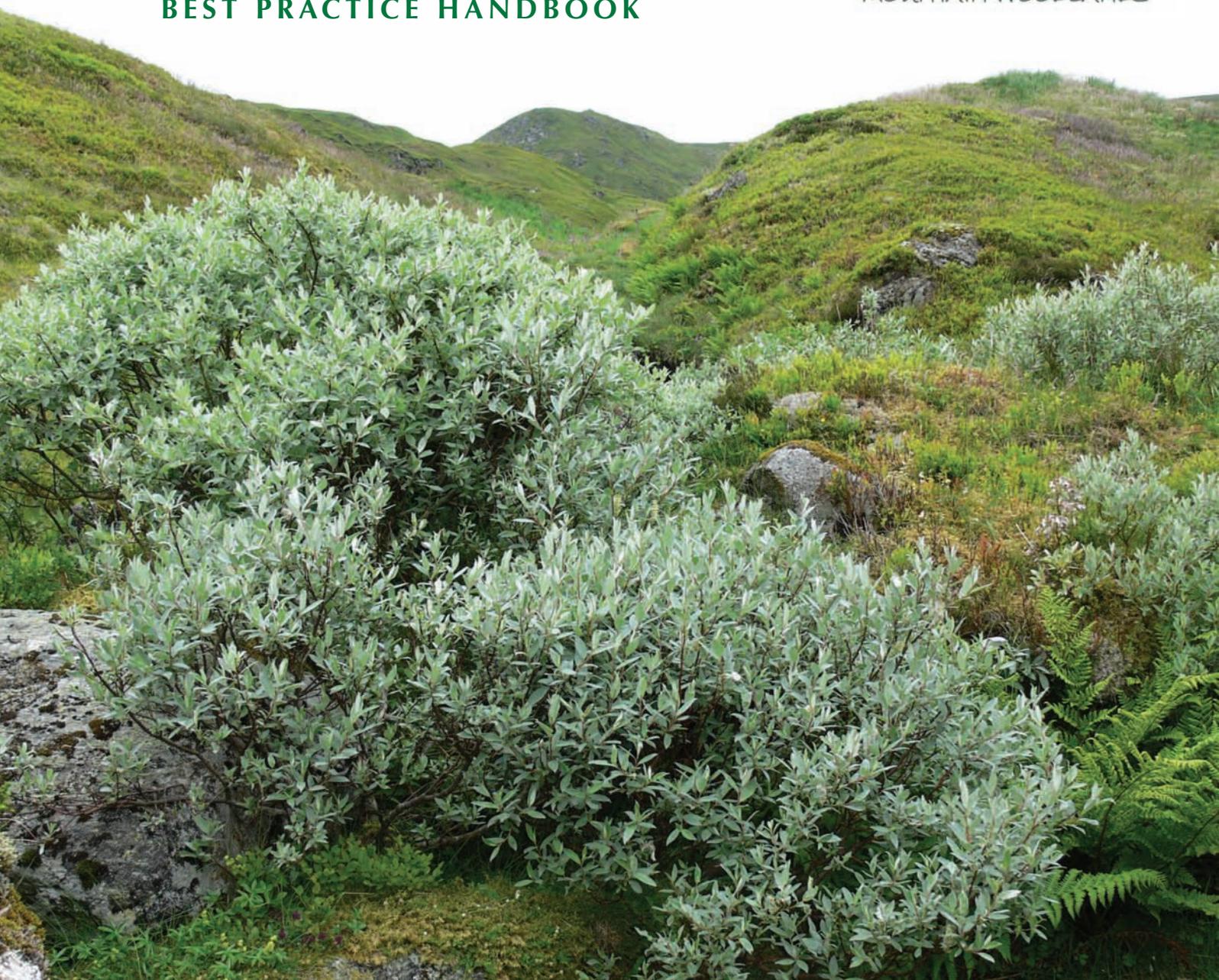


Mountain Woodlands

BEST PRACTICE HANDBOOK



ACTION for
MOUNTAIN WOODLANDS





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This booklet is divided into two parts - the first section provides background information on mountain woodlands and the trees they contain; whilst the second part provides a practical guide for land managers considering a mountain woodland restoration project.

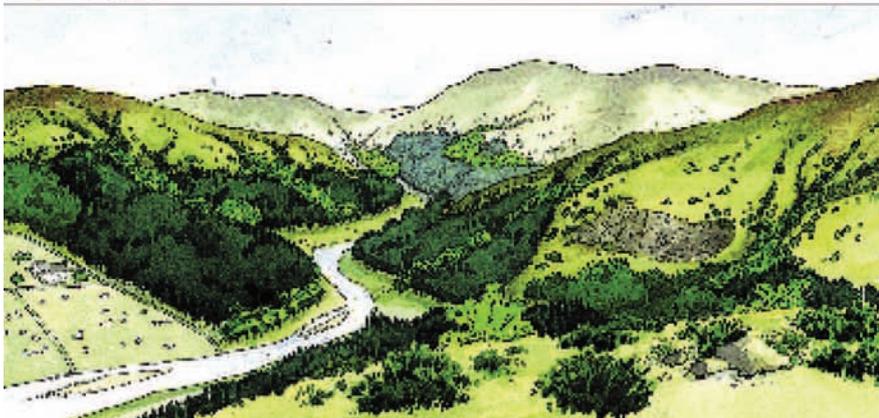
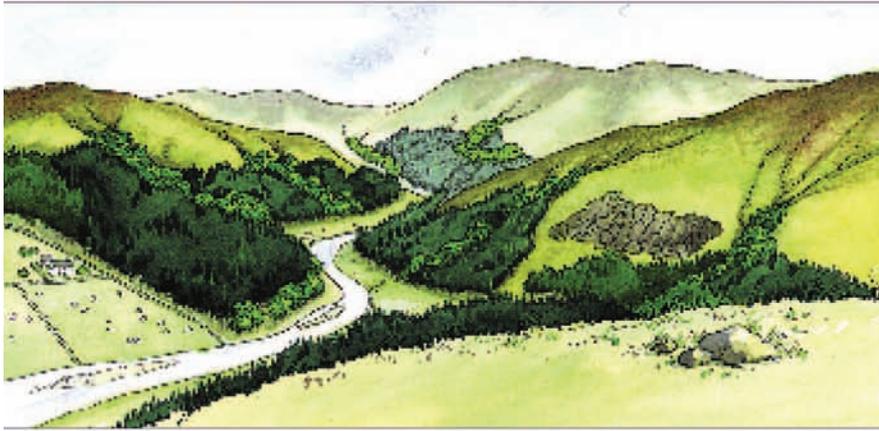
What are mountain woodlands?

