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Use of Broadleaved Species in Upland Forests

Selection and establishment for environmental improvement

A J Low

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FRONT COVER A group of birches beside Loch Tummel, Tayside Region. (*E4758*)

USE OF BROADLEAVED SPECIES IN UPLAND FORESTS

SELECTION AND ESTABLISHMENT FOR ENVIRONMENTAL IMPROVEMENT

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1. Introduction

The value and management of broadleaved woodland in Britain have recently been the subject of much discussion, which culminated in a major policy review (see *Broadleaves in Britain – Report of a policy review group (a consultative paper)*, Forestry Commission, 1984; and *Broadleaves in Britain – Review of policy*, Forestry Commission, 1985). The outcome of this was a statement of government policy, published in autumn 1985 as Forestry Commission Policy and Procedure Paper 5 *The policy for broadleaved woodlands.* Another information booklet *Guidelines for the management of broadleaved woodland* (Forestry Commission, 1985) was also published at this time. Both the review and the policy statement laid great emphasis on the importance of broadleaved species and woodland for wildlife conservation and for maintenance and enhancement of landscape and amenity.

Inevitably, broadleaved woodland is and will continue to be of much greater general significance in lowland than in upland Britain. The more fertile, less exposed conditions of the former are much better suited to most broadleaved species which grow in this country. Upland climatic and soil conditions generally necessitate the planting of conifers if acceptable timber yields are to be obtained. However, there is no doubt that even limited use of broadleaved species can do much to diversify habitats and landscape in commercial upland forests. In recognition of this, one aim of the stated policy for broadleaved woodlands is "to encourage the maintenance and greater use of broadleaves in the uplands, particularly where they will enhance the beauty of the landscape and the wildlife interest – including the extensive conifer plantations". It was also recommended that the aim should be for broadleaves ultimately to form 5 per cent of the total woodland area in the uplands.

The purpose of this leaflet is to give practical guidance on how best to select and establish broadleaved tree species for conservation, amenity and landscape purposes within upland coniferous forest areas of Scotland, Wales and northern England. It applies both to afforestation and to restocking of felled areas, but is not intended to cover the establishment or management of broadleaved woodland aimed primarily at timber production on unusually fertile well-sheltered sites in upland forests. Treatment of such crops is essentially similar to that for broadleaved woodland in lowland areas and is described in Forestry Commission Bulletin 62 *Silviculture of broadleaved woodland.* Also excluded is the treatment of ecologically important remnants of semi-natural woodland, the specialised requirements of which necessitate consideration on an individual basis and consultation with conservation organisations. The most important semi-natural woodland sites are identified in the Nature Conservancy Council's *Register of ancient woodland.*

This leaflet should be read in conjunction with *Guidelines for the management of broadleaved woodland.* Other important sources of information are referred to in the sections which follow and are listed at the end of the text.

2. Management objectives

As in other aspects of forest management, it is essential to have a clear aim in mind when

considering the role of broadleaved species in an upland forest area. From the outset it must be decided whether the objective is to use them primarily as a means of improving or diversifying habitats for wildlife (and if so, for what species); as an element in landscape design to improve the overall appearance of the forest; or as a means of enhancing amenity at picnic sites, car parks and other recreational facilities. These objectives are obviously not mutually exclusive and will often apply in combination. However, it is important to identify the main objective as this will have an important influence not only on the general approach adopted but also on specific aspects such as location and scale of planting within the forest, choice of species and type of planting stock, and methods of establishment and protection.

3. Retention of existing broadleaved growth

Most existing upland forests already contain at least small areas of broadleaved tree or scrub growth. Some will be the result of deliberate planting in the past, but most stem from patches of broadleaved growth present at the time of afforestation, or have resulted from the growth of natural seedlings in gaps or along rides or roadsides within the developing

