MOUNTAIN WOODLAND ACTION GROUP

Scrubber's Bulletin 14

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

The current members of the group are:

Diana Gilbert (Chair)	individual member
Philip Ashmole	Borders Forest Trust
Phil Baarda	NatureScot
David Blair	Cairngorms Connect
Mick Drury	Trees for Life
Izzy Filor	John Muir Trust
John Holland	Scotland's Rural College
Peter Livingstone	Eadha Enterprise
Peter Lowe	Woodland Trust Scotland
David Mardon	individual member
Richard Mason	RSPB
Richard Thompson	Forest and Land Scotland
Andrew Warwick	National Trust for Scotland
Alistair Whyte	Plantlife

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We are most grateful to the authors for their contributions to this issue, and we're always keen to receive articles for future editions. Please contact **http://www.msag.org.uk/contact.html** for more information and submission details.

This issue compiled by:

Phil Baarda, NatureScot (formally SNH),
Great Glen House, Leachkin Road, Inverness IV8 8NW
phil.baarda@nature.scot 01463 725 208 07483 251514

Photos are by the individual authors, unless otherwise stated.

Island on Loch nan Eun. (Photo by Alan Watson Featherstone) (from Scrubbers 11)

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Update from the Chair
Diana Gilbert

As the most surreal spring/summer & autumn of my lifetime draws to a close it is interesting to reflect on the Montane Scrub Action Group, or, as we agreed in 2019 to change our name to the 'Mountain Woodland Action Group' (& so MWAG, rather than MSAG): what have we achieved and where are we going?

Over 2019 we reviewed our twenty-four years and developed a forward plan[1]. The name change came from that process and recognises that our focus is the full treeline ecotone, including all the woody vegetation types that might occur, but that we have struggled to shift the emphasis from the rarer willows and dwarf birch. The review acknowledged that Scotland is a state of flux in relation to land use and biodiversity conservation but as the MWAG we need to stay abreast of developments and link into the key processes through whatever channels are open to us. While the Scottish Government (SG) has still to publish their proposals for future biodiversity protection post-Brexit, and the debate around upland land management and the control of native wild animals (red deer and mountain hares in particular) continues, the abnormal circumstances for many organisations, and individuals, has potentially provided time for reflection and consideration. We still await the SG response to the Deer Advisory Group's report[2], published in January. We are particularly keen to see the reaction to part 6 'Refocused Approach', which opens the door to vegetation-sensitive (rather than deer number-based) management.

Our suite of 5 Best Practice Guides[3] is now widely known and being used by practitioners. The next step is to more effectively sell the vision to a wider group of potentially sympathetic land owner. As a result the MWAG has now expanded and welcomed members of staff from a number of Scotland's key membership-based land-owning charities. As well as those with specific knowledge and expertise of the habitat this expansion will facilitate knowledge exchange and better enable us to influence incentives and practical activity to improve the chances of restoration or new establishment projects achieving their goals.

To achieve wider promotion we need to better articular the wider public benefits that an expanded, functioning treeline-ecotone will bring. This should provide the evidence to support the continued inclusion of specific incentives for land owners to undertake suitable projects. We would welcome sight of any evidence readers are aware of.

Deer management is just one of the elements of upland land-use which has serious consequences for the future of a healthy treeline ecotone rich in wildlife. The Perth College 'Challenging Upland Futures' conference, scheduled for September 2020, has inevitably been postponed but keep your eyes open for a new date in Spring 2021. Meanwhile the BES annual meeting has moved on-line and promises a really interesting range of very relevant talks so check out the 'Festival of Ecology'[4].

[1] http://www.msag.org.uk/uploads/4/0/7/3/40732079/msag_2019_forward_plan.pdf
[2] https://www.gov.scot/publications/the-management-of-wild-deer-in-scotland-deer-working-group-report/
[3] http://www.msag.org.uk/best-practice-guides.html
[4] https://www.britishecologicalsociety.org/events/festival-of-ecology/

We wish you a peaceful, safe winter from the MWAG.

Diana

Diana Gilbert, PhD, is an Upland ecologist with 30 years' experience working in the Highlands focussing on upland vegetation, particularly montane scrub, treelines and upland woodland. She initiated the MWAG in 1996. Since then, she has undertaken specific montane scrub research and continues to survey & advise on upland vegetation ecology.

gilbertdianaj@gmail.com

Note from the Editor – S turns to W

Don't be alarmed… S and W don't refer to shifts in El Niño wind patterns…

…as Diana's update highlights, the 'Montane Scrub Action Group' is now the 'Mountain Woodland Action Group' – hence MSAG to MWAG. However, the website will remain **http://www.msag.org.uk/** – for the time being at least.

Note from the Editor – Silver Scrub!

Similarly, alarm-ye-not, 'silver scrub' is not a new novel plant disease…

The Mountain Woodland Action Group was formed at a seminar at NatureScot's Battleby office on 27th March 1996 – as highlighted in the inaugural Scrubber's Bulletin issued in Winter 1996/7[1]. Those readers inclined to mathematically-numerate significances will note that March 2021 will be the Twenty-Fifth anniversary of the MWAG and the start of mountain woodland and montane scrub's ascendency into land management recognition and prominence in Scotland.

This landmark requires marking in some way! Though what? Please contact us with any ideas on how to celebrate this incredible milestone of the wee trees…

[1] http://www.msag.org.uk/uploads/4/0/7/3/40732079/scrubbers-bulletin-1.pdf

Phil Baarda is an ecologist who has been involved in land management in Scotland for the last couple of decades - the last 15 years of which with Scottish Natural Heritage (now NatureScot).

phil.baarda@nature.scot

Plantlife and Important Plant Areas

Alistair Whyte

Across the globe, plant species and the important habitats that sustain them are disappearing at an accelerating pace. The Important Plant Areas (IPA) Programme is a means of identifying the best sites for wild plants (higher and lower), fungi and their habitats using 3 consistent criteria, threatened species, botanical richness and threatened habitats.

Important Plant Areas are globally significant sites for wild plants and threatened habitats. Identified at a national level, they provide a framework for implementing target 5 of the CBD Global Strategy for Plant Conservation (ensuring the protection of at least 75% of important areas for plants) and are a vital tool in conserving wild plants and their habitats in situ. Plantlife is actively campaigning for a new global strategy for plant conservation from 2020 onwards.

IPA identification is intended to inform and underpin existing international, regional and national conservation programmes and legislation. Ultimately the aim is that IPAs will act as a benchmark for determining whether the strongest protection, under any existing legislation, is being afforded to the most important sites for plants.

IPAs contribute to the following Global and European agreements and initiatives:

- UN Sustainable Development Goals
- Convention on Biological Diversity (CBD)
- CBD Global Strategy for Plant Conservation
- Pan European 'Environment for Europe' Process (PEBLDS, PEEN, High Nature Value Farmland, the Aarhus Convention)
- RAMSAR Convention
- European Strategy for Plant Conservation
- EU Habitats & Species Directive, Natura 2000 network
- EU Water Framework Directive
- Bern Convention & Emerald Network

Plantlife leads on the identification of, and conservation of, IPAs in the UK. They allow us to target our resources and direct our work to where it will have the greatest impact. We want to see IPAs in good condition, and we want to ensure that they are protected.

Scotland is home to 47 IPAs, covering 698,703ha between them, 9% of the entire land cover. Scotland's IPA network includes large mountain ranges, entire islands and coastal regions. Over 60% of the Scottish IPAs have an area of 1,000 or more hectares. Caithness and Sutherland Peatlands, Cairngorms and the West Coast IPAs are all larger than 100,000ha.

Three Scottish IPAs have no SSSI protection. These are the Isle of Cumbrae, Beinn Bheigier on Islay, and Clearburn Loch in the Scottish Borders. 18 IPAs have a 100% overlap with SSSIs and a further 9 IPAs have a >80% SSSI overlap. The remaining 17 IPA's overlap with SSSI ranges from 25% to 67%.

Over the last year, Plantlife Scotland have been working with NatureScot and other partners to assess the condition of IPAs. Because we have been using NatureScot Site Condition Monitoring data, we can only do this with some degree of confidence when we can accurately match individual IPA features to SSSI features. The fact that some IPAs are only partly, and in a few cases, not at all, covered by SSSI legislation, has made this a patchy exercise, but it's a start.

From this analysis, we can see that 50% of IPA features which correspond to SSSI features are assessed as being favourable declining, unfavourable declining, unfavourable no change or unfavourable recovering. Of these, only 10% are unfavourable recovering. We looked at the pressures behind these results. The most significant pressure is over-grazing, which affects a total of 121 individual IPA features. Upland oakwood, upland assemblages, blanket bog and native pinewoods are among the habitats most threatened by overgrazing. Non-native invasives are also a highly significant threat. This is likely to be linked to the large West Coast of Scotland IPA, with its high number of features. This habitat is under significant pressure from invasive *Rhodedendron ponticum*, and it is probable that this makes up a large proportion of the threats in the analysis. It is notable that undergrazing is also a significant threat for upland assemblages.

We're aware that, due to SCM methodologies, we're missing certain pressures which are likely to be impacting on plant populations. One of these is nitrogen deposition, which we think is causing significant change to plant communities, particularly in the uplands. We have mapped nitrogen deposition levels within IPA boundaries, for different habitat types, and the next stage of our work will be to look at those areas which appear from this mapping to be most at risk from nitrogen deposition. This year, we want to ground-truth some of these predictions.

We have a good understanding of the species and habitats which make up each IPA, which means that we can target our work according to both our priorities and those of our partners. Several IPAs contain montane scrub. For example, an analysis of our IPA database indicate five IPAs for which 4080 Sub-Arctic Salix spp. scrub is recorded as a criterion c (threatened habitats) feature.

Plantlife is keen to work with partners to conserve and restore IPAs. We know that 11 IPAs are wholly or partly within RSPB reserves, 6 are associated with National Trust for Scotland sites, and 5 overlap at least partly with Scottish Wildlife Trust reserves. Other key partners with IPAs within their landholdings are John Muir Trust and Forestry and Land Scotland.

Plantlife takes action within IPAs through projects such as our Cairngorms Wild Plants project and Secrets of the Celtic Rainforest. We're actively looking for partners for new projects. If you would like to work with us on the conservation and restoration of Important Plant Areas, we'd like to hear from you!

Alistair Whyte is Head of Plantlife Scotland, which works across the country to promote the conservation of wild plants and their habitats. Current work includes projects in the Cairngorms, on Atlantic woodlands, and in the Flow Country.

