Forest Research

Growing Birch in Scotland for Higher Quality Timber

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Contents

Executive Summary

I. The aim of this report is to collate and review published and unpublished information regarding the planting and management of birch in order to produce the higher quality grades of timber plus a summary of the end-uses, products and marketing considerations relevant to this type of material.

II. Guidance is included relating to species and wood characteristics, uses and markets, the relative profitability of growing birch and also the potential for future utilisation of birch as a productive timber species.

III. Also included is a summary of known best practice relating to site and silvicultural characteristics, with particular regard to spacing and thinning recommendations. Regular and heavy thinning to hasten the onset of full and permanent crown release is crucial to producing higher quality timber.

IV. Birch plantations, once established, are quite well suited to management under continuous cover systems (especially uniform shelterwood).

V. There is a relative lack of interest in planting new birchwoods; traditionally this has been due to the perception of birch as an unproductive, scrub species with generally poor form. There is strong evidence however from Nordic countries that form and productivity can be greatly improved with good silviculture.

VI. Markets for birch timber and processing capacity tend to be well or highly developed in countries with an established culture of growing birch, whilst in Scotland or the wider UK there are currently no volume markets specifically for birch timber (even for pulp), nor are higher-grade logs likely to command a price premium except perhaps from niche consumers. Market development in Scotland is likely to be hampered both by the high costs of installing processing capacity and also the lack of supply material both in terms of volume and quality.

VII. Birch enjoys a favourable status with regard to nativeness, conservation value, relative productivity and also wood properties in relation to other common plantation species. At present new hardwood plantations are also prioritised for grant-funding where timber production is a key objective. However the minimum stocking density specified for birch, at 1,100/ha, is unlikely to favour higher quality timber production and the requirements may need to be revisited.

VIII. Dieback of young birch was significant in Scotland following the increase in native woodland type plantings during the 1990s. The potential for this should be considered for any future increases in planting particularly with regard to site, species, choice of planting stock and potential changes in climate.

IX. Predicted climatic changes for Scotland during this century are likely to extend the suitable geographic range for planting downy birch very significantly across much of Scotland. Areas likely to be increasingly suited to the planting of silver birch are more localised and better-defined, which may enable the effective targeting of new plantation areas specifically for the production of better quality timber. The overall suitability for either species (but especially downy birch) is likely to decrease significantly in the Central Belt.

1.0 Introduction

Despite being the most commonly occurring native hardwood species, birch is relatively under utilised in the UK with the demand for higher quality timber fulfilled mainly by imports. This may result in part from lack of interest by growers due to low demand and to perceptions of poor form and slower growth rate relative to conifers.

Domestic birch woodlands are however undoubtedly capable of yielding high quality and valuable timber if well planned and properly managed. They can also provide numerous non-market and environmental benefits including landscape, amenity, biodiversity and soil improvements as well as contributing to riparian / watershed management and enhancement. As such new birchwoods are likely to enjoy a positive public image.

Productive broadleaved woodland in Scotland now attracts a favourable status with regard to national and regional forest policy and to the provision of grant-funding. Improved planting stock is now becoming available and may significantly increase yields on better sites. Regular and heavy thinning to hasten the onset of full and permanent crown release is crucial to producing higher quality timber from birch woodlands.

With the associated development of markets and processing techniques, birch in plantation may represent an increasingly important aspect of Scottish commercial forestry. This paper outlines the various silvicultural and marketing considerations associated with growing birch for the production of higher quality timber.

Upland birchwoods are a priority habitat in the UK Biodiversity Action Plan and best practice guidance for the management of semi natural birchwoods in the Scottish uplands is given in a Forestry Commission Practice Guide (Forestry Commission, 1994). The guidance notes that improving timber values and the financial viability of birch woodlands can be an important factor in ensuring continuity of management. Whilst this paper addresses issues primarily related to birch stands being managed specifically to produce high quality timber, the general principles can be applied to semi-natural woodlands to help owners maximise timber quality and value.

2.0 Species characteristics

2.1 General tree characteristics

There are about 40 species of birch (genus *Betula;* family, *Betulaceae*) distributed across North America, Europe and Asia. Three species are native to Britain: silver birch (*B. pendula* Roth) and downy birch (*B. pubescens* Ehrh.), both of which are capable of producing timber, and montane shrub dwarf birch (*B. nana* L.)

Silver birch is widespread throughout Scotland except for in the north and west Highlands, where downy birch predominates. Silver birch requires better site conditions than downy birch and tends to be restricted to drier, freely-draining soils in moderate to low rainfall areas and at lower elevations (typically <350m). It is extremely light-demanding and in plantations requires careful management to avoid shading and competition effects. Silver birch is faster growing than downy birch and has better inherent form characteristics so it is generally the preferred species for higher quality timber production.

Downy birch is the most commonly occurring tree species in Scotland and is tolerant of a much wider range of site types and altitudes than is silver birch. Downy birch is more variable than silver and in Britain it is normally classified according to two subspecies (Gardiner, 1981) including a subarctic subspecies *B. pubescens* ssp. 'tortuosa' (a.k.a. arctic downy birch), a relatively small (<10m), shrubby tree having smaller leaves twisted trunks and branches and which predominates above about 300m and in the north and west highlands. *B. pubescens* ssp. 'pubescens' is typically larger and of better form, having greater potential to produce sawlog grade material on the better sites and is more common in lowland areas . Growth rates are typically lower than silver birch. Although downy birch is a little more shade-tolerant than silver, in plantation it also requires considered thinning in order to maximise potential for timber production.

A comparison of overall form, bark appearance and leaf morphology for both species is presented on page 6 (Fig. 1).

Upland birchwoods are a natural ecotype and birch is one of the few native broadleaved trees that grow well in the uplands and provides native wildlife with habitat. In terms of associated insect diversity birch is only exceeded in the UK by oak and willow. Birch has significant value for birds, especially in conjunction with a native pinewood component. Since light levels are more favourable, the ground vegetation under birchwood tends to be better developed and more native in character than below plantation conifers, except for open pinewood. Birch is also valued for its appearance in the landscape, and since there is a natural association between birch and pinewood it can be a useful component in transitional areas (Evans, 1984; Callandar, 1991; Hynynen *et al*., 2010).

