Site and species selection, and planting and establishment

Some initial considerations

As noted in BPG2, a viable montane scrub population would be self-sustaining through natural regeneration.

However, this is often impractical, unpredictable or otherwise not possible – due to absence of seed sources, seed viability, seasonal weather, vacant regeneration niches, soil suitability, lack of resources, high herbivore pressures and the short-term nature of grant scheme contracts.

Planting is a significant commitment in these environments but is often necessary given these constraints.

Growth rates are likely to be much slower than at lower altitudes, and clear decisions will need to be made on planting and its aftercare including:

- **reducing herbivore browsing pressure.**
- **whether to use fencing, and its type.**

or a combination of both. See BPG4 for more information.

Planting at high altitude sites in different phases would be ideal, although this is usually difficult to achieve within a time-bound grant contract. Revisiting a site with additional planting in one or several episodes may be necessary and is also pragmatic – new planting should be on ground where earlier work has been most successful. This also leads to a more diverse age range of trees complementing natural variation in a planting cohort's growth rates.

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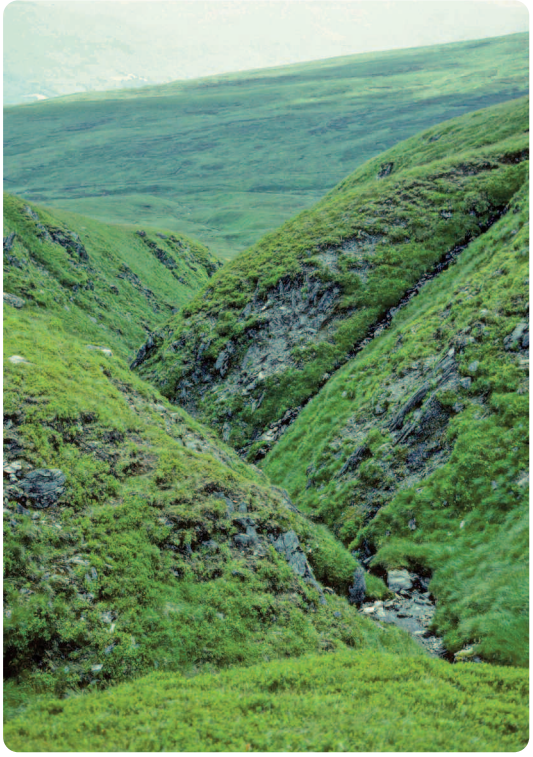
Site selection

At the landscape scale, an area with a good selection of microsites is ideal. The sides of burns or streams, the lower sections of steep slopes, richer soil areas and minerally-enriched patches are all generally good sites, especially if they provide some shelter from the prevailing wind.

At higher elevations, landslips and rockfall sites can provide smaller patches of bare ground for good establishment. A southerly aspect will take advantage of solar warmth, with planting in the lee of natural features being also of benefit. E.g. such as behind boulders.

Conversely a northerly aspect may allow winter snow to lie for longer into the spring and so reduce the effect of browsing animals on the scrub. Such late snowbeds, often persisting well into May at very high altitude sites (above 700m), crucially provide shelter to certain rare species. E.g. such as woolly willow.