Mountain woodlands are found above the altitude where trees can be grown commercially (the timberline) and below the height where shrubs can no longer survive (the scrubline).

Mountain woodlands form a soft upper edge that feathers out from the denser forests below and gradually transforms into the windswept heath and rock of the mountain top. The trees within mountain woodlands are usually less than 5 metres tall, with some only rising a few centimetres off the ground. Mountain trees often take on distinctive twisted and gnarled forms as the constant battering of the wind clips and distorts their growth.



The lower slopes of a mountain are usually within the forest zone, where trees grow tall and erect and can produce good quality timber. At a certain altitude, trees are no longer suitable for commercial timber production because they are too small and misshapen - this point is known as the timberline. Further up the mountain is the scrubline, which marks the upper limit of the area where small trees and shrubs can survive - beyond this point there's only heathland and bare rock. Somewhere between these two points is the treeline, the point at which trees no longer grow above a few metres in height.



It's in the zone between the timberline and the scrubline where we find mountain woodlands. Sharp edges rarely occur in nature, so it's a zone of patches and gradual transitions, filled with crooked, wind-pruned trees and bushes, fighting to survive against the harsh weather conditions. Only certain tree species can cope with these conditions, so mountain woodlands usually have a characteristic mix of species.

You may also find similar patches of twisted trees in coastal areas where the exposure and gusty winds produce similar conditions to those found at higher altitudes.



What species do you find in mountain woodlands?

Mountain woodlands can contain various willow species, upright and dwarf juniper and dwarf birch. Contorted versions of trees usually found at lower altitudes, such as Scots pine, rowan and downy birch are also common.

As you gain altitude through a mountain woodland the single stemmed trees that dominate on the lower slopes begin to thin out, and are replaced by tall-shrubs that grow as many-stemmed bushes. Some species of trees and tall-shrubs are high altitude specialists and tend to dominate the highest altitudes of the mountain woodland zone.

Close to the timberline, mountain woodlands may contain individual trees of many species. Some species which are often associated with this zone on the edge of the forest include: scots pine (*Pinus sylvestris*); rowan (*Sorbus acuparia*); rock whitebeam (*Sorbus rupicola*); upright juniper (*Juniperus communis* subsp. *communis*); downy birch (*Betula pubescens* ssp. *tortuosa*); aspen (*Populus tremula*) and willows such as dark-leaved willow (*Salix myrsinifolia*); tea-leaved willow (*S. phyllicifolia*); goat willow (*S. caprea* subsp. *sphacelata*) and eared willow (*S. aurita*).

You may find tree species in the mountain woodland zone which more commonly grow at lower altitudes, these may look significantly different from the trees lower down. At these higher altitudes the trees are

likely to be much smaller with strange twists and gnarls. European foresters have a special name for these - they call them 'krummholz', which translates as twisted wood.

At the higher altitudes specialist mountain woodland plants dominate:

Montane willows - are a group of willow species which are particularly suited to high altitudes and sub-arctic conditions. These species usually occur as ground-hugging bushes and can be difficult to tell apart. Willow species considered to be mountain specialists include: mountain willow (*Salix arbuscula*); woolly willow (*S. lanata*); downy willow (*S. lapponum*); whortle-leaved willow (*S. myrsinites*) and net-leaved willow (*S. reticulata*).

Dwarf or prostrate juniper (*Juniperus communis* subsp. *nana*) - this is a very low shrub (usually between 1 and 50cm high) which grows on exposed and high altitude sites.

Dwarf birch (*Betula nana*) - a tall-shrub which generally only grows to a maximum of 1 metre high, this birch species has stiff, dark brown branches and twigs. Dwarf birch has a wide altitudinal growth range and can be found at high altitudes (800m above sea level) and at low altitudes on the periphery of bogs which are otherwise devoid of trees.



Net-leaved willow



Downy willow



Dwarf birch



Dwarf juniper



Tea-leaved willow

Are mountain woodlands good for wildlife?

In comparison with large forests, mountain woodland areas may seem insignificant. But as a transition zone between forest and heath, mountain woodlands are a unique habitat with major benefits for biodiversity.

The trees themselves provide some protection from the harsh mountain weather and you can expect to find plants like Smooth lady's mantle (*Alchemilla glabra*) and Water avens (*Geum rivale*) growing beneath mountain woodlands, as well as some rarer species such as alpine saw-wort (*Saussurea alpina*) and holly fern (*Polystichum lonchitis*). Other colourful highlights which are associated with mountain woodland habitats include the bright purple of the Wood crane's-bill (*Geranium sylvaticum*), the almost spherical Globe flower (*Trollius europaeus*) and the succulent Rose root (*Sedum rosea*).



Roseroot

Many birds and animals also benefit from the shelter and food provided by mountain woodlands. Mountain hares (*Lepus timidus*), a UK Biodiversity Action Plan species, are obligate browsers and must eat woody shrubs e.g. juniper, willow and dwarf birch. Important bird species, such as the Black grouse (*Tetrao tetrix*) use mountain woodland areas for shelter. Other birds which might increase or begin breeding in Scotland if the area of mountain woodland expanded include the stunning Bluethroat (*Luscinia svecica*) and the Lapland bunting (*Calcarius lapponicus*).

Areas of mountain woodland also provide habitat for small mammals such as voles, mice and shrews. These can provide food for birds



Redpoll



Ladies mantle

such as the hen harrier as well as for stoats and pine martens.

There's also a wide range of invertebrate species that can be associated with mountain woodlands - and that's from only limited research that's been done to date. For example, each species of mountain willow is thought to have an associated species of sawfly which feeds on it.

The mountain willows also form an association with a type of fungi known as mycorrhizae. These fungi are found in the roots of many plants and enhance the plant's capacity to acquire nutrients. Researchers have identified over 20 different mycorrhizal species which are found only in association with mountain willows. As our knowledge grows, we may find there are many other species that rely on these woodland areas.



Black grouse



Vertigo modesta



Water avens



Puss moth caterpillar

How have mountain woodlands changed over time?

