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The Montane Scrub Action Group Bulletin.

The contents of this issue are the 5 Guidance Notes, edited by Diana Gilbert.

With this edition, many of our readers will receive the Bulletin electronically. We would prefer this method of circulation, and it facilitates the use of colour illustrations, as in this issue. For future use, if you have been sent a paper copy but have an email address that we could use, please email it to me at the address below.

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If any readers are not on the circulation list but wish to be, please let us know and we can add your name to the list.

Since Bulletin No. 3, two other targets were achieved. The illustrated booklet '**Montane Scrub**' was published by SNH in the Natural Heritage Management series. The authorship is: Michael Scott for the Montane Scrub Action Group; ISBN 1 85397 103 0. Copies are available @£3.95 (post free in the UK) from The Publications Section, SNH, Battleby, Redgorton, PERTH, PH1 3EW.

A second one-day conference, 'Montane Scrub: The challenge above the treeline', was held on 26th April 2001. The illustrated proceedings will be published imminently, as follows: Gilbert, D. (2002) *(ed) Montane Scrub: The challenge above the treeline*. Highland Birchwoods, Munlochy.

Following the conference, with the achievement of the targets set at the 1996 conference, the future of the Montane Scrub Action Group was reviewed. The result is that the group will continue in existence, with evolving targets. The current membership is given in Diana's editorial, overleaf. The work programme will be discussed more fully in the next issue of the Bulletin.

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David Mardon

MONTANE SCRUB RESTORATION PROJECT

GUIDANCE FOR THE RESTORATION OF MONTANE SCRUB

A series of five booklets providing practical guidance on restoration issues.

Edited by Diana Gilbert,
on behalf of the Montane Scrub Action Group

The production of these notes has included a process of consultation and opinions expressed in them are not necessarily endorsed by Highland Birchwoods or members of the Montane Scrub Action Group.

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SCOTTISH NATURAL HERITAGE

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Montane Scrub

"The priority now is to restore and expand from the existing remnants and to develop the strategies, locally and nationally, to ensure success. This series of guidance notes has been written to assist with the practical elements of montane scrub restoration."

Note No. 1 "Montane Scrub in Scotland"

- provides an overview of the habitat, providing a definition of what constitutes montane scrub and the species involved, followed by a review of the distribution and extent and the state of current knowledge. The note then discusses the role of scrub in the uplands and the way forward in terms of its status and the action needed to secure its future.

Note No. 2, "Montane Scrub Restoration Action Planning"

- guides the manager through the process of how to implement a restoration programme. Beginning with a survey to ascertain the condition and extent of the habitat, collation of existing records and consultation with relevant agencies and individuals the planning process can then identify the most suitable areas for restoration and consider what level of intervention is required. The Note then compares natural regeneration, the preferred mechanism for restoration, with planting, discusses the need for monitoring and concludes with a section on funding opportunities.

Note No. 3, "Integration with Other Land Uses"

- discusses the value of montane scrub to other land use activities and how integration should be achievable with agriculture, forestry, sport, nature conservation and recreation. The aim is to achieve a balance between healthy and vigorous montane scrub communities and viable populations of grazing animals as well as improving biodiversity and benefiting recreation and landscape.

Note No. 4, "Protection"

- identifies the principal browsing agents and considers the main methods used to control browsing. Reduction of livestock or deer numbers are the preferred option but the advantages and disadvantages of fencing and exclosure techniques are discussed in some detail. Shepherding and supplementary feeding practices are briefly mentioned as possible alternatives to fencing.

Note No. 5, "Propagation of Scrub Species"

- describes the various techniques involved in obtaining suitable material for planting. Guidelines on the selection of the appropriate genetic origin of source plants are provided as well as details on seed collection and treatment, nursery practice and planting out. Ideally, montane scrub is best propagated by seed but the use of vegetative reproductive material is also discussed.

Note 1 : Montane scrub in Scotland

By Neil A MacKenzie, Norbu, Lochgarthside, Inverness-shire, IV2 6PY

Overview

Subalpine scrub and treeline woodlands are a natural part of the upland vegetation communities of Scotland. They represent the ecotone across the forest, subalpine and low alpine zones and are an important component of the overall native woodland resource (Figure 1). Subalpine scrub and natural treelines are very largely absent from the uplands having been lost as a result of many centuries of land management.

The few relicts of subalpine scrub that remain on crags and rock ledges and the dwarf trees known as 'krummholz', for example on Creag Fhiaclach in the Cairngorms, are the remnants of a natural treeline which once existed above the forest zone in all the high mountain areas of Scotland. True subalpine and low alpine scrub are also very scarce and, although probably never as widespread as treeline scrub, these communities now rarely form part of the continuum between the forest and the alpine zones. The wind-pruned scrub of exposed coastal locations has also been included here. Although not strictly montane, such communities do have affinities, in respect of form, stature and slow growth rates, with subalpine and treeline scrub. They can include a range of species and indeed are often classified as woodland but the unique habitat created by the canopy of semi-prostrate trees and shrubs, sometimes less than 2 metres high, is a climax community maintained by salt spray and exposure.

Treelines have always fluctuated as a result of climate change and at one time during the Holocene were considerably higher in altitude. However, fire and grazing have been the main factors limiting the development of treelines and subalpine scrub and there is frequently an abrupt margin between the upper forest edge and the open moorland or bog beyond. In some places steep cliffs or scree can be the upper barrier to woodland and scrub expansion but this is an edaphic constraint rather than a climate induced treeline. The maximum altitude of natural treelines today varies between north and south and between east and west Scotland. The south and east of the country have the potential for the highest treelines at over 600 metres while treelines in the north and west drop to below 300 metres and, as exposure increases, to almost sea level in the Northern and Western Isles.

The definition of what constitutes treeline and subalpine scrub is an arbitrary one but will generally include all tree species under five metres in height at the upper levels of the forest zone and all shrub species at or above this zone. Ericoid and Dwarf shrub heath communities consisting of *Calluna vulgaris*, *Arctostaphylos* spp., *Salix repens*, *S. herbacea* and other prostrate shrubs are not included in this definition. Coastal wind-pruned scrub can be regarded as treeline scrub where there is no other woodland of higher stature, such as on the Western Isles, and on the fringes of mature woodland where coastal exposure limits growth in a manner similar to the altitude related exposure of the treeline.

The tree species which are considered to be the main components of the treeline are Scots pine (*Pinus sylvestris*), downy birch (*Betula pubescens*), and rowan *(Sorbus aucuparia)*, with subsidiary species such as aspen (*Populus tremula*) and willow (*Salix* spp.), occasionally present. These trees which would be growing at the natural altitudinal limit of tolerance, where the forest meets the subalpine zone, would generally exhibit a stunted, multi-branched and sometimes semi-prostrate form and would usually reflect the species present in the forest zone immediately below. The coastal and wind-pruned scrub in the north and west can include most of the species associated with the native woodland found in these respective areas. In the subalpine and low alpine scrub zone the main components are juniper (*Juniperus communis*), which can also exist at lower altitudes and as a woodland understorey shrub, dwarf birch (*Betula nana*) which is also present at lower levels where there are suitable blanket bog communities, and the mountain willows, the majority of which are restricted to base-rich areas. Tree species can also be found along

Figure 1. Altitudinal vegetational zonations in the Scottish uplands, including approximate altitudes for the different zones in the east and west.

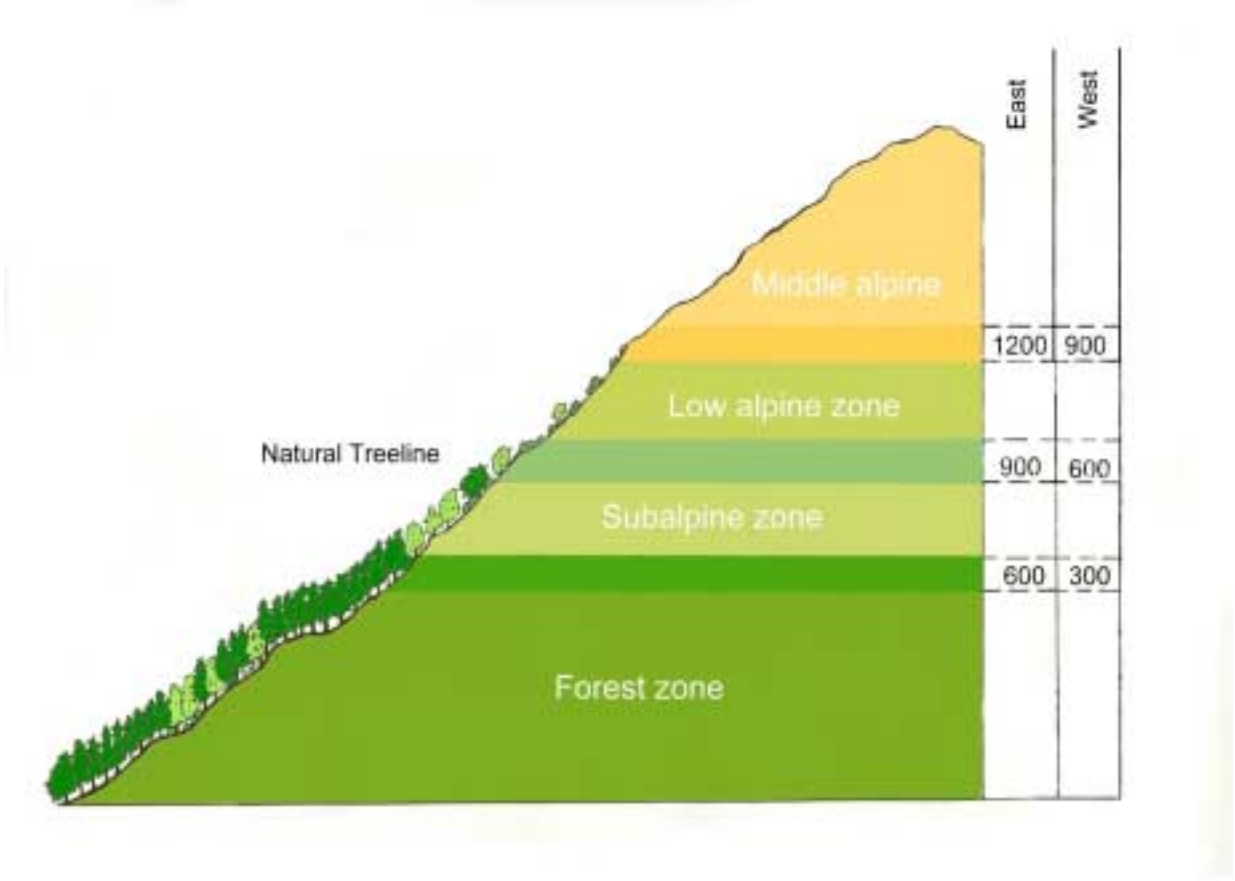

Figure 2. Tree and shrub species associated with treelines, subalpine and wind-pruned coastal scrub

All 6 montane willows:	Mountain, (*Salix arbuscula),* Woolly (*S lanata),* Downy (*S lapponum),* Dark-leaved (*S mysinifolia),* Tea-leaved (*S phylicifolia),* Net-leaved (*S reticulata*) Whortle-leaved (*S myrsinites*)
Upright juniper, (*Juniperus communis* ssp *communis*) and	
Prostrate juniper (*J communis* ssp *alpina*);	
Dwarf birch (*Betula nana*)	
Treeline '*Krummholz*' and wind pruned coastal occurrences of:	
High altitude goat willow (*S capraea* ssp *sphacelata*) eared-willows (*S aurita*), Downy birch, (*B pubescens*), Pine (*Pinus sylvestris*), Oak (*Quercus petraea*), Rowan (*Sorbus aucuparia*) and rock whitebeam (*S rupicola*), Hazel (*Corylus avellana*), Aspen (*Populus tremula*)	

with juniper and mountain willow scrub in the subalpine zone. For example, rowan has been recorded at 850 metres on Beinn Dearg, Scots pine at 800 metres in the Cairngorms and downy birch and aspen survive at altitudes of 700 metres in many mountain areas. Such an overlap is indicative of a treeline transition zone where tree species achieve some stature in sheltered areas, and survive in a stunted, twisted form on exposed slopes in the subalpine zone (Figure 2).

