Forestry Commission

Research Note

Choice of silver birch planting stock for productive woodlands

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Silver birch is second only to oak in terms of total broadleaved woodland area in Britain. In the last two decades there has been an increase in the planting of birch woodlands both for timber production and the creation of native woodlands. The GB map of Native Seed Zones and Regions of Provenance provides guidance to managers wishing to source suitable local stock when creating native woodlands, but is the local seed zone the most suitable planting stock when timber production is the objective? This Research Note presents an analysis of early-height data involving 58 silver birch provenances collected from woodlands all over Britain and the near continent, and then planted in replicated trials on eight sites in the UK. Analysis of the early height data suggests that when timber production is the objective, for which early height growth is taken as a surrogate, then local seed sources are rarely optimal. Managers interested in optimising financial return could consider planting stock from at least 2° latitude south without suffering any detrimental effect on over-all survival or increased frost-risk. The benefit of planting more southerly-based stock varied from between 24 cm and 55 cm for each degree of latitude. Managers need to be confident that the silver birch planting stock they plant now, will perform satisfactorily over the next 30–60 years and so selection now of more southerly material offers growers a potential opportunity to 'future proof' their planting choices.

Introduction

Silver and downy birches are important elements of British woodland communities. Collectively they account for 227 000 hectares (98 000 hectares in England, 118 000 in Scotland, 11 000 in Wales), representing 7% of the total woodland area. This is second only to oak (230 000 hectares) in terms of total broadleaved woodland area (Forestry Commission, 2013). At present, many birch woodlands are either unmanaged, or managed at low intensity, mainly for a combination of landscape, amenity and biodiversity. In the last two decades, and in line with respective country forestry policies promoting the planting of native broadleaved species, there has been an increase in birch planting, especially in Scotland and the north of England.

Seed transfer guidelines were introduced in 1999 to avoid the planting of stock from distant seed sources, which were generally thought to be poorly adapted to local conditions and the consequent possible dilution of local genetic material. The original four Regions of Provenance within Britain were subdivided into 24 Native Seed Zones (NSZ), delineated largely on climatic and topographical variations, with a further within-zone subdivision below or above 300 m above sea level (Herbert *et al*., 1999). At the time of delineating the NSZ, it was accepted that there were limited scientific data on the genetic variation in trees available for designation of the zones; lines may well be redrawn when new data relating to adaptability and growth performance become available. Since the NZS were introduced, managers in Scotland have been required to source seed from the most local NSZ possible when plantings are mainly for landscape, amenity or biodiversity (Forestry Commission Scotland, 2006).

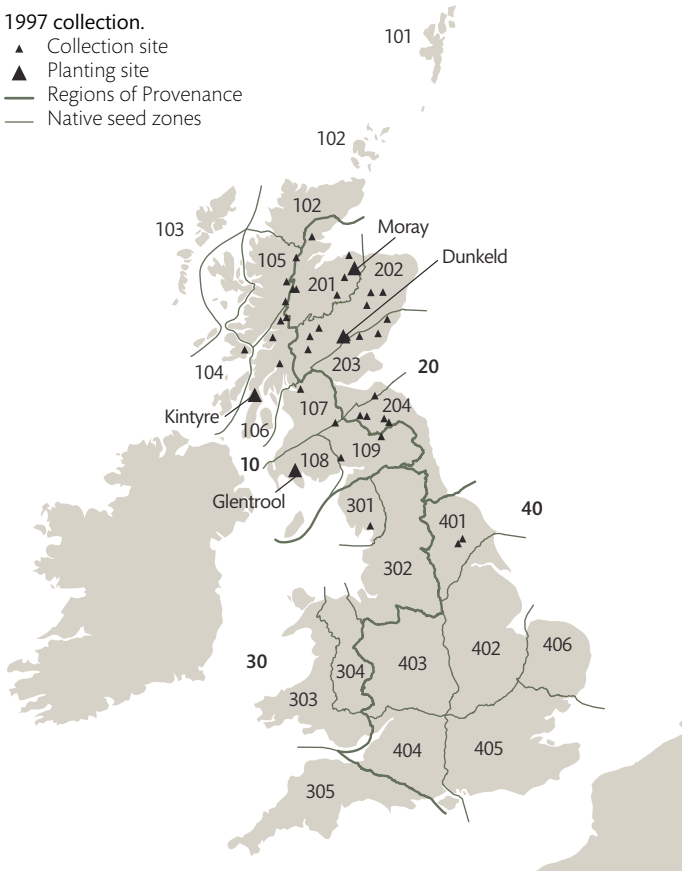
Whether or not the local NSZ is the most suitable source when timber production is the main objective will require additional guidance based on data collected from trials planted in different locations involving seedlots collected from around the country. This Research Note summarises early height data for silver birch from multiple site experiments planted around Britain containing a nationwide provenance collection in addition to sources from Ireland and the near continent. Superior early height growth is taken as an indicator of superior late-rotation timber production.