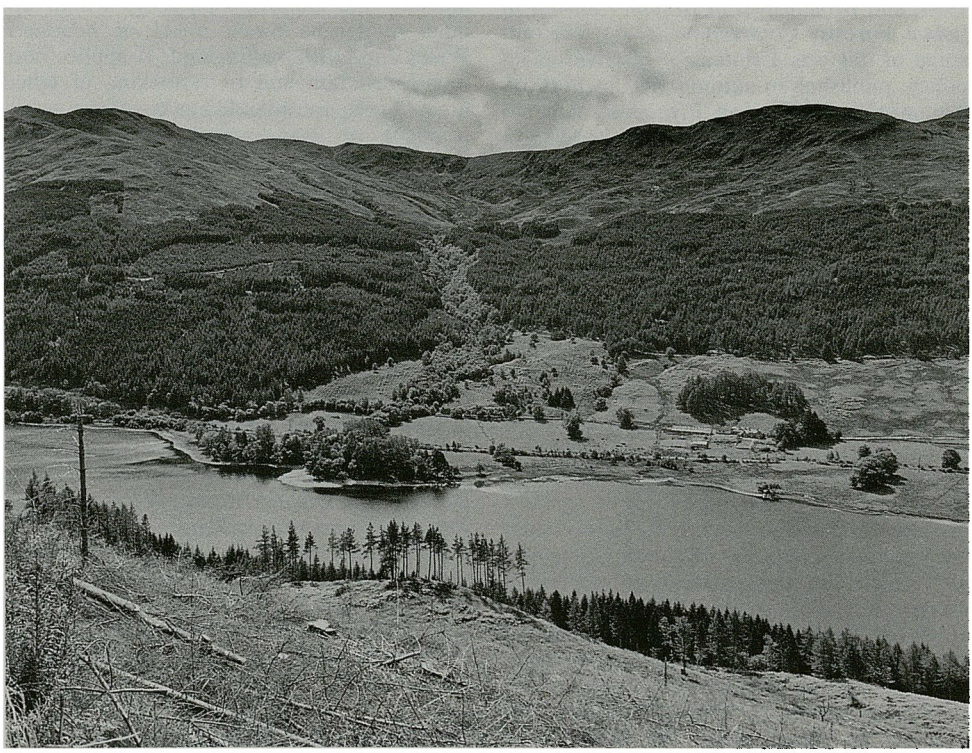

Plate 1. Semi-natural birch retained along the sides of a gully running through plantations of spruce and larch. The birch provides important conservation and landscape benefits. Strathyre Forest, Central Region. (*ED1682*)

forest. At the time of harvesting, it will normally be worth considerable effort to minimise damage to these areas and to conserve them for incorporation into the restocked forest. Underplanting them with coniferous species should be avoided, and they may well form the basis for extended broadleaved planting for conservation or landscape reasons (see Section 5 – Selection of planting sites).

Patches or groups of broadleaved species (most commonly birch, but occasionally including oak, rowan, willow and other species) are often found within areas scheduled for afforestation. This broadleaved growth is frequently associated with watercourses (especially gullies) and crags, where pressures from grazing and muirburn are lower. As in the case of restocking areas, it is usually important to retain such growth because of its high conservation and landscape value (Plate 1). Damage during ploughing and other site preparation work should be minimised, and under-planting with conifers avoided.

4. The place of natural regeneration

Various broadleaved species (notably birch, rowan and willows) frequently seed naturally into a forest area after clear felling has taken place, particularly if there is adequate protection from browsing. At times, such natural regeneration, especially of birch, can develop on such a scale that control by herbicide treatment or cutting is necessary to prevent unacceptable competition damage to the second rotation coniferous crop. However, where natural regeneration of broadleaved species is occurring or can reasonably be expected to occur in suitable locations and quantity, it can form the basis for a valuable broadleaved component in a forest block. Sensible incorporation of such growth into restocking plans will reduce the need for costly establishment of broadleaved species. Natural seeding will often provide a more effective and certainly cheaper alternative to planting for establishment of broadleaves on such awkward sites as gully sides, steep slopes, screes and rock outcrops where the presence of broadleaved species may be particularly valuable for both conservation and landscaping. The general protection normally given to a forest area during the restocking phase may be sufficient encouragement for appropriate broadleaved growth, but judicious use of scarification, ploughing or herbicide treatment of dense ground vegetation may help to obtain the desired natural regeneration, and special fencing may sometimes be justified.

5. Selection of planting sites

A number of factors influence the choice of planting locations, including conservation, landscape and amenity requirements. Most important, however, are the inherent site requirements of the tree species themselves. In comparison with the coniferous species commonly used in upland forests, young trees of most broadleaved species are generally more demanding as regards soil moisture and nutrient status, more sensitive to early competition and more susceptible to climatic and animal damage. Site conditions in upland forests rarely favour the use of broadleaved species for wood production, and the generally prevalent impoverished soils and harsh climate create difficult conditions for the establishment of broadleaved species for any purpose. It is therefore important that sites for broadleaved planting are carefully chosen to provide as favourable conditions as possible. Failure to do so is likely to lead to costly tending operations and will reduce substantially the chances of achieving the planting aims.

Within any upland forest block, it is almost always possible to identify small areas where soil conditions are substantially better than average. Examples are 'flushed' locations generally, and stream sides in particular; and patches of upland or podsolic brown earth or intergrade ironpan soil within blocks dominated by poor peaty gley soils or even by extensive deep peat. Particularly where they have at least some shelter from wind exposure,

these 'better' sites must be considered as the basis for any broadleaved planting scheme. The scope for site selection will generally be wider in many current restocking situations, because the older forest blocks are frequently at lower elevations and on less exposed, more fertile sites than have been available for more recent afforestation. Site conditions may have been improved by the presence of the first rotation crop, and there may also be some shelter from the adjacent standing crops. On the other hand, there may be new problems caused for example by the presence of lop and top, or the close proximity of cover for deer.