Distribution, extent and condition

Although natural treelines are rare throughout Scotland there still remains a substantial number of high altitude native woodlands which have the potential to develop such a zone. The best example of a well developed treeline is the Scots pine and juniper grading into low juniper scrub between 550 and 650 metres on the steep slopes of Creag Fhiaclach in the western Cairngorms. However, with recent reductions in deer numbers and the absence of muirburn, more treelines are developing across the northern slopes between Inshriach, the Northern Corries and Meall a'Bhuachaille. In the west, birch woodland on Beinn Bhan at Ballachulish extends from near sea level up to the vestiges of a natural treeline at an altitude of over 350 metres. Treeline remnants elsewhere are often isolated fragments such as those on the north slopes of Aonach Mhor (Lochaber) at 500 metres altitude or the high altitude birchwood in a sheltered gully at 670 metres in Gleann Einich in the Cairngorms.

In the subalpine and low alpine zone, scrub is in a much more precarious position, particularly the mountain willows which are largely restricted to small isolated populations on cliffs and crags and are rarely part of any forest to alpine zone continuum. The seven species of mountain willow are concentrated in the central Highlands although there are a few records from the Southern Uplands and a substantial number from the north, including a single *Salix lapponum* plant in Shetland. The potential for extinction of these small populations has implications for the overall genetic diversity of the whole Scottish population. Most populations consist of no more than a few individual plants, some are single sex communities and only at a few notable locations do numbers exceed 100 plants. As all the mountain willows are dioecious, single sex communities can only reproduce vegetatively which may also have long term repercussions for genetic fitness. Willows are also insect pollinated and successful cross-fertilisation requires a number of plants of both sexes within a reasonable distance. This is not the case at many sites. The current known distribution of subalpine and low alpine scrub has been described in more detail in MacKenzie (2000). *Salix lanata* is listed in the Red Data Book and is classified as endangered (Wigginton, 1999) while most of the other mountain willows are now regarded as scarce (Stewart *et al*, 1994). All the mountain willows occupy a very small area, often too small to identify boundaries on a map, and probably cover little more than 10 ha in the whole of Scotland (Horsfield & Thompson, 1997). Juniper and dwarf birch are still relatively widespread in their distribution but successful regeneration of these species is infrequent, populations are often in poor condition and there has been an overall decline in area during the past century.

High level native woodlands are also frequently impoverished in their structure, lack sufficient regeneration and there is rarely a treeline scrub component along the upper edge. The woodland edge is the area favoured by red deer and therefore receives a disproportionate amount of grazing pressure. The effect of grazing pressures on the treeline is further compounded because at upper altitudes seed production and germination are less reliable, growth is slower and natural mortality higher.

Virtually every population of low alpine, subalpine and treeline scrub continues to be affected by overgrazing and muirburn which are preventing the regeneration and expansion of existing remnants. Small, isolated and fragmented plant populations co-existing with high deer numbers make it difficult to achieve a balance between grazing and regeneration.

A review of current knowledge

Our current understanding of the former subalpine scrub distribution is very imprecise. We can speculate from the current widespread distribution of juniper that this species was probably once a common treeline and subalpine scrub component in many parts of the Highlands and perhaps also in some upland parts of the Scottish Lowlands, either as the semi-prostrate or bush form of *communis communis* or the

prostrate form of *communis nana.* It may have been found in association with Scots pine, such as currently found in the Cairngorm juniper scrub, but also with birchwoods, such as in Deeside or in the upper Findhorn straths. Relict populations of the prostrate form of juniper can be found in many mountain areas and these may also have been more widespread in some coastal heath communities. There are particularly extensive stands of *Calluna - Juniperus* heath on the quartzite plateaus of Beinn Eighe and Foinaven and there are intermediate growth forms along the Bettyhill - Strathnaver coast. Other areas, such as some moorland parts of Perthshire and Argyll and perhaps localities where there is extensive blanket bog, may never have had a juniper scrub zone.

Mountain willows on the other hand were probably much more localised and largely restricted to areas with a base rich influence just as the present day remnants are. However, *Salix lapponum*, which is tolerant of more base poor flushes and scree, might once have been found along many upland burns and gullies similar to the remnants found in the tributaries of the Findhorn or in the Drumochter Hills. Dwarf birch appears to favour areas of blanket bog, but its former distribution and dominance as a scrub community similar to that of dwarf birch in mineral soil sites in Norway is not known. The only known record of dwarf birch growing on a mineral soil site in Scotland is the extensive colony at the head of Loch Muick on Deeside. A reduction in the burning and particularly grazing of these moorland areas could see a dramatic resurgence of dwarf birch as a major component of blanket heath (Scott, in press).

Although treelines are scarce today they would generally have been present at the upper zone of natural woodlands whenever the ground rises to an altitude where exposure limits growth. This zone would have been constrained in some areas by edaphic features such as cliffs or bogs but, however narrow, there would always have been some kind of transition between forest and alpine heath. The marked altitudinal drop in summer temperatures and increase in wind speed in Scottish mountain areas results in a much lower natural treeline zone than in continental areas of a comparable altitude (Pearsall, 1971).

The present area of treeline scrub in Scotland, including Scots pine and juniper, only amounts to a few hundreds of hectares in total. Any native woodland with sufficient high ground above has the potential to expand and develop a natural treeline and there are numerous examples of such sites throughout the mainland and islands. The Cairngorms is an area with good potential for the restoration of extensive high level treelines and this can be relatively easily achieved by continuing the reduction in deer numbers and preventing muirburn in areas where tree seedlings are present. If restoration were to occur at all suitable locations upland heather moors would not suddenly disappear. A natural treeline could take, at the very least, 50 to 100 years to develop and would still only occupy a narrow zone above the forest with occasional patches of scrub following sheltered burns and gullies to higher altitudes. It would also not be a uniform or dense canopy but a mosaic of scrub amongst heath and moor. The existing small and fragmented remnants of mountain willow will take many decades to expand significantly and are unlikely to ever occupy extensive areas of upland habitat. Most of the willows prefer base rich sites and late winter snow lie, conditions which are simply not available over much of the Scottish hills (Sydes, 1997).

The Role of Montane Scrub

The restoration of treelines and subalpine scrub is likely to have a number of conservation and biodiversity benefits. The inevitable reduction in grazing would permit more structural diversity, increase the variety of tall herbs and other mountain plants and extend the range of many mammals and birds. Various invertebrates, including beetles, sawflies, moths and gall-forming mites, are dependent on mountain willows and juniper. In time, wider benefits would include an improvement in soil and water quality with consequent benefits to water catchment management. Juniper and treeline birch are known to be soil improvers and there would be an increase in nutrient recycling and the formation of mull humus following scrub restoration. The provision of upland shelter and climate amelioration would have value for deer, livestock and game such as black grouse while the proximity of treeline scrub will help to minimise windthrow in the forest below. Treeline and subalpine scrub also provide dramatic improvements to the landscape by softening the often abrupt forest edge and

creating a mosaic of scrub among montane grasslands and heath which is good habitat for a range of flora and fauna.

The way forward

As part of its commitment to safeguard and enhance biodiversity, the Government has recognised certain priority habitats and species which are under threat or are declining. These have had action plans prepared which set targets for restoration (UK Biodiversity Steering Group, 1995). At present there are action plans for juniper and for woolly willow. But there are no specific plans for the remaining mountain willows, dwarf birch, treeline scrub or coastal scrub; furthermore existing Habitat Action Plans (HAP) do not take account of transitional habitats or mosaics. However, there are proposals for a montane heath and grassland HAP which would incorporate mountain willow scrub and also recommendations to amend the existing plans so that account is taken of transitional habitats such as treelines and coastal scrub (Strachan & Yeo, 2000). Although some of the individual scrub species have a widespread distribution the actual communities are among the rarest in Scotland and most are declining. Action is, therefore, required to conserve these unique communities as part of the vision of restoring Scotland's upland habitats.

The following key recommendations for action may assist in developing the way forward:

- Develop a national strategy with guidelines for sustainable land use management to ensure existing treeline and subalpine scrub populations are perpetuated.
- Ensure the highest value sites have appropriate designation or protection and that a management strategy is put in place to regenerate and expand the scrub communities.
- Species Action Plans are required for all the mountain willows while treeline restoration and coastal scrub should be incorporated into existing and proposed upland HAPs (montane heath, birch, oak and Scots pine).
- Recognition of the ecological and biodiversity importance of transitional habitats such as treelines, subalpine-coastal and scrub in all the appropriate HAPs.
- A conservation strategy should be aware that marginal and transitional habitats such as treelines and subalpine scrub may be vulnerable to the effects of climate change. The existing remnants must therefore be in the best of health to be able to cope with any adverse effects.
- Establish links with existing native woodlands in order to extend the continuum from forest zone to alpine heath, including links with woods at sea level and the riparian zone.
- Expand the national database and, ideally, carry out a detailed survey to provide information on the condition and health (including sex ratio) of the main subalpine willow populations.
- Identify the most suitable sites for restoration and expansion, and consider the type of intervention management required to safeguard or restore such populations.
- Consider the fencing of regeneration schemes only as a last resort.
- Re-establish treeline or subalpine scrub on appropriate sites where the community no longer exists but which probably occurred in the historic past.
- Consider a treeline component as part of native woodland regeneration schemes in suitable upland sites; perhaps promoting the restoration of scrub as a biodiversity benefit.
- Review the present system of grant aid (eg from Scottish Executive Rural Affairs Department, Scottish Natural Heritage and the Forestry Commission's Woodland Grant Scheme) to take account of the special attributes of treeline and subalpine scrub and to maintain and expand existing populations.
- Alter the present Woodland Grant Scheme survey requirements to incorporate survey methods which actively map treeline and subalpine scrub (National Vegetation Classification surveys rarely include such scrub as a component of the vegetation community).
- Liaison is required between the appropriate government agencies over the sustainable management of the montane habitat and the need to control grazing at a level which maintains and perpetuates treeline and subalpine scrub. Cross-sectoral compliance in relation to

any financial incentives should form part of any restoration management programme.