Mountain woodlands have a very limited distribution in Scotland. We don't know how much of the country they covered in the distant past, but we do know that changes in climate, grazing and fires have reduced their coverage over time.

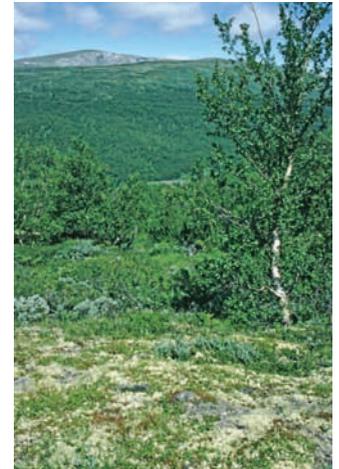
Mountain woodlands are often described as a 'Cinderella' habitat - they don't receive much attention and can be hard to track down. That's partly because there are so few mountain woodlands left in Scotland. If you've climbed a Scottish mountain recently you might have noticed this - you don't see a gradual transition from dense forest to sparse heath. Instead, most of the 'feathered edges' that mountain woodlands provide have been lost and we have sharp changes from one habitat to another, often marked by a fence or wall.



There are a number of reasons why we have so few mountain woodland areas in Scotland. Many of those reasons are related to the way that we've managed and used the land over the past few millennia.

However, it's difficult to know for sure how much of Scotland was covered by these woodlands in the past. The pollen record was analysed to try and discover where the different species occurred previously, but the results were inconclusive for Scotland. It's possible that mountain woodlands were always sparsely distributed. On the other hand, most mountainous regions elsewhere in the world have extensive transitional areas of mountain woodland, so it is reasonable to expect the mountains of Scotland to be similar.

Although we don't know the precise extent of mountain woodlands in the distant past, we do know that the remaining areas were reduced in recent centuries. Some of the species associated with mountain woodlands are now very rare - for example, the woolly willow is only recorded at 12 sites in Scotland and some of those records are just a single plant!



Why have mountain woodlands declined?

The altitude at which mountain woodlands grow will have moved over the millennia in response to changes in the climate. However, more recently, the main pressures affecting their distribution are related to human activities.

Several thousand years ago Scotland's climate became wetter, which may have created conditions that were less favourable for some mountain woodland species. For example, both juniper and pine prefer well-drained soils and the increased soil water-logging experienced in the past may have reduced their distribution in some mountainous areas (Hester, 1995).

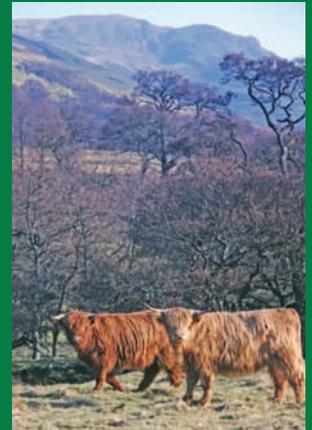
Since then, human activities are likely to have impacted on many of our natural treelines. Historically, wood cutting for firewood and charcoal production was certainly one factor but it's grazing by livestock that's had the most significant impact. In the past, farmers would have taken their cattle and sheep to high shielings for summer grazing. Whilst in the mountains, the stock would have used woodland areas for shelter and as a source of food, removing many of the younger trees. This cycle of annual removal of young trees and seedlings stops the process of natural regeneration within woodlands, eventually reducing the area they cover.



More recently, numbers of red deer increased dramatically on the hillside, putting further browsing pressure on these trees, many of which never grow tall enough to avoid being browsed. Most of the remaining fragments of mountain woodland now cling on in narrow ledges and inaccessible rock faces, where they are beyond the reach of browsing animals.

Some mountain woodland areas are regularly affected by fire and the slow growth rates of tree species at high altitude reduces their ability to recover from catastrophic events.

Many of these pressures still exist today and whilst they continue, mountain woodlands are unlikely to recover and will certainly be unable to expand. If we want to conserve this special habitat then we need to find ways of managing these pressures - the second section of this booklet looks at some practical ways to encourage mountain woodland conservation and restoration.



Future pressures

Mountain woodlands already have a lot to cope with, but climate change may add yet another pressure to the list. The location of the treeline is likely to move as human induced climate change begins to take effect. The precise nature of those changes is difficult to predict, but most species are going to need to move northwards and upwards in search of suitable climate conditions. Where there are limited populations of particular species, their chances of successfully moving in response to climate change will be reduced. It's therefore important that we conserve mountain woodlands where possible now, to help ensure the habitat is robust enough to respond and adapt to changing climates in the future.



Why should mountain woodlands be restored?

Mountain woodlands are botanically special habitats which should be conserved for the future; they also provide practical benefits, such as reduced soil erosion, flooding and wind throw.

It's clear that mountain woodlands and many of the species associated with them are only just surviving in Scotland. If we don't want to lose them, or if we want to see them in areas where they've been lost, conservation and restoration action will be necessary. This could involve managing browsing/grazing in certain areas to allow natural regeneration to take place or planting suitable areas with appropriate mountain woodland species.

This sort of restoration action takes time and money, so it's worth thinking about the potential benefits that it could bring. Many people are already aware of the ethical and moral argument for restoring biodiversity and the need to maintain and enhance habitats for the benefit of future generations.

But morals aside, there are also some very good practical reasons for restoring and enhancing mountain woodlands. Although grazing has reduced their distribution, well-established mountain woodlands can provide shelter for some hill stock during bad weather. They can also improve conditions further down the hill

as their deeper root systems bind loose soils together, helping to reduce erosion and stabilise slopes. Tree and shrub cover can also contribute to the regulation of water flows, with the leaf litter beneath the trees acting like a sponge, absorbing rainfall during wet periods and releasing it gradually. This helps to reduce the impact of extreme weather events and retains water on the hillside during drought conditions (Scott, 2000).

There are also potential benefits for adjacent areas of forestry. Creating a feathered edge to the forestry block, rather than a sharp boundary, provides a natural wind

break. Winds are swept up and over areas of commercial forestry, reducing windthrow within the plantation (Scott, 2000).

From a landscape perspective, removing sharp edges and allowing woodland areas to peter out more naturally at higher altitudes creates a softer, more visually appealing view. That adds value to Scotland's unique landscape, which attracts so many tourists to our mountain areas.