From the conservation viewpoint, it is particularly valuable to establish and maintain groups of broadleaved species near watercourses and ponds (Plates 2 and 3). Note, however, that a stream should not be heavily shaded continuously along its length. It may also be desirable to enlarge existing groups or areas of broadleaved tree or scrub growth. Selective planting of broadleaves on the edges of roadlines and major rides can benefit both conservation and amenity. However, the practice of planting continuous lines of trees (whether at close or wide spacing) in 'avenue' style should be avoided. It is far better to plant groups of varying sizes at irregular intervals, concentrating on the more favourable sites.

Where the use of broadleaved trees is aimed primarily at contributing to landscape design in upland forests, the location and extent of planting areas should be planned with the aid of appropriate design maps and sketches. Guidance on forest landscape and design is given in Forestry Commission Booklet 44 *The landscape of forests and woods* and Forestry Commission Leaflet 84 *Guide to upland restocking practice*. Important principles include: use of broadleaved species to emphasise natural land form by planting up gullies and areas beside watercourses; planting in clumps and irregular shapes related to land form; and making use of or augmenting existing broadleaved trees and woodland, e.g. on exposed crags, along lower boundaries to link with hedgerows, or at higher elevations to soften upper margins. If broadleaved planting is to contribute effectively to landscape, site conditions must be sufficiently favourable to give reasonable prospects of healthy growth. There is little point in struggling to establish broadleaved species on locations with unsuitable soil and climatic conditions in the mistaken belief that this constitutes good forest design practice.

6. Species choice

Selection of appropriate broadleaved species will be strongly influenced by the planting objectives, and by local environmental factors. Frequently, the choice will be very restricted due to prevailing site conditions. Wherever wildlife conservation is important, native broadleaved species should be preferred. Common alder, Silver and Downy birch, Sessile and Pedunculate oak, rowan and various willows are the main species to be considered, but aspen, Bird cherry, gean, hawthorn and hazel may also have a limited or more sophisticated role on suitable sites (see Forestry Commission Booklet 29 *Wildlife conservation in woodlands*). In other circumstances it is reasonable to use any broadleaved species visually compatible with the local landscape, including Grey and Sitka alder, *Nothofagus procera*, sycamore and beech. Doubts are often expressed about sycamore from the conservation viewpoint, but there is little clear evidence to support these. The species has a long tradition of use in many upland areas and has the merit of being very tolerant of wind exposure once it has become established. Beech, which is non-indigenous in the uplands, has site requirements and growth rate similar to those of oak. It may have a limited role in landscape planting, particularly in Wales and northern England. Ash, although native, seems unlikely to have a significant role because of its dislike of acid soils. Red alder is also a dubious prospect because it tends to suffer severe early frost damage following a promising early start on many upland sites. Suitable conditions for poplar species

Plate 2. An example of good streamside treatment, with retention of adjacent broadleaved trees and shrubs, and the edge of the coniferous tree crop set back from the stream edge. Elibank Forest, Borders Region. (*E5243*)

other than aspen will seldom be available. The use of elm is ruled out by the widespread presence of Dutch elm disease.

Table 1 summarises the main relevant features of the most important broadleaved species which can be considered for use. The listing is not exhaustive but is considered to include all the species likely to play a significant role in planting for conservation and landscape purposes in the main upland forest regions. The emphasis is very much on native species because of their conservation value.

7. Site preparation

In upland afforestation, normal practice prior to any tree planting is to cultivate as much as possible of the site using spaced furrow ploughing (in conjunction with widely spaced cross-draining) to provide weed-free planting positions, improve local drainage and mobilise nutrients. Broadleaved species are likely to benefit from ploughing even more than conifers, particularly on the poorer, more exposed areas, despite the fact that sites selected for broadleaved planting will generally have above average conditions. Similarly, broadleaved species will benefit from the effect of cultivation on restocking sites, whether by ploughing or scarification. There will, however, be locations selected for broadleaved planting where mechanical site preparation will be impossible or undesirable, e.g. because of steepness or rockiness, or because of adverse run-off effects if ploughing is done very close to stream sides. In such cases, inverted turfs can be cut to provide raised plant-

Table 1 Summary of information on broadleaved species for use in upland coniferous forests