Alistair.Whyte@plantlife.org.uk

Surveying *Salix myrsinites* (with galls and catkins) at Beinn Bhrotain in the Cairngorms IPA (photo: Diana Gilbert)

Grazing exclusion and vegetation change in an upland grassland with patches of tall herbs

Sarah H. Watts

In 2000, an electric deer fence was erected around 180 ha at Creag an Lochain in the Ben Lawers Natural Nature Reserve, Scotland (Photo 1). Owned and managed by the National Trust for Scotland, this upland site in the Southern Highlands is part of a Special Area of Conservation which is arguably the most important location in Britain for arctic-alpine flora. Creag an Lochain contains a large, complex crag system with ledges inaccessible to sheep and deer on which trees, shrubs and tall herbs grow. Prior to 2000, these contrasted with the grazed ground below where grasses were dominant, and the only tall plants present were either spiny or toxic. The fence was intended to exclude large herbivores from the hillside and facilitate the restoration of threatened plant species and habitats which had been suppressed by overgrazing. It has been a key part of the long-term pioneering montane scrub restoration work currently ongoing at Ben Lawers, allowing large-scale tree planting to be undertaken without the impact of sheep and red deer.

Photo 1: The tall herb community thriving below a section of crags within the fence at Creag an Lochain, Ben Lawers NNR.

It was also hoped that removing these large herbivores from the site would promote the expansion of the tall herb community from patches on ledges into the calcareous grassland adjacent to the cliffs. This is a mix of tall, grazing-sensitive luxurious broad-leaved flowering plants which is found throughout upland Europe but currently has an unfavourable conservation status. It is a ground flora that can form an intimate mosaic with montane scrub and in which much of the upland *Salix* spp. planting at Ben Lawers has been carried out.

In this study, we investigated how the vegetation has changed within the Creag an Lochain fence after 18 years and whether one of the desired outcomes, an increase in tall herbs, has been achieved. The results will also have a direct impact on the conservation and restoration of other communities at the site, including montane scrub.

In 1999, one year before the fence was built, nine transects were established running downhill from the base of the crags to the Lochan na Lairige reservoir below (Photo 2)

Photo 2: Some of the flowering plants featuring in the restored tall herb community at Creag an Lochain, Ben Lawers NNR (*Filipendula ulmaria, Valeriana officinalis, Cirsium heterophyllum, Cirsium palustre* and *Silene dioica*).

The presence and abundance (estimated percentage cover) of all vascular plant species were recorded in sixty-three 2×2m study plots positioned at 30-m intervals along these lines. This was then repeated in 2017 using the exact same plot locations as 1999 (Photo 3).

Photo 3: Tall herb study plot being set up at the base of a crag in Creag an Lochain in 2017.

The data analysis has revealed that although species diversity remained constant and the total number of species (richness) declined slightly between 1999 and 2017, the average number of tall herb species present in the plots increased significantly (Table 1). There was a large expansion in tall herb cover (+29.67%) and a corresponding decrease in grass cover (-26.16%), as well as smaller increases in bryophytes and small herbs and a reduction in bare ground (Figure 1). The only species group to show no significant change was sedges and rushes. Detrended correspondence analysis (DCA) showed that the composition of plants moved from a typical upland calcareous grassland (NVC habits CG10, CG11 and U4) towards a tall herb community (NVC U17).

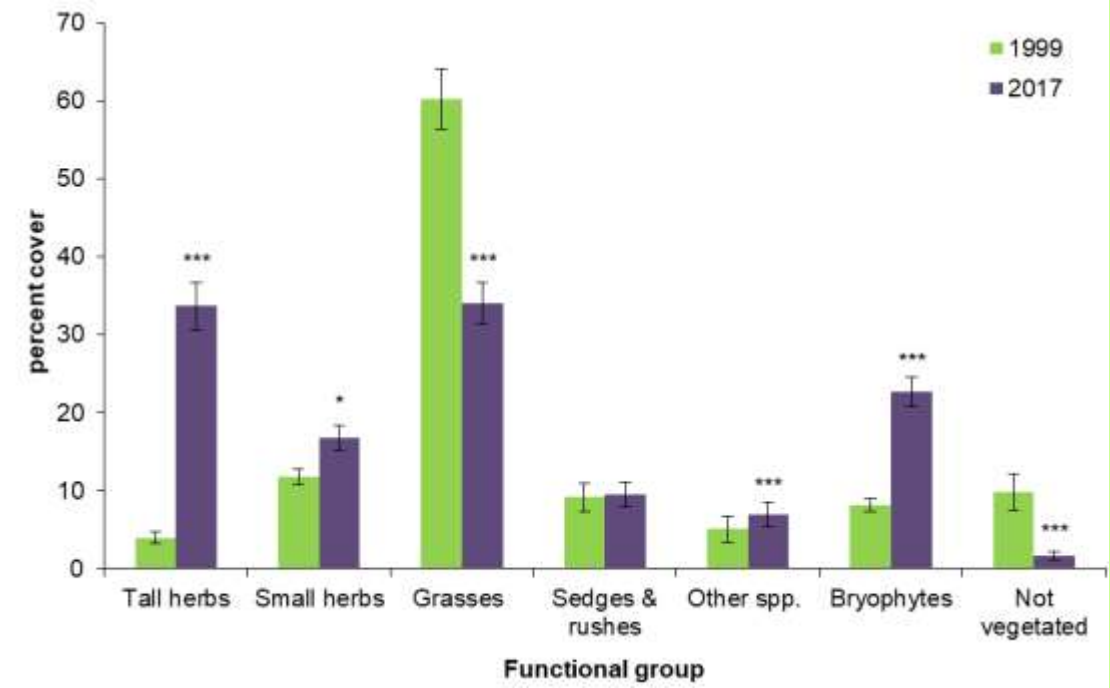

Figure 1: The mean percent cover of species groups in the 1999 baseline and 2017 resurvey of the tall herb transects at Creag an Lochain. 'Other spp.' includes pteridophytes, trees and shrubs. Significant differences between surveys: **P*<0.05, ****P*<0.001. Error bars = 1SE.

Amongst the individual species exhibiting the greatest increase in cover were seven tall herbs (*Luzula sylvatica*, *Alchemilla glabra*, *Filipendula ulmaria*, *Angelica sylvestris*, *Geum rivale*, *Rumex acetosa* and *Heracleum sphondylium*), and the taller and shade-loving grasses (*Holcus mollis*, *Deschampsia cespitosa* and *Deschampsia flexuosa*). However, there were large declines in grazing-tolerant grass species (*Anthoxanthum odoratum, Nardus stricta*, *Agrostis* spp. and *Festuca* spp.) and low-growing, rosette-forming or annual herbs (including *Alchemilla alpina*, *Prunella vulgaris*, *Trifolium repens*, *Scorzoneroides autumnalis, Taraxacum* agg. and *Euphrasia* agg.) which require gaps in the vegetation to survive. Understory species (for example *Anemone nemorosa* and *Oxalis acetosella*) capable of growing in the lower light levels created by the proliferating tall herbs had thrived. In fact, the mean Ellenberg values of the plots indicated a trend towards species tolerant of shadier, wetter, more fertile conditions and with a higher pH requirement (Table 1).

	1999 mean	2017 mean	Change	*P*-value
Tall herb sp. richness*	3.14	6.06	+2.92	**<0.001**
Total number of sp. (richness)	25.89	24.06	-1.83	**0.040**
Diversity (Shannon-Weaver)*	2.14	2.23	-0.09	0.056
Ellenberg light (*L*)	6.78	6.64	-0.14	**0.005**
Ellenberg wetness (*F*)	5.60	5.90	+0.30	**<0.001**
Ellenberg pH (*R*)	4.51	4.70	+0.19	**0.013**
Ellenberg fertility (*N*)	3.15	3.36	+0.21	**0.009**

Table 1: Changes in plot mean species richness (number of species), Shannon-Weaver diversity index, and cover-weighted Ellenberg scores between the 1999 baseline and 2017 resurvey of the tall herb transects at Creag an Lochain. Significance tested using paired t-tests, except for categories marked *, which were tested using Wilcoxon signed-rank tests. *P*-values in bold are significant at the 5% level or less.

Competition for light, rather than resilience to herbivory, now has a major influence on the vegetation at Creag an Lochain, although there is no evidence of an overall negative impact on vascular plant community composition. However some rare bryophytes and lichens at the site are experiencing a loss of suitable open habitat, and bare soil niches for germination of montane willow seed may be lacking, which warrants further investigation. Nevertheless, we have shown that large herbivore removal can be used to aid the conservation and restoration of the grazing-sensitive tall herb habitat at upland sites where it was previously confined to cliff ledges.

This is a summary of the full paper of Watts *et al,* published in Applied Vegetation Science which can be found at https://onlinelibrary.wiley.com/doi/abs/10.1111/avsc.12438 or available from the author on request.

Sarah Watts is an ecologist specialising in upland vegetation, habitat restoration and applied science. As a former seasonal NTS ecologist (2013 – 2019), she worked at Ben Lawers NNR monitoring rare arctic-alpine species and plant communities. Sarah recently started a PhD at the University of Stirling studying montane scrub restoration.

s.h.watts@stir.ac.uk

Discussing Ben Wyvis's dwarf birch monitoring plots - MWAG field trip (remember them?); June 2019 (photo: Phil Baarda)

Developments in our Knowledge of the Scottish Uplands - Micromoths and Sawflies

Dan Watson & Keith P. Bland

In 1997 a paper on montane entomology (Bland, Entwistle & Horsfield, 1997) outlined some of the species associated with the tree-line and above. Here we consider aspects of our current knowledge of some montane species and how our understanding has improved. In short have we made any progress in the intervening 12 years or is the upland fauna still as elusive as ever due to our poor understanding? Without a knowledge of the life-history of a species little can be done for its conservation. Similarly, without knowing the distribution of a species we cannot assess whether it requires conservation.

Microlepidoptera (small moths).

In an article on Conserving Scottish Insects at the launch of the Initiative for Scottish Insects in 1994, a list was drawn up of all the Scottish microlepidopera that had not been seen for some time. Many of these species fell into the upland category. Three species had at that time just been rediscovered and additional information on their biology discovered, namely:

Species	Last seen	Rediscovered	Foodplant
Eana argentana	1920	1985	Probably polyphagous
Stenoptilia islandicus	1954	1993	*Saxifraga hypnoides*
Callisto coffeella	1984	1992	*Salix myrsinifolia*

Of these three only the boreomontane *Callisto coffeella* is directly associated with montane scrub, having been found only in Glen Clova, Glen Doll and Glen Callater. Although the Scottish records are all associated with *Salix myrsinifolia,* in other countries the larva is known to mine the leaves of *S. arbuscula, S. phylicfolia* and *S. repens* along with other willows which do not occur in Scotland. *Stenoptilia islandicus* (fig.1) is only known from a small area centred on Creag an Lochain near Ben Lawers. Creag an Lochain was enclosed in 2000 to benefit montane scrub and tall herbs. There was some concern at the time that the subsequent growth of vegetation could be detrimental to the sprawling *Saxifraga hypnoides*, but thankfully this has not been the case and recent searches have found the moth to be more widespread along the crags than was previously known, always close to patches of the saxifrage.