Is there a downside to restoring mountain woodlands?

There are concerns that restoring mountain woodlands may lead to a reduction in grazing land. Fencing large areas to allow regeneration to take place can also cause access problems, so fencing projects need careful consideration.

There are a lot of positive reasons for restoring mountain woodlands, but there are some valid concerns about the potential consequences of conservation/restoration work.

For example:

Land managers are worried about 'scrubbing up' and that if mountain woodlands spread across too much of the hillside it could make gathering stock more difficult.

Many of the tree and tall-shrub species found in mountain woodlands have specific requirements for growth and will have a patchwork distribution.



Scrubbing up refers generally to secondary scrub like whins, establishing beneficial mountain woodlands could be a decisive way to avoid invasion of these less desirable plants.

Others are concerned about the potential loss of grazing ground if mountain woodlands increase.

Some of the plants associated with these woodlands can provide a complementary range of nutrients for grazing stock. For example, willows provide high levels of calcium which can be important to pregnant animals. Whilst too much grazing will prevent the woodlands establishing, limited grazing in mature woodlands may allow both the mountain woodland and local livestock to flourish. Given the specific growing conditions required for some mountain woodland plants it will be possible to combine creating shelter with preserving good grazing areas.

Both land managers and the public have concerns about the use of fencing to protect mountain woodland areas. Large fences are unsightly and they can restrict access for recreation and increase bird mortality.



It's inevitable that some fences will be needed to allow mountain woodlands to recover, but wherever possible fencing should be minimised. If fences are required, they need to be carefully designed and sympathetic to the locality to avoid future problems.

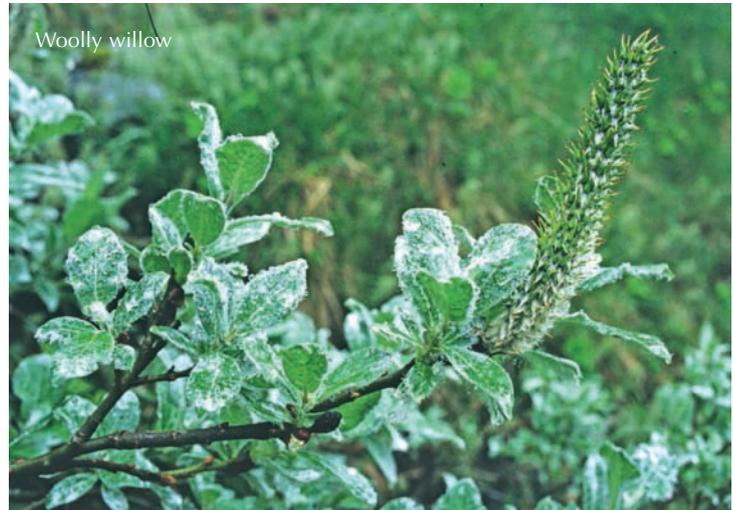
The legal and policy context

As more organisations become aware of the plight of mountain woodlands, the number of references to them in policy and strategy documents has increased.

In recent years, European, UK and Scottish policy makers have become more concerned about the plight of mountain woodland species. As a result, more policies, plans and strategies are highlighting conservation/restoration as an important aim. To help deliver that aim, there are also more references to mountain woodlands in grant schemes and funding packages.

The funding that's available changes all the time, so the most up-to-date information is included in a pull out leaflet at the back of this booklet. You may find that there's a funding scheme to help you implement some of the actions that are needed to restore these woodlands in your area.

Some of the most significant policy and legislation references are included below. By restoring mountain woodlands you're helping national governments deliver their biodiversity aims, which is why they may be prepared to offer funding. It's well worth checking these policy references prior to completing any grant applications so that you can demonstrate what impact your work will have.



■ International and European references

Convention on Biological Diversity - this is an international treaty which aims to conserve biodiversity and which was prepared at the 1992 Earth Summit in Rio de Janeiro. The convention also led to the creation of Biodiversity Action Plans - one of the UK habitat action plans is for mountain heaths and willow scrub.

The European Habitats Directive (92/43/EEC) requires member states to protect the species and habitats listed in Annex 1 of the Directive. Included in that annex is 'Sub-arctic willow scrub', a habitat description which could be applied to many of our mountain woodlands.



■ **Scottish references**

The Scottish biodiversity strategy highlights the mix of habitats and scenery found within Scotland. It emphasises the importance of biodiversity to both our economic well-being and for the continued healthy functioning of the ecosystems on which we depend. It also recognises the need to create a mosaic of linked and varied habitats, which includes the spectrum of habitats found within and around the treeline.

Several Local Biodiversity Action Plans also recognise the importance of mountain woodlands, whilst their value to Scotland is acknowledged by Scottish Natural Heritage in their Natural Heritage Futures document 'Hills and Moors'. This highlights the lack of a natural treeline in Scotland and recognises that the uplands could have a more extensive cover of native woodland. SNH's species action framework also includes woolly willow as a species which requires conservation action.

Finally, the Scottish Forestry Strategy also highlights the importance of targeted action for woodland and its associated priority species and habitats. Actions proposed within the strategy include supporting the creation of new woodland areas, focusing particularly on woodland types which are currently under-represented in Scotland.

What do mountain woodlands need to thrive?

Some mountain woodland species, particularly the willows, need certain conditions in order to thrive. These include base-rich soil; insect pollinators; short-term protection from grazing; areas for seed germination and links to surrounding habitats.



MacDonald & Horsfield, 2002), whilst juniper can grow in a range of soil types (FCS, 2009).

In order for mountain woodlands to be successful, we need to create the right conditions for them. Those conditions are quite specific, so we need to be confident that we can get them right.

■ Soils

Mountain willow species prefer base-rich, damp soils, such as those which can be found on mica schist rocks in the Scottish Highlands (Horsfield & Thompson, 1997). In contrast, dwarf birch tends to occur mainly on wet peaty soils (Thompson,

■ Pollination

Some tree species have both male and female flowers occurring on each tree (this is known as being monoecious). For example, an alder tree has both the long yellow male catkins and the small, cone-like female catkins on the same tree. In contrast, willows have male and female flowers on separate trees - so a willow tree can either bear male or female flowers, but not both (known as dioecious). Therefore, in order for viable seed to form, the male and female trees need to be reasonably close to one another. Willows are mainly insect pollinated, so if the plants are too far apart pollination won't take place. The prevailing wind direction can also affect pollination chances, by blowing insects towards particular trees.