Species	Status	Growth characteristics	Special features
Alders			
Common alder *Alnus glutinosa* (L.) Gaertn.	Native	Small/medium sized bushy tree; short lived, but rapid early growth.	High conservation value. Coppices vigorously. Regenerates freely on moist soils. Root nodules fix nitrogen.
Grey alder *Alnus incana* (L.) Moench	Introduced	Medium sized tree; short lived, but very rapid early growth.	Medium/high conservation value. Coppices vigorously and produces root suckers. Root nodules fix nitrogen.
Red alder *Alnus rubra* Bong.	Introduced	Medium sized tree; short lived, but very rapid early growth.	Medium/high conservation value. Coppices vigorously. Conspicuous catkins. Root nodules fix nitrogen.
Sitka alder *Alnus sinuata* (Reg.) Rydb.	Introduced	Large bushy shrub; short lived, but rapid early growth.	Medium conservation value. Coppices readily. Very conspicuous catkins. Root nodules fix nitrogen.
Ash			
Fraxinus excelsior L.	Native	Large tree; relatively long lived; rapid early growth after establishment.	Medium/high conservation value. Coppices readily and regenerates freely on moist mineral soil. Large seeds.
Aspen			
Populus tremula L.	Native	Small/medium sized tree; short lived, but rapid early growth.	Very high conservation value. Produces many root suckers and also coppices. Striking autumn colour.
Beech			
Fagus sylvatica L.	Native to southern England. Widely planted elsewhere.	Large tree; long lived; slow growth.	Medium/high conservation value. Coppices when young. Good autumn colour. Shade tolerant. Large seeds.

Site requirements and limitations	Other limitations and notes
High moisture requirement and tolerates winter waterlogging. Grows on wide range of wet soils but not suitable for acid peat. Moderate exposure tolerance and very frost hardy.	Lacks autumn colour. Less severely browsed than most other broadleaved species. Best suited to group planting near water.
Grows on very wide range of soils including heavy clays; tolerates drier conditions than Common alder but dislikes very dry sites. Moderate exposure tolerance; less frost hardy than Common alder.	Lacks autumn colour. Prone to dieback after promising start on higher upland sites.
Grows on very wide range of soils including heavy clays. Moderate exposure tolerance; less frost hardy than Common alder.	Lacks autumn colour. Prone to dieback after promising start on many upland sites – may be related to seed origin.
Grows on very wide soil range, including heavy clays and deep peats; very dry sites are unsuitable. High exposure tolerance, frost hardy.	Lacks autumn colour. Best suited to group planting but may have a nursing role in mixture with Sitka spruce on very poor sites.
Requires well drained base rich soil, preferably deep. Low exposure tolerance.	Poor autumn colour. Difficult to establish, especially in grass. Very few suitable sites in upland forests.
Prefers well drained fertile soils but tolerates acid and heavy conditions if not waterlogged. Unsuitable for peats. High exposure tolerance and frost hardy.	Best suited to group planting on better soils. Very palatable to deer.
Tolerates a wide range of soils but is unsuitable for poorly drained sites and very acid soils, including peats. Early frost damage common. Moderate exposure tolerance.	Difficult to establish in open ground. Upland sites suitable for beech are probably better planted with oak for conservation reasons.

Species	Status	Growth characteristics	Special features
Birches			
Downy birch *Betula pubescens* Ehrh. and Silver birch *Betula pendula* Roth.	Native, with Downy birch more common in north and west of Britain.	Small/medium sized tree; relatively short lived; vigorous early growth.	Very high conservation value. Coppices readily. Regenerates very freely and the small seeds can be carried long distances by wind. Striking autumn colour. White stem bark.
Blackthorn or sloe			
Prunus spinosa L.	Native	Bushy shrub, often forming dense thicket; short lived; relatively vigorous early growth.	High conservation value. Coppices and produces root suckers freely. Conspicuous flowering. Large fruits (sloes). Good autumn colour. Produces spines.
Cherries			
Bird cherry *Prunus padus* L.	Native	Small bushy tree or large shrub; rapid early growth; short lived.	High conservation value. Coppices and produces root suckers freely. Conspicuous flowering. Large fruits. Good autumn colour.
Gean or wild cherry *Prunus avium* L.	Native	Small/medium sized tree; rapid early growth; short lived.	High conservation value. Coppices and produces root suckers readily. Regenerates freely from seed on suitable sites. Conspicuous flowering. Large fruits. Striking autumn colour.
Hawthorn			
Crataegus monogyna Jacq.	Native	Shrub or small bushy tree; rapid early growth; short lived.	High conservation value. Coppices readily. Conspicuous flowering and large fruits. Good autumn colour. Produces spines.

Site requirements and limitations	Other limitations and notes
Grows on a very wide soil range including deep peat. Very wet or waterlogged mineral soils unsuitable. High exposure tolerance and very frost hardy: also reasonably tolerant of air pollution.	Downy birch is better choice for wet, acid upland soil or peats, and for exposed conditions but species difference is small. Best broadleaved species for peaty sites. Handle bare-rooted planting stock carefully and consider use of containerised stock.
Grows on a wide range of soils, apart from very wet conditions and acid peat. High exposure tolerance and frost hardy.	Suitable for group planting only.
Prefers well drained fertile soil but tolerates a wider range of conditions. Unsuitable for very heavy or poorly drained soils and peats. Moderate exposure tolerance but frost hardy.	Best suited to group planting on better soils in sheltered locations.
Prefers well drained soils but tolerates a wide range of conditions. Dislikes poorly drained acid or peaty soils. Low exposure tolerance but frost hardy.	Best suited to group planting on better soils in sheltered locations.
Tolerates very wide soil range. Not suitable for very dry and very wet conditions, and peats. High exposure tolerance and frost hardy; also tolerates air pollution and salt spray.	Best suited to group planting.