Subsequent efforts have led to the rediscovery of more of the species on the list and discovery of their biology:

Species	Last seen	Rediscovered	Foodplant
Kessleria fasciapennella	1851	2014	*Parnassia palustris*
Ethmia pyrausta	1853	2010	*Thalictrum alpinum*
Plutella haasi	1954	2002	*Arabidopsis petraea*

This has been real progress. In addition, several more well-known upland species have had their life-history clarified.

Sawflies (Symphyta)

Another group of specialist insects that occupy the montane region at and above the tree-line are the Sawflies. Several species of willow (*Salix* spp.) are predominantly restricted to these higher levels, namely *Salix arbuscula, S.herbacea, S.lanata, S. lapponum, S.myrsinifolia, S.myrsinites* and less strictly *S.repens.* Interestingly most of these species will grow well at lower elevations if planted but in nature are able to thrive high up. Most species of sawfly in the genera Euura and *Phyllocolpe* cause gall-formation on their *Salix* host-plants, and the development of the very specific chemicals that cause the gall formation has restricted them to a single host species.

The careful experimental breeding work of Jens-Peter Kopelke of Frankfurt has elucidated this high degree of species specificity and this allows them to be recorded from their galls – the adults are difficult for the non-specialist to separate and even challenging for the specialists. *Euura* species form leaf-galls that are either pea-shaped or sausage-shaped, while *Phyllocolpe* species deform the leaf into rolls or folds. One branch of the genus *Euura* form swellings on the twigs.

The current known gall-forming sawflies on upland willows in Scotland and their gall-form are shown as follows:

***Salix* species** [1]	**Pea-gall (*Euura*)**	**Sausage-gall (*Euura*)**	**Leaf-fold gall (*Phyllocolpe*)**	**Twig-gall (*Euura*)**
S.arbuscula	***arbusculae***	**-**	-	-
S.herbacea	***herbaceae & aquilonis*** [2]	-	-	-
S.lapponum	***samolad & crassipes*** [3]	***lapponicola***	***?acutiserra & plicalapponum***	-
S.myrsinifolia	***saliciscinereae***	***nigricantis***	***ischnocera***	-
S.myrsinites	***myrsiniticola***	-	-	-
S.repens	***collactanea***	-	-	***weiffenbachiella***

1. Taxonomy follows Liston *et al,* 2017 and biology abstracted from Liston *et al,* 2012.
2. Differ in colour of larvae.
3. Differ in gall form – *E.crassipes* bisected by leaf lamina such that 1/3 to 2/3; *E.samolad* not bisected by leaf lamina.

? Needs confirmation as a Scottish species.

Interestingly the two sawfly species, *E..glabrifrons* (pea-gall) and *E.lanatae* (bud-gall) which are monophagous on our rarest upland willow, *Salix lanata,* have still not been found in Scotland; neither has *E.reticulatae* which forms a pea-gall on *Salix reticulata*. In nearly all cases our knowledge of the distribution in Britain of all these sawflies is extremely poor, but as the table indicates their identification has now become more

simplified due to their monophagous tendency, and we also now have twice the number of species! Based on current knowledge some of these sawflies would appear to be very rare. For example, *Euura arbusculae* (fig.2) is only known from Creag an Lochain and the western slopes of Meall Corranaich, whilst *Euura myrsiniticola* (fig.3) is fairly easy to find on the *Salix myrsinites* on Meall Mor at Glencoe but appears to be unrecorded in many places where its foodplant occurs. It is rare to come across *Salix herbacea* without spotting pea-galls. These are most likely to be *Euura herbaceae*, but if you're keen you might find *Euura aquilonis*, which seems to be much the rarer of the two. Get searching, and you could discover one of Scotland's 'missing' species on *Salix lanata* or *Salix reticulata*.

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Keith P. Bland has been interested in natural history from an early age, which got him channelled into entomology – at first macromoths, then micromoths, then phytophagous flies and then…*etc.* Due to a Cumbrian childhood the uplands have always had an irresistible draw.

valannbland@gmail.com

Dan Watson is the NTS Ecologist for Ben Lawers NNR and Glencoe NNR, having a wide-ranging interest in natural history, particularly botany and moths. Galls are also of interest, mainly as obscure things such as sawflies can be identified relatively easily.

dwatson@nts.org.uk

Investigating the impacts of browsing on three mature species of montane scrub at Ben Lawers – *Juniperus communis, Betula nana* and *Salix myrsinites.*

Izzy Filor

Introduction

Understanding the effects of browsing on mature montane scrub species is of great importance to restoration projects. Practical land management decisions such as timing fencing removal or locating ideal transplanting sites will benefit from autecological research on these species.

This study focused on three species of montane scrub: dwarf birch (*Betula nana*), whortle-leaved willow (*Salix myrsinites*) and common juniper (*Juniperus communis*). The intensity of upland grazing restricts montane scrub to inaccessible crags, out of reach of grazing animals (Poore and McVean 1957, Thompson and Brown 1992). These remnant populations often comprise so few or gender-imbalanced plants that, without management intervention, their terminal decline is certain (SMWRG 2005, Borrell *et al,* 2018).

This study aimed to assess effects of browsing on mature species of *B. nana*, *S. myrsinites* and *J. communis*, using a pre-existing study site where these three species were planted in individual cages in 2007 (Photo 1). It is well known that grazing animals negatively affect young, regenerating saplings. However, this study aimed to address the unexplored effects of browsing on mature, previously ungrazed plants.

Photo 1: The study location and one of the remaining cages in situ on Meall Corannaich

Methodology

A study conducted by Diana Gilbert between 2007–9 as part of her PhD thesis explored the impacts of wind exposure and browsing on young *B. nana*, *S. myrsinites* and *J. communis* plants (Gilbert 2011). Saplings were planted on the slopes of Meall Corannaich (Ben Lawers NNR) between 2007–8 under herbivore-proof cages. Several of the cages were left on the hill at the end of Gilbert's study. This study made use of the three cages that remained (one of each species) although in the case of the *B. nana* cage, all plants had already died. Four additional uncaged plots contained remaining plants (all of these were *B. nana*), which were also measured. In total, 34 plants were studied.

Initial monitoring took place in May 2019 when remaining cages were removed and measurements of plants, surrounding vegetation and soil were taken. In September 2019, second measurements were taken, allowing four months for potential browsing.

Results

Linear modelling produced the most valuable results from the study. The changes seen in leader length after the four-month uncaged period are shown in figure 1. The mean leader length in caged plots reduced an average of 6.22cm over the four-month period. There was also a reduction in leader lengths in uncaged plots, but this was slightly smaller, with a mean leader length depletion of 4.16cm.

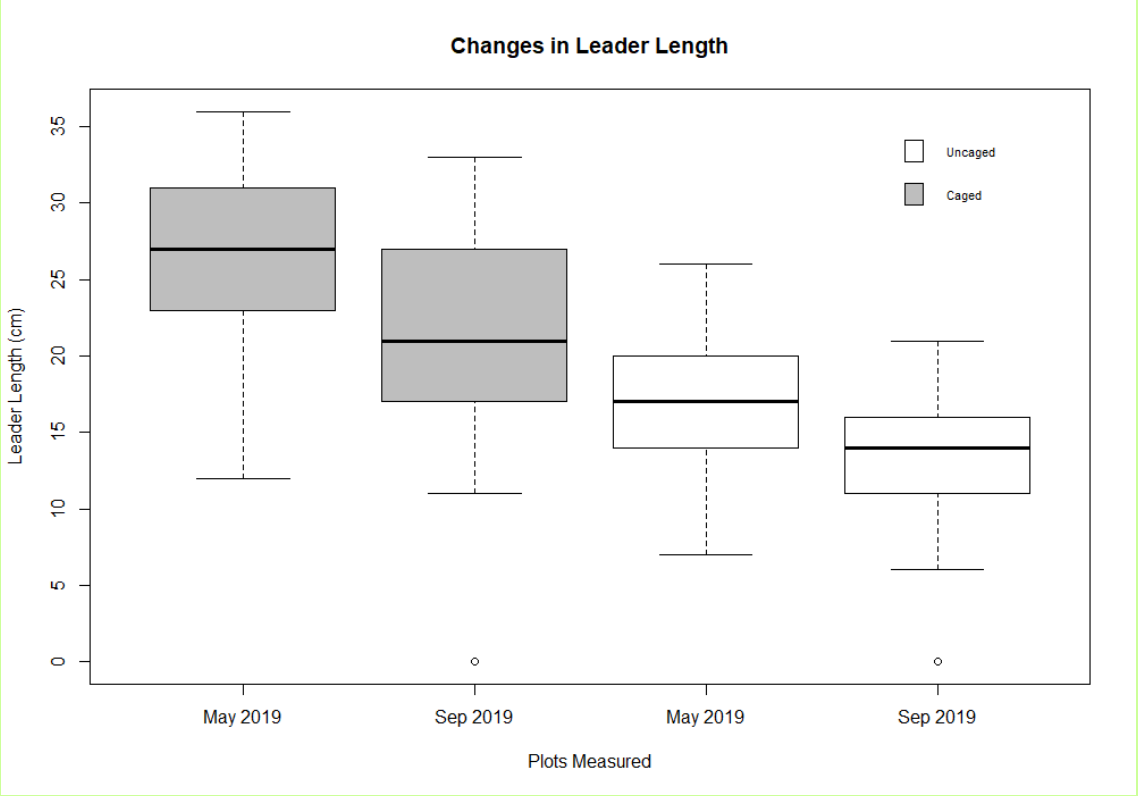

Figure 1: Boxplots showing the heights of leader stems, before cages were removed in May 2019 and four months later in September 2019. The bold line represents the median value, the whiskers, the extreme data points, with dots representing any outliers in the data (plants that died during the four-month period). The shaded boxes are caged plots, the white boxes uncaged.

Leader length changes for each species are shown in figure 2. All *B. nana* plots were initially uncaged, with a consistent browsing treatment throughout the four-month period. Conversely, as shown in map 2, both the *J. communis* and *S. myrsinites* sites were originally caged. Their results show the difference in browsing treatments over the four-month period. Mean losses for *J. communis* and *S. myrsinites* plots were far higher than for the uncaged *B. nana*, although leader lengths of all three species reduced.