Birchwoods have long been believed to improve soil conditions on less fertile sites. Birch leaf and twig litter, being less acidic and quicker to decompose than that of conifers, is thought to develop beneficial humus that can lead to a rise in pH and exchangeable calcium and an increase in the number of earthworms. Birch roots can grow quite deeply and intensively and are believed to be able to penetrate and disturb the ironpans characteristic of some acid soils. Birch roots are also relatively quick to decay which may improve overall soil porosity. Accordingly, podzolic soils may eventually modify to a more acid brown earth character (Evans, 1984; Callander, 1991; Hynynen *et al*., 2010).

Riparian birchwoods are useful for fishery and catchment management. The associated leaf litter is valuable for nutrient cycling and as a food source for aquatic invertebrates. Bank-side trees increase local populations of flying insects (for surface feeding) and the light foliage of birch creates the ideal pattern of dappled shade / intermittent light to maintain the right temperatures for fish habitat. Edge trees will stabilise banks and moderate run-off rates, reducing siltation. Their rapid establishment make birchwoods ideal for riparian improvement; downy birch is suitable for protecting upland headwaters and silver birch, being tolerant of occasional water-logging can be useful in lowland riparian woodlands and on floodplain sites (McRobbie, 1991; Worrell, 1999).

Species	Form (general)	Bark	Leaf
Silver birch			
Downy birch			

Figure 1: Visual characteristics of silver and downy birch

2.2 The birch resource

Birch is the most common broadleaved tree species in northern and eastern Europe (Hynynen *et al.*, 2010). In Britain birch woodlands extend to just under 160000 ha, representing 16.5% of the broadleaved woodland area and 6.7% of the total woodland area (Forestry Commission, 2003). Almost half of this resource, around 78000 ha, is in Scotland where birch is the main broadleaf species (38% of all broadleaved woodland) (Forestry Commission, 2001). Less than 20% of the birch woodland area across Britain is owned by the Forestry Commission.

2.3 Growth and yield

Growth rates in birch are very rapid at first and then steady up to about 50 years of age after which they decline, becoming increasingly susceptible to pathogens and decay (Hynynen *et al*., 2010).

Silver birch in plantation and on better quality sites may achieve a yield class of 8, with up to 10 possible on the best ground and/or with the use of selected planting material.

Yield class 4-6 is more typical under less favourable conditions. Mature trees can reach up to 30m in height. Rotation length may be as little as 40-45 years on higher yield class sites and 50-55 years on lower. Volume yield is typically 15-20% greater than that of downy birch (Cameron, 1996; Worrell, 1999) and the majority of birch sawlogs used by the Finnish wood processing industries are of Silver birch (Heräjärvi, 2005). Improved planting stock is now becoming available and it has been suggested that this material may have the potential to achieve YC 10 on better sites indicating a potential mean breast-height of 30cm on a 30 year rotation (Malcolm and Worrell, 2001).

Downy birch commonly achieves a yield class of 4, but this may be reduced on poorer sites and rotations will be proportionately longer. Height growth is less than that of silver birch, generally reaching a maximum of about 20m. A recent study of unthinned downy birch growing in eight stands in Ireland concluded that a Yield Class of 8 was achieved on better sites: it seems likely that similar growth rates could be achieved in Scotland on selected sites (Nieuwenhuis and Barrett, 2002).

The normal form of birch is very well suited to better quality timber production, although active management of spacing of spacing is required to minimise natural tendencies to sweep and form crooks, forks and larger diameter side branches (Heräjärvi, 2005). Given a favourable stocking density a high proportion of biomass (up to 70%) is allocated to the main stem, with only around 10% to the crown and 20% to the stump and roots (Hynynen *et al*., 2010).

Note: Volume growth is not well quantified for either species of birch in the UK and the projections described later in this report are largely based on Scandinavian models. The UK yield models (Edwards and Christie, 1981) are combined for sycamore, ash and birch ('SAB'), assume a close initial spacing of 1.5m and prescribe an incremental five-yearly thinning cycle. As such they have been suggested not to accurately represent the growth patterns of birch or be ideally-suited where higher quality timber production is the objective (Lorrain-Smith, 1991).

Figure 2: Birch sawlogs

2.4 Wood properties of birch

Birch wood is strong, versatile and easily worked. It suits gluing, nailing, polishing and staining and can be bent to shape so long as the grain is straight and knots are absent. Birch wood is light in colour, bright in appearance and is finely-textured. Cut timber is relatively quick drying but is prone to minor distortion unless dried under restraint (since tension wood is often present). Grain angle is usually straight unless the tree is distorted. It is also considered a suitable timber for heat-treatment. Both silver and downy birch share similar characteristics (Cameron, 1996; Worrell, 1999; Heräjärvi, 2005).

Birch is a diffuse-porous species and there is no clear demarcation between sapwood and heartwood (or between early and late season growth). Nor is actual heartwood present so the timber has quite a uniform appearance. Vessels are of medium, uniform diameter and are evenly-distributed. Wood rays are present but are not usually prominent (Petty, 1991; Heräjärvi, 2005).

Birch fibres are typically of 1.1-1.5mm in length, 16-22µm in width, 3.0-3.6 µm wall thickness and 114 µg/m in coarseness (PITA, 2012). Fibre tracheids range from thin to moderately thick walled. Mean fibre length increases with distance from the pith so younger trees have a lower average fibre length than older ones. Volumetric wood composition for both species of birch in Norway is approximately 65% fibre tracheids, 25% vessels and 10% rays. Composition by weight of dry birch wood is approximately 41% cellulose, 30% hemicelluloses and 27% lignin, and 2% as ash and extractives (Panshin and de Zeeuw, 1980; Vadla *et al*., 1980, both cited in Petty, 1991). Note that other researchers in Finland have reported composition to be 75% fibre, 18% vessel and 7% ray, with cellulose content approximately 50%, hemicellulose 25% and lignin 23% (Heräjärvi, 2005).