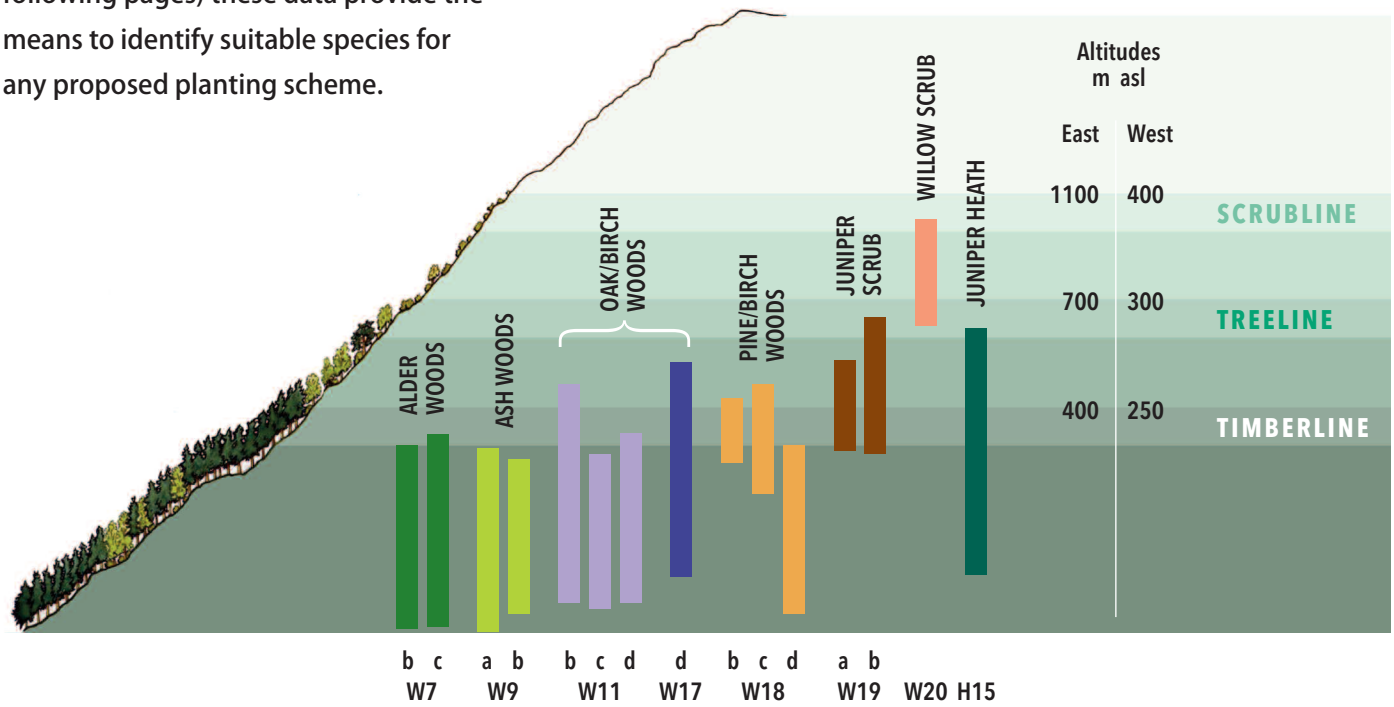


The area of plantable ground within a scheme is likely to be less than on lower altitude sites, and larger areas of open ground are normally accommodated within incentive schemes. This will aid a sympathetic and naturalistic future landscape to develop, where spacing within each microsite is determined by soil depth, accessibility and topographical constraints. There is a supposition towards excluding important open ground habitats from planting, and Scottish Natural Heritage should be consulted regarding any management on designated sites.

For ectomycorrhizal tree and shrub species (willows, birches, alder, hazel, pine, and aspen), siting near a source of suitable mycorrhizal inoculum could aid establishment and survival (see 'Ectomycorrhiza' box page 7). This would include planting in proximity to remnant trees, shrubs and woodland margins of ectomycorrhizal species, or in common bearberry heath.

Species choice

BPG 1 provides a comprehensive list of montane scrub and treeline woodland species. The diagram below gives an indication of the altitudes that woodland and scrub vegetation communities currently reach in the UK. Table 2 (page 9) provides a comprehensive overview of each species requirements. Together with specific site information (outlined on the following pages) these data provide the means to identify suitable species for any proposed planting scheme.



Soils

Tables 1 and 2 show species specific soil requirements. On a micro-scale, small-scale variation in the site (such as drier knolls or richer flushes) may allow a diverse choice of species selection according to their tolerance of differing soil quality and/or wetness regimes. Vegetation communities give a good indication of soil conditions but conclusions should be confirmed by digging soil pits. See Forest Research's Ecological Site Classification system for more information (www.forestry.gov.uk/esc).