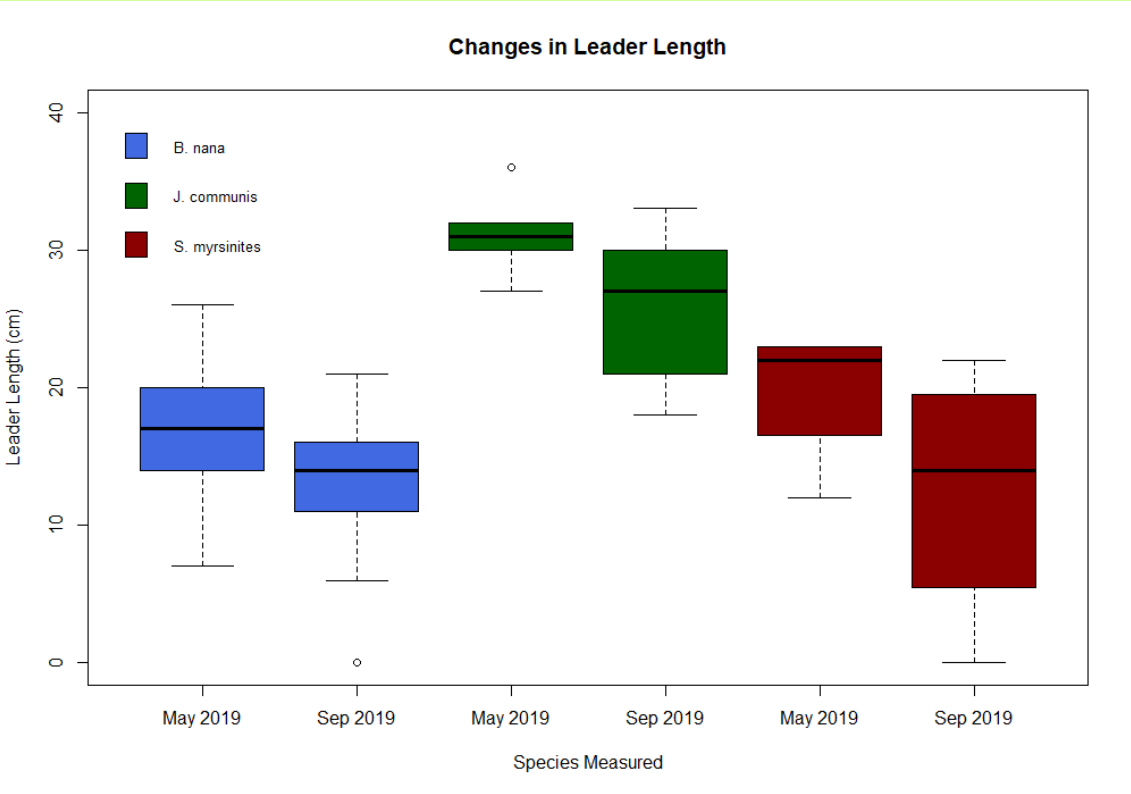

Figure 2: Boxplots showing the length of leader stems by species, before and after cages were removed. The bold line represents the median value, the whiskers the extreme data points and dots represent outliers in the data.

Discussion

Combined pressures of sheep and deer grazing at the cage study site at Ben Lawers resulted in significant plant losses over the 12 years since planting. Before monitoring in 2019, only 34 out of the original 270 plants remained alive.

The two cages that were still in place and contained plants (one *J. communis* and one *S. myrsinites*) proved the most interesting and allowed a direct unbrowsed/browsed comparison. However, neither of these species survived in uncaged plots – arguably highlighting the detrimental effects of overgrazing. Conversely, the four uncaged sites where plants remained alive all contained *B. nana*. The growth of uncaged *B. nana* was less than expected for 12 year-old plants (with a mean leader length of 16.84cm) although they appeared to be the only species able to withstand the site's grazing and environmental pressures (see figure 2). The third remaining cage contained *B. nana*, but all plants had died before the start of this study. These results suggest *B. nana* may

actually prefer grazed locations; however, this was contradicted in additional data collected from naturally-occurring Perthshire populations.

Previous literature on the effects of browsing on montane species is limited. However, Shipley *et al* (1999) concluded that, when accounting for energy and digestive losses, optimal bites of larger herbivores were small and from recent, non-woody growth. Results from this study contradicted their findings, as the two plots where cages were removed had a greater amount of stem eaten over the four-month period than uncaged plants. Mean leader length reductions for the mature, caged species were 5.4cm for *J. communis* and 7.25cm for *S. myrsinites*. The rapid destruction of these mature, woody plants at Ben Lawers would therefore suggest that herbivore bite sizes are perhaps less predictable than Shipley *et al* concluded.

Speed *et al* (2013) suggested that sheep grazing at lower elevations could benefit willow scrub growth. Sheep were found to preferentially graze other plants, reducing vegetative competition for the willows. At higher elevations due to a lack of alternative food, sheep grazing had a damaging effect on scrub. The lack of surrounding vegetation at the Ben Lawers site, which was predominantly overgrazed grassland would suggest it is best compared to Speed *et al*'s high elevation category. At Ben Lawers it appeared that herbivory was the biggest issue for scrub, likely due to the lack of alternative food for grazers.

The results over the four-month period showed an extraordinary amount of browsing on all plants. Photos taken in September 2019, after cages had been removed highlight the intense grazing at the site (see photos 2 and 3). When the cages were removed, visible grassy hummocks surrounded the plants, making plots visible from a distance. After the four-month period, the caged areas were unrecognisable; the vegetation indistinct in height from the surrounding area. The high grazing pressure seen during the summer months is contrary to the assumption of literature, which suggests grazing of tall-shrubs and scrub occurs towards the end of summer and during winter (Gilbert 2011). The data collected in this study, however, shows that grazing is a year-round problem, except in places where plants are protected by snow lie, inaccessibility or a wealth of alternative food.

Conclusions

Overall, it seems highly likely that grazing pressures are the greatest deterrent to these species (Scott, R. 1997, MacKenzie 2000, Richards 2009, Millard *et al,* 2001). Due to the small data set available for this study, future research on the impacts of browsing on mature planted species would greatly benefit land managers restoring these habitats. The surveyed *S. myrsinites* and *J. communis* plants had managed to survive in caged locations – but their survival looked highly uncertain after just four months without herbivore protection. To ensure the future viability of these montane plant populations in Scotland, a shift in upland land management practices will undoubtedly be crucial to their success.

Photo 2 (left): *J. communis* after four months without herbivore protection. **Photo 3 (right)**: *B. nana* which was uncaged before the study period. Both had been subject to intense browsing.

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Izzy Filor is currently the mountain woodland project officer for the John Muir Trust, based at East Schiehallion. This study was part of a larger piece of research for an MSc through the University of Stirling.

isobel.filor@johnmuirtrust.org

Dundreggan Estate Update

Jill Hodge & Mick Drury

Our team at Dundreggan continues to progress woodland creation projects on the higher ground of the estate. In 2018 we completed the Allt Ruadh native woodland scheme, up to 500m asl, funded through the FGS, planting 160ha of upland birchwood plus16ha through the Native Low Density Option. (See Scrubbers Bulletin 13 for a fuller description of the scheme). Much of the ground was machine prepared, using inverted mounds. The approved planting mix for the higher elevation area was 30% downy birch, 30% dwarf birch, 15% aspen, 15% juniper, 5% eared willow and the remaining 5% a mix of montane willows. We set up monitoring plots, in part to compare fertiliser treatments of rock phosphate v high phosphate granules. We also experimented with a mycorrhizal inoculant in some of the plots, this created from woodland soils on the estate. It's too early for results as yet, but many plants are establishing well.

Last year, 2019, we again used a NLD grant, to fence an area of 18 ha around 500m asl, at Beinn Bhan in the north-west of the estate. There is a small burn running through the exclosure with some patches of better alluvial soils; otherwise the soils are peaty podzols and deeper peats as usual. Altogether some 16000 plants went in here, a mix of pine, downy birch, rowan, aspen, juniper and five willow species ... eared, tea-leaved, creeping, downy and woolly, almost half of the willows as cuttings. In particular it will be interesting to see how the woolly willow does, thought to be more demanding of basic mineral soils. The planting was all done by hand by our Conservation Week volunteers. We used high phosphate granules and again set up mycorrhizal treatment plots, specifically for pine and downy birch this time.

In 2020 we will be planting up a large new montane exclosure at Dundreggan, funded through the first round of NatureScot's Biodiversity Challenge Fund. At 280 ha this will hopefully evolve into one of the largest areas of mountain woodland habitat in Scotland. Trees will be planted around Carn na Caorach (the 'sheep cairn') at an altitudinal range of 450-600m; as elsewhere on the estate there is already a good population of dwarf birch here.

Planting will be done by our volunteers again. There is potential for creating a higher elevation pinewood in places, with downy birch, rowan and some aspen. Otherwise plans are for trialling a variety of willows, as at Beinn Bhan, amongst a scatter of birches and juniper (Photo 1). As before, plants with mycorrhizal treatments will be included. We look forward to seeing ring ouzels, maybe bluethroat, on the estate in the future!

A recent public appeal has helped with this work, in particular the collection of seeds and cuttings from the rarer willows for propagation at our tree nursery, and funding the ecological monitoring programme. All the trees are coming from the nursery, now producing up to 80,000 each year. Montane willows, from a range of species and provenances, are being grown from seed stands which have been developed with a good range of genetic diversity. Some are grown for other sites and organisations,

including the NTS Mar Lodge Estate. Again our volunteers have a big role to play here, with some of the Conservation Weeks dedicated to nursery work, enabling less active folk to contribute. We welcome enquiries about growing trees for other restoration projects.

Photo 1: Volunteers planting willows in Dundreggan's Beinn Bhan (photo by Stephen Couling)

Jill Hodge is Dundreggan project co-ordinator at Trees for Life. Her work includes managing the tree nursery and organising tree planting on Trees for Life's Dundreggan estate in Glen Moriston

jill@treesforlife.org.uk

Mick Drury is Field Projects Co-ordinator for the charity Trees for Life. The TfL mission is the restoration of native forest in the Highlands, the ancient Caledonian Forest.

mick@treesforlife.org.uk

Montane woodland conservation on Mar Lodge Estate – an evolving process.