Birch grain is usually straight but occasionally a decorative *flame* or *ripple* figuring may be occasionally be present (Figs. 3 and 4), making the timber highly desirable for use in furniture making or for veneer and commanding a premium price (Petty, 1991).

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Figure 3: Flame figuring

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Figure 4: Ripple figuring

Birch wood is of medium density (about 660 kg/m^3 at 12% moisture content), which is almost double that of most conifer species. Birch compares favourably with oak and beech in terms of overall strength. In toughness it is similar to ash (Cameron, 1996). Tested density and strength properties for domestic birch in relation to other common timber species are presented in Table 1.

Wood Property (at 12% moisture content)	Birch	Beech	Oak	Sycamore	Sitka spruce
Density (kg/m^3)	670	690	690	560	384
Bending strength, or *modulus of rupture* (N/mm^2)	123	118	97	99	67
Stiffness, or *modulus of elasticity* (N/mm^2)	13,300	12,600	10,100	9,400	8,100
Compressive strength, parallel to grain (N/mm^2)	60	56	52	48	36
Toughness (impact strength) (kJ/m^3)	1.04	1.14	0.84	0.84	0.51

Table 1: Density and strength properties (after Lavers, 1983 reproduced in Petty, 1991). Note that the strength properties of actual plantation timber, rather than in the test samples used, may well be reduced due to likely higher frequency of wood defects.

The density of birch wood is known to increase, with fibre length, from the pith towards the bark and to decrease slightly with height above ground (Heräjärvi, 2005). Birch timber is classed as “not durable” (durability class 5) and is subject to decay in exposed environments, although the timber can be satisfactorily preserved using pressure treatments. Cut logs are prone to degrade by decay and should be removed from site and processed as soon as possible.

3.0 Uses, markets and economics

3.1 Timber uses and suitability

Birch timber is very suitable for use in bespoke furniture manufacture and higher quality joinery, in packaging, barrel-making, turnery and (when treated) for fencing (Cameron, 1996). Sawlogs of suitable dimensions and quality can potentially be cut for veneer. Birch flooring is a market that has developed in more recent years; its bright, pale and uniform character, subtle figuring and light brown/golden colour are said to make it particularly suitable for spaces with ample sunlight.

For birch, ‘large sawlogs’ are defined as sawlogs >24cm top diameter. ‘Small roundwood’ is either small sawlogs or pulp of 7-24cm top diameter (Davies *et al*., 2001a).

Sawlogs produced either for commercial or for standard-type mobile sawmills should ideally be approximately 25cm top diameter over bark and be from two to five metres in length. Specialist mobile mills may be able to process material of 15-25 cm top diameter and as little as 1.2m in length. Some higher-value uses can be derived from quite small dimension material, so logs that are not particularly straight or long can be quite saleable (Worrell, 1999).

Current data relating specifically to the production of birch timber in Scotland are not available. In 2011 the total UK production of hardwood timber in was around 0.5 million green tonnes, compared for almost 10 million green tonnes for softwood timber. In Scotland hardwood timber production was 37 thousand green tonnes, compared to softwood timber production of 6.3 million green tonnes.

Overseas, birch is commonly used for plywood (including high quality veneer panels) and for block board manufacture in Scandinavia and Russia. It is also suitable (of 'intermediate' quality) for particle board when in mixture with other less dense species (Cameron, 1996).

Birch fibres have a high volumetric content, relatively high width to length ratio and lack extractives which makes the wood very suitable for hardwood pulp, although this is now limited to northern European and North American markets (Cameron, 1996). This low-value product is better suited to material from unmanaged and naturally regenerated, unthinned woodlands (Hynynen *et al*., 2010).

Birch makes very good fuel wood and produces 25-60% more heat than the equivalent volume of softwood (Worrell, 1999). This may be beneficial given the developing markets for fuel wood in terms of marketing potential for residues and pre-commercial thinnings.

There are also co-products that may be associated with birch woodlands such as edible fungi, cosmetics, artificial sweeteners and pharmaceutical substances derived from sap and leaves (Worrell, 1999). Most of the harvested tree can be used, although crown material is limited to rustic and craft uses and is unlikely to be saleable in volume (Elliot, 1991).

3.2 Markets for birch timber

Birch is considered to be the most important commercial hardwood species in northern and eastern Europe (Hynynen *et al*., 2010). This is a relatively recent development with Scandinavian interest and processing capacity having been developed during only the last 70 years (Frivold and Mielikainen, 1991). UK markets for roundwood are currently constrained by an insufficient standing resource and due to concerns regarding the consistency and continuity of future supplies in terms volume, quality and location.

In the UK there is significant demand for birch *timber* for higher value and niche end-uses such as furniture, joinery and turning but only a relatively minor proportion of which is supplied by domestic sources. In the 1990s approximately 20,000 m^3 of sawn birch timber was imported annually, mainly from Canada but also from Nordic and Baltic countries (Elliot, 1991; Worrell, 1999; Malcolm and Worrell, 2001). There is thought, therefore, to be considerable potential to develop the internal supply market.

It should be noted that markets are favourable for birch timber in Scandinavia and Canada due to the demand from established plywood, pulp and saw mills. The UK imports birch products from these countries and if domestic processing is to develop then it will need to be competitive with world markets and meet international standards (Elliot, 1991). The market for Scottish grown birch sawlogs is limited however since there are no UK-based plywood manufacturers and there is very limited interest from the hardwood merchants who export veneer butts. Domestic sawmill interest is also poor: in 1991 around 400,000 m^3 of hardwood logs were processed annually by UK mills but only about half of one percent of this was birch (Elliot, 1991).

Birch (mostly imported) was previously the main component in the UK manufacture of pulp, although this had dropped to about 50% by 1991 and its use was discontinued entirely after 2006 (Forestry Commission, 2007 and 2012a). In 1991 there were none of the more lucrative types of pulp mills (chemical and bleached sulphate) in the UK that might otherwise pay a premium for birch fibre; the semi-chemical industry paying only a flat rate for all hardwood material. In 1991 there was strong demand from the particle board industry but which again paid only a flat and relatively low rate for the timber of any commercial species (Elliot, 1991).