Species	Status	Growth characteristics	Special features
Hazel			
Corylus avellana L.	Native	Bush shrub; rapid early growth; short lived.	High conservation value. Coppices vigorously. Conspicuous catkins. Large fruits (nuts). Good autumn colour. Shade tolerant.
Oaks			
Sessile oak *Quercus petraea* (Mattuschka) Lieblein and Pendunculate oak *Quercus robur* L.	Native; both widespread but Sessile oak more common in north and west of Britain.	Large trees; long lived; slow early growth.	Very high conservation value. Coppices readily. Large fruits (acorns). Good autumn colour.
Rowan			
Sorbus aucuparia L.	Native	Small bushy tree; short lived; vigorous early growth.	High conservation value. Coppices readily. Conspicuous flowers and large fruits. Striking autumn colour.
Sycamore			
Acer pseudoplatanus L.	Introduced, but widely planted and naturalised.	Medium/large tree, relatively long lived; vigorous early growth once established.	Moderate conservation value. Coppices readily. Shade tolerant when young. Good autumn colour. Can regenerate profusely from seed on suitable sites.
Whitebeam			
Sorbus aria L.	Native only to southern England, but widely planted elsewhere.	Small bushy tree; short lived; vigorous early growth.	Moderate/high conservation value. Coppices readily. Conspicuous flowers and large fruits. Leaf undersides conspicuously light coloured.

Site requirements and limitations	Other limitations and notes
Tolerates very wide range of conditions, apart from peat. Prefers relatively deep, moist fertile soils. Avoid waterlogged sites.	Best suited to group planting on relatively sheltered valley or lower slope sites.
Prefers reasonably fertile, deep, well drained soils. Sessile oak more tolerant of poor, drier soil conditions. Poorly drained sites and peats are unsuitable. Moderate exposure tolerance when established. Young trees prone to spring frost damage.	Can be difficult to establish because of slow early growth and mammal browsing. Best planted on valley bottom and other relatively sheltered sites, avoiding frost hollows.
Prefers freely drained conditions but tolerates very wide range of soils, including peats. Waterlogged sites are unsuitable. Very high exposure tolerance; and frost hardy; also tolerates salt spray and air pollution.	Best suited to group planting. Performs well on deep peats. Attractive to browsing mammals.
Tolerates a wide range of soils apart from acid peats, but prefers moist well drained conditions. Very high exposure tolerance; also tolerates pollution and salt spray well.	Can be difficult to establish, especially on grassy sites. On some sites produces dense invasive natural regeneration; doubts sometimes expressed about conservation value. A 'traditional' tree in many upland areas.
Tolerates a wide range of conditions, although preferring base rich soils. Unsuitable for very wet or waterlogged sites, but can survive on acid peat. High exposure tolerance; also tolerates air pollution and salt spray.	Suitable for limited group planting only. Shows some promise for deep peat sites. Rowan should normally be preferred. Swedish whitebeam *Sorbus intermedia* (Ehrh.) Pers. has similar performance to *S. aria*.

Species	Status	Growth characteristics	Special features
Willows			
Eared sallow *Salix aurita* L. Goat willow or sallow *Salix caprea* L. Grey willow or sallow *Salix cinerea* L. Common osier *Salix viminalis* L. Purple osier *Salix purpurea* L.	Native	Large shrubs or small bushy trees; short lived; rapid early growth.	Very high conservation value. Coppices vigorously. Conspicuous catkins. Variable autumn colouring. Can regenerate freely from seed on suitable sites.
White willow *Salix alba* L. Crack willow *Salix fragilis* L.	Native	Small/medium bushy trees; short lived; rapid early growth.	As for other willow species above.
Southern beech			
Nothofagus procera (Poepp. and Endl.) Oerst. and *Nothofagus obliqua* (Mirbel) Blume	Introduced	Medium/large trees; very vigorous growth.	Moderate/high conservation value. Coppices readily when young. Good autumn colouring.

Site requirements and limitations	Other limitations and notes
Prefer wet alluvial sites but are surprisingly tolerant of relatively dry conditions if deep rooting possible. The sallows tolerate deep peats. Generally high exposure tolerance and frost hardy; also tolerate air pollution and salt spray.	Best suited to group planting adjacent to watercourses or ponds. Unrooted sets can be used for establishment. Use sallows for high elevation and poorest sites, including peats.
As for other willow species above but requiring somewhat moister, more fertile conditions and less tolerant of exposure.	Best suited to group planting on moist sites near water. Avoid high elevation, very exposed or peaty sites.
Prefer deep, freely drained soils but tolerate a wide range of conditions apart from very wet sites and peats. *N. obliqua* can accept drier conditions than *N. procera*. Low/moderate exposure tolerance. Can be damaged by low winter temperatures; unsuitable for frosty locations.	Among the fastest growing broadleaved species used in Britain. Soil requirements relatively undemanding. Avoid frosty and high elevation sites. Usually easy to establish. In most upland areas, *N. procera* is likely to do better than *N. obliqua*. Avoid origins from north of 38° S latitude.

ing locations, particularly in moist situations. On drier ground, patch treatment with herbicide in the season prior to planting can be used to produce weed-free planting spots (see Forestry Commission Booklet 51 *The use of herbicides in the forest*). Pre-planting use of herbicide is of particular benefit in establishing broadleaved species because the risk of damage from post-planting herbicide application is considerably greater than for most coniferous species.