Shaila Rao

Background

Until recent years, the primary focus of woodland management on Mar Lodge Estate has been the regeneration of the native pinewoods in the glens. This is being achieved through a deer reduction process which started in 1995 and began to deliver visible results on the ground around 2009. It has been a long and at times contentious process of adaptive deer management but the fruits of our labour on the estate are now clear and dramatic to see. Both pine and broadleaved regeneration (within our regeneration zone) are now growing freely and spreading throughout the glens creeping up to higher altitudes (photos 1 & 2). However, one cannot be complacent and the hard work must continue should the potential woodland expansion on the estate be realised.

Photo 1: Scots pine regeneration, Glen Luibeg.

The conservation of montane woodland habitat and species such as juniper, willows and dwarf birch was little talked about in the early days. Should you have walked around Mar Lodge Estate in the late 1990s then most people would have struggled to notice that these species were present in the landscape unless they were spotted clinging on to a crag or overhanging a burn (photo 3). I'd often wondered why Mar Lodge didn't support the fantastic junipers that could be seen in Speyside.

Photo 2: Broadleaved regeneration, Mar Forest.

Photo 3: Downy willow overhanging the Allt Christie Mor.

Photo 4: Dwarf birch emerging from heather, Clais Fearnaig

However, little by little as the deer numbers came down we increasingly noticed junipers, willows and even dwarf birch slowly emerging out of the heather (photo 4). At first just one or two but over time these became more numerous and started to indicate to us that potentially we had a significant montane woodland resource on the estate but we just didn't know much about it.

The rising awareness of these species on Mar Lodge Estate coincided with an impetus in 2014 from David Hetherington at the Cairngorms National Park to develop a Cairngorms Montane Woodland Project. This project would bring land managers from around the Cairngorms together to try and develop work which would establish, and expand the montane woodland habitat. While this project as a whole did not take off, it definitely stimulated healthy discussions about the current distribution of montane woodland species, how this habitat could be expanded and what were the barriers to overcome. At Mar Lodge Estate we had a definite reluctance to throw ourselves into planting species such as juniper and willows particularly when we had little knowledge on the existing distribution or abundance of these species throughout the estate.

In 2016, NTS commissioned Great Glen Ecology to conduct a montane woodland survey of the ground from 50m outwith the edge of the existing pinewood up to 950m. The ground below this had already been surveyed separately. Over three years (2016-2018) 15,473ha of ground was surveyed (photo 5). North-south transect lines spaced 50m apart were walked and all montane woodland (scrub and trees) species within 2.5m either side of the transect line were recorded. The level of browsing present, height relative to the vegetation, likely browser and any other damage was also

recorded. The mat forming species (creeping willow and juniper) proved challenging to record as it was often difficult to identify individual plants. On such occasions these were recorded as 'clumps' and an estimate of percentage cover within each transect section was recorded.

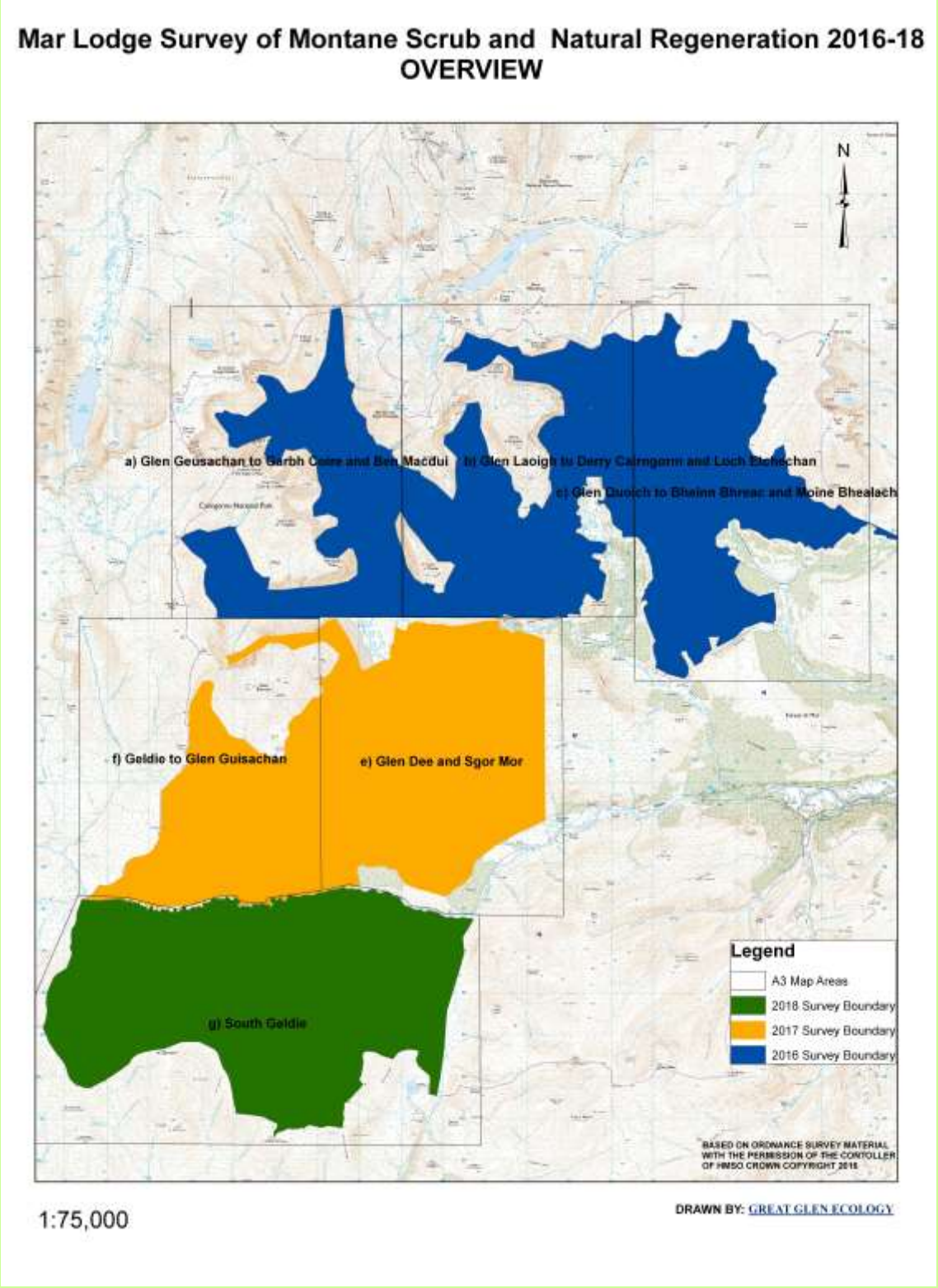

Photo 5: Overview of montane woodland survey areas

The survey data first and foremost showed us that generally montane woodland species were more widely distributed and more common than we had thought (photo 6).

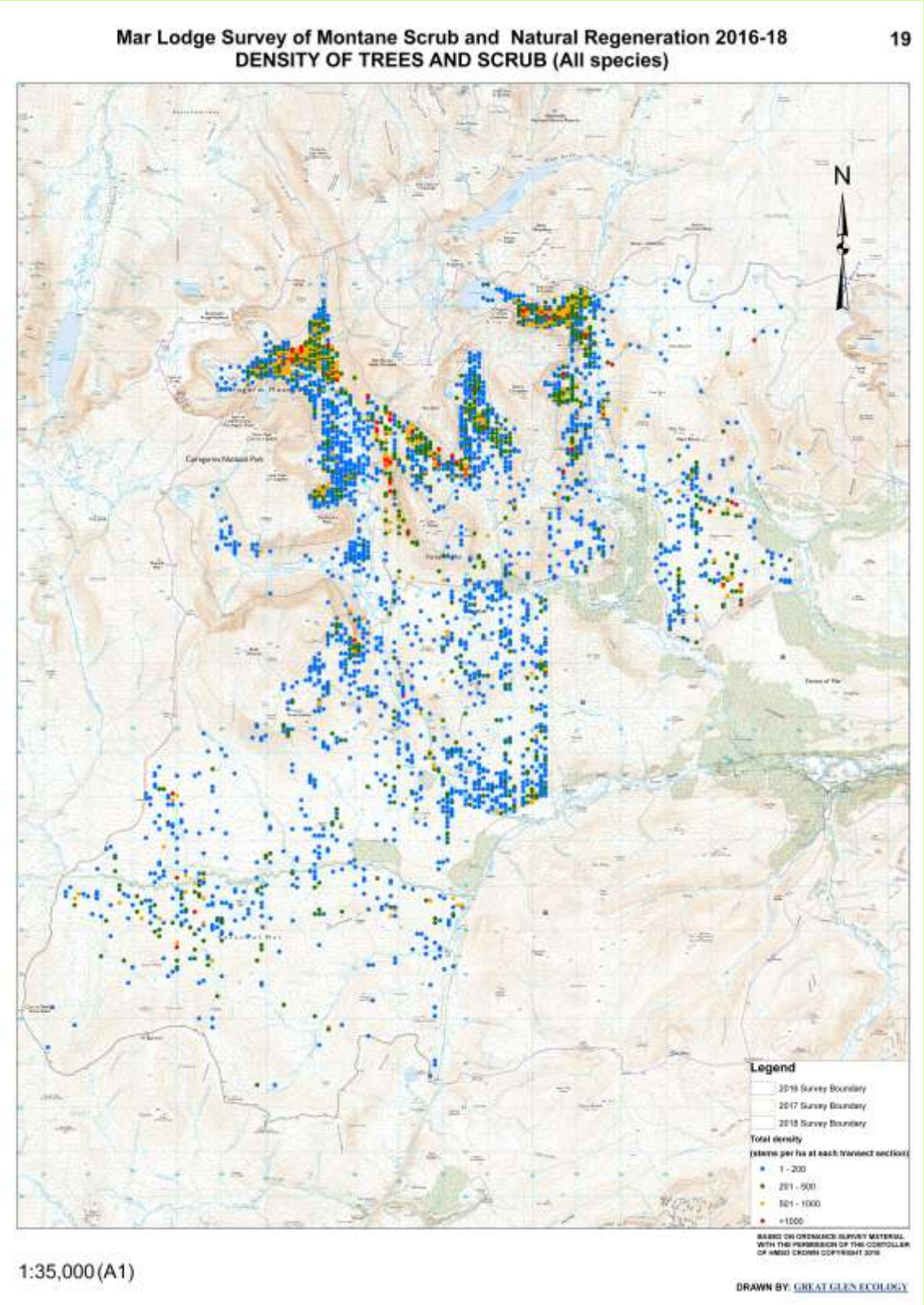

Photo 6: Density of species across the survey area

The extent, diversity and abundance of species was greater in the northern part of the estate (2016 blue survey area) which has experienced low levels of deer (<1 per km2) for a number of years now and is within our ‘regeneration zone’ (photo 7).

