located on a steep, southwest facing slope of the Cobbler, not far from the similar "Rest and be thankful" site. A landslip occurred on 21st February 2022, the source being approximately 65m above the existing conifer treeline within an immature gully.

The initial planting by FLS will be limited to a 2-ha section which is regarded as most unstable and will be used to assess working methods to inform planting over a wider area. The planting mixture will mainly include willow and common alder in the area affected by a still active landslide. Two buffer zones surround the designated area to the side and above the landslip area. The innermost buffer zone will include a 10% proportion of minor species (likely blackthorn and hawthorn). The external buffer zone will be planted with sessile oak (40%), common alder (40%) and minor tree and shrub species with a range of rooting structures. These species choices aim to stabilise the soil and mitigate the effects of surface and sub-surface water flow effects on the moraine. Plants have been produced in FLS nurseries from seeds gathered where possible in the surroundings of Loch Lomond and Loch Katrine. The core area will be planted with a density of up to 3100 stems per ha, with the density reduced to about 1600 stems per ha in the buffer areas.

The area will not be fenced to protect trees from browsing as deer are not considered to be a high risk in the area, however small square netting will be used to prevent browsing sheep. Due to the instability of the area, hessian matts will be adopted to provide surface protection and aid vegetative regrowth in areas with signs of erosion and creep. They will not be used over the entire area, to allow comparison of their effect with uncovered areas. Willow cuttings will be collected from local shrubs, identified within the conifer block below and along the forest road. The props will be put into the hessian matts as stakes to reinforce the soil, and will coppice from there.

Conclusion

SUPERB recognises local stakeholders as being key to successful restoration. Local communities, private landowners, municipalities, state forests, forest and nature agencies, restoration SMEs, and NGOs are an essential component of future restoration upscaling and management. Separate workshops were held in the demo area in November 2022 and November 2023, when

the views and visions of the stakeholders of the three proposed restoration activities were collected. Stakeholder contributions are used to inform restoration actions and to identify barriers and enablers to upscaling forest restoration to other areas of Scotland. Forest Research is currently planning a meeting to be held in November 2024 where key policy decision makers will be invited to discuss future strategies for forest restoration and indicate which they would prioritise to remove some of the barriers. Some of the monitoring activities and the work with the stakeholders will continue beyond the duration of the SUPERB project under the EU Horizon Europe FORWARDS project (forwards-project.eu). More on the SUPERB demo restoration activities, project objectives and outcomes can be found here.

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The Highland Nymph *Callisto coffeella*, a montane willow specialist moth on the edge of extinction in the UK

by Patrick Cook

The Highland Nymph *Callisto coffeella* (more affectionately known as the Alpine Coffee Moth) is the only moth in the UK that is a true montane willow specialist. This stunning leaf-mining micro-moth, only a few millimeters long, is a member of the Graciilaridae family. The larval stage is associated with smooth leaved willows with both Dark-leaved Willow *Salix myrsinifolia* and Tea-leaved Willow *Salix phylicifolia* documented as hostplants in the UK. In continental Europe, including the Alps and Scandinavia, further willow species have been documented as hostplants including Mountain Willow *Salix arbuscula*, Creeping Willow *Salix repens* and *Salix glabra*. Initially the moth caterpillar feeds on the leaves of the willows in small blister mines. The caterpillar feeds internally creating a crease of the underside of the leaf, similar to a crinkled crisp, and a slight distortion to the upper surface (Fig. 1). During later instars it emerges from the mine but remains on the leaf in the fold which it creates with silk (Fig 2). Once feeding has finished the caterpillar forms a papery cocoon in the fork of a willow twig (Fig. 3) where it over-winters before emerging as an adult the following year in June.

Figure 1. Leaf mine

Figure 2. Folded leaf

Figure 3. A suitable looking Cocoon

The moth was initially discovered by Bob Palmer in June 1983 in Glen Callater when an adult landed on the rock next to him whilst having his lunch. What a superb way to find a new species to the UK! Subsequent searches found the moth in other locations in Glen Callater and also in Glen Clova. *Callisto coffeella* has always been rare, known from just these two glens in the UK, but wasn't considered under any imminent threat. In his seminal paper about the moth in the Entomologist's Gazette in 1993, Keith Bland describes the species occurring across ten monads in these glens and wherever suitable montane willows were present. Records for the moth continued until 2003 which as far as I am aware was the last year individuals were recorded from either glen.

We began surveys for the species in 2022 and 2023, mainly out of personal interest, to see an interesting montane species. It immediately became apparent however that something had changed in the intervening 20 years since the last record. In many of the old haunts where the species had been recorded, we were struggling to find suitable willows. It was apparent that severe over-browsing by deer had reduced or in some instances completely destroyed the habitat. The palatability of *Callisto coffeella's* main foodplant, *Salix myrsinifolia*, likely made it an early casualty to the increasing deer numbers across the two glens.

The situation for the moth was looking increasingly perilous and concern was growing that it could have gone extinct in the UK. Personal searches quickly became formal surveys. In 2024, surveys for cocoons and leaf mines were planned. With the help of various montane willow experts, a targeted search was made in April to a promising area of Glen Clova (Fig. 4). The search involved looking for the distinctive cocoons. Upon accessing the site around 15 suitable looking cocoons (Fig. 3) were located on *Salix myrsinifolia*. Hopes were raised the species was indeed still present and hadn't gone extinct! Later in the year in mid-end of July, surveys to find

the larval feeding signs were carried out. Both the blister mines (Fig. 1) and leaf folds (Fig. 2) were located and we were even lucky enough to see a caterpillar in the process of creating a fold. We believe these photos are amongst some of the first documenting the early life stages of the species. It is critical to record both these stages to prevent any confusion with Phyllonorycter leaf mines or the often-abundant folds made by montane willow feeding sawflies.

Figure 4. Searching for the pupae in Glen Clova.

Finding the moth required several years of survey effort and it was excellent to confirm its continued presence in the country. The situation remains perilous however as the moth is known from only a single small habitat patch with a population of perhaps as few as 30-40 individuals. There is an urgent need to increase the habitat area of the species to allow it to expand from this low ebb. This includes increasing host plant availability and control of deer numbers to levels to allow natural regeneration of willow populations. There is also hope, given the remote haunts of the moth, that further populations will persist on ledges or isolated trees, inaccessible to surveyors, in the two known glens. There is also a very real possibility of finding new colonies in areas where natural montane willow populations have persisted and surveys in these areas will be a high priority in 2025. This stunning wee moth is currently on the brink but by working with various partner organisations, Butterfly Conservation Scotland is hopeful the moth will have a brighter, more willow filled future!

I am incredibly grateful to all the individuals who have given their time to help with the surveys, for providing advice and taking photos. In particular I wish to thank Paul Brookes, Sarah Watts, Billy Dykes, Bethia Pearson, Richard Marriott and Mark Young for going above and beyond with their help and time.

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