The possible use of cultivation or herbicide to encourage natural regeneration of broadleaved species has already been mentioned in Section 4.

The need for appropriate fencing will be discussed in Section 15.

8. Type of planting stock

There will often be a temptation to opt for large planting stock in an attempt to achieve 'instant' or very rapid effect. However, experience indicates that in most situations large plants (1 m or more in height) will confer no early survival or growth advantages and in fact are prone to check after planting, as well as being expensive to purchase or produce. For most species, the most satisfactory results will be obtained using sturdy, bare-rooted plants 25–50 cm in height, with well-developed fibrous root systems, high root:shoot ratio and root collar diameter in the range 6–8 mm. Depending on where they are produced and the nursery regime employed, such plants are likely to be 2 + 1 or 1 + 1 transplants or similarly aged undercut stock. In the case of alders and *Nothofagus*, somewhat taller 40–70 cm 1 + 1 transplants are likely to be appropriate because of the very rapid first year seedbed growth of these species. Birch (both Silver and Downy) has a reputation of being difficult to establish using bare-rooted planting stock, but satisfactory results can be obtained with compact sturdy plants (even good seedling stock) if these are handled carefully so as to minimise root drying. The use of container-grown birch seedlings, either in Japanese paper pots or larger removable containers, can give worthwhile improvements in survival and early growth. For other species there is little evidence to encourage the use of containerised stock, which is generally considerably dearer and more awkward to handle in quantity than bare-rooted stock.

When planting for local amenity purposes, e.g. in the vicinity of a picnic site or car park, there may be justification for using large transplants in excess of 1 m or even whips and small feathered stock. However, except where 'instant' effect is considered essential, it is usually better to stick to good quality 25–50 cm transplants which can be expected to give healthy rapid growth if carefully planted and tended.

Nursery-produced willow planting stock is normally in the form of one-year rooted cuttings (designated C + 1). Willows can also be established by inserting unrooted hardwood cuttings (sets) directly on the planting site between November and March (and preferably in early spring). The minimum cutting size is 20 cm in length and 10 mm in diameter but, cuttings up to 1 m in length and 35 mm in diameter may be worth using on more testing sites.

Aspen is also raised in the nursery from cuttings, using either softwood cuttings rooted under mist or root cuttings. Where only a small number of plants is required, lifting and transplanting small suckers is a possible alternative source of stock.

9. Plant spacing and pattern

As with species choice, decisions on plant spacing, planting pattern and the possible use of species mixtures will be influenced by the primary objective. For example, conservation planting adjacent to streams and ponds is likely to favour the creation of relatively dense broadleaved groups separated by irregular open spaces. In the vicinity of picnic sites and other recreational facilities, planting in groups is also likely to be desirable, but wider spacing (up to 3 m) can be considered if the aim is to

encourage the development of bushy crowns. Wider spacing may also be appropriate if tree shelters are used (see Section 15). Where the ultimate aim is to have individual specimen trees, the most effective approach will usually be to plant a small group (3–5 trees) and reduce this to the best specimen some years after establishment. Where the aim is to improve the distant appearance of a forest landscape, then the scale of planting requires to be more extensive, although still irregular in outline and related to landform (see Section 5); a regular spacing of around 2 m is likely to be most appropriate to facilitate establishment and tending at acceptable cost. There is little merit in scattering broadleaved trees at very wide spacing through conifer plantations in the mistaken belief that this will improve the landscape.

The use of nursing mixtures with conifers is sometimes advocated for the growing of commercial broadleaved crops on less favourable sites. Such mixtures are best avoided where landscape is important, and because of tending and protection complications it is doubtful if there is any place for them when broadleaved species are being established in upland forests for landscape and conservation reasons.

Mixtures of broadleaved species are generally acceptable for any of the objectives in this leaflet. It is unlikely to be worth incurring extra costs for planting intimate mixtures, but areas of mixed broadleaved species will often arise through natural regeneration in open areas (see Sections 3 and 4) or within areas planted with broadleaved species.