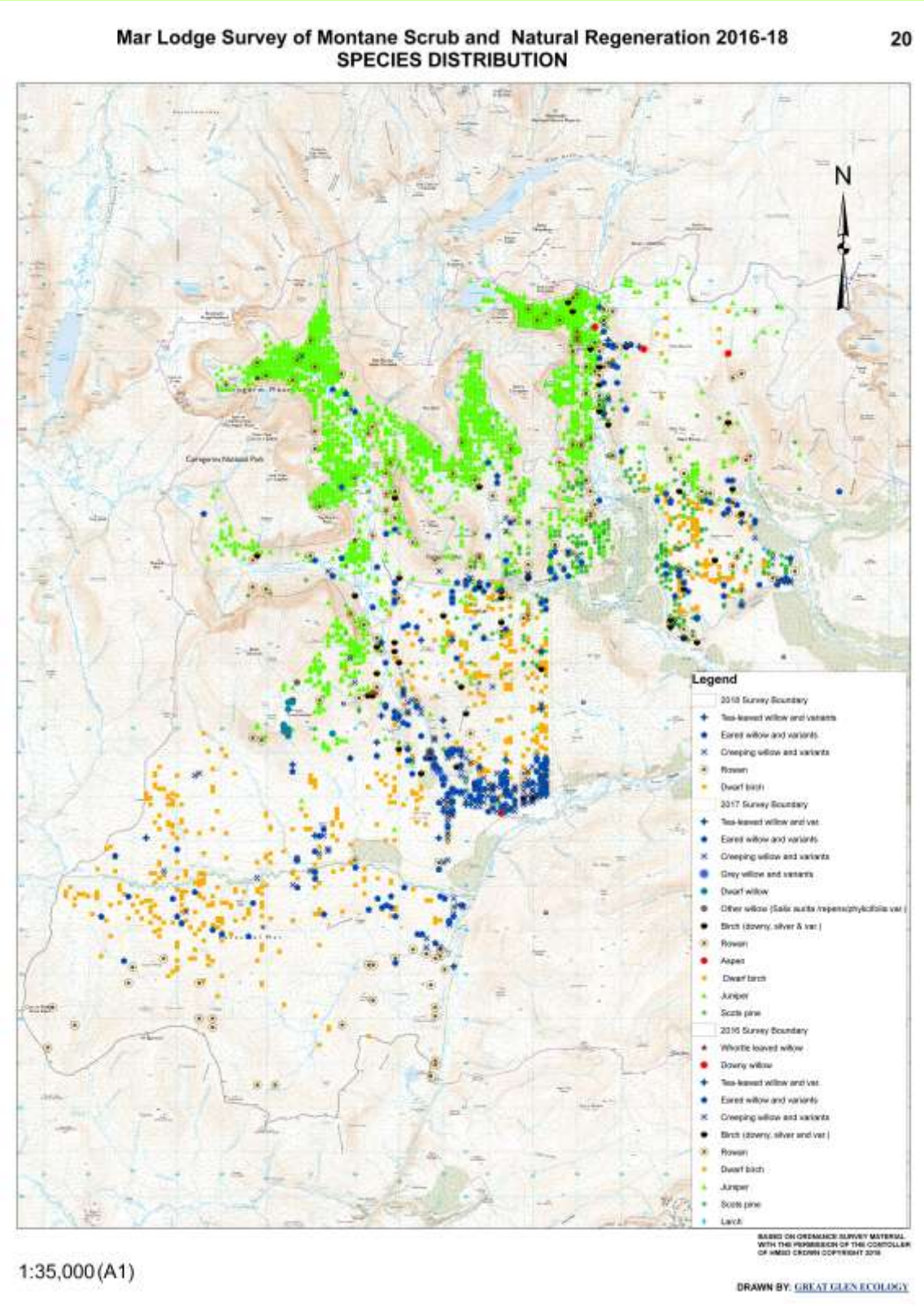

Photo 7: Species distribution across the survey area

As you move south through the survey areas into the green and yellow areas surveyed in 2017 and 2018 the diversity, abundance and extent of the montane woodland species declines in line with an increasing deer density. The level of browsing recorded on these species also correspondingly increased moving south through the areas. The majority of the green and yellow survey areas are within our 'moorland zone' and have historically supported high deer densities. In the last few years the average deer density has been 5-6 per km2. However, it is also likely that other factors such as ground conditions, burning and topography could also have contributed to differences between the areas. In the 2016 blue survey area tree or scrub species were recorded on 19% of transect sections completed compared to 9% in the 2017 yellow survey area and 3% in the 2018 green survey area.

Twelve tree or montane woodland species were recorded in the survey with juniper being by far the commonest species. In the 2016 survey area (blue) which covers the northern part of the estate, juniper occurred at an average density of 200 clumps per ha but was frequently recorded at 500-1000 clumps per ha in places such as the Lairig Ghru and Coire Etchachan. Juniper was recorded up to 950m altitude and Scots pine and rowan were both recorded above 900m. The extent of dwarf birch across the 2018 survey area was considered remarkable by the contractors and it appears to link to a continuous stand which extends north and east to Glen Derry. It is known this also continues west into Glen Feshie. Densities of between 500-1000 stems per ha were recorded on a number of occasions. This population could be of national significance, as one of the largest continuous remnants of dwarf birch scrub in Britain.

The extensive survey confirmed the rarity of two montane willow species on the estate - downy willow (*Salix lapponum*) and whortle-leaved willow (*Salix myrsinites*). The survey picked up five of the recorded sites for these species on the estate but no new sites were found. As expected the sites for these species are at higher altitudes in remote corries and glens often out with the reach of browsers.

Overall the general emergence of species such as Scots pine, birch and rowan above vegetation height and at high altitude in the northern part of the estate is encouraging. The density, extent and altitudes to which juniper has been recorded is also an encouraging sign that montane woodland is recovering following a period of reduced browsing pressure (photo 8). The recovery of the montane scrub species is visibly slower than that of species such as Scots pine so the next few years will be interesting to see how this continues to develop under low herbivore pressure. Data from the 2018 green and southern part of the 2017 yellow survey area on species diversity, browsing impacts and emergence above vegetation height suggests that long term browsing by herbivores may have led to a more impoverished and sparser montane woodland resource here. Deer densities have come down in this area in recent years and NTS has plans to reduce them further. It is good to know that species such as dwarf birch are still present here and let's hope we can see a recovery in this resource in the years to come.

Photo 8: Juniper emerging from heather, Upper Glen Derry

Based on the results from this survey NTS decided that the priority for immediate action was the rare montane willow populations of downy and whortle-leaved willow. What could we do to bring these populations into a position where they can reproduce and expand successfully and their future secured? A project proposal was put together with the primary objective of re-enforcing the existing populations of downy and whortle-leaved willow on the estate where survey information has indicated that these populations do not have the capability of expanding without some intervention. This was considered a logical first step in the conservation of these species rather than creating new populations in different parts of the estate.

In June 2019, all known site records of these species on the estate were visited and a detailed survey of each population was conducted. This included recording specific details about the population (size, NVC community, percentage cover of scrub, altitude etc) and the individual plants (sex, age class, number of catkins, browsing etc). At the same time cuttings were taken (under license and following the Mountain Woodland Action Group Best Practice Guidance) to be passed to Trees for Life at Dundreggan for propagation and creation of a seed stand. Two leaf samples were also taken for genetic analysis by the Royal Botanic Gardens, Edinburgh. In July 2019, the sites where female catkins had been recorded during the survey were re-visited (often more than once!!) in the hope of collecting seed for propagation. This venture was successful for both species and Trees for Life are now growing on seedlings for planting out from this seed. Interestingly some of these seedlings look like hybrids!!! We are using

genetic analysis to determine whether this is the case and if so should we plant them out or destroy them?

The aim of the project was to use the survey and genetic data to inform the future management action. The survey identified eight downy willow populations and two whortle-leaved populations. The whortle-leaved populations occur at an average of 840m altitude in Garbh Coire and on Beinn Bhrotain and are of a good size, 150+ clumps and 80+ clumps respectively (difficult to distinguish individual plants) (photo 9). There is a mix of both sexes at these sites and there is evidence of regeneration with small seedlings being recorded during the survey.

A third site in Coire Etchachan with a single *S.myrsinites* has since also been discovered. Although more downy willow populations were identified the condition of these is much more precarious (photo 10). The populations are fragmented across the estate occurring at a mean altitude of 776m. Six of the populations have fewer than four individuals and have plants of only a single sex. Three populations have an estimated 10-20 individuals and contain a mix of both sexes. There seems to be a skew towards female plants with five of the single sex populations being females and only a single population being male. The browsing levels recorded on the plants were not severe with generally less than 25% of shoots being browsed. However most of these plants are on inaccessible ledges or overhanging burns and it is not known what the impact would be now should the plants be in easily accessible areas. We are hopeful that the deer pressure has reduced significantly in these areas on Mar lodge Estate and that unprotected planted trees would have a good chance of survival.

Photo 9: Whortle-leaved willow, Garbh Coire (with sawfly larvae) (photo: Diana Gilbert)

Photo 10: Downy willow, Upper Glen Quoich

So what is next? Hot off the press are the willow genetic results and this also includes results for Glen Feshie and RSPB Abernethy's willow populations – our neighbours on the high ground. These results and the implications for management across the three estates will be discussed at a forthcoming meeting. We currently have remote cameras on a few of our willow sites to determine which populations are least visited by herbivores. Based on the survey data, camera information and the outcome of the genetics discussion, NTS will make a decision about which populations we will re-enforce and to what extent. NTS are also co-partners in a three year Knowledge Transfer Project funded by Innovate UK to develop a novel herbivore deterrent to use in protecting trees and alerting us to deer incursions in remote locations. This is an exciting innovation project the results of which hopefully will help us in our quest to protect and expand the montane woodland resource in Scotland.

It has been an interesting road so far and hopefully this is just the start of a brighter future for the rarer montane willow populations on the estate and in the Cairngorms.

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Acknowledgements

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Shaila Rao has been working in the uplands since leaving university, often on work related to the impact of herbivores on the landscape. For the last 17 years she's been the ecologist for NTS at Mar Lodge Estate.

SRao@nts.org.uk

Habitat connectivity and genetic diversity of *Salix lapponum* and *Salix myrsinites*

Aline Finger

Mainly due to grazing and historic burning, montane willow populations in the Cairngorms National Park (CNP) are very small and geographically isolated from each other. Small populations are not only at higher risk of stochastic catastrophic events (*eg* landslides) but also tend to suffer from genetic problems, such as inbreeding depression and the loss of genetic diversity (Reed, 2005). Inbreeding depression can lead to a reduced seed production, germination rate or survival rate. Genetic diversity is the basis for any organism to evolve and adapt to new environments. Thus a low genetic diversity may limit a species' ability to adapt to environmental change, such as climate change or the outbreak of new pests and diseases.