Dwarf birch, although now largely confined to mire habitats in Scotland, does much better when planted where there is some mineral component to the soil. It requires some shelter to get established. As a wind-pollinated species, any planting site for dwarf birch should be considered in relation to the nearest large population of downy birch and the prevailing wind direction to avoid possible subsequent production of hybrid seed.

At the National Trust for Scotland's Ben Lawers property, downy birch, rowan, eared-willow and some grey willow have been used in a wide variety of habitats including peaty moorland and rough grassland. Downy and dark-leaved willows were planted mostly on slightly wetter ground with some flushing, often on ground below crags and large boulders. Tall herb communities were often used as indicators of suitable ground for the willows. Dark-leaved willow has also been planted in rougher grassland in similar conditions to good effect.

Juniper prefers well drained base poor soils. At the National Trust for Scotland's Ben Lawers property, procumbent juniper has been planted generally in *Vaccinium* heath from 450m–750m and appears to do best on well drained steeper slopes.

Being dioecious, male and female juniper must be planted. Sexing young plants is difficult so where this has not been possible a higher, than normal, number of individuals should be planted to ensure inclusion of both sexes."

Montane willows have differing and specific requirements regarding soil types (see Tables 1 & 2), with the woolly willow the rarest and most demanding of these. Due to its high conservation status, the Scottish Code for Conservation Translocations (https://www.nature.scot/scottish-code-conservation-translocations) should be consulted if intending to plant this species. See also BPG2.

For the insect-pollinated dioecious willows, the pattern of planting should optimise the chance of fertilisation; a female within 5m of a male will normally be very fruitful and 50m is considered the maximum distance between sexes for successful pollination (see BPG2). The optimal sex ratio of plants is unknown but roughly 50:50 should be aimed for.

Size and types of plants

For specific montane species see BPG2 for information on appropriate sources of planting stock. For more widespread species planting stock should be from the relevant seed zone (see Forestry Commission Scotland's native seed source guidelines http://scotland.forestry.gov.uk/images/corporate/pdf/seedsourcefcfc151.pdf) and, to take advantage of genetic differences, grown from seed ideally sourced from a similarly demanding environment, especially at a comparable elevation. See BPG2 for more information.

A plant's root collar diameter is the most important size parameter on which to base assessment of whether the tree is large enough to plant out. A tree with a sturdy stem will generally have the most developed roots. For example, the minimum size for birch is regarded as 4-5 mm (see the British Standard for nursery stock BS 3936-4:2007)

Regarding height, smaller trees are preferable (20-40 cm) to ensure that the root/shoot ratios are in balance. If much taller than 20 cm, the tree can be cut back to vegetation height or planted at an acute angle with the tip facing away from the prevailing wind.

The health of the tree should be assessed from the appearance of the roots, shoots and buds - evidence of rust or other fungal growth or insect damage and scarred bark all indicate poorer quality stock. Biosecurity procedures should be followed to reduce the risk of infection of wild populations – see BPG2. Take care of stock en route to the site to avoid damage and desiccation.

Cell grown planting stock is generally preferred and the Sherwood-type root trainer size (12cm depth) allows sufficient nursery growth prior to planting but is still reasonably portable on site.

A wider shallow cell would be ideal as it does not require a lot of depth to allow the tree to be planted properly and without root damage. Cells should be planted so that the final soil level is 2-3 cm above the root collar to avoid frost heave and prevent the tree being pulled out by any deer or stock present.

Planting willow setts (ie stem cuttings) can be successful, especially for eared and tea-leaved willows. Spring is preferable just before leaf bud burst and the setts should be cut on the same day as planting.