10. Plant handling

Provided planting stock is of acceptable quality and type, a common cause of establisment failure is bad plant handling between nursery lifting and forest planting. Plants must be handled carefully to minimise physical damage, particularly to roots, and must be protected against drying out and heating. Packaging in sealed waterproof containers such as polythene bags or waxed cardboard boxes will prevent desiccation during storage and transport. Loads of plants should be fully covered during transport to the forest. Except where container-grown stock is involved, lifting should be done only when plants are fully dormant and the time between lifting and planting should be minimised. If cold storage is used for nursery management reasons or to extend the planting season the storage temperature must not exceed 2 °C at any time.

11. Planting method

Where ploughing has been done, planting should be by spade notch into the side of the plough ridge, taking care to avoid doubling up the root system during insertion in the slot, and to firm the soil properly after planting. In turf planting, the tree roots should as far as possible be sandwiched between upturned turf and the ground surface. Normal notch planting with a spade or mattock will also be appropriate in most other situations, with screefing as necessary in dense vegetation if the latter has not been controlled by pre-planting herbicide application. Pit planting will seldom be worthwhile except where larger than normal planting stock has been selected for amenity purposes.

If unrooted willow cuttings are to be used, these are best inserted vertically with the aid of a spade or crowbar, and must be adequately firmed. On soft ground, it may be possible simply to push in the cuttings. At least half the length of each cutting must be below ground level and care should be taken to ensure that the buds point upwards.

12. Planting season

In lowland forestry, late autumn is usually regarded as the optimum time for broadleaved planting, but in upland areas early spring (March) planting may be preferable in exposed situations. Bare-rooted stock should

not normally be planted later than the end of April, but if dormancy has been maintained by cold storage, planting can, with care, be extended to late June.

13. Fertiliser treatment

The locations for broadleaved planting in upland forests will normally be selected as having above average nutrient status. In consequence, the fertiliser regime applied to the adjacent conifer crops will usually be adequate, even though broadleaved species generally have higher soil nutrient requirements than the commonly used conifers. At planting time, areas to be planted with broadleaved species should be treated with broadcast application of phosphate or phosphate/potash mixture as required for the main conifer crop, and should also be included in any subsequent top dressing operations. Even on poor peatland, where the choice of broadleaved species is restricted to birch and possibly rowan, willow and alder, there is little evidence at present to suggest that extra fertiliser applications (including additional nitrogen) will produce a worthwhile response in terms of vigour, or extend the range of possible species.

14. Weed control

Because of the better than average site conditions on most broadleaved planting locations, growth of grasses and other ground vegetation will be vigorous. Furthermore, most broadleaved tree species are particularly vulnerable to weed competition during the early establishment years. It is therefore doubly important that effective timely weed control is applied wherever necessary to broadleaved plantings in upland forests. If this is not done expensive failures are likely and at best there will be a serious delay in establishing the trees and achieving the planting objectives.

The use of appropriate herbicides will usually provide by far the most effective and least costly means of controlling competing vegetation in young tree crops. The value of pre-planting herbicide treatment has already been mentioned for sites where cultivation is impossible. Treatments suitable for both pre- and post-planting use are described in Forestry Commission Booklet 51 *The use of herbicides in the forest* and reference should always be made to the current version of this booklet for up-to-date recommendations. Use of herbicides in broadleaved plantations generally requires considerable care because most chemicals which kill broadleaved weeds are also lethal to broadleaved tree species. Spot weeding within a 0.8–1.0 m diameter circle centred on each tree is likely to be the most appropriate technique for the majority of sites requiring treatment.

15. Protection against browsing damage

Most common broadleaved species are attractive to browsing mammals and are therefore particularly prone to serious browsing damage during the early years of growth. Later, they are also subject to fraying and bark-stripping. It is therefore essential that adequate protection is given against whichever harmful mammals are known to be present in the forest area. The approach adopted will be affected by the scale of planting, the mammals present and their numbers.

Basic protection of most broadleaved areas in upland forests will be provided by the protection measures applied to the forest block as a whole. In some cases, this level of protection will be adequate for any broadleaved plantings – for example, where effective external fencing against domestic stock or deer is standard practice. Routine deer fencing protection of conifer restocking areas will also be necessary in many established forests and any included broadleaved areas will benefit. There will, however, be circumstances in which the expected damage levels to the main coniferous crop will not justify the cost of deer fencing an entire planting block – for example,

where only small numbers of roe deer are present. It will then be necessary to take specific action to protect broadleaved areas, using either lightweight internal deer fencing (see Forestry Commission Leaflet 87 *Forest fencing*) or individual tree guards (see Forestry Commission/Department of the Environment Arboricultural Leaflet 10 *Individual tree protection*). Both methods are compared in Chapter 3 of Forestry Commission Bulletin 14 *Forestry practice* (10th edition, 1986); which option is selected will depend on the relative costs and the scale of broadleaved planting, together with the practicality of erecting an effective fence. Amenity broadleaved planting at facilities such as picnic sites will frequently require the use of individual tree protection as it is seldom practical or aesthetically desirable to use continuous fencing around such locations.