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Note 2 : Restoration action planning

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Introduction

The practical element of habitat restoration is often the most satisfying aspect of a project. However, bringing together the relevant scientific, fiscal and social strands that lie behind any well-planned project is undoubtedly both challenging and time consuming. For a vulnerable and fragmented species group such as montane scrub, it is imperative to develop a strategic approach that targets limited resources, both spatially and temporally, with regard to appropriate conservation management. If well planned, the end-result is a project that achieves maximum gain from often limited resources. This guidance note aims to assist in the planning of a restoration project providing guidance on how to plan and implement the different stages in the process. It is largely based on the practical experience of restoring juniper in the borders. How the guidance relates to a particular project will depend on the individual circumstances, particularly the scale of land involved. To avoid confusion the phrase 'project land' has been used throughout this note and refers to the whole area of land (regardless of size) which is under consideration for a restoration project. The guidance is broken down into the following stages:

Stage 1	**Background Research**
Stage 2	**Assessing the condition of an existing habitat.**
Stage 3	**How to identify areas with restoration potential, and prioritise action.**
Stage 4	**Current best practise in restoration.**
Stage 5	**Core Areas: a system for focusing action.**
Stage 6	**Restoration management planning.**
Stage 7	**Monitoring the success and impact of restoration action.**

Stage 1 : Background Research

The restoration of montane scrub is a relatively recent activity but where possible draw upon the experiences of others. Contact relevant organizations like The National Trust for Scotland, Scottish Natural Heritage and Highland Birchwoods for advice and to benefit from experience of similar restoration projects.

At this early stage, consider why you actually want to restore montane scrub and what you actually hope to achieve. These considerations will form the basis of a management plan with a clear visionary aim and SMART (specific, measurable, achievable, relevant and time limited) objectives. Such a systematic approach will help ensure success.

Establish the legal implications of a restoration proposal at an early stage so as not to waste time later. Pay particular attention to land ownership, legal designations (for example SSSI's), rights of way, access, archeological interest, land management agreements and public liability. The terms and conditions of funding bodies almost certainly will have implications for the project proposer or land holder. For example, the Woodland Grant Scheme requires consideration of the effect of any proposal on the landscape.

Stage 2 : Assessing the condition of an existing habitat.

Throughout the project land, the survey stage should bring together all the available information which will assist with planning restoration work. There are two key sources of information, written records; and the vegetation and its condition on site. The first can include records of previous management and other land use interests, such as archaeology, giving early warning of other interests that may need to be taken into account during restoration works. It can also provide useful background to the current conditions in the field, for example, restoration is most likely to be successful where scrub was known to have been more extensive in the

recent past.

In the field it is important to gather information about the overall vegetation in the area, as well as on the scrub element. Key elements of any field survey are:

- Classification of the main vegetation types present, particularly in proximity to scrub plants;
- information on the species present, population size, stand densities, growth rates and age structure; evidence of flowering and seed production; and for dioecious species information on the balance of sexes present ;
- information on outside factors such as browsing and grazing pressure.

Details of these specifications can be found in Appendix 1.

Stage 3 : How to identify areas with restoration potential and prioritise action

Establishing a system that prioritises sites within the project land allows for the development of a targeted restoration strategy. The following list of priorities given in Table 1 works on the premise that where restoration is physically feasible, the conservation and expansion of an existing population is the favoured option. These priorities can be assessed at either a strategic or a site level as a means of targeting resources effectively. They are provided as a guide and all strategic plans should be flexible enough to take advantage of opportunities for restoration that arise outside the plan framework.

The range of existing knowledge covering montane scrub is relatively limited and the effect of climatic change on mountain communities uncertain. Therefore, from a long-term perspective, site selection should consider areas of varying conditions, to allow for future colony expansion in a variety of potential outcomes.

When considering the above list of priorities, give preference to the following site attributes:

- The national (or international) status of the species present and their vulnerability.
- The extent and size of a population: larger colonies composed of native remnants possess higher conservation value than smaller colonies.

Table 1. Ranking of Site Types

	Priority ranking	Management Strategy
Existing community	1	The community is in poor condition.
	2	The community is in good condition but under threat.
No existing community	3	The site is adjacent to an existing community.
	4	Records indicate the past presence of montane scrub (question why this is no longer the case).
	5	Site conditions are suitable.

- Sites of existing willow and juniper with both male and female bushes.
- The presence of other, associated plants or animals of conservation value.
- Native woods in the locality with the potential for expansion both up and down the altitudinal range
- Where planting is required sites already fenced through other funding schemes could present a cost effective option, for example, the upper margins of commercial forestry schemes, where it is likely that the infrastructure for herbivore management will already exist.
- Conditions requiring minimum resources to control herbivore damage.

Throughout this process thought must be given to the practicalities of effecting restoration. The subjective assessment of physical site conditions collected in the detailed survey provides the necessary information to assess whether restoration is practical.

Consideration should also be given to the long term. The more robust in scale a scrub habitat that is created when the opportunity is present the more likely it is to survive when priorities have moved on. There are also natural heritage advantages to a large scale scheme, or core area (see Stage 5). There are not many areas where developing such areas is likely to be practical in the long term.

Stage 4 : Current Best Practice in Restoration

Restoration action now is taking place at a time of political and economic change in upland land use. It is possible (although by no means definite) that the future will see greatly reduced grazing pressure in the uplands. Such a change would enhance the scope for future expansion of montane scrub from small nuclei populations either safeguarded or re-created now. This potential has implications for the method of restoration selected.

It is rare that a restoration project has unlimited resources, with the result that a process of prioritisation is required, as explained in stage 3. Through this process it is often possible to identify 'core areas' and the benefits and methods of this approach are set out in Stage 5. Throughout the process of restoration action planning it is important to be aware of the level of resources available and not to underestimate the costs associated with any action decided upon. With this in mind it is normally advisable to take a tailored approach to action based on individual site assessments and perceived management requirements. This should take into account as a priority, the conservation of existing remnants of montane scrub and the range of influences upon those remnants. It is important that the project objectives drive the practical activity and not vice versa.

An approach to identifying appropriate action is that advised by T. Clifford (1997) of allowing the objectives to determine the level of intervention required. This is often referred to as 'minimum intervention', and has often been mis-understood as meaning none or limited intervention. The adoption of this approach is a way of ensuring that the amount of disturbance created in the name of restoration is restricted to that necessary to achieve the desired end point. The approach requires, at the planning stage, greater consideration of the impact of any proposed action, both in the short term and, as importantly, in the longer term on the project land. Often it will require the input of experienced surveyors and land managers to provide sound advice.

Little is yet known of the best methods of scrub restoration beyond extrapolating experience from native woodland, and the direct experience gained with willows by National Trust for Scotland at Ben Lawers, and with juniper in the Borders by Borders Forest Trust. Below is information about a number of key factors that are likely to feature in any restoration scheme.

Culling or removal of herbivores

The present size of most montane scrub plants and communities is determined by browsing, either by deer or sheep, or both. Through herbivore reduction existing plants may flourish, and produce more seed. For many any browsing continues to cause damage and it is unlikely that reduction of deer or sheep alone will allow natural regeneration to succeed (see below), and more drastic measures will be required, at least in the short term. The removal or reduction of sheep on moorland can be achieved with the assistance of the Rural Stewardship Scheme, which can provide payments through a holding-scale grazing plan. The most common method of excluding herbivores is through fencing (See Note 3 for more information on protection.).

Natural Regeneration

It can normally be assumed that new recruitment to a population will be the basis of at least one objective in many restoration projects. Natural regeneration is likely to be the least interventionist approach to achieving this. It has the following key characteristics:

- Relatively inexpensive;
- Maintains genetic integrity;
- Is unpredictable and dependent on a healthy parent population producing large quantities of viable seed.

In order to achieve natural regeneration there are a number of conditions which need to be in place, as with native woodland:

- Small patches of exposed mineral soil need to be present for small seed, particularly willows and birches, to land on if they are to germinate and survive (often created by animals moving over the ground);
- Levels of grazing must be low enough to allow for seedling plants to develop undamaged.
- Quantities of seed, which means, in

dioecious populations (willows and juniper) male and female plants need to be close enough for pollination.

The key benefit of using natural regeneration is the 'natural' mosaic form the new habitat develops reflecting localized variations in fertility, exposure and drainage. However, at high altitudes the process of regeneration is often slow and restricted by the availability of viable seed and seed predation. These factors illustrate the need to set specific objectives which allow an assessment of the chance of success. For example, if, due to the state of an existing population it is imperative to achieve new recruitment within ten years or risk extinction, it is also likely that conditions are unsuitable for natural regeneration. If the community is impoverished to the extent that there is very little seed being produced, and the existing plants are unlikely to recover and produce quantities of seed quickly, there may be little alternative but to consider planting (see below). Conversely, where there is a reasonably robust existing population there may be no hurry to achieve new recruitment. Providing conditions (removal or reduction in herbivores, see below) that allow the individual plants to recover and increase the seed production levels of the whole community may be all that is required in the short term.

Consideration of action to promote natural regeneration may be required if it does not occur unaided once seed levels are predictably high.

Scarification is the method used to create open ground within the ground vegetation sward for regeneration. If grazing is reduced to the extent that the ground vegetation develops a thick, unbroken sward across the site it may be necessary to break it up either through the use of stock, preferably cattle, or by hand using appropriate tools, depending on the scale of operation required.

Artificial Expansion

Artificial expansion, by comparison, uses a greater level of intervention to enable the recovery of existing plants, or to create new montane scrub communities by planting. It has the following characteristics:

- Expensive;
- Requires much more effort to maintain genetic integrity, which may sometimes be impossible;
- Allows restoration across a wider range of sites.

Artificial restoration is likely to occur in two situations; when establishing a new community and as a last resort for expanding an existing, threatened community. Planting enables relatively quick establishment and is particularly appropriate if aiming to establish montane scrub on new sites. Refer to Guidance Note 5 Propagation of Shrub Species for details on selection of propagation material. Careful choice of species to match soil, exposure and altitude is important (for additional information see table 2, appendix 2). But, by simply mimicking existing scrub woodlands in the locality, whose recent development has been strongly influenced by the presence of browsers, a species poor habitat may be created where a more diverse one is more appropriate.

As alternative to planting when expanding a willow community layering is particularly applicable and can be encouraged by pining a shoot to the soil with a rock. Where both sexes are present this is a useful way to expand the colony, and bring male and female plants into closer proximity thereby increasing the chances of pollination.

As for natural regeneration, when planting new young plants competition from other surface vegetation needs to be minimal. Chemical weed control on many montane shrub planting sites is infeasible due to inaccessibility and terrain. The following methods will create optimum conditions for planting and reduce the after care required:

- Plant at the end of the winter so that new plants have the whole summer to establish.
- Plant into bare soil. This can be achieved in various ways:
  - Remove a turf and plant into the soil beneath. The thickness of turf removed will vary depending on the vegetation type, but always ensure that all growing parts of the surface vegetation are removed.
  - Clip back shrubby vegetation like heather (with secateurs), from the edge of 'holes' to reveal a bare surface suitable for planting.