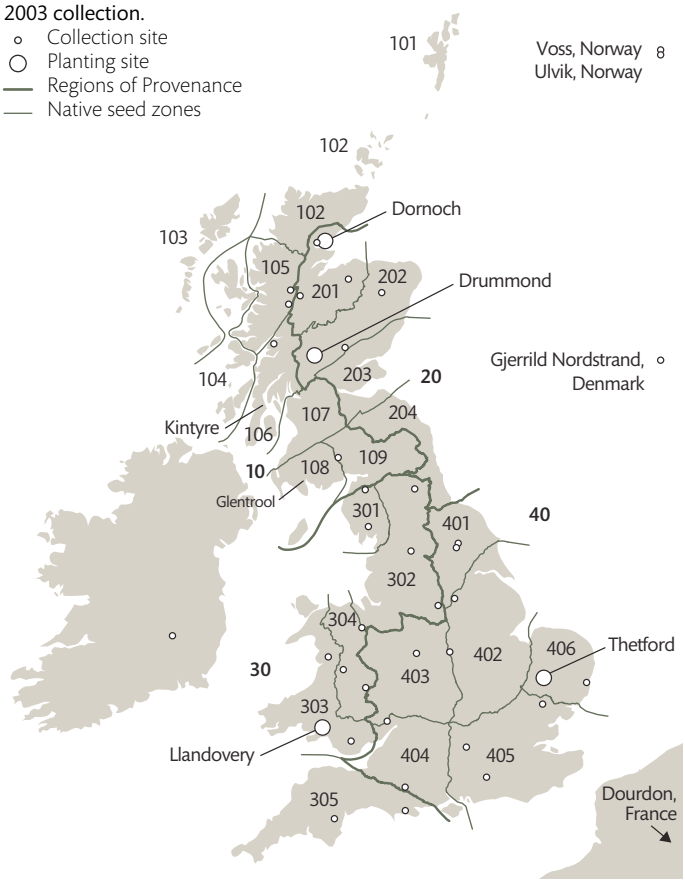
Methods

Two different collections of birch provenance trials were planted in 1997 and 2003, collectively designed to compare the survival and performance of trees raised from seed collected in 58 silver birch woodlands (Figure 1).

The 1997 collection was planted on four sites in Scotland and one in Ireland (Ireland not reported here). It is biased to

Figure 1 Maps of Britain and Ireland indicating Regions of Provenance, native seed zones, provenance collection sites, and trial planting sites within the 1997 and 2003 collections.





northern provenances of Scotland and northern England, involving predominately Regions of Provenance 10 and 20 but also a collection from an indoor seed orchard of plus trees selected in the Great Glen (Central Highlands; Regions of Provenance 20). The 2003 collection was planted on four sites across Britain and is biased more to the south (Regions of Provenance 30 and 40) with just a few Scottish provenances but also representatives from Ireland, France, Norway and Denmark. Trees were planted as 1-year-old cell-grown seedlings that had been raised in a greenhouse and hardened off outside over winter at the Northern Research Station before spring planting on the fully replicated trial sites. A more detailed explanation of the materials and methods used is available from Lee *et al*. (2015).