British birch can be grown to meet Finnish veneer specifications so could potentially be exported or support a UK veneer plant if one were to be established (Worrell, 1999). In Finland, birch firewood substitutes for a very substantial quantity of imported fuel oil, which was known to be 700,000 tonnes in the late 1990s (Worrell, 1999).

3.3 The relative profitability of growing birch for timber

Financial analysis by Lorrain-Smith (1991) indicated that if prices for birch timber were improved 'modestly' (due to improvements in marketing and timber quality) then birch could be grown profitably at YC6 or above, more successfully even than YC8 Scots pine. The analysis showed that profitability was more sensitive to improvements in timber price than to yield class. It should be noted however that calculations were heavily influenced by the level of grants and higher discounting rates applicable at the time.

A market analysis was later undertaken by Davies *et al*. (2001b) which indicated that middle grade birch timber was only attracting low volume (<100 ft^3) buyers. Nine firms reported buying this material (at a mean price of £8/ft^3), though only four could quote for supply of domestic material. There appeared to be no trade in top quality logs at the time of the study.

Policy and grant support in Scotland is currently quite favourable to the establishment of new productive broadleaf woodland. The Rural Development Contract payments for woodland creation were reprioritised in May 2012 with the stated intention of encouraging options 'likely to yield a future timber harvest'. Rates of support for new *productive broadleaved woodland* planting are substantially greater than for new conifer plantations; initial planting payments are 75% higher and annual maintenance payments are 32% more. There are also farm woodland premiums for planting on agricultural land in current production.

Note however that new birch woodland is not officially recognised under this option (which includes oak, beech, sycamore and ash), but comes under the 'other broadleaves' category for which a minimum stocking of 1,100/ha is stipulated. It may be useful if a policy amendment could be made identifying plantation birch in its own right and with a minimum stocking density better suited to commercial production (see above).

3.4 Future utilisation potential

Local and regional demands for birch firewood and timber for agricultural and rustic products is likely to remain stable, along with requirements for low-volume/high value outputs such as turnery, crafts and bespoke flooring *etc*. These end-uses are thought unlikely to influence demands for volume or timber quality to any significant extent or the increase the price of birch sawlogs.

To increase volume supply and justify the investment in producing higher quality birch timber and larger log sizes there will need to be a corresponding demand from the larger national processors such as furniture manufacturers and producers of high quality pulp or wood-based sheet materials.

The difficulties associated with developing high-grade hardwood processing capacity in Scotland were identified by Davies *et al*. (2001a) as follows:

- **Large-scale processing**: plywood or premium grade flooring mills are likely to require a capital investment exceeding £10 million and an annual supply of around 50,000m^3 of high quality sawlogs. This investment is unlikely to be justified given the current and projected availability of suitable timber. It might be more achievable to look for export markets for this material.
- **Medium-scale processing**: a new hardwood sawmill mill is estimated to require capital investment of £1-10 million and an annual supply of at least 2,000m^3 of high quality logs. In 2001 the only dedicated medium-scale hardwood mill in Scotland had recently switched to softwood only, and it was considered unlikely that a new mill would attract investment given the limited hardwood resource.
- **Small-scale processing**: a small hardwood sawmill would probably require more than £500,000 of investment and an annual supply of up to 1,000m^3 of high quality sawlogs. Potential operators are generally restricted due to a lack of capital, low product diversity and a limited knowledge of marketing. Although suitable supplies of timber were potentially available within Scotland the operating costs for existing mills had been increasing greatly and by 2001 more small static and mobile sawmillers were closing than were being established.

Albeit with regard to utilisation of low to middle grade hardwood logs, the minimum costs of establishing a viable hardwood flooring mill were estimated by Davies *et al*. (2001b) to be at least £110,000 for plant and working capital and with an annual requirement for 3,000-5,000m^3 of sawlogs. Output was indicated at upwards of 20,000m^2 of flooring, with a selling price of £12-28/m^2 depending on species and thickness.

4.0 Growing and managing birch for timber production

4.1 Silvicultural systems for birch

Silvicultural practices are recommended that maximise height growth and *then* diameter growth (see below). For birch there is no disadvantage for timber quality associated with rapid tree growth (Hynynen *et al*., 2010).

It should be noted that a very large proportion of existing birch woodlands are unmanaged or degenerate, or considered as scrub. In the early 1990s there were estimated to be some 59,000 ha of birch in Scotland (some 39% of the national Scottish broadleaf estate; Elliot, 1991), but only 29% of birchwood existed as high forest and much of it was of poor quality (McRobbie, 1991). Although there has been a recent increase in new native planting (as favoured by previous grant regimes) these woodlands have often been established at low stocking densities of 1,100 or 1,600/ha, which is unlikely to yield good quality timber due to the natural growth characteristic of the species. Woodlands specifically planted and managed for higher quality timber production are much more likely to be successful than are new native plantings or existing woodlands brought back into production.

Management of birch woodland for higher quality timber is best suited either to formal planting or otherwise to continuous cover with natural regeneration under a *uniform shelterwood* (seed tree) system. Felling by *group* (patch or strip) may also be considered as an alternative to clear-fell; perhaps where amenity or wildlife interests may constrain coupe size. Management by planting (or clear-fell and replanting) will give the greatest degree of control and predictability and enables the use of material of known quality and origin, albeit at higher initial capital outlay. Continuous cover systems avoid costs associated with plant supply and planting, but require more detailed site knowledge, confidence and experience.

4.2 Choice of planting stock and genetic improvement

Traditionally it has been recommended that planting stock is raised from seed from an FC-registered stand known to produce good quality timber, from within the same general region and from a similar site type and altitude (Worrell, 1999). Selected material has rarely been available up until now due to low demand, but is now beginning to become more readily available.

The selective breeding of birch has been established in Finland and Sweden since the 1940s (Hynynen *et al*., 2010), though imported improved material has not been grown successfully in the UK due to climatic maladaptation (Malcolm and Worrell, 2001).