- Where the soil is thin, cut and reverse a square turf and plant directly into it.
- A light application of bonemeal onto the plants before planting improves shrub establishment.
- To ensure that shelters stay in place in adverse weather, and are safe from itinerant grazers always use twin stakes on shrub guards.

Site maintenance and aftercare

Site maintenance is important for both existing and newly planted scrub species, particularly to deter the attention of browsing by deer. In order to make appropriate aftercare decisions quarterly condition checks of both planted and regenerating scrub are necessary. These include the checking of fence condition, signs of browsing, and shrub fatalities. During the growing season these checks can incorporate hand weeding of each plant and the marking of dead plants. For further details of scrub protection refer to Guidance Note 4: Protection.

Stage 5 : Core Areas: a system for focusing action

Developing core areas

The establishment of core areas provides a focus that aids the effective targeting of resources and sets the restoration within the context of the whole landscape and other habitats. For this reason, the development of core areas should take place at the planning stage. In effect, a core area is where existing montane scrub, clumped or scattered, along with adjacent ground forms a larger area suitable for restoration. Ideally, a core area will contain a site of established montane scrub where expansion is feasible and other sites with potential for the establishment scrub, ie sites with a priority ranking of 1 or 2, see table 1.

Identification of core areas

To identify core areas, use the data gathered from the collation, survey and condition assessment stages to plot the location of all known montane scrub populations on a map. This provides a visual indication of the distribution of population clusters. Soil and geological maps can be used to correlate the edaphic and altitudinal factors that affect the existing populations. This information can then be used to identify other areas with potential for restoration. It is not necessary to stick rigidly to the altitudinal and edaphic limits of the current population as this often reflects the constraining effect of current management regimes upon the development of montane scrub and might not accurately indicate the potential range. Also, when exploring the options for core areas, it is important not to encroach excessively on to other important habitat sites. The topography and scale of the landscape will determine the extent of core areas. In addition the Forestry Commission Forest Landscape Guidelines (1994) may influence the size and shape of restoration sites.

It should not be forgotten at this stage that montane scrub and treeline wooodland are the natural upper margins of native woodland. Every opportunity should be taken when identifying core areas to re-connect scrub with semi-natural woodland at lower altitude.

Constraints upon core areas

The limitations that may impede core area establishment are varied. These may relate to land management issues or legal matters. Land management issues might include deer and livestock management, or the feasibility of fencing lines in relation to rock, or landslips and avalanches. Possible legal implications are land ownership, legal designations, access and public liability. For these reasons, it may not be appropriate to focus upon such sites at the start of restoration. However, it is important to maintain the potential for longer-term opportunities. With this in mind, the management plan should highlight and record the value of such sites.

Stage 6 : Restoration management planning

Project objectives and funding

The objectives should take into account the terms and conditions of potential funding bodies and the realistic availability of funds. Within each objective, identify measurable elements in order to evaluate success. This enables a

focused approach with a clear indication of the projects aims for funding. Having identified objectives and suitable sites a costed management plan for the project area can now be written.

Project funding and preparation of budgeted time scales

Project objectives form the basis for financial apportionment decisions. It is crucial at an early stage to ascertain the project costs and timescale. This should identify possible sites and management phases:

- On going project management
- Site preparation – for example grazing control
- Planting
- Monitoring
- Short and long term maintenance

For more details of selected funding sources see Appendix 3

Potential sources of funding might include Scottish Natural Heritage, The Forestry Commission, local authorities, Trusts, and commercial sponsorship. It may be useful to consult the 'Charities Aid Foundation' and 'The Directory of Grant Making Trusts' (see local library).

Establish a project whose size is in accordance with available funding

Aim to secure funding for both the launch of the project, and to safeguard longer-term site management requirements.

Identify the implicit constraints of a funding body's terms and conditions

For example, does the grant require spending before a specific date? Such a condition can appear straightforward. However, adverse weather conditions and unavailability of contractors can all too easily create havoc with the best-laid plans. Such factors have consequences for the timing of grant claims, and should therefore be taken into account at planning.

Ascertaining realistic project costs and work schedules

To estimate realistic project costs and an indication of how long a job will take, contact experienced contractors for advice and price estimates. However, be straight with them and explain the context of the enquiry. An estimate from an experienced contractor will be accurate enough for these initial stages, especially if a contingency for cost variations is included. Contractors generally do not mind providing outline figures. However, to prepare a proper costing is time consuming, especially if the contractor provides detailed figures and background information. Unless there is a concrete guarantee of work, it is unfair to expect such detail. Especially, as original specifications often change as project planning progresses. It is just as well to remember, that whilst most contractors are willing to help potential clients, their valuable information can soon dry up if they feel taken for granted and their time wasted.

The estimates collected from contractors will form the basis for a cost per site. Where funding does not allow for the implementation of all elements of a plan, hold onto the details of all the work. It pays to be flexible and ready to take advantage of short notice funding opportunities, such as early each year when many agencies are approaching their financial year-end and are frequently keen to spend money fast.

Include appropriate budget contingencies. This is particularly important for long-term projects as cost alterations invariable arise over time. Experience often demonstrates that with good management, the overall budget total will be correct, even if details vary.

Stage 7 : Monitoring the success and impact of restoration action

Monitoring ensures measurement of the original restoration objectives. However, as with all long term maintenance aspects, build the monitoring cost component into your original budget. Increasingly funders require monitoring as a condition of grant, but more importantly it is a valuable tool for the land manager. By assessing success, resources can be targetted more efficiently.

The main objective of monitoring is to check

survival and growth rates with a view to implementing management actions as appropriate, for example an assessment of shrub mortality. Measurements covering the survival rate of regenerated and planted populations and growth rates provide the basis to measure the success of restoration. Timing of the assessment is critical, particularly for deciduous species. These should be assessed between July and September when they are in leaf and any flowers or fruit are visible. Evergreen species are most visible when other vegetation, particularly heather, is still brown after winter between March and May. Repeat monitoring visits are best done when plants are at the same growth stage. Fixed point photography is one of the most effective methods of monitoring for gross change. Photographs at fruiting time allow a quick assessment of the recovery of reproductive capacity.

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Suggested Reading

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Appendix 1

Specifications for survey

Gather and collate existing records

With the aim of establishing the historical status of existing montane scrub within the project locality, collate information from past surveys. To gather relevant information, contact local Scottish Natural Heritage offices, biological data recorders, naturalists and historians, and other relevant organizations.

In addition, collect information on past and current management including grazing density and /or muirburn regimes. Consult old maps, statistical accounts, aerial photographs and site records. Also, speak to local landowners, farmers, estate workers and community members. Information from seemingly disparate sources often link up and contribute to the establishment of a more complete overview.

Site survey and condition assessment

An initial Phase 1 Survey of the principle habitats will identify the potential of the area and the location of the best sites for restoration. [Further information on Phase 1 Survey methodology is available from local SNH offices]. At this stage, all potential sites (existing remnant communities) should be photographed in order to provide prints for a more detailed survey of individual sites. Potential sites include those where montane scrub is already growing and those where there is a possibility for the expansion uphill of existing semi natural woodlands or conifer forest. Where it is not possible to access montane scrub safely, mapping and photographing the extent of the population with an estimate of numbers and an assessment of condition will suffice. The Phase 1 Survey will require the services of an experienced ecologist familiar with montane communities.

From the initial survey a more detailed survey of sites with existing montane scrub should be undertaken to assess and measure the aspects detailed overleaf.

When on site, make a photographic record of the scrub community and environs to complement the survey cards. Visual images prove a useful interpretation aid for third parties unfamiliar with the site. In addition, photographs and slides will form an historical reference for future researchers.

1. Spatial extent	Map the area covered by the total population. Also, take into account outlying individuals and whether the colony appears to be expanding or contracting.
2. Total population numbers and stand density	A simple count at each site will allow for comparisons of colony sizes within the project area. Count individual species, although it may not be possible to specify the exact species of willow, notorious for their ability to hybridize. If it is impossible to make a count of total numbers due to the extent of the colony, calculate the density in a sample area and extrapolate.
3. Growth rates	Measure the previous seasons growth as an indication of plant health and vigour. A general visual assessment of shoots and measurement of those where the growth extension is representative of the colony gives an indication of the growth rate.
4. Age structure	Estimate the percentage of plants falling into three broad age categories, namely young, middle age and old. This will indicate the regenerative health of the colony. Indicators of age are stem width, plant size and brown wood to green wood ratio. If possible, collect dead wood samples to aid age estimation through a ring count, although for willows this is likely to be a minimum.
5. Distance between sexes	As many montane scrub species (willows and juniper) are dioecious, the sex ratio is important to assess the potential for future restoration through natural regeneration. Mardon (pers. com.) suggests that the sexes of montane willows need to be less than 50m apart for effective pollination by bees.
6. Browsing damage	Browsing damage indicates the limiting effect herbivores currently have upon plant growth and colony expansion. Often grazed willows develop horizontal growth habitat and in damp areas may persist by layering. Layering is the term used where a plant stem sends out roots in damp conditions.
7. NVC assessment	Assess the montane scrub and surrounding area allocating an approximate National Vegetation Classification (NVC) vegetation type. The detail of full NVC survey is not necessary for the purposes of montane scrub restoration, unless on a SSSI. Many of the NVC communities supporting willows are also internationally important in their own right and therefore consultation with SNH is recommended at an early stage.
8. Estimation of the potential for future propagation	With particular reference to juniper, whose seeds take between two and three years to ripen, it is useful to note the presence of individuals with seeds. With regard to cutting material, note the health of the growing tips and ascertain the presence of other organisms such as plant eating insects or disease.
9. A subjective assessment of physical site conditions	This data will assist decisions on future site management. For example, information on avalanches and rock falls becomes pertinent when planning future fence alignment. An assessment should note: gradient; substrate stability; regular snow accumulation; the risk of avalanche, rock falls or landslips;
10. Identify the National Grid Reference for each survey site	This will enable organizations such as SNH, to add the survey information to their databases. This has relevance for designated areas such as National Parks, Natural Heritage Zones, and regional administrative boundaries. When the survey is completed, offer the data to the Biological Records Centre database.
11. Record current levels and management of stock and deer	This information is important when considering the need for stock or deer removal, or fencing.
12. Additional details to record:	Landownership and/or land-management contact; surveyor, date and length of time on site.

Appendix 2

Table 2. National Vegetation Classification communities and soil types suitable for different montane plants.