The trials making up the 1997 collection were assessed for height growth at around 10 years old while the 2003 collection was assessed for 8-year height. Analysis of the height data from both collections allows an investigation into early growth and how this varies between provenances, and between sites. In particular, it is possible to investigate whether the seed source collected from the NSZ local to the test site has the fastest growth rate or whether other provenances would appear to be more suitable when commercial production of timber is the objective. Multilinear regressions of the provenance height data against various different climatic site variables allows an investigation into which variable is having the greatest impact on growth at this early stage of a tree's development.

Results for early height growth

Details of the various trial sites are presented in Table 1. The names and site variables for the 58 provenances tested across the eight trial sites, along with their relative height performance, are presented in Table 2. Provenance height performance at each site is colour coded relative to the average performance of all trees at that site. Dark green indicates early height performance well above the site average; light green is above the site average; orange is around the site average and red is well below the site average.

The results highlight that the local NSZ is not always the best for height growth at this relatively early stage of a tree's development. Local sources generally performed around average (orange) for the site, although the variation between sources within the same NSZ can vary greatly. The best performing provenances (light and dark green) are often located well to the south of the test site. For example, the Dunkeld test site is located within NSZ 202. Local NSZ 202 sources varied in relative performance from below average growth (Tummel Bridge, Loch Rannoch and Black Wood of Rannoch) to average (Aboyne, Alford, Strathdon, Dunkeld and Killin). The best sources at the Dunkeld site, each with well above average height, were from Sand Hutton (NSZ 401) and Windermere (NSZ 301), both located over 2° latitude south of the trial site. These same sources from northern England grew consistently above or well above average at all trial sites where they were planted, including the Moray trial site (NSZ 201) representing a 3° latitude shift north and the Dornoch trial site (NSZ 201), a 4° latitude shift north. Other provenances with well above average height at the Dornoch site were Baintree (NSZ 405) on the SE coast of England (6° latitude to the south) and Dourdon, France, some 9° latitude to the south.

At more southerly trial sites such as Llandovery (NSZ 303) and Thetford (NSZ 406) it was a similar story, in that local NSZ sources were generally only of average growth. More southerly

Table 1 Details of trial sites planted in 1997 and 2003.

	Regions of Provenance	NSZ	Latitude (degrees)	Longitude (degrees)	HASL	AT_5	MD	Number of provenances under test
1997 collection								
Moray	20	201	57.59 N	3.19 W	127	1122	111	37
Dunkeld	20	202	56.61 N	3.66 W	263	1047	76	37
Kintyre	10	106	55.93 N	5.56 W	26	1445	118	37
Glentrool	10	108	54.96 N	4.56 W	65	1491	126	37
2003 collection								
Dornoch	20	201	57.91 N	4.07 W	127	1096	99	17
Drummond	20	202	56.57 N	4.11 W	183	1159	92	33
Thetford	40	406	52.40 N	0.63 E	50	1753	214	35
Llandovery	30	303	51.77 N	4.08 W	108	1754	140	32

Note: 1997 collection measured for 10 to 11 years height, 2003 collection measured for 8 years height, AT_5 = Accumulated temperature above 5°C, MD = Moisture deficit (mm), HASL = Height above sea level (m)

Table 2 Provenance performance relative to the mean for the site.

How to use this table:
Provenance source and trial site location have the same colour coding for Regions of Provenance. Provenance height within a given site is colour coded as being below average, average, above average or well above average (see key)

Example 1: The Kintyre site is located in Regions of Provenance 10, NSZ 106. The local NSZ 106 sources were of average height apart from Inverarary which performed below average. The best seed sources (well above average) were from Dumfries (NSZ109), Montreathmont (NSZ 203), and Windermere (NSZ 301).