Select straight hardwood growth with a minimum thickness of a pencil. Make a straight cut just above a bud and an angled cut 15-20 cm above this and approximately 1 cm above a bud (see BPG2 images page 7 &12). Use a similar thickness stick to make a hole and insert cutting, with angled cut and highest bud left above ground, or above surrounding vegetation.

Avoid taking cuttings from plants that are heavily browsed or otherwise stressed and do not take more than 33% of the plant's shoots.

For the rare montane willows, individual plants that are sampled should be identified with an accurate grid reference and photographs to aid re-finding and recorded with a specific ID, and the cuttings taken from them labelled as such.

At lower (sub-montane) elevations (350m-550m), larger bare-rooted birch have been used with varying effectiveness. This can sometimes give the planted tree the edge in taller vegetation where establishment is expected to be slow

It is advisable to harden off polytunnel stock prior to planting out on site.

Ground Preparation

Most ground in the Scottish uplands has been heavily grazed for long periods and often also burned. This has resulted in soil compaction which must be relieved by cultivation to improve aeration, root penetration and drainage. The aim is to create a cultivated, weed-free and slightly raised planting position. It is important to mix mineral and organic soil horizons and to break any iron pan.

Mechanical ground preparation (such as the usual forestry mounding) is often impractical in these locations, and can have a big initial impact on landscape and lead to soil erosion.

- If it is possible to get a machine on site then a recommended method is to create inverted mounds, where the turf is lifted and then inverted into the hole.
- Avoid sandwiching compacted soil layers beneath mounds, as roots are then unable to break through.

By hand:

- **Screefing** is often used – the removal of vegetation and organic matter to form a shallow mineral scrape for planting into. A minimum area is at least 30 x 30 cm, however in shallow or peaty soils screefing alone can create ponding which will kill the tree if prolonged bad weather ensues. The aim, therefore, is to dig sufficiently deeply to break through any compacted soil layers.
- Hand turfing is preferable, within a wider screefed area, although this is labour intensive.

Likes	Dislikes
Free drainage	Waterlogging
Shelter	Desiccation
Deep soil for rooting	Exposure
Nutrition	Very poor nutrition
Warm soil temp	Cold <5° soil temp
Minimal root competition	Root competition
Full sunlight (most spp)	Shade (most spp)

Table 1 - Tree establishment

Selecting the right individual planting site, taking account of the natural features can be as important as ground preparation. For example, choosing to plant in the lee of natural features may help protect new trees, as can communal planting (i.e. a 'seeding pulse' type of planting with very high densities). See Table 2 (page 9) for a summary of 'likes and dislikes' when considering microsite location and ground preparation.

Vegetation competition at these altitudes is not usually an issue demanding herbicide usage, as the initial screef or mound should provide enough time for the tree to get established before the vegetation recovers. At lower altitudes, using a brushcutter in dwarf shrub habitats can be helpful to clear competing vegetation. Bracken may grow up to 400m asl, but will usually be relatively weak at these altitudes and can be weeded by hand if necessary. At lower levels, herbicide or mechanical control may be necessary before planting.

Season to plant

Late spring planting is preferable as it will allow the plant to establish before that year's winter dormancy. Rising soil temperatures in the spring ensure that root growth can continue even if the plant is stressed. At higher levels, planting in the summer is also acceptable as the soils will usually remain moist. Due to altitude and exposure root growth is likely to be slower, which is a potential problem with autumn planting if desiccating winds occur.

If autumn planting cannot be avoided cell grown stock will have a better chance of survival, than bare rooted trees, due to the soil buffer around the roots.

Protection from herbivores

See BPG4 for detailed information on protection and fencing.