Montane Scrub Species	Altitudinal range (m asl)	Suitable precursor NVC community at planting site	Suitable soil conditions at planting site
Salix arbuscula	420 - 890	W20, CG10, CG14,U4, U17, M10	Base rich soils
S. lanata	550 - 1000	W20, CG11, CG12, CG14, U4, U5, U16, U17	Base rich soils
S. lapponum	450 - 1100	W20, CG14, U4, U15, U16, U17	Moderately calcareous, wet free draining
S. myrsinifolia	15 - 940	U4, U15. U17,	Moderately calcareous
S. myrsinites	300 - 980	W20, CG12, CG14, U17	Moderately calcareous
S. phylicifolia	0 - 690	W20, CG10	Moderately calcareous
S. reticulata	450 - 1125	W20, CG14, U16, U17, M11	Base rich soils
Betula nana	130 - 850	M15, M17, M19ciii, H12	Mainly blanket peat, known from 1 mineral soil site.
Juniperus communis spp *communis*	0 - 900	W19, H10, H12, H13, H14, H15, H16	Tolerates a wide range of soil types
Juniperus communis spp *nana*	0 - 950	H7, H10, H15, H21	Bare acidic rocks & humic rankers

Sources: Horsfield & Thompson (1997), Scott (1997), MacKenzie (2000), Hester (1995) and G. Sullivan (pers. com.)

NVC communities referred to in Table 2.

W19 *Juniperus communis* spp *communis-Oxalis acetosella* woodland
W20 *Salix lapponum-Luzula sylvatica* scrub
CG10 *Festuca ovina-Agrostis capillaris-Thymus praecox* grassland
CG11 *Festuca ovina-Agrostis capillaris-Alchemilla alpina* grass heath
CG12 *Festuca ovina-Agrostis capillaris-Silene acaulis* dwarf herb community
CG14 *Dryas octopetala-Silene acaulis* ledge community
U4 *Festuca ovina-Agrostis capillaris-Galium saxatile* grassland
U5 *Nardus stricta-Galium saxatile* grassland
U13 *Deschampsia cespitosa-Galium saxatile* grassland
U15 *Saxifraga aizoides-Alchemilla glabra*
U16 *Luzula sylvatica-Vaccinium myrtilllus*
U17 *Luzula xylvatica-Geum rivale*
M15 *Scirpus cespitosa-Erica tetralix* wet heath
M17 *Scirpus cespitosa-Eriohorum vaginatum*
M19ciii *Calluna vulgais-Eriophorum angustifolium* blanket mire, *Vaccinium vitis-idaea-Hylocomium splendens* sub-community, *Betula nana* variant
H7 *Calluna vulgaris-Scilla verna* heath
H10 *Calluna vulgaris-Erica cinerea* heath
H11
H12 *Calluna vulgaris-Vaccinium myrtillus* heath
H13 *Calluna vulgaris-Cladonia arbuscula* heath
H14 *Calluna vulgaris-Racomitrium lanuginosum* heath
H15 *Calluna vulgaris-Juniperus* heath
H16 *Calluna vulgaris-Arctostaphylos uva-ursi* heath
H18 *Vaccinium myrtillus-Deschampsia flexuosa* heath
H21 *Calluna vulgaris-Vaccinium myrtillus-Sphagnum capillifolium* heath

Appendix 3

Selected Funding Sources for Restoration
please note this list is not exhaustive

Name of Scheme	Standard SNH Grant or management agreement	Rural Stewardship Scheme (RSS)	Woodland Grant Scheme (WGS)	Landfill Tax
Run by	SNH	SERAD	Forestry Commission	Local Authority
Eligibility	Landowners, constituted bodies	All agricultural land, through a farm business	All land through owner or legal tenant	All land within 10km of landfill site, Applicant must be registered with ENTRUST
Payment for	Fencing, planting, and maintenance with stock of local origin	Suitable management for the protection of the environment and natural resources in specific areas	Establishment and expansion of woodland (including scrub) by natural regeneration or planting	Establishment, maintenance and project management costs
Rates of Grant	50—100%. 50% for projects not covered by other grant schemes, upto 100% were land is within a SSSI	£55 per ha for the enclosure of suppressed and grazed scrub and tall herb communities. £3 per metre for stock fencing, £6.50 per metre for deer fencing, £1.50 per metre for rabbit proofing, £25 per metre for gates and £45 per ha for stock removal	On regeneration sites a discretionary payment of 50% of agreed costs is available for required work. On planting sites up to £1.50 per plant. Planting @ £1350 per ha, natural regeneration @ £525 per ha	100 % of an approved project
Suitability	Small sites <1ha, high altitude sites, above the woodland edge and conservation sites where timescales and operations make WGS unsuitable	Heathland and scrub sites	Open ground, existing woodland and mixed woodland/ scrub sites	All sites within the eligible area, where restoration is the objective. Plantlife are a registered body and can lead any bid
Issues	Long-term maintenance needs to be taken into account at the start	Scheme requires total stock exclusion, which can hinder natural regeneration on some sites	The small scale of most schemes means the fencing costs are often higher than the grant, therefore other sources of funding are required	Restricted to areas surrounding landfill sites and registered organisations.

Note 3 : Integration with other land uses

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Striking a balance

As outlined in Guidance note 1, very little montane scrub has survived in Britain. That which remains is limited to scattered stands of trees or shrubs, few including more than one or two species, typically on cliff ledges or other remote, precarious locations which have afforded plants protection from sheep, deer and fire by virtue of their inaccessibility. For montane scrub and the individual species which it comprises to survive, active restoration is required. This may involve encouraging and enabling recovery of existing plants to allow them to produce seed, and/or establishment of new plants by natural regeneration or planting.

Even in ideal circumstances, the proportion of ground on which montane scrub restoration is feasible or likely is extremely restricted in Britain. It is estimated that even downy willow, the least demanding upland willow species, is likely to be restricted to less than 5% of the montane zone in the Highlands. Many areas of heather, grassland and wet flushes will remain free of trees or shrubs. Nevertheless, allowing and enabling the expansion of montane scrub obviously has implications for other land use interests, including crofting, hill farming, sporting and recreational interests, our natural and cultural heritage. Restoration schemes need to be designed and implemented to ensure that the benefits are maximised for all concerned, and any adverse impacts minimised.

This note explores some of the issues and offers guidance on how the conservation needs and interests can be integrated with the needs and interests of farmers, landholders, foresters and the general public.

Hill farming, deer and montane scrub

Reduced deer and sheep numbers are likely to be essential to long-term restoration of montane scrub where browsing by sheep and/or deer is currently limiting growth. This need not necessarily have a negative impact on farm or stalking income. The high altitude land on which montane scrub thrives is amongst the most remote, but varies in productivity from some of the best to the poorest quality grazing. Given the relatively small scale of most scrub communities, any loss of grazing will normally equate to only a small reduction in sheep stocking numbers. Such projects may be eligible for funding through the Rural Stewardship Scheme (page 16).

Other positive benefits from a farming and stalking perspective are:

- Reducing stocking density to more sustainable levels will allow the many other species of plant on which sheep and deer graze to re-establish. This in turn will lessen need for supplementary feeding and potentially lead to long-term improvements in condition of sheep and quality of deer, which on shooting estates may be of equal importance to quantity. Only in occasional cases could it be argued that deer numbers need to be maintained artificially high in order to sustain herds of many deer with large antlers.
- Montane scrub provides a different range of nutrients to other species found growing at similar altitudes. Calcium in willows is particularly important for pregnant hinds, ewes and stag antlers, and might beneficially impact carcass weights, as well as potentially reducing need for licks or other costly supplements.
- Increase in montane scrub could also potentially provide increased shelter and cover for sheep and red deer which can improve growth rate and performance of individual animals.

Montane scrub restoration can be compatible with hill farming and stalking, but successful integration requires careful planning and management.

- Identify sites suitable for different types of

scrub and consider these in relation to movement and grazing patterns of deer and sheep to ensure that short and long-term shelter and grazing requirements are taken into account in planning restoration schemes.

- Priority should be on establishing sustainable stocking levels rather than fencing wherever possible.
- As a general guide, removal of up to 40% of current season's growth will not detrimentally affect productivity of heather or other dwarf shrubs. Guidance note 4 offers further practical guidance on protection options.
- Regeneration of suppressed scrub on grazing land may qualify for an annual payment under the RSS (see page 16). Further information and advice on eligibility is available on request from SERAD, FWAG or SAC.

Forestry considerations

By definition, montane scrub thrives at higher altitudes than those favoured for commercial timber production, and as such is unlikely to compete with land which might profitably be managed for forestry. However, species such as willow, rowan, juniper and birch can play a useful complementary role in bridging the gap between tall trees and open hill, softening stark plantation edges and creating a natural transition to open ground, which can protect more intensively managed lower altitude woodland from windthrow.

- Forestry schemes usually offer greater potential for deer and browsing control than grazed moorland, which may allow montane scrub restoration without need for fencing.
- Forestry Commission's Woodland Grant Scheme includes discretionary allowance for montane scrub regeneration.
- Removal of exotic conifers increasingly commonly found above existing plantations will usually be desirable to reduce competition for montane scrub, but may not be an urgent priority where remnant montane scrub is not currently threatened.

Game considerations

Black grouse is one of various species whose native habitat is the woodland edge but which shows a distinct preference for the mosaic of different types of vegetation resulting from naturally regenerating scrub. Birch, willow and rowan provide three of the key food plants in early spring. Lack of necessary open scrub habitat in many parts of Scotland is responsible for restricted distribution and population density of black grouse. Montane scrub regeneration is likely to be highly beneficial for black grouse.

- Diversification of a sporting estate to include black grouse can increase variety in clients' bags and offer the additional challenge of hunting for birds within a scrub/heath or scrub/grass mosaic.
- The upper tree line of Scots pine woods of Strathspey and Deeside offer particular scope for encouraging game through restoration of birch, willow, rowan, pine and juniper.
- Restoration schemes should be designed to recreate a natural mosaic of habitats, which will usually be favoured by maintaining grazing at low levels to avoid scrub becoming too thick.
- Specific advice should be sought on the line and design of any fences near known black grouse lek sites.
- Protection of clumps of shrubs rather than fencing of large areas is likely to be preferable from a game perspective.

Natural and cultural heritage and montane scrub

Montane scrub is a natural component of the mixture of upland habitats which characterise the Scottish uplands. Measures to allow its regeneration could potentially benefit many other species currently restricted by grazing, including grassland, tall and woodland herb species currently restricted in their distribution in the uplands, which could be particularly valuable in more base-rich areas which carry the widest species range, including some rare montane species. Increasing variety in the structure of vegetation, as a result of montane scrub restoration, will increase the biomass and variety of associated insects, some of which are

recognised as being of very restricted distribution and in urgent need of protection. This in turn will increase food resources for insectivorous vertebrates and for predators higher up the food chain.