UK provenance trials are being undertaken by the Future Trees Trust (FTT, formerly British and Irish Hardwoods Improvement Programme) using seed sourced from Scotland and northern England, and more recently including material collected from the whole of the UK and some from Norway, Denmark and France. Early indications are that survival is quite uniform but early growth rates are highly correlated to the latitude of origin, usually corresponding to the timing of flushing and senescence.

A very wide variation in phenotype has been found which may indicate high genetic variability within origins. Future form assessments will enable material to be selected on the merits of both growth rate and stem straightness and also their specific site and environmental suitability. It appears likely that future seed transfer zones could be quite large since trials indicate that collected material may be planted up to 2° of latitude (or 150km) further north than its origin without risk of maladaptation, particularly in terms of susceptibility to late frosts (FTT, 2012).

The FTT, in conjunction with Forest Research has established three clonal seed orchards (in polytunnels; Fig. 5) based on cuttings from superior 'plus' trees based on the regions of north-east Scotland, Tayside, and south Scotland/north England. Once established these are intended to be transferred out, perhaps to commercial nurseries, and be replaced with new collections from other regions (Hubert *et al*., 2010). Seed production began after 2006 and improved material from the provenances of *Grampian* (zone 202) and *Tayside* (zone 203) became available during 2012 via Alba Trees.

Figure 5: FTT birch clonal seed orchard at FR's Northern Research Station

4.3 Site selection

Silver birch, although adapted to quite a wide range of conditions, will only produce high quality timber and satisfactory volumes on the better types of site. Altitude should generally be below 300-350m, though this may be increased by up to 100m in very sheltered locations and should be reduced to 150m or lower in more exposed and coastal areas. Soils should be light, free-draining, mineral types *i.e.* brown earth, fertile ironpan, podzol or drier surface-water gley.

Although birch is tolerant of organic soils, its performance is unreliable and growth rates are lower so peaty sites are unlikely to be suited to timber production (McRobbie, 1991; Cameron, 1996; Worrell, 1999).

Downy birch is tolerant of a much wider range of elevations and soils (including peaty), although where higher quality timber production is an objective only the better, more mineral, site types (and lower elevations) should be considered.

Optimal (*i.e.* 'very suitable') characteristics according to Ecological Site Classification (ESC: Pyatt *et al*., 2001) are indicated for silver birch as:

- Accumulated temperature: >1200 day degrees
- Moisture deficit: 60-200mm
- Windiness (DAMS score): <14
- Continentality: >5
- Soil moisture regime: *fresh, moist,* or *very moist*
- Soil nutrient regime: *poor, medium,* or *rich*

And for downy birch:

- Accumulated temperature: >975 day degrees
- Moisture deficit: <160mm
- Windiness (DAMS score): <14
- Continentality: <9
- Soil moisture regime: *moist, very moist,* or *wet*
- Soil nutrient regime: *poor,* or *medium*

Note that the middling grades of fertility, *i.e.* heathland, upland acidic or herb-rich grassland are preferable to the richer soil types (bracken-dominated, improved pasture or ex-arable) as they are less likely to favour competing vegetation during germination and establishment.

Forest Research's ESC Decision Support System in conjunction with multi-themed GIS analysis is a powerful and effective tool in identifying suitable and optimal site types by location.

4.4 Stocking density

For better quality timber production initial stocking must be relatively high and evenly-spaced. A density of at least 2500-3000 stems per hectare, equivalent to 2.0m-1.8m spacing, is recommended (Worrell, 1999). The lower planting densities as used in native woodland establishment (1100-1600/ha) will not yield high quality timber without costly pruning and are likely to suffer from reduced height growth.

4.5 Ground preparation and cultivation

Depending on site type, some form of ground preparation may be required to expose a favourable germination bed, to improve drainage and rooting conditions, and to provide a weed free planting location. Richer sites may require more intensive preparation.

New planting on sites dominated by bracken or on ex-arable ground, improved pasture or herb-rich grassland is likely to need preparation by at least hand turfing or mechanical mounting, and may require shallow ploughing. Cultivation on either heathland or upland acid grassland is not considered essential but may be advantageous in terms of rapid and successful early establishment (Worrell, 1999).

Natural regeneration on any site other than heathland is likely to require some form of mechanical preparation; either by scarification on less fertile sites or by mounding on the richer ground (Worrell, 1999).

Bare restock sites may not normally require preparation, due to lack of existing competing vegetation, though there may be advantages in promoting early growth (Worrell, 1999).

4.6 Planting birch

Either bare-rooted or containerised stock may be used but container-grown plants are less vulnerable to damage by either desiccation or poor handling and have a wider planting season so are preferable in terms of rapid early establishment and good early stem form. Recommended plant size is 20-40cm for exposed locations and where weed competition is low. 30-60cm plants may be useful on more sheltered sites and where any surrounding vegetation is relatively high. Larger plants are likely to suffer from slow early growth and their use is not normally recommended. Spring planting is advised, although back-end may be considered on very sheltered sites if containerised plants are used which may benefit from initial root growth before winter (Worrell, 1999).

4.7 Natural regeneration of birch

Birch trees can be relied upon to seed annually and relatively profusely, though the overall volume and quality of seed produced is sensitive to low spring temperatures (which may limit pollen production). An abundant seed year will be indicated by profuse female catkins (Fig. 6) appearing during April and May, which mature with seed during June. These visible indicators can be used to time felling and scarification operations (see below) in order to maximise germination potential, or postpone work if a poor seed year appears to be likely. Each catkin may contain between 50 and 450 seeds (usually at the higher end of this range). Seed is usually shed during September and October, often over only 2-3 days, typically giving ground coverage of 500-40,000/m^2. Note that although seeds are light and wind-borne the actual dispersal distances are relatively short and most seed falls within only 50m of the parent tree.

Figure 6: Female birch catkins

The viability of fallen birch seed reduces drastically (to about 6%) after one year. Germination success is highly sensitive to light levels and also to relative humidity. It is therefore vital to achieve successful seeding and regeneration in the first year.