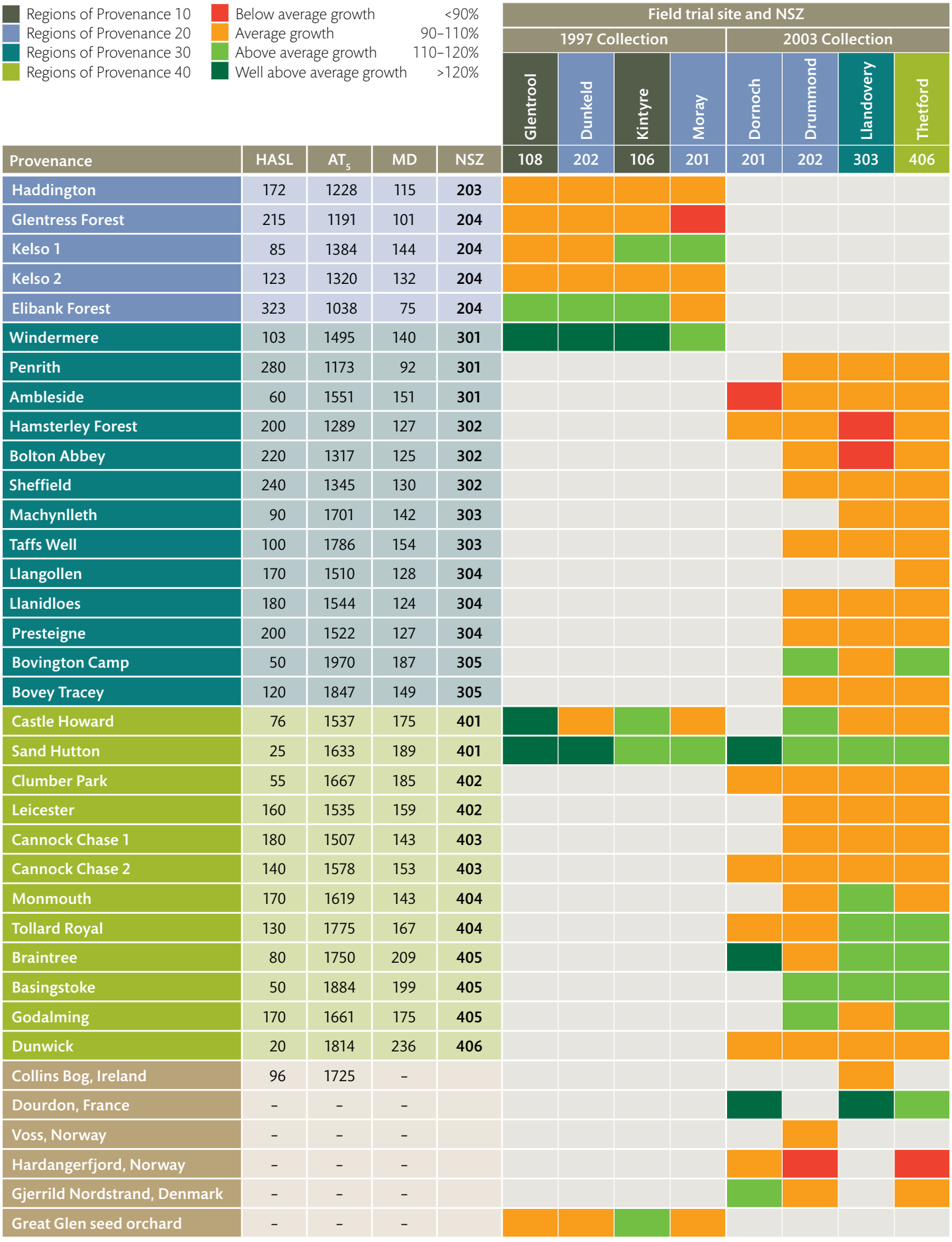
Example 2: The Drummond trial site is located in Regions of Provenance 20, NSZ 202. The representatives of the local NSZ all performed at average height. The best provenances (above average growth) were from Bovington Camp (NSZ 305), Castle Howard and Sand Hutton (both NSZ 401), and Basingstoke and Godalming (both NSZ 405).