As well as being of inherently high nature conservation value, montane scrub restoration can therefore be beneficial to other species. Care is needed, though, to make sure increased competition from scrub does not threaten some of the shorter mountain herbs and characteristic grasses which thrive on base-rich soils, or result in loss of birds such as red grouse, curlew and ring ouzel which favour open moorland. To avoid any adverse impacts on other wildlife:

- Establish the existing nature or archaeological conservation interest of proposed site(s).
- Assess the implications of montane scrub restoration, including threat to any other species of particular wildlife interest such as alpine and boreal heaths. Scottish Natural Heritage and RSPB are amongst the organisations who will offer expert guidance free of charge.
- Consider how measures to allow montane scrub regeneration might affect other montane species currently restricted by grazing, such as species-rich flushes and montane grassland.
- Seek advice from SNH on the comparative conservation value of the site in its current condition.
- Consult the Local Authority archaeology service before considering restoration of montane scrub on any sites of historic or archaeological interest.
- Ensure that montane scrub restoration along burns is not so dense as to discourage dippers.

Access, recreation and landscape conservation

Experience in Norway suggests that there is no real cause for concern that montane scrub restoration would restrict public access or interfere with recreational use of the countryside. Seedlings are unlikely to establish in areas of recreational pressure such as slopes favoured for skiing, and exposure will limit growth of shrubs on the ridges typically favoured by walkers. Rather than the impenetrable thickets which some people fear, the scattered bushes which are more likely to be the reality, will add interest and challenge for skiers, whilst improving the snow holding capacity. This may also improve the walking experience by providing shelter and stability to erosion prone paths and slopes. Any thickets which do develop are likely to be so small that they are easily by-passed.

Similarly, the shrubs which maintain a foothold in the hostile terrain associated with montane scrub will enhance rather than detract from the austere beauty of the upland landscape. Dense blocks of scrub of uniform height and age are highly unlikely to develop, particularly if low-level grazing is maintained.

Even so, all montane scrub restoration schemes should take account of the implications for recreation and landscape. Early planning should consider:

- Restoration plans should take account of recreational use of sites, including how short-term protection such as fencing might affect such use, and how long-term plans for scrub restoration would affect walking, skiing or other recreational use.
- It is worth considering how recreational use could be positively used to encourage montane scrub, for example by diverting sheep or deer away from certain areas (see guidance note 4, page 21).
- Visual implications of montane scrub restoration should be taken into account short and long-term, including possible adverse impacts of protection such unnatural straight edges of heather regeneration within enclosures.
- Restoration schemes should aim to replicate the natural mosaic of habitats previously typical of the Scottish uplands. Where planting is necessary, it should be random and clumped.

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Note 4 : Protection of Sites

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Restoration and browsing

Limited browsing by sheep and deer can be advantageous in encouraging side-branching and denser growth habit of some species, which in turn will reduce competition from surrounding vegetation and so discourage vole damage. On the other hand, too much browsing of leaves and shoots severely suppresses the growth rate and reproductive capacity of individual plants. As with other plants, very heavy browsing can kill shrubs. Successful restoration therefore depends on restricting browsing to levels which will allow seedlings to establish and existing plants to flourish. The best way of achieving this will vary between sites depending on the cause of browsing, location, terrain, land ownership, access, wildlife and historical interest.

Is browsing always a problem?

The majority of scrub species are relatively unpalatable. So long as there is a more attractive and nutritious bite to eat in the form of grass, herbs or other vegetation, browsing of montane scrub can be relatively limited and therefore may not be a problem. Montane scrub species become vulnerable when the quality, quantity or availability of other edible material is reduced due to seasonal growth, competition for grazing or snow cover, or when the alternatives available are even less palatable. Dwarf birch is a good example. In theory its characteristically high concentrations of secondary compounds should serve as a natural deterrent to grazing, but in practice deer still browse on dwarf birch in preference to the heather in which it is usually found growing. Similarly juniper's evergreen leaves are for much of the year at low risk, but when other plants are in short supply, juniper is subject to heavy browsing by sheep, deer and hares.

During hard weather the majority of sheep, feral goats and deer will move downhill in search of shelter, so reducing the risk to scrub found at higher altitudes. Snow brings with it mixed blessings. Shrubs smothered in snow are to some extent protected from browsing, and from ice blasting, which can be particularly devastating for montane scrub, much of which is now restricted to exposed north-facing sites which are also snow-holding areas. On the other hand, the lack of alternative food means that any shoots, stems or remaining leaves protruding above the snow are almost certain to be eaten. Snow movement due to avalanches or rapid melt can damage individual shrubs. Snow is also the most significant complication to effective protection by fencing.

Identifying the cause of browsing

Sheep and red deer are the main culprits of browsing damage. Roe deer are rarely a problem at the altitude at which montane scrub is found. Mountain hares are a significant problem on some sites, particularly in the eastern and central Highlands, and in favoured feeding areas, such as among short heather. As with sheep and deer, most damage occurs in winter when other food sources are limited, particularly during heavy snow, and in early spring when swelling buds are highly palatable. Exposed sites typically suffer less damage because of hares' preference for sheltered feeding sites. In the Southern Uplands, mountain hares are being encouraged as prey for golden eagles, but current population densities are too low to represent a problem for montane scrub regeneration. As with other trees and shrubs, plants regenerating naturally *in situ* appear to be less favoured than planted nursery grown stock. Rabbits are more of a problem at lower altitude, for example in the Angus Glens.

Voles browse bark and bite off the apical shoot of shrubs. The level of damage varies according to palatability and nutrient levels which in species such as willow vary between sexes. Coppice regrowth from shoots bitten off at lower level is in some respects more acceptable in montane scrub than trees managed for timber production, but vole damage can be

particularly bad following deep snow cover.

Protection options

Treating the problem at source by reducing stock numbers, whether by culling or by changing management practices to modify grazing patterns, is always the preferred option. Several deer management groups have already successfully negotiated reductions in deer numbers. As more follow their example, deer culled from small areas may be less likely to be replaced by incomers from adjacent land.

Where stock reduction is not currently viable, for example due to land ownership and grazing rights, physical protection of shrubs and seedlings may be the only feasible choice, but fencing is not necessarily an easy option. Due to the inaccessibility of most sites on which montane scrub has survived, uneven terrain, minimal soil cover and need to drill posts into exposed bedrock, average costs (up to £9 per m) can amount to double the usual cost of hill fencing. Once maintenance costs are added into the equation, fencing often proves far more costly than other protection methods. Fencing has also proved less effective in encouraging new seedling establishment, in part due to nutrient, water and light competition in ungrazed swards. Propagation and planting within fenced areas may therefore be necessary.

Wherever fencing is used, it should be a short-term measure only to provide sufficient breathing space to allow recovery of remnant stands of suppressed scrub. Long-term reduction in stock numbers is likely to be essential to survival of seedlings which have established within protective exclosures.

Assessing the options

The following checklist summarises points which will need to be taken into account in deciding on the most appropriate option for any particular site.

What is currently restricting growth?

- Is there any evidence of browsing damage? If so, what has it been caused by?
- Do sheep/deer have year-round access to areas where montane scrub is growing or is to be encouraged? How do sheep/deer use surrounding ground? How wide is their range relative to the site?
- Do sheep/deer have a pattern of movement which varies during the day/week/year?
- Is there a resident hefted hind population or is risk of deer browsing more likely to be from itinerant stags?
- Are mountain hares a problem? Would montane shrub restoration be feasible without protection against mountain hares if other forms of browsing were reduced?
- What factors other than browsing might be restricting growth?

Site assessment

- How is the site (and area of land within which it lies) currently managed (stocking and shepherding regime, muirburn, commercial shoot)?
- What is the terrain like?
- How accessible is the proposed site? Would fencing materials need to be air-lifted onto site or is there ground access?
- Which direction is the prevailing wind?
- Is the site on or near a rock face? Is it likely to suffer rock fall? Willows are particularly vulnerable to avalanche, rock fall and spate water damage.
- Is the site subject to heavy snowfall? The proposed route should be surveyed at different times of year, including at various stages of snow build-up and melt, to assess depth of snow, how long it lies, risk of avalanche and how often the site is affected by snow.
- What other wildlife species are present, might be encouraged or threatened by montane scrub restoration? Consult SNH, RSPB, Scottish Wildlife Trust and local groups for further information.
- Are there any sites or features of historical interest and how might these be affected by montane scrub restoration or protection? Historic Scotland or the local authority based regional archaeologist may be able to offer further information.
- What public access is there in the area? How might this be affected by proposed

montane scrub restoration or short-term protection?

Modifying stock movement

Browsing pressure on montane scrub is determined by grazing patterns and preferences as well as overall stocking density. Changes in supplementary feeding practice such as relocation of feeding blocks, rings and troughs which have proved effective in heather moorland regeneration could be used to good effect in diverting sheep away from montane scrub. The benefits and practicalities of modifying deer movement by such means are more debatable. Fertilising areas in the bottom of glens causes less social disruption to the herd than supplementary feeding with concentrates, but deer are still likely to range on higher ground during the day, with consequent risk of damage to montane scrub.

Grazing patterns, particularly of deer, may also be influenced by human disturbance. The main drawbacks are the labour implications of managing stock movement on a day to day basis, particularly at high altitude, and the effects on other habitats.

Reduction of stock numbers

Where behaviour modification is inadequate or inappropriate, reduction of stock numbers may be necessary and as mentioned above is likely to be essential to long-term survival of montane scrub. Sustainable stocking levels vary considerably between sites. Recent work (Scott, in press) has shown that dwarf birch recovers at stocking rates of 3 to 4 deer per square kilometre. Partial regeneration of birch woodland has been documented at stocking rates of four to ten deer per square kilometre, or between 0.3 and 0.9 sheep per hectare. Lower stocking densities are often necessary to allow unimpeded regeneration of both montane scrub and other plants growing in association with it. To a large extent establishing sustainable stocking numbers will therefore be a matter of 'suck it and see', with further adjustments based on monitoring. All grazing animals must be taken into account, including deer as well as farm livestock.

A combination of control and protection regimes may work in some situations, such as a limited cull combined with some shepherding and human disturbance. It is worth remembering that browsing of many areas of montane scrub is restricted to certain times of year. Target culling of particular areas has successfully reduced browsing damage to montane scrub on the Mar Lodge estate, and may be a practical option on other estates.

Individual protection

Individual tree shelters might in principle seem an attractive means of providing the necessary protection for montane scrub restoration without the complications of larger scale fencing, but in practice are rarely suitable. Factors to bear in mind include:

- Material and labour costs to erect and maintain individual protection on exposed, remote sites at high altitude are very high.
- Most shelters are insufficiently robust to withstand deer or the exposure and high winds typical of the higher altitudes at which montane scrub is found.
- Individual shelters can look very out of place in a wild, open landscape.
- Tree shelters can provide an attractive warm home for voles, which can increase browsing damage. Quills overcome this problem but are unsuitable for shrubs.
- Additional shoots or top growth encouraged within the protective environment provided by the shelter will be insufficiently hardy to withstand exposure once above the shelter.
- Shelters do not encourage the more important root growth essential to stabilisation and shrub growth at high altitude.
- Netting may be a better option for individual protection of montane scrub, but weeding within the fenced area and removal once the netting has fulfilled its role will be essential.

Fencing

Siting of fences

- Siting and design of fencing should take account of management of sheep hefts,

gathering regimes and other habits and species which may depend on maintenance of grazing.