Varoius studies are summarised by Cameron (1996) and Worrell (1999) enabling the following prescriptions to promote successful natural regeneration:

- Light levels of about 43% full light are optimal for the germination and subsequent growth of birch seedlings. This equates to 20-40% canopy cover.
- Use of a shelterwood system is the recommended method to promote regeneration. When felling to leave seed trees approximately 20-40 well-developed individuals per hectare (evenly-spaced) are optimal in terms of seed dispersal and light / moisture regime.
- If a group selection system is adopted then coupe size or strip width should be a minimum of 20m (in terms of light levels) and a maximum of 60m (maximum seeding distance) for regeneration to be successful. Smaller coupes should be used for warmer, drier sites and larger ones for cooler, wetter ones.
- Time seeding felling to coincide with a good seed year
- Substrate conditions are critical for germination. Bare mineral soil or an exposed humus layer is better than leaf litter and moss due to better temperature and moisture retention. Some ground preparation will normally be required to coincide with a seeding felling. Mechanical scarification is the preferred method of exposing a seed bed, with burning also effective (though naturally less practical). Scarification should be carried out in August, immediately prior to seed-fall.
- Seed trees should be removed after 1-2 years to avoid suppression and to control any competing shade-tolerant vegetation, but only if regeneration has been successful. (There may be justification for retaining a limited number where landscape or amenity is important.)
- Coupe size needs to be quite substantial both for economies of scale and overall regeneration success. A minimum of 2ha is recommended with 10 ha likely to be the upper limit.
- Browsing by deer, rabbits, hares and any domestic livestock must be eliminated or at least minimised. Voles may be a very significant problem especially during ‘plague’ years. Note that where regeneration already exists but has been repeated browsed it may give rise to trees of poor subsequent form once browsing pressures are removed.
- Weed control is likely to be required in order to prevent shading. Birch seedlings and saplings are extremely light demanding and must always be taller than completing vegetation. This may be complicated by more rapid weed establishment where browsing animals have been excluded from a site.

Note: Seed trees must be wind-firm, of superior form, and be well-spaced in order to provide an even ground coverage of seed. Ideally they should be identified and marked over a period of years to enable proper consideration. Individuals likely to be ‘good parents’ should be chosen: those with large crowns that will produce a lot of seed; straight stems with low taper; persistent leaders (no forking); light crowns; flat branching angle. The Future Trees Trust publishes a useful Plus Tree Ideotype guidance (FTT, 2012).

Note: Environmental conditions may induce poor form in an otherwise genetically superior tree, so phenotype is not necessarily a reliable predictor particularly with regard to stem straightness. If genetic quality is highly likely to be poor throughout a stand (as may be indicated by a predominance of forking, heavy branched, or steep branching angle) then full or partial replanting may need to be considered.

4.8 Direct seeding for birch

Direct seeding would not normally be considered where timber production is an objective due to costs, practicalities, and the inherent unpredictability of the method. However studies in the US (Cameron, 1996) have demonstrated that direct seeding is a viable method so long as the conditions required for germination and establishment can be achieved (see 'Natural Regeneration', above). It may therefore be a useful additional technique in terms of regenerating small areas or enriching patchy natural regeneration.

The coverage required for direct seeding is approximately 1,000,000/ha, equating to between 1-2.5 kg of seed. Ground should be exposed in patches of about 5cm square either by scarification or hand-screefing immediately prior to sowing. Dry seed can be sown in autumn on dry sites or during spring on wetter sites, ideally to coincide with a period of wet weather. If pre-chilled seed is used then it should be sown in spring, again when the ground is damp and when wet weather is expected to continue (Worrell, 1999).

4.9 Protection and maintenance

Whether planted or regenerated naturally, young birch will not establish satisfactorily in the presence of livestock, deer, rabbits or hares. Whilst native woodlands may tolerate some limited densities of these animals, any intrusion in a plantation where timber production is an objective is likely to lead to an unacceptable level of damage both in terms of stocking and tree form. Fencing is likely to be required where total control is not feasible. Voles are a perennial problem and may cause catastrophic losses when populations reach plague levels. The use of tree shelters for birch is not recommended due to the risk of abrasion and snapping of the slender stems. If voles are likely to be a problem then either vole guards or spiral wraps should be considered. Maintaining a weed-free patch of bare ground around a tree may also inhibit vole damage, since they will naturally avoid any situation that exposes them to predators.

Weed control (chemical or manual) will be required in any situation where competing vegetation is likely to be taller than the crop trees. Weeding in early summer will confer the greatest advantage in terms of light conditions (Cameron, 1996). Natural regeneration is likely to require scarification to expose germination patches and this will provide a degree of initial weed control. Additional weeding is not usually carried out but may be required where competition is severe (Worrell, 1999).

4.10 Re-spacing naturally regenerated birch

Where crops are naturally regenerated the initial stocking may be extremely high (commonly upwards of 11,000/ha) and will require re-spacing. Where higher quality timber is an objective this should ideally be done when mean height is at 1.5-2m favouring the better trees in terms of vigour, stem straightness and crown form, and leaving an approximately even spacing. Should this not be possible then young birch may be re-spaced at up to 6m in height, although subsequent timber quality may be affected.

Re-spacing is usually done by clearing saw although hand tools may be appropriate for lighter work. Snapping and breaking of the upper tree will lead to suppression and mortality so may also be effective at lower densities (Worrell, 1999).

4.11 Pruning birch

Any area of exposed wood can represent an entry point for fungi and other pathogens. The spacing and thinning models presented below are designed to maintain even competition and homogenous growth rates. Birch will self-prune under these conditions so manual pruning is not usually necessary. If any uneven growth develops and coarse live branches need to be removed then this must be done after the heavier spring sap-flow and before leaf-fall in autumn (ideally from mid-July to early October) in order to reduce the risk of decay and discolouration in the timber. Any potentially troublesome branches should be removed as early as possible. No applied treatments are recommended and any wounds should be left to heal through natural processes. Coppiced trees are unlikely to regenerate satisfactorily in terms of form and subsequent timber quality (Strouts and Winter, 1994; Cameron, 1996; Worrell, 1999).