Some of the Scottish records of Woolly willow (*Salix lanata* - the rarest mountain willow) are for populations of a single plant (MacKenzie, 2000). As that means only one sex will be present, the presence of Woolly willow at that site can't be expected to continue in the long-term without intervention.



■ Protection from grazing

Most trees and tall-shrubs can tolerate some grazing from wild and domesticated animals. However, younger trees and small seedlings are particularly susceptible to grazing pressure and can easily be destroyed by a browsing animal. Within mountain woodland areas, the main grazing pressure is likely to come from red deer and sheep. However, trees and tall-shrubs can also suffer damage from mountain hares, goats, voles and slugs. In order for mountain woodlands to regenerate and expand, grazing pressure needs to be reduced to a level where enough seedlings and small trees can survive. It may be enough to protect the plants from grazing for a short period, enabling a viable population to establish from which they can then continue to grow unprotected.



■ Germination

Although too much grazing pressure can reduce tree survival, complete removal of all grazing animals may not be the solution either. That's because the feet of grazing animals create small bare areas on the ground that can be ideal for seed germination (McBride, 2002).

Without these bare areas, seeds will be smothered by vegetation and are unlikely to germinate successfully. In some cases, the processes of natural erosion on slopes can create these bare patches.



■ Shelter

Many of the remaining patches of mountain woodland are located on inaccessible rock ledges where they are protected from grazing. However, these ledges are often very exposed and trees can be washed away, damaged by rock falls and snow avalanches. If the mountain woodland was in a good condition and thriving then these annual losses wouldn't be problematic. Ideally woodlands need to expand into areas where they are less exposed to these catastrophic events.

It's also thought that some of the willow species benefit from being in areas where winter snows lie longer. The snow cover provides some protection from spring frosts as well as discouraging grazing stock.

■ Connections

Mountain woodlands are part of a continuum of habitats from the valley floor through to the mountain top. They shouldn't be thought of as an individual feature, but as part of a broader, landscape-scale pattern. The plant and animal species which use mountain woodlands may also use other habitat areas - but to do that they need connections between those patches of habitat. Those connections don't necessarily need to be physical 'bits' of the same habitat, they could just be an area of grass or heathland which isn't intensively managed and which provides sufficient cover and resources.





Part 2

A land-manager's guide to restoring mountain woodlands

To secure the long-term survival of mountain woodland habitats we need to increase their total area. The second section of this booklet provides practical advice on how we can do that. It looks at some of the ways in which these woodlands could be restored and evaluates the pros and cons of each method.

But why should land managers be interested in restoring mountain woodlands? Earlier in this booklet we've looked at some of the practical benefits that woodlands can bring, including reducing soil erosion, regulating water flows and stabilising snow fields and reducing wind-throw within commercial forestry. They also make a visual improvement to the landscape which will encourage more tourists to spend more time and money in our mountains.

The current reduction in the numbers of sheep on our hills provides an opportunity for conservation and restoration of areas of mountain woodland. This reduced grazing pressure should enable viable plant populations to become established, these could then withstand an appropriate level of grazing without upsetting the balance.

As mountain woodlands are considered to be an important part of our natural heritage, there are also financial incentives to encourage land managers to undertake restoration projects. These schemes offer land managers the opportunity to improve the financial standing of their business and restore an important habitat at the same time.

If you agree that these benefits are worthwhile, there are two potential ways to increase the total area of mountain woodlands:

- Create suitable conditions and allow natural regeneration of mountain woodlands to take place;
- Plant up new areas in suitable locations with young seedlings of mountain woodland species.

There are advantages and disadvantages to both methods, and costs will also vary between the approaches.

First things first

Before you think about restoring mountain woodlands, you need to know whether your site is suitable for them and what's there at present.

At the outset of a mountain woodland restoration project, it's important to establish a few things about your site:

- **Is the site suitable for mountain woodlands?** Ideally there'll be some remnant patches of mountain woodlands in the restoration area, which will provide an indicator of potential site suitability. However, you'll also need to check conditions around those remnant patches.
- **Is a habitat of high conservation value there already?** There's no point trying to recreate mountain woodlands in an area that's already supporting an important habitat. So it's worth checking, or taking advice from others, to see what sorts of plants and animals are there now.
- **What's the bigger, landscape-scale picture in the area?** Will a new patch of mountain woodland be isolated, or will it be linked to other areas of habitat, such as woodlands lower down the hillside?
- **What sort of things might impact on an area of mountain woodland at your site?** Are there a lot of grazing animals; is the area used by the public for recreation; is it prone to avalanches? Having this sort of knowledge about a site will help you to plan an effective restoration project.



Natural regeneration

Although we don't know the exact locations of mountain woodlands in the past, we do know that grazing and burning have reduced their extent over recent years. If those pressures are reduced, and if there are sufficient viable source populations to provide seeds, it's reasonable to assume that the extent of mountain woodland in Scotland could increase by natural regeneration.

■ Site selection

Natural regeneration won't be effective in all situations and so careful site selection and preparation is important. The following factors should all be considered:

Do you have a reasonable sized source population nearby? Natural regeneration needs a local, viable seed source which can produce a sufficient seed rain in the restoration area. So a restoration site needs to be located near a remnant patch of mountain woodland

which is producing viable seed, in sufficient quantities to allow a reasonable number of seedlings to germinate. For the dioecious willow populations, that means both male and female plants need to be present



Catkins shedding seed, dark-leaved willow

and within a distance of each other that will allow insect pollination. The source plants also need to be in good physical condition in order to produce fertile seed - heavily browsed plants are unlikely to produce sufficient pollen.

Prevailing wind directions can also influence the effectiveness of natural regeneration. If the prevailing wind blows seed from the remnant population away from the restoration area, it's unlikely that many seedlings will be produced. An alternative is to consider directly seeding the restoration area with seed gathered by hand.

Even if you're confident that sufficient quantities of fertile seed will reach the restoration site, you also need the soil to have sufficient bare patches to allow germination to take place. Usually this will occur

naturally through the processes of rock fall and landslips in high altitude areas, but it's important to ensure this is taking place within your proposed restoration site.