Negative genetic effects following population isolation can be avoided or reversed by creating gene flow, the exchange of seed or pollen between populations. To maintain healthy, self-sustaining populations in a fragmented landscape it is therefore crucial to (re)create gene flow between genetically isolated populations. Additionally increasing population sizes is key to maintaining genetically healthy populations. This is to allow populations to retain their evolutionary potential, their ability to adapt to changing environments. For that, population sizes of thousands of reproducing individuals are needed (Traill *et al*, 2010), which is a challenging aim for conservation and restoration programmes.

There are cases though where restoring populations by mixing between two populations of the same species is not beneficial as it can lead to outbreeding depression. Outbreeding depression is a lowered fitness due to the disruption of local adaptation through the introduction of non-adapted individuals. Outbreeding depression is only expected if populations have been isolated for more than 500 years and grow in different environments (Frankham *et al,* 2011). Despite there being a low risk it is good practice to make sure that outbreeding depression is taken into account when planning reinforcements or reintroductions.

Salix lapponum and *S. myrsinites* are two rare montane willow species which grow at high altitude locations in the Cairngorm Mountains. Both species were more widely distributed historically but centuries of burning and heavy grazing pressure have reduced their distribution and extent significantly. Both now have extremely small and scattered populations in the CNP, many comprising of less than ten individuals. Reproduction in populations is very limited, particularly in the more palatable *S. lapponum*, and it is not known whether this is due to grazing alone or whether there are genetic problems following long-term population isolation. Glen Feshie and Abernethy of the Cairngorms Connect Partnership along with the National Trust for Scotland's Mar Lodge Estate are working collaboratively at a landscape scale to improve the conservation status for both willow species. The main aim is to reinforce existing

populations to avoid losing populations altogether, and use best suited material for reinforcements to maximise diversity while avoiding outbreeding depression. Creating new willow populations through planting will also be considered.

To make best practice management decisions data is needed on the number of remaining individuals, *ie* the amount of clonal reproduction to make sure that population sizes have not been overestimated. Furthermore, to avoid spending resources on the wrong species a further aim is to resolve taxonomic uncertainties, particularly as willow species frequently hybridise with other species. To this aim all known wild populations of *S. lapponum* and *S. myrsinites* have been sampled across the three estates. In collaboration with the Royal Botanic Garden Edinburgh the samples have been analysed genetically to test i) whether populations are genetically isolated, ii) whether inbreeding depression could lower population fitness, iii) how many individuals remain, and iv) the possibility of resolving taxonomic uncertainties.

Study species and area

S. lapponum and *S. myrsinites* are two low growing willow species growing on rocky ledges, crags and mountainside from approx. 300-900m (photos 1 and 2). Both species have a wide but scattered distribution in Scotland (see Fig. 1). The current study involved sampling the willow populations growing around the main central massif of the Cairngorm Mountains at the heart of the Cairngorms National Park. In this area the willow populations generally occur between 700 and 900m altitude and the populations are few in number, small, and isolated. Populations are often clinging to crags and overhanging burns out with the reach of grazing animals. All populations within Glenfeshie and Mar Lodge Estate were found on north facing crags beneath late snow beds, and may rely on the irrigation from meltwater trickling from above – adding to the fragility of these populations as the climate warms. Both species have insect pollinated flowers and wind dispersed seeds.

Photo 1: *Salix mysinites* growing in Coire Lochan Uaine

Photo 2: *Salix lapponum* at Allt an Aghaidh Mhilis, Dubh Ghleann

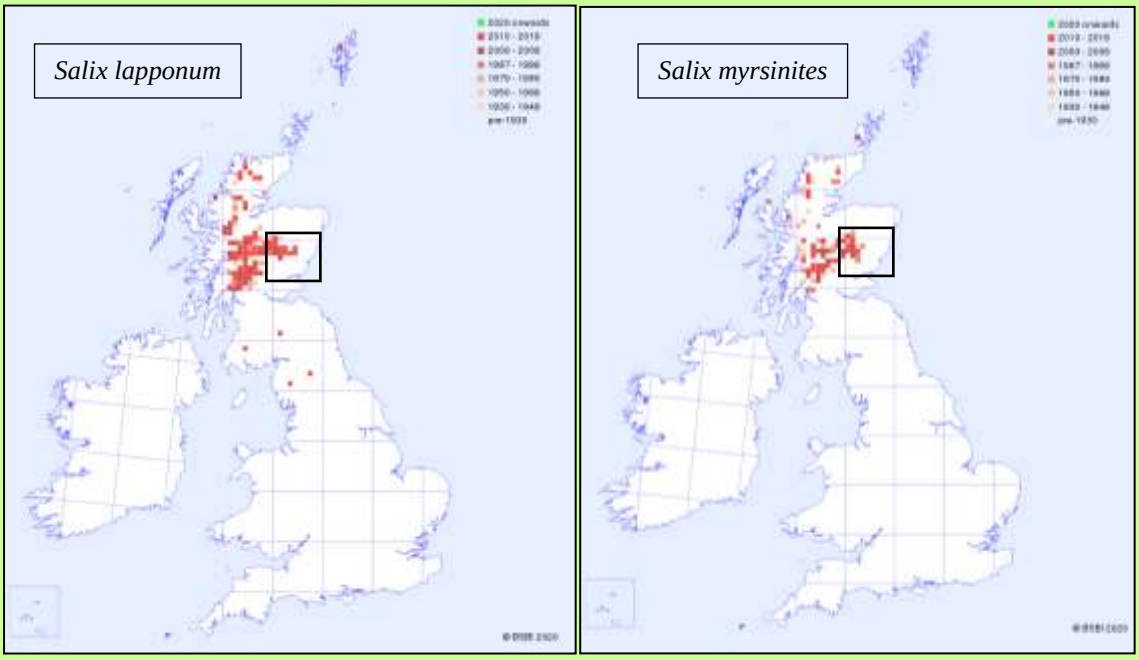

Figure 1: BSBI UK distribution maps of *Salix lapponum* (left) and *Salix myrsinites* (right) populations and rough outline of study area (Glenfeshie, Mar Lodge Estate and Abernethy).

Genetic analysis

Leaves of 112 *S. lapponum* and 190 *S. myrsinites* shrubs have been collected in the field from 14 and nine populations, respectively (see Fig. 2). DNA has been extracted from each leaf and cut at specific locations (using microsatellite markers). The comparison of these bits of DNA allows us to look at the partitioning of genetic diversity within and between populations. After removing clones and hybrids this left 92 samples for *S. lapponum* and 188 samples for *S. myrsinites* for genetic analysis.

Salix lapponum is a diploid species, inheriting one set of chromosomes from each parent whereas *S. myrsinites* is decaploid, inheriting 5 sets of chromosomes from each parent. Most population genetic theories and calculations are based on diploid species and therefore some calculations are limited for *S. myrsinites*.

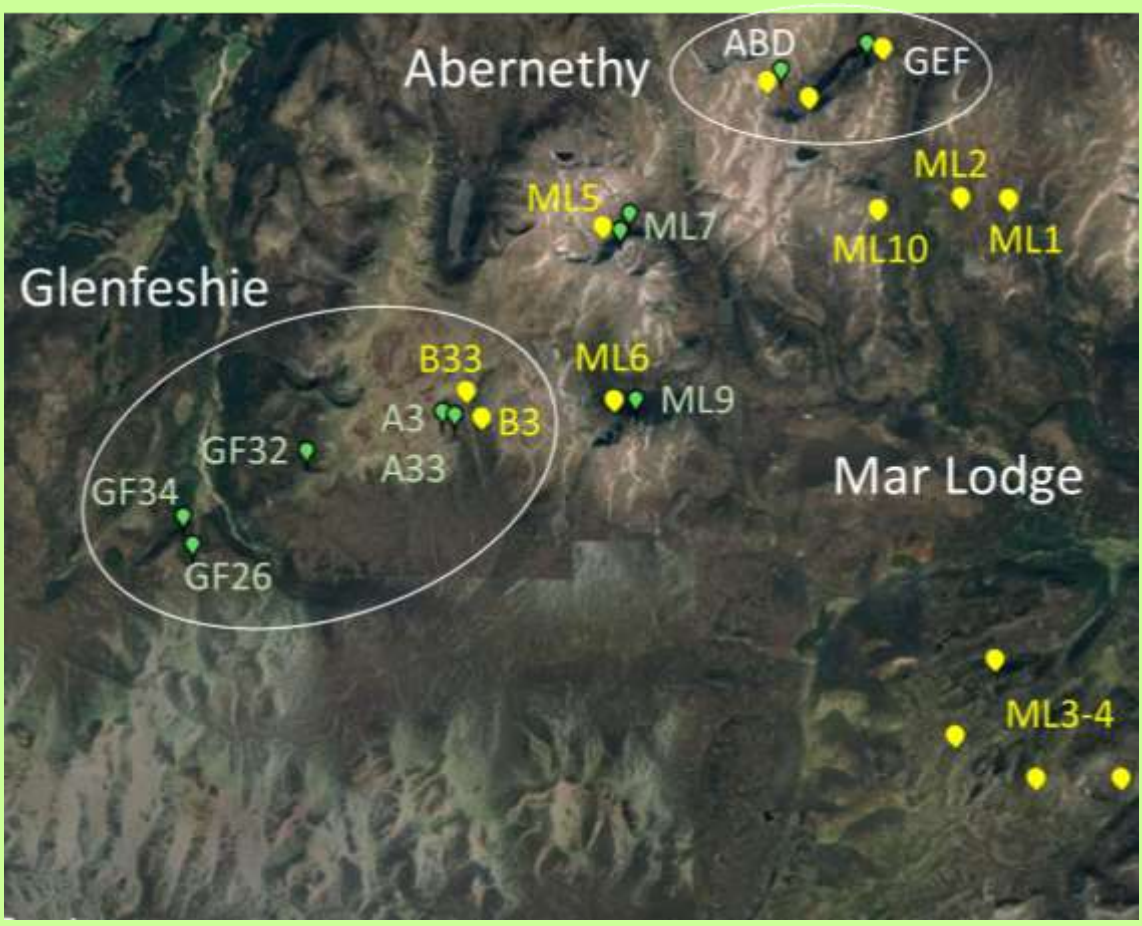

Figure 2: Population distribution of *Salix lapponum* (yellow) and *Salix myrsinites* (green) across Glenfeshie, Mar Lodge Estate and Abernethy.