4.12 Thinning practice (for clearfelling and shelterwood systems)

As an extremely light-demanding species birch (especially silver) requires careful and considered thinning. Maintenance of a living crown at above half tree height is critical and growth will decrease significantly if it falls below 40% (Worrell, 1999). Key to promoting higher timber quality is the removal of approximately half of the trees at each thinning in favour of dominant and co-dominant trees of better form (Cameron, 1996).

> ***Note***: Neglected and under-thinned stands do not respond well to late thinning and may not be suited to the production of higher quality timber unless they are resumed into management when relatively young (15-25 years old), are adequately stocked (2000-3000/ha) and generally of good form (Cameron, 1996).

A high degree of advance planning is required for natural regeneration to be successful.

The generalised Forestry Commission yield models (Edwards and Christie, 1981) for sycamore/ash/birch are believed to be inaccurate for birch, which requires quite specific regimes to manage the height, diameter and crown growth characteristics necessary in order to produce higher quality timber. Two regimes, of either *heavy* or *light* thinning are recommended based on established Scandinavian systems which may also be suitable for Scotland (Worrell, 1999; Cameron, 1996).

The models assume an initial density of 2,500/ha and a rotation of 45-60 years, as determined by site quality. Timing is relative to top height rather than to fixed intervals. Thinning should be selective and aim to leave the best stems as final crop trees. Although usually uneconomic, the first thinning is critical to later stem quality and must not be neglected. Final felling should aim for a target mean breast-height diameter of 25-25cm. Since older birch wood is prone to natural degradation there is probably no great advantage in aiming for longer rotations and large stem diameters (Heräjärvi, 2005).

Manipulation of spacing to manage growth is the key factor in growing birch for higher quality timber and the models presented here are suited to both clear-felling (including group selection) and shelterwood systems (the only significant difference being the retention of seed trees at the final felling stage).

> ***Note***: the models are based on Scandinavian systems where yield classes are typically middling. Greater performance of up to YC10 might be expected on the best types of site in Scotland and where improved planting stock is used, so it may be possible to reduce rotations to around 35-40 years. Managers are encouraged to adopt these as general guidelines and to adapt them according to individual circumstances as required.
>
> ***Note:*** where the highest grades of birch timber are being harvested it may be necessary to consider motor-manual felling to avoid damage which may occur when logs are passed through harvester heads (Heräjärvi, 2005).

- **Heavy thinning**

This system is done on the basis of two or three heavy interventions, each removing about half of the standing trees. Either method may be adopted for silver birch but the later-intervention, two thinning system will usually be required for downy birch. Shelterwood systems should adopt the two thinning method for either species but note that seed trees (see beneath) at an even density must be retained for 1-2 years at 20-40/ha after final felling.

A tabular summary of the heavy thinning model is presented overleaf in Table 2.

	Two Thinnings	Three Thinnings
First Thinning		
(Mean Height)*	9-10m	8-9m
Top Height	11-14 m	10-12 m
Age	16-28 yrs	15-25 yrs
Volume Removed	30-40 m^3/ha	20-30 m^3/ha
Stocking After Thinning	800-1000/ha	1200-1300/ha
Second Thinning		
Top Height	18-20 m	15-16 m
Age	29-48 yrs	25-40 yrs
Volume Removed	40-50 m^3/ha	35-40 m^3/ha
Stocking After Thinning	400-500/ha (silver) 500-700/ha (downy)	800/ha
Third Thinning		
Top Height	-	20-21 m
Age	-	34-60 yrs
Volume Removed	-	60-70 m^3/ha
Stocking After Thinning	-	400-500/ha

Table 2: Summary of heavy thinning model for birch (after Worrell (1999). *Mean height data is not published in the model, but is referenced in Cameron (1996)

- **Frequent / light thinning**

Lighter thinnings are done on a cycle of 5 to 7 years during early rotation and 8 to 10 years later in the rotation. The first intervention is made when top height reaches about 10m when stocking is reduced from 2,500/ha to 1,400-1,600/ha. Each thinning should aim to remove 20-35 m^3/ha.

4.13 Pests and diseases

- **Birch Dieback:** Following a widespread increase in the planting of birch for new native woodlands in Scotland during the 1990s, a widespread incidence of crown dieback in young trees was reported in the early years of the 21st century. This was traced to two main species of shoot fungi: *Marssonina betulae* and *Anisogramma virgultorum.* Symptoms include sunken cankers and fissures on stems and branches, with discrete lesions and tip-dieback on young shoots. Incidence and severity was found to be higher at planted sites than naturally-regenerated ones. The current FC recommendation is specifically to avoid planting silver birch on exposed sites as this species is highly susceptible to *M. betulae* (Green, 2005; Forestry Commission, 2012c). The potential for new plantations to be affected by birch dieback is likely to be an important factor to consider (perhaps also in relation to provenance of planting stock and the effects of predicted climate change).

Otherwise, birch is a well-adapted native species and healthy trees that are not otherwise stressed are generally resilient to pests and diseases, other than mammal or weevil damage which must be controlled by good silviculture. However, it should be noted that in Scotland bracket and honey fungi may be fairly common where damage and decay is present.

Strouts and Winter (1994), and Gregory and Redfern (1998) describe the other principal factors and symptoms affecting the health of birch in plantation as follows:

- **Drought Damage:** In common with many other species and especially when newly-planted or young, birch may suffer from either a lack of available soil water or the rapid loss of water through leaves leading to reduced growth, wilting, defoliation, crown thinning, dieback, and eventually to mortality. This will initially be noticeable as scattered yellowing of foliage giving a speckled appearance to the crown. Note that drought stress may also make trees vulnerable to secondary infection by other pests and pathogens. Practical measures to avoid drought damage are limited to careful site selection and, in particular, avoiding late planting.