Where it is decided to utilise individual tree protection, there is the possibility of using plastic tree shelters rather than mesh tree guards (Plate 3). Tree shelters are now being widely used as a means of obtaining accelerated early growth of broadleaved species on lowland sites, while simultaneously providing protection against browsing damage (see Arboriculture Research Note 63/85/SILS *Tree shelters*). Although they are being used in increasing numbers in upland forests, there is at present little direct evidence from which to

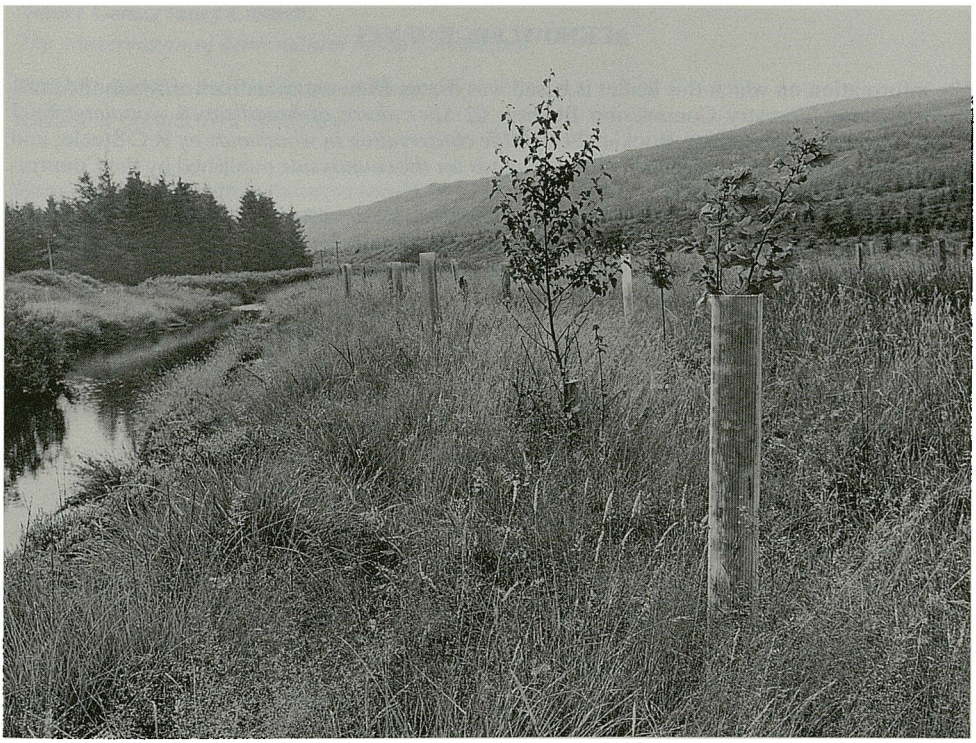

Plate 3. Establishment of oak and birch for streamside improvement in an upland coniferous forest. Tree shelters have been used on some trees to provide protection against browsing and promote rapid early growth. Big Water of Fleet, Castle Douglas Forest District, Dumfries and Galloway Region. (*ED1899*)

assess their effectiveness on climatically severe upland sites. Provided planting locations are at moderate elevation, not excessively exposed, and outwith serious frost hollows, then there is reasonable expectation that tree shelters will produce results similar to those obtained in lowland forestry. They are likely to be of greater value for species with slow early growth, such as oak, than for the initially more vigorous alder, birch and rowan. On upland sites with more severe conditions, the use of tree shelters should be approached cautiously until more is known about their possible limitations.

ACKNOWLEDGEMENTS

The information on which this leaflet is based was drawn from many sources of which the most important are: Forestry Commission Bulletin 62 *Silviculture of broadleaved woodland* by J Evans; Forestry Commission Booklet 29 *Wildlife conservation in woodlands* by R C Steele; and information sheets on *Plants and planting methods for the countryside* published by the Countryside Commission for Scotland.

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The photographs are from the Forestry Commission collection.

RECOMMENDED FURTHER READING

Countryside Commission for Scotland.

Plants and planting methods for the countryside. (A useful set of information sheets including several on broadleaved trees and shrubs, and their use for amenity and conservation.)

Forestry Commission.

Bulletin 14: *Forestry practice.*
Bulletin 62: *Silviculture of broadleaved woodland.*
Booklet 29: *Wildlife conservation in woodlands.*
Booklet 44: *The landscape of forests and woods.*
Leaflet 84: *Guide to upland restocking practice.*
Leaflet 87: *Forest fencing.*
Arboricultural Leaflet 10: *Individual tree protection.*
Arboriculture Research Note 63/85/SILS: *Tree shelters.*
Policy and Procedure Paper 5: *The policy for broadleaved woodlands.*
Information Booklet; *Guidelines for the management of broadleaved woodland.*

Nature Conservancy Council.

The conservation of semi-natural upland woodland.

Royal Society for the Protection of Birds.

Birds and broadleaves handbook.

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