Landslip



Male catkins



Female catkins

■ Encouraging natural regeneration

Once you've found a suitable site where natural regeneration could take place, it's also important to ensure that the pressures of grazing and burning are managed so that young seedlings have a chance to develop.

In some ways burning is an easier pressure to manage - although we can't control the location of natural fires, we can prevent muirburn taking place in or adjacent to areas where we want mountain woodlands to regenerate.

Controlling grazing is more problematic. Excluding all grazing animals from an area may not be ideal as it reduces the number of bare patches of ground where seeds can germinate and allows rank vegetation to dominate. But uncontrolled grazing in an area will have a severe impact on all mountain woodland species. A compromise between too much and too little grazing is needed - for example, livestock could be excluded from a site for a period of time to allow seedling development, then reintroduced at a low level to control rank vegetation.

In order to control grazing pressure effectively, it's important to identify what types of animals are feeding in an area. Deer and sheep can be fenced out of areas or their populations reduced, whereas mountain hares, voles and slugs will also consume young trees and may require different control methods.



■ Fencing

One option for removing grazing pressure is to fence off an area that's been ear-marked for mountain woodland restoration. There are a number of pros and cons to using fencing for live-stock exclusion, but overall it is not likely to be a widely applicable solution.

Assuming that you've established that browsing is preventing mountain woodlands from regenerating naturally in an area, one potential option is to use a fence to keep animals away from particular areas. There are pros and cons to this approach:

On the positive side, a fence can exclude all large herbivores, which will ensure protection for young seedlings and growing trees. Although it's a more expensive investment than a similar fence in a lowland area, a fence allows land managers to maintain overall stock levels whilst preventing damage in particular areas.



However, fencing has a number of drawbacks. Most mountainous areas will have significant accumulations of snow, which can flatten fences during avalanches or spring melts and permanently damage them. Deep snow drifts can also reduce the effective fence height enough to allow deer to walk into the woodland. Even with careful siting of fences to avoid areas of deep snow, annual maintenance will be required and fences will need regular checking during heavy snowfalls.

Scotland's Land Reform legislation means that people have a right of responsible access to most land. Putting fences around large areas of land goes against the spirit of the legislation, so provisions have to be made to ensure that public access can still take place. Fences are also visually intrusive and can cause problems with bird strikes if they are badly sited or poorly marked.



Positives	Negatives
Excludes all large herbivores	High annual maintenance cost in mountain areas
Allows maintenance of existing stock levels within targeted areas.	Can impact on access for walkers and climbers
	Visually unappealing
	Usually results in removal of all stock, which may not be ideal for some mountain woodland species

Consideration must be given to marking fences to discourage bird strike. Such marking must be undertaken in black grouse areas.

■ Fencing do and don'ts

Installing a fence in a mountainous area is more complicated than in lowland areas. If a fence is likely to be required for your conservation/restoration project, you should consider the following suggestions:

Do	Don't
Assess the planned fence route prior to construction, ideally over a period of several years, so you can avoid areas that are vulnerable to avalanches or that have deep snow beds	Install a fence unless you have sufficient resources for regular maintenance of the fence - fences in mountain locations are more frequently damaged than lowland fences
Survey the ground conditions and take into consideration the different types of fencing for different ground types e.g. peaty bogs - exposed rocks	Install a fence on a ridge line where it will be visually intrusive and be subject to more bird-strikes
Consider how to route the fence around rockfall areas - bear in mind that you might need to go further away from cliffs than you expect to avoid damage	Impede access routes for walkers, climbers and skiers. Check the Scottish access code requirements
Use a fence design that will reduce or eliminate bird strikes, for example, avoid the use of mesh or rye lock on the upper sections of the fence	Expect natural regeneration to take place instantly after fencing an area - it may take many years
Use short, replaceable sections of fencing if the fence line has to go through areas where deep snow accumulates	
Vary the fence design depending on the local situation (e.g. consider the use of a second wire outside the fence in some places; avoid electrification if you have a lot of existing ground vegetation etc)	
Provide interpretation information which explains why the fence is there and ensure there are sufficient warning signs fixed in place for an electric fence	

■ Stock and deer management

An alternative to fencing off small restoration areas is to reduce grazing pressure across an entire hillside. This also has advantages and disadvantages.

If fencing isn't a good solution to managing grazing pressures, alternative solutions need to be considered. Options include changing the way in which stock use an area or reducing total livestock numbers across an entire area, so that overall grazing pressure is reduced.

Managing deer movements can be difficult, but changes to management practices can help to divert sheep away from mountain woodland areas. For example, changing the location of supplementary feeding areas (troughs, rings etc.) can encourage sheep away from particular areas.

Reducing total livestock numbers is already happening in some areas, with estates managing deer numbers so they have fewer, better quality animals. However, reducing numbers needs to be done over a large area



and will often require several estates to work together. Funding may be available for reducing sheep numbers on moorland areas.

Scientific studies have found that birch woodland starts to recover when total livestock densities are reduced to around 0.03-0.04 deer or 0.3 to 0.9 sheep per hectare (Wood-Gee, 2002). Densities might need to be reduced still further to allow full regeneration of all mountain woodland species.

Positives	Negatives
Production of fewer, better quality animals	Requires several land-owners to work together
Funding may be available	Reduced stock numbers may impact on the profitability of rural businesses
Can provide ideal conditions for mountain woodland restoration	

Planting new areas

Natural regeneration will take many years, so planting new areas of mountain woodlands may be an alternative approach. Young trees can be produced from seed or cuttings and planted out in suitable locations. Newly planted areas will require protection from grazing animals and survival rates may be low in harsh conditions.

The tough conditions at higher altitudes mean that natural regeneration of mountain woodlands could take many decades. An alternative is to expand mountain woodland areas through planting programmes. Just like natural regeneration, this method has pros and cons.

From an ecological perspective, allowing woodlands to regenerate naturally is the preferred option. Planting

new trees may be quicker, but there's a risk of our interventions producing something different from what would occur naturally. It can be difficult to source suitable trees and seedlings that have been grown in sheltered nurseries may not be able to withstand high altitude conditions. The young seedlings will also be at risk from grazing animals, so careful management of the grazing pressure will still be required.

However, given the precarious state of some mountain woodland species, human intervention in the form of young tree propagation and planting may be the only way to ensure the survival of this habitat in the future.