- Fencing of areas which are traditionally favoured by deer, such as sheltered corries, will inevitably result in problems. Similarly, fencing should not restrict access to lower ground for sheltered deer grazing, which will reduce carrying capacity.
- Scrub regeneration should not be encouraged around black grouse lek sites, which can be identified from local information or by consulting the Game Conservancy Black Grouse Recovery Project.
- Fencelines should stay clear of ridge summits where birds fly closest to the ground.
- Public access provision, including hill walking and cross-country skiing, must be maintained by providing gates and stiles wherever necessary. Consultation with recreational user groups will be necessary prior to any fencing in areas used by the public.
- Visual impact of fences should be taken into account, avoiding obtrusive skyline fences wherever possible.
- Healthy growth of vegetation inside enclosures may prove irresistible to deer, sheep and hares when competition for grazing elsewhere is fierce.
- Plant specific fencing may be practical in small vulnerable sites.

Snowfall and fences

- Snow is the biggest practical problem with fencing: the weight of snow moving downslope during avalanches or when snow on higher ground begins to melt is enough to flatten even the sturdiest of fences. Annual repairs are inevitable for effective exclusion of stock. Getting extra materials delivered to site at the time of initial fence erection for future repairs and replacement will save time and money in the long term.
- Temporary protective fencing or fence removal in advance of heavy snow forecast is rarely feasible because of labour implications and remoteness of sites.
- Careful routing is the most significant means of limiting snow damage. Ideally fencing should link areas which blow free of deep snow. Avoiding areas of deep snow (e.g. north-east facing slopes where the prevailing wind comes from the south-west) may involve more strainers and turning posts, and extra costs in surveying and planning, but will save time and money wasted on a failed project in the longer term. Rocky summits and short bedrock ridges may prove the only snow-free sites suitable for strainers or posts.
- Lowering the top strands of wire over winter to minimise snow damage has been tried on Ben Lawers NNR, although consequent browsing of leafless shoots by sheep has tended to result in loss of any growth achieved over the preceding summer courtesy of the fencing.
- Short sacrificial sections constructed to give easily under snow pressure may be worthwhile where the fenceline unavoidably crosses areas of deep snow, with fencing secured to strainers either side of the snow bed to prevent unnecessary damage to feasible sections.
- Where there is particularly high risk of rockfall or frozen snow damaging the fence from above, it may be worth erecting additional section(s) of protective sacrificial sheep netting parallel to and the main fence on the uphill side.

Size and shape of enclosure

- Location of snow beds, susceptibility to avalanches and rock falls are likely to be the main determinants of size and shape of high altitude enclosures, although terrain will also be an important consideration.
- Larger enclosures are generally more cost effective but are more prone to snow damage, carry increased risk of affecting deer movement or constricting public access and may result in more bird losses from black grouse and other species flying into and out of the enclosure.
- Large enclosures may simply shift sheep and deer (and hence browsing problems) to another site.

- Small enclosures (<50 square metres) may obviate need for higher specification deer fencing or scare wires as deer seem reluctant to jump into small fenced areas.

Fencing techniques

Considerations relating to different types of fencing are given in Table 3. Below are considerations for any fencing system

- Flexible posts offer greater capacity to bend with the snow and snap back into place after snowmelt, but are difficult to erect on rocky terrain and tend to go brittle on exposure to sun and extreme temperatures.
- Electrification using batteries powered by solar cells or a small windmill (cost for latter are about £1,100, at publication) increases protection but power sources need to be carefully sited to avoid loss or damage during high winds or heavy snowfall. Regular control of vegetation adjacent to the fence is also essential to avoid shorting out. Spraying is subject to stringent controls due to risk of damage to sensitive vegetation of potential conservation interest beyond the immediate fenceline. Strimming is therefore usually preferable, but where it is not feasible, advice should be sought from your local Scottish Natural Heritage office regarding types of spray which may be allowed and need for advance application for permission to spray. Flashing diodes which indicate loss of current are a useful addition to electric fences.
- Due to the higher maintenance commitment, Forestry Commission may be reluctant to fund applications for Woodland Grant Scheme to be protected by electric fencing.

Table 3. Considerations required when using different types of fencing.

Fencing height/type	Considerations
1.2 m sheep netting with single strand electrified plain wire offset 1m from net	Effective against red deer and minimises bird strike losses, but susceptible to snow damage.
1.3 m electric parallel line wire with double strand electrified back fence offset 1 m (see below for example specification)	More resistant to snow damage and easier to repair than conventional deer fencing, particularly if wire attached to downhill side of posts (so snow pulls off wires which can be reattached to intact posts). Less prone to bird strike, and birds which do collide have better survival rate. Less visually intrusive.
1.8 m or 2 m high deer fencing	Associated with high mortality rates amongst black grouse, red grouse, ptarmigan and fieldfare. Research ongoing into viable alternatives to reduce risk.
Parallel electrified wires 1m apart, 15-20 cm above ground	Avoids bird losses but SAC experiments at Kirkton Farm reveal practical drawbacks including flattening of fences in snow, insulators breaking after frost, shorting out of electric current as grass “hedge” grows between fences and complications with sheep gathering.
Horizontal sheep netting	Forest Enterprise have plans to experiment with small enclosures to provide protection against sheep and feral goats in Galloway
Fencing against mountain hare damage	Requires double height rabbit netting or a top strand of barbed wire over single height netting. High risk of snow damage and consequent high maintenance requirement.

Fencing specification

Appendix 4 gives a recently developed specification for a new fence at Ben Lawers National Nature Reserve and is based on a design from Rutland Electric Fencing. It has been used successfully on 2 local estates and its selection for use at Ben Lawers was based on practical experience with both conventional and other electric fences on the reserve, along with consultation with practitioners and consultants.

It is expected to be more easily repaired than conventional fencing when damaged at high altitudes, and is also expected to be much less likely to kill birds such as grouse species. In addition it is less visible in the landscape from a distance than conventional fencing.

This fence is designed to protect montane scrub from browsing by deer and sheep, and basically involves a standard stock fence (for which precise specification varied according to altitude, terrain and vegetation), backed up around the entire perimeter by an offset electrified plain wire fence. Both main and back-fences use the same 150 mm x 3.15 m strainers. Rails have been used for under-building across gullies and water-gates. At Ben Lawers, mountain hare damage is considered insufficient to warrant additional fencing, although the need for additional rabbit netting or alternative control for hares would need to be assessed on an individual site basis.

Considerations when determining the fence route

- The fence must tightly follow ground contours.
- Zig-zagging of the fence in some areas will gain height without allowing deer the advantage of being on the uphill side of the fence with the exclosure beneath. However, as deer will follow the fence line looking for a way round, careful routeing is required to avoid deer exerting pressure at points where they find themselves on the inside of a corner, particularly at acute angles.
- Collapsible section(s) to allow herding out of intruding deer and sheep should be incorporated into a funnel shaped section of fence lying below a natural deer jump.
- Staggering of main and back fence posts can make the fence more visible to approaching birds.

Further reading

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Appendix 4

Specification for fence recently put up at Ben Lawers NNR.

Main fence specification

- 1.3 m height, parallel high tensile 12 gauge plain wire fixed with over-size staples and small sections of ‘insu-tube’.
- Lower altitude sites over grass: 6 strands wire on 75 mm x 1.9 m posts spaced at an average of one every 6 m, 100 mm x 3.15 m turning posts.
- Higher altitude sites over heather: 8 strands wire with six plain lower wires supported by 75 mm x 1.9 m posts spaced at average 4.5 m, strengthened with 1 m wooden dropper between posts. Top two wires are electrified, with droppers on the remaining top 30 cm of posts.
- Bottom 2 wires should not be electrified to prevent shorting out on vegetation.

Back-fence specification

- 2 parallel wires, set at 450 mm and 900 mm above ground (550 mm and 900 mm on steep ground), must be between 800-900 mm away from main stock fence wires, supported by a separate set of 50 mm x 50 mm x 1.65 m posts (rather than connected to the main fence) spaced at an average of 1 every 6 m, with 100 mm x 1.9 m turners.

Note 5 : Propagation of Scrub Species

By Graham Sullivan,

Introduction

Promotion of natural regeneration is the philosophically and ecologically preferable option in restoring montane scrub, but in some circumstances this is impossible or unlikely. In such situations the re-establishment or augmentation of populations may be justified on ecological and conservation grounds. Experience and knowledge of propagation of plants for restoration of montane scrub, and understanding of the ecology and reproduction of the shrub species, is far from complete. There is generally greater knowledge of the tree species which sometimes appear in the montane (or coastal) scrub zone, such as Scots pine, oak, downy birch, rowan, aspen, hazel and goat willow, but there has been little application of this knowledge in the montane zone.

This Note aims to provide a guide to propagation of plants for restoration projects by describing selection of appropriate material, propagation methods, and planting. It is a first attempt to collate the information which does exist in order to fill some of the gaps in our knowledge, and modification may well be required in the light of further experience.

Choosing propagation methods

Both vegetative methods and seed can be used to propagate montane scrub species. Genetic diversity of populations is maintained or enhanced by plants grown from seed, while plants propagated vegetatively are genetically identical to the plants from which they are propagated. Pest and disease transmission is reduced with seed, and equipment required for propagation is often less complex and specialised than that required for cuttings. However, viable seed may not be produced, or produced only infrequently or in small quantity, due to the harsh climate of the subalpine zone, small population size, inadequate sex ratios in dioecious species, lack of pollinators, or inbreeding depression.

The origin, and thus adaptation, of vegetatively propagated plants is known with certainty. Production of plants is not dependent on sometimes unreliable sexual reproduction, and can be quicker than production from seed in some species. Aspen suckers can provide plants almost immediately, and these may be large, acclimatised as well as adapted to the site, and already infected with beneficial mycorrhizal symbionts. Vegetative propagation may be limited by the amount of suitable material and removal of material may have detrimental effects on existing plants.

For some species, such as pine, downy birch, oak and rowan, propagation from seed is the only practical option. For species in which more than one propagation method is possible, factors to be considered include the availability of suitable propagating material, the effect on the source population, when and how many plants are required, and what facilities and skills are available. However, the genetic and plant health advantages of seed are such that this should always be preferred. Except for aspen, vegetative methods should only be used for well-founded and properly justified specific reasons, such as maintaining or increasing a particular genotype, or the proportion of a particular genotype in a population, and with recognition of their limitations.

Selection of Sources of Propagating Material

The source of propagating material must be considered at an early stage in any restoration project, as the availability of suitable material will influence its scope, scale, and design. In some cases unavailability of suitable material may lead to the conclusion that a project is not viable or inappropriate. The introduction of unsuitable genotypes may compromise restoration success or have undesirable effects on any existing gene pool or the ecology of the site.

Genetic considerations

Four important factors relating to the genetics of the source population must be considered, with the aim of maintaining the adaptedness of the restored population.