Regions of Provenance 10
Regions of Provenance 20
Regions of Provenance 30
Regions of Provenance 40

Below average growth <90%
Average growth 90–110%
Above average growth 110–120%
Well above average growth >120%

Provenance	HASL	AT_5	MD	NSZ	Field trial site and NSZ							
					1997 collection				2003 collection			
					Glentrool	Dunkeld	Kintyre	Moray	Dornoch	Drummond	Llandovery	Thetford
					108	202	106	201	201	202	303	406
Isle of Mull	47	1364	107	**104**								
Affric	118	1171	96	**105**								
Fort William	232	1075	68	**106**								
Roy Bridge	160	1162	87	**106**								
Inveraray	6	1434	128	**106**								
Loch Creran	26	1372	118	**106**								
Langbank	52	1405	124	**107**								
Lamington	221	1194	94	**109**								
Wauchope Forest	211	1220	110	**109**								
Dumfries	29	1523	147	**109**								
Great Glen	68	1199	109	**201**								
Abernethy Forest	329	917	56	**201**								
Elgin 1	140	1126	107	**201**								
Elgin 2	11	1251	138	**201**								
Spinningdale	38	1200	120	**201**								
Glen Garry	54	1276	113	**201**								
Invermoriston	65	1246	111	**201**								
Tummel Bridge	309	981	59	**202**								
Black Wood of Rannoch	213	1110	81	**202**								
Aboyne	178	1108	104	**202**								
Alford	142	1136	116	**202**								
Strathdon	174	1097	105	**202**								
Dunkeld	143	1208	109	**202**								
Loch Rannock	210	1113	82	**202**								
Killin	154	1209	97	**202**								
Montreathmont Forest	97	1249	130	**203**								
Alyth	84	1276	128	**203**								
Inglismaldie	62	1277	140	**203**								

Table 2 Provenance performance relative to the mean for the site (continued).



sources from NSZ 405, or the French source, generally performed above or well above average, although Sand Hutton to the north again performed consistently well at these two sites.

Sources from northern Scotland performed poorly across all sites, even when planted close to home, such as NSZ 106 at the Kintyre trial site (average or below average) or NSZ 201 at the Moray trial site (average or below average). Based on these early data, local seed sources would not appear to be the best if timber production is the objective.

Survival and transfer north

Tree survival varied from 68% at Glentrool to 99% at Thetford. Survival at Dornoch, the most northerly site, was 89% after 8 years. There is no indication that provenances from the southern Regions of Provenances 30 and 40 had poorer survival when transferred north to trial sites in Regions of Provenance 10 and 20. The most southern provenance, from Dourdon, France, exceeded 70% survival on all sites including Dornoch, Dunkeld and Moray (Table 3).

The multilinear regression found a significant negative linear regression between height growth and latitude of NSZ source, indicating that provenances from more southern latitudes will have greater mean height on any given trial site. Regression coefficients varied from 25% at Dornoch to just over 63% at Llandovery (Figure 2). On average, analysis of the 1997 collection suggests an advantage of 55 cm extra height over 10 years by planting a provenance located 1° of latitude south, and 24 cm over 8 years for the equivalent shift in the 2003 collection.

Is local best?

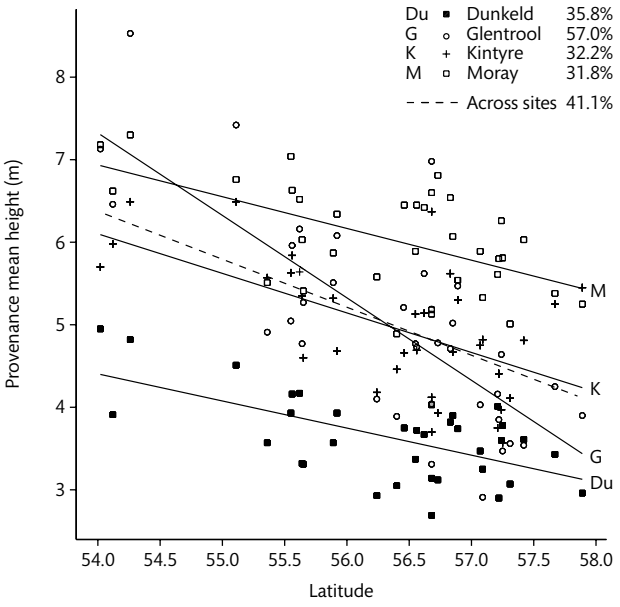
The birch trees in the trials reported here are still young and only height data are reported; no quality data such as stem straightness have yet been collected. However, early indications seem to be that if timber production is the objective, it would be better to source the planting stock from seed source areas south of the planting site. A 2° or 3° shift north for provenance planting stock would not seem to incur any losses in survival, but is likely to bring a gain in early height growth relative to locally sourced stock.