Small downy willow plants on edge of cliff-bound population



■ First things first

The same considerations apply to planting new areas as to encouraging natural regeneration. You need to be



sure that the site is suitable for mountain woodland species; check the conservation value of what's there already and establish whether or not impacts like grazing can be effectively managed in the future.

If you're looking at creating a newly planted area, you'll also need to think about how to integrate it with the surrounding land use. Creating an isolated area will be of limited ecological value, so it makes sense to ensure it's located where species can move into it from elsewhere. For mountain woodlands that'll probably mean ensuring it 'follows on' from existing woodland on the lower slopes.

■ Sourcing plants

Buying plants for a mountain woodland planting programme isn't as simple as for commercial forestry. As with all tree species, the provenance of the young trees is important - they should be from a local source and not imported. However, as some of the mountain woodland species are quite rare, finding a source of young trees can be challenging. In many cases, you will need to propagate your own seedlings, or contract someone to do it for you, using material from adjacent sites.

■ Producing tree stock from seeds

Producing young plants from seeds can often be challenging but will be worth the effort. Seeds are produced from sexual reproduction, so they combine genetic material from two parents. This means you get greater genetic diversity amongst the seedlings, producing a population that's likely to be more robust and healthy in the long term.

Seeds need to be collected from existing mountain woodland areas and each species will have its own 'window of opportunity' for seed collection. Some species' seeds can be stored for several years (e.g. juniper and birch), whereas most willow seeds only remain viable for a few days. Many of the existing mountain woodland sites are difficult to access, so you



might need a significant investment of labour to collect and germinate seed in such a short time period. Some species, particularly the willows, may also hybridise, so you can't always be sure exactly what seed you are collecting.

Once collected, the seeds may require some preparation before being sown into labelled trays on a moist seed compost. Some species, such as *Betula nana* and *Juniperus communis*, need certain conditions to break seed dormancy, whereas other species, such as willow seeds, have no dormancy period.

Germination times will vary between species, but as seeds germinate within each tray, they can be pricked-out and grown on.

There are pros and cons to this method of production.

Positives	Negatives
Genetic diversity	Time and skill needed to collect seeds
Birch and juniper seeds can be collected and stored	Small window of opportunity in remote locations
	Some species may take several years before they can be planted out
	Risk of hybridisation if seeds are sourced from a mixed species stand

■ Producing tree stock from cuttings

An alternative to seed production is to produce young trees from cuttings taken in the field and grown on in nurseries. Cuttings can potentially be taken at any time of year but they will produce genetically identical clones of the parent plant. If all the cuttings are taken from only one or two plants, the subsequent woodland area will have very limited genetic diversity and will be more susceptible to disease and damage. To avoid this, cuttings should be taken from as many plants as possible. This is particularly important for willows which have both male and female plants - if all the cuttings are from just one plant, the new trees will be unable to produce viable seed! It's also important to make sure you identify the parent plants correctly.

Positives	Negatives
No hybridisation (in willows)	Potential for limited genetic diversity
Reasonable success rate	Over collection can be damaging to the source population

■ Growing on young trees

Once the young seedlings have established, either from seed or from cuttings, the trees need to be grown on until they are a sufficient size for planting out. Growing the plants on in individual containers is more useful for mountain woodland restoration as it gives greater flexibility when it comes to transferring them to their final location. Many people use 'root trainers' which produce a healthy root system and can be used several times. The young trees should be potted in a soil / compost which closely matches the soils at the restoration site. Once potted up into individual cells or root trainers, the plants can then be grown on either indoors or outside.

■ Indoors

This approach is likely to reduce the growing time from start to 'site ready'. However, growing conditions indoors will be very different to those experienced in a typical mountain woodland location. Plants are likely to have softer growth which will be more vulnerable to both weather and grazing damage and so subsequent survival rates may be very low. Plants grown indoors will need to be hardened off before they are moved to their final location, so a suitably fenced area needs to be available.

■ Outdoors

This approach will require additional time for growing on compared with indoor methods, but will produce plants that are more suited to mountain conditions. The

growing space needs to be carefully protected against grazing animals.

■ Planting out

Once the young trees have reached a sufficient size, they can be planted out at the restoration site. The best time to do this is in spring, which gives them a full summer to acclimatise before the worst of the winter weather. However, mid-summer planting is also likely to be possible as many mountain soils are permanently damp. When willows are planted, it's important to make sure you've got plenty of seedlings in one area so there's a mix of male and female plants. Willows are primarily pollinated by insects, so the male and female plants need to be within insect flight distance of each other to ensure effective pollination. For example, at Ben Lawers in highland Perthshire, mountain woodland seedlings have been planted in a random pattern with an average distance of about five metres between each plant.

■ Protection

The young trees will be very vulnerable to grazing animals and so they'll need to be protected. There are two options for this - fencing around the restoration site or using tubes or shelters on individual plants.

The pros and cons of fencing mountain woodland sites have already been considered. The use of individual



shelters is likely to be expensive and may not be successful on very exposed and remote sites. The shelters can't stand up to the high wind speeds in mountainous areas and they can also be attractive to voles, resulting in grazing damage at the base of the tree.

Some weed control may be needed around the base of the plants during the first couple of years to allow them to establish. Fertilisers shouldn't be used as they're likely to lead to softer tree growth as well as an increase in competing species.

Growing your own trees - dos and don'ts

Most large-scale mountain woodland planting projects will need to produce their own tree seedlings, either from seeds or cuttings. The following dos and don'ts provide a summary of some of the pointers to remember if you decide to do this.

Do	Don't
Ensure you have space to allow indoor grown plants to harden off before transplanting them	Take too many cuttings from a limited number of source trees
Expect success rates to vary between species and throughout the year	Leave any hardening off areas un-fenced
Grow plants on for a second year if possible, before planting them in their final locations	Try to establish a nursery unless you have a potential source population to provide either seed or cuttings.
Grow planting stock in containers to increase flexibility for planting out	Collect significant numbers of willow seeds unless you can sow them immediately
Check the seed preparation and germination requirements for different species	Plant out seedlings without giving them sufficient time to acclimatise to high altitude conditions.
Check the Forest Reproductive Materials regulations if you plan to grow tree species commercially	Plant out young seedlings when vole populations are at a peak - most vole populations fluctuate, so it should be possible to avoid peak years.
	Expect to get it right straight away - experience will increase success rates

Monitoring

Both new and existing mountain woodlands should be monitored to see how well they are surviving. Guidance on how to survey these woodlands can be obtained from Highland Birchwoods.