1) Is the potential source population

unambiguously of the desired species or subspecies? While for most species this is unlikely to be a problem, precise identification is sometimes vital. Prostrate juniper (*Juniperus communis* subspecies *nana*) and upright juniper (*Juniperus communis* subspecies *communis*) can be confused and may be found in close geographical proximity. Many of the montane willow species, and eared willow, are known to hybridise freely, so correct identification is important. Where more than one species occurs in a potential source area, it is impossible to know with certainty the pollen source, and plants raised from seed must be screened in the nursery to ensure that undesired hybrids are not introduced.

2) Is the potential source population truly native and local? Material of non-local origin of species such as Scots pine, oak and birch has often been planted. Many montane scrub species are available in nurseries, but are frequently of non-native origin and should not be used, since such a source population is of uncertain or inappropriate origin, and may have been contaminated by gene flow. Seed should be collected from source populations.
3) How well adapted are the propagated plants to the restoration site? Natural selection increases the ability of an interbreeding population to survive and reproduce in the environmental conditions which exist where it grows. Over many generations the population, along with its pollinators, pathogens and symbionts becomes genetically adapted to those conditions, and the ability of plants from this population to survive and reproduce in environmental conditions which are different, even only slightly, is likely to be reduced. Ideally plants for use in restoration projects are most likely to be found in the same locality at similar altitude, and climate. The interactions between the plants and other organisms may also be affected and compromise the success of a project.
4) Is the genetic variation within the source population adequate? Many montane scrub populations are small and have been isolated for many generations. This combination of circumstances can lead to a reduced gene pool, compromising the ability of the population to adapt to changes in environmental conditions, and increasing self-pollination resulting in inbreeding depression (see below).

Guidelines for Selection of Sources of Propagating Material

These will in some cases require to be treated flexibly, although if a project would be impossible without seriously breaching them then the appropriateness of the project should be reconsidered.

- Is there an existing population in the area? Unless other factors make it unsuitable, the nearest population (ideally an existing population on the site) is the most suitable source of propagating material.
- Is the potential source population growing in environmental conditions similar to those of the restoration site? Populations which are geographically close to the restoration site but growing in markedly different environmental conditions will be less suitable than populations further away but in similar environmental conditions. For example, a 1 km distance is likely to be much less important than a 100m altitude difference.
- Is the potential source population gene pool adequate? If inbreeding depression is considered possible, for example where the source population consists of less than 50 plants which are believed to have been isolated for many generations, this population should not be used, or should only provide a proportion of the restored population.
- Would the proposed restoration violate Forestry Commission Local Seed Zone boundaries, or Scots Pine Seed Zones? This should be avoided wherever possible. However, given that these zones were not devised with montane scrub in mind the importance of sourcing material from a similar environment, exceptions are likely. It should be noted that for some species marketing of reproductive material across seed zone boundaries is regulated by the Forest Reproductive Materials Regulation.
- Where seed is not produced in the montane zone, is it acceptable to use seed from lower altitude? Only if the seed-producing individuals are part of a continuous population spanning a wide altitudinal range, encompassing, but not producing

seed in the montane zone.

- Will the source population be affected by removal of propagating material? Such removal should not be carried out if it will have unnacceptable effects. Removal of seed should not threaten natural regeneration, and removal of cutting material should not cause unnacceptable damage to plants.

Selection of individuals for seed collection from a source population

The variation within a suitably adapted pure source population should be maintained in a restored population. A representative sample of seed from the population should be obtained, and this is likely to be achieved by collection from 20-30 randomly selected individuals. Seed should be collected without bias towards individuals with characteristics seen by the collector as desirable, and equal amounts of seed should be collected from each source plant. As individuals which are closer to each other are more likely to be related, it is desirable that a minimum distance between source plants, related to the area of the collection site, be established.

Selection of individuals for collection of vegetative propagation material from a source population

In order to ensure genetic variation in the new population, as many source plants (clones) as possible should be used, and clones should be equally represented in the new population. For dioecious species such as willows, aspen and juniper, a balance of male and female plants should be aimed for. Aspens can grow as very extensive clones reproducing by suckers, and while it may be difficult to differentiate between clones, as many as possible should be used. In order that pest and disease problems are minimised, healthy, uninfected source plants should be selected.

The propagation of plants for montane scrub restoration

The propagation of pine, oak, birch and hazel is adequately described in many widely available nursery practice and Forestry Commission publications, some of which are listed under Further Reading, and will not be considered here. This section is therefore concerned with those species for which less information is available: the montane willows, eared willow, aspen, dwarf birch, and juniper. The montane willow species and eared willow are treated as a single group because their requirements are similar.

Hygienic procedures, such as ensuring all equipment is clean, and promptly removing dead or dying material, should be observed in order to reduce the possibility of fungal infections. Routine treatment of at least willow seedlings and juniper cuttings with proprietary systemic fungicides approved for use on ornamental crops, such as those containing penconazole, is advisable. Daily inspection is recommended, and is crucial in the early stages of willows and aspens.

Details of seed collection and propagation are given in Table 4 (page32). Time of seed maturity will vary with latitude, altitude, and aspect, and it is unrealistic to expect that a single visit to a site will be sufficient to collect seed of some species. Familiarity with and monitoring of source populations is necessary to determine harvest times. For willows and aspens, timing of seed collection is crucial as viability declines rapidly, and it should be borne in mind that even short periods of warm sunny weather can markedly accelerate the onset of maturity.

Details of vegetative propagation for each species are given in Table 5 (page 33). Cutting material should be placed in polythene bags on collection to reduce moisture loss and inserted as soon as possible. If insertion is to be delayed material should be refrigerated. Some willows have preformed root initials, and cuttings root very readily. An open rooting medium can be obtained by mixing an equal volume of sharp sand with peat substitute or vermiculite.

Growing on

In growing plants for montane scrub restoration, the temptation to attempt to produce the largest plants in the shortest time must be resisted. The shock of transplanting into sites with harsher climates than those of the nursery must be minimised. Growing conditions in the nursery are likely to be much less severe than those in the restoration site, and lush plants with open structures and soft growth will be more vulnerable to weather damage and herbivory. Plants which appear robust and vigorous in the nursery are not necessarily best suited for survival in the montane scrub zone.

Container growing is most suitable as this allows most flexibility in planting time and reduces transplant shock. Root trainers or cell growing systems are suitable, and sizes used will depend on the age at which it is intended to plant out. It is worth bearing in mind that plants are likely to have to be carried to the restoration site, and size of container should therefore be kept to the minimum compatible with adequate plant growth. Potting media should as far as possible match the soils of planting sites, for example compost for dwarf birch should be based on peat substitute, while soil-based composts such as John Innes Potting will be more suitable for montane willows. The incorporation of soil and root material from the source site into the compost may provide opportunities for mycorrhizal infection.

Plants should be grown in the open, watered and weeded as required, and inspected regularly.

Planting out

Although container-grown plants may be planted at any time, spring planting gives the longest possible period for acclimatisation before winter. For species such as the montane willows which are almost invariably planted into permanently wet soils, summer planting is possible, and autumn planting may be appropriate in some sites. Winter planting should be avoided, for the sake of both plants and planters.

In accordance with the principle of minimum intervention, planting should involve no more than is necessary to ensure that plants that are suitably adapted to the site can survive without further intervention. With small plants of slow-growing species such as juniper, where severe competition from surrounding vegetation is likely, minimal ground preparation such as removing vegetation from small areas around each plant may be useful, although this may make plants more vulnerable to herbivory and promote erosion.

Fertilisers should not be used, as they will promote soft growth in the desired plant, and may well provide greater benefits to competitors than to the desired plants.

Planting method will vary according to the site and the plants being planted. Corers or solid dibbers which make planting holes of a size appropriate to the plant container, or notch planting, are suitable. Some control of competitors may be beneficial for small plants in the first and second years after planting, but generally aftercare should be kept to a minimum. Restoration should not be confused with gardening.

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Species	Collection	Dormancy	Sowing	Germination	Growing on
Aspen	Years of high seed production are infrequent. Seed matures in June. Remove fluff using screen and vacuum cleaner.	No dormancy. Sow immediately. Can be stored at 6% moisture content, -2^0 C for 1 year.	Thinly on moist seed compost, ensuring good contact. Do not exclude light.	Within 24 hours. Viability high.	Ensure adequate soil moisture. Transplant when required.
Dwarf birch	Seed matures in August.	Will not germinate below 12^0C. Dormancy can be broken by moist stratificat-ion at 2-3^0C for 15 days.	Thinly on moist peat-substitute compost. Do not exclude light.	Low percentage, increased by stratificat-ion or Gibberelic Acid at 1g l^{-1}.	Seedling growth very slow,- <3cm in first year. Transplant when required, normally spring.
Juniper	Cones mature in autumn of second year. Can be collected until winter, when most fall off. Subspecies *communis* normally has 3 seeds per cone, subspecies *nana*, 1. In grey cones with holes seeds have been eaten by larvae (presumably *Megastigmus bipunctatus).* Some viable seeds may still be present, so worth trying when few cones are available. Remove seed from cones before sowing or stratifying.	Stratify in peat/sand for two winters. Dormancy of some seed can be broken by moist stratificat-ion at 2-3^0C for 4 weeks, then >10^0C for 4 weeks, repeated.	Sow either immediately after collection or in spring after stratification. Thinly on surface of moist seed compost. Cover with compost or sand, keep moist.	Viability varies, lower for seed from old plants. Spasmodic germination, occurring throughout the growing season and in successive years. Maximum germination in second or third year.	Trans-plant when required.
Willow	Seed matures late June-early August, very variable. Collect catkins as soon as first dehiscence occurs. Rub capsules gently so they split, allow fluff to expand in a dry place, and separate seed.	No dormancy. Sow immediat-ely seed is mature.	Thinly on surface of seed compost, ensure good contact of seed with surface. Cover with glass to prevent rain splashes, ensure ventilation.	Within 24 hours. Initial viability high, decreasing to zero in a few days.	Ensure high soil moisture. Transplant when required, normally in spring following sowing.

Table 4: Propagation from seed

Species	Timing	Type	Culture	Rooting	Growing on
Aspen cuttings	June-July	Softwood cuttings from vigorous shoots. Treat with hormone rooting powder.	Insert in open medium, maintain high humidity (eg mist bench).		Wean, harden off and pot up as required.
Aspen suckers	During dormant season.	Suckers removed with a small section of root. Cut back by half.	Pot up into compost in container appropriate to the size of root.	Already rooted.	Repot only if required before planting.
Juniper	Variable, but rooting percentage can be very low. Best results are obtained from cuttings taken in spring just before growth starts.	Cutting with heel of ripened wood at base. Treat with hormone rooting powder	Insert in open medium. Water in with proprietary fungicide containing propamocarb hydrochloride approved for use on ornamental crops. Do not overwater. Rooting is enhanced by bottom heat (20^0C).	Format-ion of callus usually occurs rapidly, this may persist for some weeks before roots begin to form.	Harden off and pot up as required.
Willow	During dormant season, preferably autumn.	Hardwood cuttings of one or two year-old shoots.	Insert outdoors to more than half their depth. Check for frost lift in winter.	Cuttings inserted before soil temper-ature falls will root almost immed-iately.	Pot up as required.

Table 5: Vegetative Propagation