Mycorrhizae

All willow, birch, alder, hazel, pine and aspen species require ectomycorrhizal fungi to survive in the wild. In montane woodlands these species and bearberry (Arctostaphylos spp.) have been found to host diverse communities of ectomycorrhizal fungi specifically adapted to the montane zone. Mycorrhizal inoculum does not persist in locations where suitable host trees or shrubs are absent, and has limited dispersal capabilities. For sites with low inoculum potential, it may be beneficial to add a small amount of humus from a suitable 'donor' woodland when planting. Initial results at Borders Forest Trust's Carrifran site indicated some benefit from this approach to aid early establishment. Donor sites should be selected close to the receptor site, and matched for altitude, soil type and host plant genus as far as practicable. Standard "off the shelf' inoculations are not recommended.

Aftercare

It is often overlooked in the planning and resourcing stages of a planting project, but it is important to allow time in future years for monitoring and maintenance. Some considerations are:

- Check the plants are not frost-heaved over the first winter and continue to monitor over a few seasons.
- At higher levels, upward growth might not be measurable for the first 3 years due to a period of root establishment and possible apical shoot predation. For willows, even in optimal conditions, the onset of flowering will be gradual. However, at the National Trust for Scotland's Ben Lawers property, growth has been significant after 6 yrs.
- Checking perimeter fences regularly, especially after snow, is important, and is often a very time-consuming activity. If the site is not fenced, it is crucial to undertake herbivore impact assessments and take action to reduce the browsing pressure at the relevant time of year.

  Further applications of phosphate might be required.
- Note that slow growth rates are to be expected at high elevations, and that some losses are inevitable. It is sensible to plan for up to 25% loss every year for the first 5 years for most species. A total loss of 50% has been achieved at Ben Lawers
- Learn from the achievements of previous years and beat up those areas and locations where planting has succeeded.

Acknowledgements

This Best Practice Guide has been prepared by members of the Montane Scrub Action Group, who gratefully acknowledge input from Kenny Hay (Forest Officer), Andrew Jarrett (Forest Officer) and Rob Soutar (Forest District Manager, rtd)

Fertiliser

Ideally, trees should be grown 'hard' with no fertilisation in the nursery to lessen planting shock and give a better root/shoot ratio. As this might result in a longer period in the nursery, it may not be practical to grow trees big enough for planting out without fertiliser.

Post planting a small amount of rock phosphate is usually recommended (approximately 50 gm per tree). However, rock phosphate is a dwindling global resource and so the nutrient status of each site, or other options should be carefully considered. E.g. inoculation with local, mycorrhiza containing soil.

A slow release fertiliser, predominantly containing phosphate, applied in the hole at time of planting seems to have good initial benefit in low nutrient habitats, especially for birch (at 10g per tree) and easier to handle when wet than rock phosphate. At the Alladale Estate, some areas of planting have used both.

Attention to drainage is important as plants will be unable to access nutrients in anaerobic conditions.

Also, mycologists advise that it is best practice not to fertilise when attempting to introduce mycorrhiza. This is a poorly understood area and any research trials on this are welcomed.

Table 2 - Species site requirements tables

Common Name	Species	Soil requirement	Habit & habitat	Altitude (m above sea level)	Status RDB
Dwarf birch	*Betula nana*	Acid soils pH 2.9 - 4.4	Prostrate to erect (0.3 - 1m). Blanket bog to wet heath	130 - 855m	LC
Rowan	*Sorbus aucuparia*	Acid, poor to medium nutrient status, slightly dry to moist.*	Frequent to occasional in upland birch and pinewoods. Light demanding pioneer species. Frost hardy and will tolerate exposure.	0 – 870m	LC
Eared-willow	*Salix aurita*	Acid, sandy to peat	Erect shrub (< 5m). Wet mountain slopes	Coast - 870m	LC
Juniper	*Juniperus communis*	Acid to neutral soils pH3.2 - 6.0	Prostrate to erect (0.1 - > 3 m). Wide range of soils and vegetation avoiding deep peats	Sea level - >950m	UK BAP species
Scots pine	*Pinus sylvestris*	Acid to neutral light soils, dry to moist but will tolerate wetter peaty sites.*	Native pinewoods & widely planted elsewhere. Light demanding pioneer species. Wind firm, but suffers from exposure.	0 – 675m quoted but now up to 800m in Cairngorms	UK BAP species
Downy birch	*Betula pubescens* may be ssp *tortuosa*	Acid, moist to wet, tolerates poor & peaty soils.*	Upland birchwoods & pinewoods. Light demanding pioneer species. Wind firm.	0 – 830m	LC
Least willow	*Salix herbacea*	Wide range of soils	Prostrate (< 0.2 m). Sparsely vegetated areas: relatively dry snow bed areas to calcareous fens	600 - summits	LC
Aspen	*Populus tremula*	Range of soils, poor to rich, slightly dry to wet.*	Frequent to occasional in upland birch and pinewoods and in riparian habitats at lower altitudes. Light demanding pioneer species. Some tolerance of exposure.	0 – 640m	LC
Goat & grey willows	*Salix caprea* ssp *sphacelata & S. cinerea*	Medium base-status, moist soils*	Rocky stream sides & ravines	245 – 760m	LC