It's important to assess the success of any restoration project once it's been completed. New areas of mountain woodland should be monitored to see if the trees are establishing or regenerating successfully and to gauge whether or not the project has delivered its aims. The outputs from this monitoring can be helpful to future project managers when they are designing and implementing new restoration projects. Much of the guidance that is currently available for restoration projects is provisional, so collecting additional data will help to refine and improve future guidance.

We also need to monitor the state of existing mountain woodlands, to establish if they are expanding or declining. Within Scotland there is a network of

botanical recorders who submit records of the species they've found in particular areas to a central database (you can see this database at www.nbn.org.uk). However, in many cases it's useful to know more about an area of mountain woodland than just what species are present. We may want to know how many trees of a particular species are there; whether or not both sexes are present for willows and whether or not there's evidence of any grazing damage to the trees. Highland Birchwoods (www.highlandbirchwoods.org.uk) have commissioned a number of these surveys and can provide advice on the best way to complete a mountain woodland survey.

Case Study - BEN LAWERS TREE NURSERY

“The Ben Lawers population of woolly willows had been reduced to two individuals, so the nursery has focused on producing additional plants for restoration work.”

Ben Lawers is internationally recognised for its mountain plant communities. The National Trust for Scotland, who manage Ben Lawers, have established a nursery area for growing mountain woodland seedlings to use in restoration programmes on the site.

The tree nursery has been in operation since the mid 1990s and has been producing stock for planting out as a seed source for natural regeneration in the future. Some planting has taken place in fenced enclosures whilst in other areas individual seedlings have been planted out on unprotected sites that are difficult for herbivores to reach. The techniques used have included seed collection, germination and maturation as well as using both first and second generation cuttings. In the period 2001-2007 inclusive the Ranger Service produced 24,622 downy willows, 7,930 dark-leaved willows, 6,800 downy birch, 4,870 eared willow, 1,290

junipers and c. 100 plants of other species, for planting around Creag an Lochain, pictured below left.

In recent years, significant improvements in the survival rate of woolly willows grown from seed have been made by using a pre-germination fungicide treatment to protect against grey mould (*Botrytis*). Cross pollination between willow species can also be a problem and so trees which are being grown as a seed source are protected with fly netting to prevent insect pollination. This means pollination has to be done by hand.

Most mountain willow species are quite delicate in their early stages, so additional care is required to avoid damage from overhead watering; a polytunnel is used to protect the seedlings against heavy rain. Plants are grown in containers, which helps with the process of handling and planting out during the summer months.

The Ben Lawers population of woolly willows had been reduced to two individuals, so the nursery has focused on producing additional plants for restoration work. Each individual woolly willow cutting from the field is recorded and labelled before being planted in stock beds. Subsequent ‘second generation’ cuttings from these individuals are then taken back and planted out on the hillside. At Ben Lawers there’s also an imbalance between trees of different sexes so attempts are being made to redress this by selectively adding males to the ‘bank’ that have been grown from seed.



Further information

We hope this booklet will inspire you to restore mountain woodlands in your area. There are a number of sources of further information which will be useful in planning a restoration project.

These include:

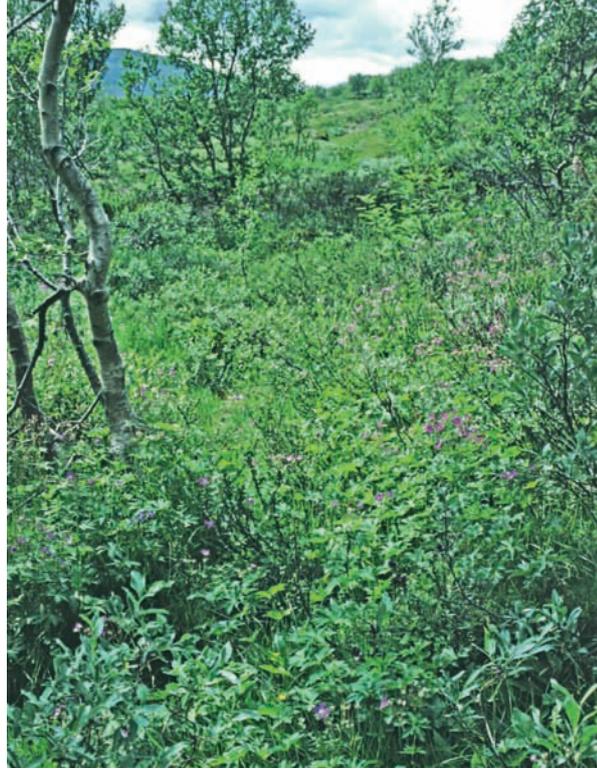
Action for Mountain Woodlands - contact through www.mountainwoodlands.org

The Montane Scrub Action Group - contact through Highland Birchwoods www.highlandbirchwoods.co.uk
Recent publications from the group include:

- A series of guidance notes published in 2002:
 - Note 1 - Montane scrub in Scotland*
 - Note 2 - Montane scrub restoration action planning*
 - Note 3 - Integration with other land uses*
 - Note 4 - Protection*
 - Note 5 - Propagation of scrub species*
- The Scrubbers' bulletin - provides news and information on mountain woodland projects
- A booklet in conjunction with Scottish Natural Heritage, as part of their national heritage management series: Montane Scrub (available at www.snh.org.uk/publications/online/heritagemanagement/montanescrub/)

Highland Birchwoods publications including:

- Low alpine, subalpine & coastal scrub communities in Scotland (July 2000)
- Montane Scrub: the challenge above the treeline (2002)



Royal Botanic Garden of Edinburgh publication - Biodiversity: Taxonomy, genetics and ecology of sub-arctic willow scrub

Practical guidance on restoration projects:
Conservation Land Management vol 5, no 2 (see www.conservationlandmanagement.co.uk/index.asp)
Plantlife: Managing uplands for juniper (2005) (see www.plantlife.org.uk/index.html)

Information on seed dormancy per species:
www.forestry.gov.uk/fr/INFD-7F8AJ4

Funding for restoration projects

- Check the latest situation at:
www.scotland.gov.uk/Topics/farmingrural/SRDP

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