- **Bracket fungi**: Birch is a common host tree for Honey fungus (*Armillaria* sp.), which may lead to localised rotting and necrosis in root, root-collar and butt areas followed by death of the entire tree. Fruiting bodies are initially cap shaped and appear in clumps before broadening out into more of a bracket shape. Honey fungus is widespread in Scotland and is more common in woodland settings than in parks and street trees. There is no effective treatment so it is important to remove any infected trees to prevent infection from spreading. To avoid creating potential infection sites on individual trees it is important to avoid pruning or otherwise causing damage at vulnerable times of year (see 'Pruning', above).

  Other bracket fungi that infect birch are generally not very aggressive and not a significant problem in healthy, younger trees. Three species in particular are effective at invading older trees and those already stressed by drought, water-logging or storm damage. *Piptoporus betulinus* is the most common, the fruiting bodies of which appear as large leathery brackets. *Fomes fomentarius* is common in Scotland and is characterised by smaller, hard, hoof-shaped brackets. *Inonotus obliquus* is also common, showing more as a black crust than a bracket.

- **Leaf-spotting**: (small and blackish) is relatively common and is caused by the *Discula butulina* fungus. Infection may result in premature yellowing and leaf loss. There is no practical method of treatment but infection is not known to cause any lasting damage.

- **Leaf rust**: Orange or yellow coloured rust developing in late summer is likely to be caused by *Melampsora betulinum*, which is common and widespread. Infection causes premature leaf loss from the lower crown upwards and may also interfere with the hardening-off process leading to winter mortality in some shoots. There is no practical method of treatment. Birch has very high genetic variation in susceptibility so some trees may be much worse affected than their neighbours.

- **Witches' brooms**: Dense clusters of twigs can be common in the crown of birch trees in which foliage flushes early but appears smaller and crumpled. These are caused by the *Taphrina betulina* fungus and are considered more of a curiosity than a serious pathogen.

4.14 The future: birch in a changing climate?

The distribution and productivity of tree species in Scotland are likely to be affected by climate change, which is predicted to lead to increased climatic warmth and changes in the regional and seasonal distribution of rainfall resulting in more frequent summer droughts and winter flooding (Ray, 2008). Assessments of the possible impact of these changes on species suitability have been made for the main UK forest tree species (Forestry Commission, 2012b). The models account for potential alterations in site accumulated temperatures, moisture deficit, exposure, and (summer) soil moisture regime.

The predicted changes in *regional* site suitability for birch in Scotland, between present and 2080, under a 'high emissions' scenario are shown in Figs. 7 and 8 and may indicate areas (*i.e.* those with dense colouration) suitable for either encouraging or discouraging future planting through policy and the grants system.

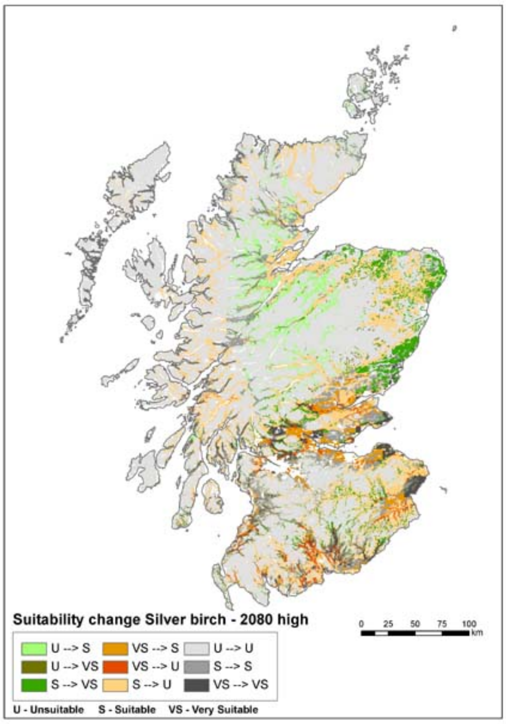

Figure 7: Forecast site suitability for silver birch – 2080 high emissions scenario

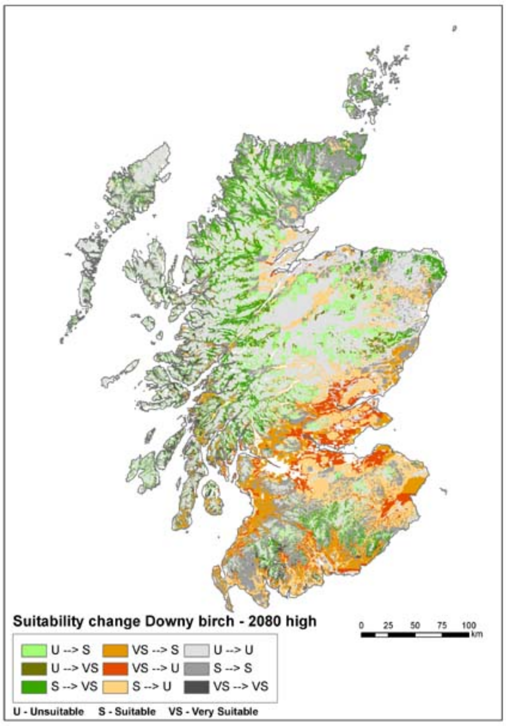

Figure 8: Forecast site suitability for downy birch – 2080 high emissions scenario

Areas marked in grey shades denote no significant change in species suitability by location. Those in green indicate an increase in site suitability. Those in brown or red show a likely decrease in suitability. The predicted changes for silver birch appear relatively minor compared to those for downy birch. Notable effects include:

- A general and very widespread increase in suitability for downy birch is indicated across much of the Highland, Wester Ross, Grampian, Perth and Kinross and Argyll regions.
- Downy birch may also increase in suitability in more precisely-defined areas of the Borders, Southern Uplands and Dumfries and Galloway.
- Silver birch may succeed downy birch in terms of suitability in quite substantial and well-defined areas of south and east Aberdeenshire, east Angus and the Cairngorms.
- Areas of north and east Grampian may increase in suitability for both species.
- There may be a very significant decrease in suitability for both species (and especially downy birch) across much of the Central Belt and the southernmost border areas of Scotland.

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