* Forest Research website **https://www.forestry.gov.uk/pdf/lru_bpg08.pdf/$FILE/lru_bpg08.pdf**

Table 2 - Species site requirements tables (cont'd)

Common Name	Species	Soil requirement	Habit & habitat	Altitude (m above sea level)	Status RDB
Tea-leaved willow	*Salix phylicifolia*	Wide range of soils, avoiding the most acid	Erect bush (< 3 m). Often associated with water-body margins, ledge communities	Sea level - 690 m	LC
Dark-leaved willow	*Salix myrsinifolia*	Wide range of soils, avoiding the most acid	Tall-shrub to small tree (1 - 5 m). Damp mountain slopes	Coast - 940 m	LC
Creeping willow	*Salix repens*	Wide range of soils, avoiding the most acid	Procumbent to semi-erect shrub (up to 1 m). Sandy heaths to wet mires with sparse vegetation	Sea level - 855 m	LC
Downy willow	*Salix lapponum*	Wide range of soils, avoiding the most acid	Erect bush (< 2 m). Often associated with water-body margins, ledge communities	450 - 1100 m	Vulnerable
Whortle-leaved willow	*Salix myrsinites*	Base-enriched soils Has been found on soils between pH 3.6 - 7.6	Low-growing and spreading (< 1 m). Rich, often shallow fens	274 - 980 m	Endangered
Mountain willow	*Salix arbuscula*	High base status to lime-rich soils	Procumbent to semi-erect (< 1 m). Damp heath and grassland	460 - 870 m	LC
Woolly willow	*Salix lanata*	High base-status, limestone	Low-growing to small bush (< 2 m). Mountain ledges, snow beds, moist soils	550 - 1000 m	Vulnerable (our rarest willow)
Net-leaved willow	*Salix reticulata*	Lime-rich soils of high base status	Prostrate (< 0.2 m). Moist soils at cliff bases, in seepage areas	450 - 1125 m	LC

Increasingly Acid soils **Increasingly base rich soils**

Status: RDB = Red Data Book (Cheffings & Farrell 2005), LC = least concern

Information sourced from:

Cheffings, C.M., and Farrell, L. (Eds.) 2005. Species Status: No. 7. The Vascular Plant Red Data Book for Great Britain. JNCC, ISSN 1473-0154 (online)
Christensen, K.I., Berg T., Jonsell B., Elven, R., Karlsson, T. 2000. Salicaceae: Salix In Jonsell, B. (ed.) 2000. Flora Nordica, Vol. 1. Lycopodiaceae to Polygonaceae. The Bergius Foundation and Royal Swedish Academy of Sciences, Stockholm, Sweden
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Meikle, R.D., 1984. Willows and poplars of Great Britain and Ireland. BSBI handbook no 4. London
Preston, C.D., Pearman, D.A., Dines, T.D. 2002. New atlas of the British and Irish flora. Oxford University Press