Are populations genetically isolated and is outbreeding depression a concern?

Historic gene flow across the CNP is present in both *S. lapponum* and *S. myrsinites* preventing genetic isolation. Depending on when shrubs established, these gene flow rates represent landscape connectivity between tens or up to hundreds of years ago. Insects seem to have effectively transported pollen between populations and seed has

been widely dispersed in the landscape through wind. It is possible that more populations used to grow in between existing populations connecting the wider landscape but have now gone extinct. Whether gene flow is still present for the next generation can't be answered with this data.

Some genetic clustering could be seen in populations of *S. lapponum* in the North-East of the study area in Abernethy (populations G+E+F) and also populations ML1 and ML2 at Mar Lodge Estate, see Fig. 2 for population locations. Such genetic structuring can arise when a) populations are (and have always been) slightly isolated through valleys or mountain ranges; b) populations are relatively young and have been founded by few individuals; c) they have been planted, though this is very unlikely in this case.

Recent historic gene flow and populations growing in similar environments make local adaptation in populations (and thus outbreeding depression) very unlikely. Mixing plants from different populations for reinforcements from within the CNP is therefore a valuable conservation strategy.

How much genetic diversity is left?

Genetic diversity is very high for all *S. myrsinites* populations, this is partly due to it being decaploid. Genetic diversity is also high in most populations of *S. lapponum*. Populations with the lowest diversity are Mar Lodge Estate ML1 and Abernethy G+E+F. A lowered diversity can arise in newly founded populations or through a degree of genetic isolation over an extensive time period. As both populations have also shown stronger genetic isolation compared to other populations they would particularly benefit from the introduction of new genes / individuals.

Is inbreeding depression likely affecting populations?

To answer this question we've looked at how closely related individuals are to each other within each population. If relatedness within populations is high then we expect the next generation to have an increased likelihood of suffering from inbreeding depression. Due to complexities around a decaploid dataset, this calculation has not been done for *S. myrsinites*.

Salix lapponum has a varying degree of relatedness in populations, some small populations consist of completely unrelated individuals while another consists of cousins. Populations at Glenfeshie show lowest relatedness between individuals and are among the few populations that reproduce successfully. Other populations produce viable seed but still seedlings are not found in populations. It is therefore possible that the low relatedness in Glenfeshie population leads to higher offspring fitness (germination and survival rates). Populations with higher relatedness may well be showing first signs of inbreeding depression through lack of reproduction. In every population there will be a natural degree of relatedness. Closely related individuals tend to grow close together as most seeds fall close to their mothers and insects

pollinate neighbouring shrubs. Such close relatedness between direct neighbours is not necessarily problematic as long as gene flow is occasionally bringing in new genes from less related individuals. Gene flow seems so far to have maintained a high genetic diversity in most adults. The question is whether this genetic diversity can be maintained for the next generations.

Even if the CNP was considered one large population (connected through gene flow) this population would still not meet the requirements of thousands of individuals needed to remain genetically healthy. Particularly in small populations screwed sex ratios could further impede reproduction. Therefore, population sizes across the CNP are concerningly low for both species. In the long-term populations are likely to suffer negative genetic effects. Reinforcing particularly the smaller and more isolated ones with new unrelated individuals and / or creating new populations in between existing ones to create stepping stones will be crucial to avoid negative genetic effects. To maintain gene flow through pollen dispersal it is imperative that insect communities, *eg* bumble bee populations, are protected along with the plants they are pollinating.

How much clonal reproduction is present?

Shrubs were sampled that were at least a few metres apart from each other and roots weren't enmeshed with adjacent shrubs. Across all sampled shrubs clonal reproduction is very low. In *S. lapponum* out of 112 sampled shrubs 102 were genetically unique (9% clonal) and in *S. myrsinites* out of 192 samples 188 were unique (2% clonal). This means that many shrubs growing only a short distance apart from each other are indeed separate genetic individuals. From a conservation perspective this is significant as it means that a) population sizes haven't been overestimated and b) almost all individuals will be useful as a source for nursery stock and future reinforcements.

Resolving taxonomic uncertainty

It remains difficult to differentiate between hybrids and pure species. *Salix lapponum* is known to hybridise widely with other *Salix* species. In this study area the following hybrids are possible: *S. caprea* x *S. lapponum*, *S. aurita* x *S. repens* x *S. lapponum*, *S. aurita* x *S. lapponum*, *S. aurita* x *S. lapponum* x *S. herbacea*, *S. myrsinifolia* x *S. phylicifolia* x *S. lapponum*, *S. myrsinifolia* x *S. lapponum*, *S. repens* x *S. lapponum*, *S. lapponum* x *S. lanata*, and *S. lapponum* x *S. herbacea* (Stace 2010).

While *S. myrsinites*, *S. myrsinifolia* and *S. phylicifolia* are polyploid, all other species are diploid. The difference in ploidy can be used as one method to identify hybrids in *S. lapponum* as hybrids will show more than 2 alleles at one given marker. It is more complex though to identify hybrids between *S. lapponum* and other diploid species as the number of alleles at a given marker will be the same. Our data showed that for *S. lapponum* out of 102 samples 10 (11%) could be clearly identified as hybrids with *S. myrsinites*, *S. myrsinifolia* or *S. phylicifolia* due to multiple alleles. It is likely though that more hybrids (with other species) are present. To identify these hybrids a combination of genetic and morphological data might give more insights.

It was not possible to identify hybrids in *S. myrsinites* with this genetic dataset. The following hybrids are possible though in the study area: *S. caprea* x *S. myrsinites*, *S. myrsinifolia* x *S. phylicifolia* x *S. myrsinites*, *S. myrsinifolia* x *S. myrsinites*, *S. lapponum* x *S. myrsinites* x *S. herbacea* (Stace 2010). We therefore expect some of the sampled shrubs to be hybrids.

Hybrids may have contributed to the high genetic diversity observed in both species as they contribute unrelated genes to populations. It is not known though whether these unrelated genes are resulting in fitness benefits or may impact plants negatively. To build healthy self-sustaining populations it is therefore best to use pure species for translocations.

Conclusions

Both *Salix. lapponum* and *S. myrsinites* have extremely small population sizes across the CNP which are likely to suffer from negative genetic effects in the long-term. The lack of reproduction observed in most populations may be a first indication that genetic problems are reducing offspring fitness. It would be beneficial for most populations to be reinforced with more individuals, ideally getting numbers as high as thousands of individuals to ensure genetically healthy population that retain their evolutionary potential over many generations. Historically populations have been connected through gene flow and have maintained a high genetic diversity. Clonal reproduction is low when shrubs are growing a few meters apart from each other. Therefore, almost all shrubs analysed in this study will be a suitable source material for reinforcements. The risk of outbreeding depression by mixing plants from different populations can be neglected due to historic gene flow. It was not possible to determine the exact amount of hybridisation in *S. lapponum* and *S. myrsinites*, and it is likely that many hybrids exist, possibly adding to the species overall genetic diversity. Whether hybrids are more or less fit than pure species is not known and it is therefore prudent to use pure species for conservation translocations.

Further work is needed to determine whether gene flow across the study area is still present today by analysing seeds and seedlings. In addition to supplementing existing populations it would be beneficial to plant new populations in between existing ones to facilitate or maintain gene flow across the estates and to create stepping stones across this fragmented landscape. To put results from this study into a wider conservation context and to explore the extent of gene flow and genetic diversity across Scotland, remaining populations should be sampled and analysed.

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Aline Finger is a molecular ecologist with the Royal Botanic Garden Edinburgh, with a research focus on conservation and ecological genetics of threatened and important plant species.

AFinger@rbge.org.uk

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Article prepared and genetic analysis done by Dr Aline Finger (Royal Botanic Garden Edinburgh)

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Abernethy nursery manager: David Blair, RSPB

AECS Payment for Montane Scrub at Ben Lawers

Andrew Warwick

Montane scrub restoration is an expensive business! The long term nature of montane scrub projects, even compared to other types of forestry, means maintenance and ongoing work will always require funds in addition to the capital funding used to set up projects. While it is comparatively easy to get capital funding to set up new projects there are far fewer options for continued funding of existing projects. This is counterintuitive as safeguarding the progress made and previous investment in successful scrub schemes should be a higher priority.

The National Trust for Scotland at Ben Lawers have been proactively restoring upland woodland including montane scrub since 1989 in ever larger areas. Of the 860Ha of land now fenced off for woodland restoration/ regeneration, over 200Ha is above the 600m contour where montane scrub species become predominant in the woodland mix. Capital funds for the various projects over that time have come from private donations, forestry grants, European funds, Millennium Forest for Scotland and from NatureScot, who have also contributed some money towards maintenance. Despite this the NTS Rangers at Ben Lawers have carried out the bulk of the expense in terms of tree production, planting, herbivore control and fence maintenance.

It is therefore good news that we have been successful in acquiring funding through the AECS (Agri-Environment and Climate Scheme) for the Montane Scrub of High Conservation Value option.

This is the first time we have had annual hectarage payments for ground which now qualifies on the basis of previous conservation work carried out there. We applied for a figure of 117ha which includes all ground above 600m but below 800m, excluding the area of cliffs where our management work has little impact.

While not a comparable income to forestry grants, this brings in an annual amount to be used as a budget for fence maintenance and further planting of scrub species which will carry the work comfortably over the next few years.

Unfortunately, ministers have made a decision that there won't be a normal AECS application round in 2020. We must hope that when it comes back on line in whatever shape or form, that this montane scrub option is retained.

The Payment in short:

- *Agri Environment and Climate - Montane Scrub of High Conservation Value*
- *Rough grazing with montane scrub is eligible.*
- *This can include land suitable for expansion of these habitats, or other land which requires to be included in enclosures for practical fencing reasons.*
- *You can claim £74.16 per hectare per year*
- *Musts and must-nots:*

- *You must manage the same area each year for the duration of your contract. The area will comprise a single parcel, and may be fenced off from a larger area.*
- *You must exclude all grazing*
- *You must not carry out supplementary livestock feeding in the area subject to payment*
- *You must not spray, except for the spot-treatment of injurious weeds (requires prior written notification) or treatment of invasive species (requires prior written approval)*
- *You must remove any invasive non-native species present*
- *You must maintain a diary*

Further details: https://www.ruralpayments.org/publicsite/futures/topics/all-schemes/agri-environment-climate-scheme/management-options-and-capital-items/managing-scrub-of-conservation-value/

Andrew Warwick is the senior NTS Ranger for the Ben Lawers property who over the last 25 years has developed considerable knowledge & expertise in the management and conservation of montane shrubs and treeline woodland, particularly their establishment and protection.

awarwick@nts.org.uk