When transferred north, southerly provenances achieve more rapid growth than locally adapted provenances by staying in leaf for a greater proportion of the year and making better use of the total available photosynthetic radiation. By contrast the more conservative local provenance places some adaptive emphasis on avoiding late spring frost damage, but more

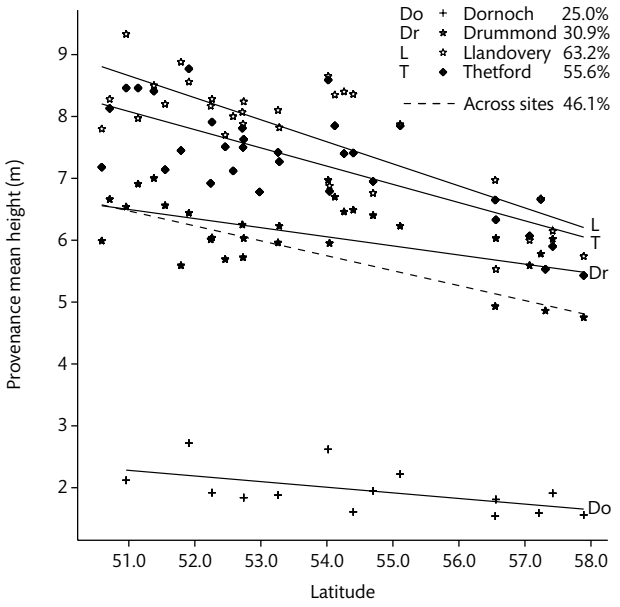
Table 3 Number of provenances with survival less than 70% when assessed for early height.

	Number of provenances planted				
		1997 collection			
		Glentrool 108	Dunkeld 202	Kintyre 106	Moray 201
Regions of Provenance 10	10	5	0	3	2
Regions of Provenance 20	23	11	0	3	4
Regions of Provenance 30	1	0	0	0	0
Regions of Provenance 40	2	1	0	0	0
Other	1	0	0	1	0
Mean site survival (%)	–	**68**	**90**	**78**	**78**
Collection mean (%)	–	**79**			
		2003 collection			
		Dornoch 201	Drummond 202	Llandovery 303	Thetford 406
Regions of Provenance 10	3	0	0	0	0
Regions of Provenance 20	6	0	2	0	0
Regions of Provenance 30	12	0	0	3	0
Regions of Provenance 40	12	1	0	4	0
Other	5	0	0	0	0
Mean site survival (%)	–	**89**	**82**	**77**	**99**
Collection mean (%)	–	**87**			

Figure 2 Linear regression of provenance–mean height against latitude.



1997 regression equation: Y = 35.772 – 0.548 X



2003 regression equation: Y = 18.781 – 0.241 X

particularly on avoiding early autumn frost damage, at the cost of a much shorter growing season. Li *et al*. (2003) found just 4 to 7 days' difference in time of bud-flushing in spring but up to 40 days in time of growth cessation when studying Estonian and Finnish silver birch provenances from across 9° of latitude.

Seed transfer implications

Seed transfer guidelines seek to identify well-adapted populations and to conserve local genetic diversity when planting for non-commercial objectives such as restoration of woodland ecosystems, conservation of biodiversity and improvement of landscape amenity. Such objectives may not require trees to grow quickly or be of particularly good stem form. However, it should be recognised that establishment costs can be much increased due to, for example, additional weeding requirements if the planted provenances are particularly slow growing. The current seed transfer guidance for native tree species in Scotland differentiates between (i) planting in or near ancient woodlands, (ii) planting of native species to create new native woodland habitat, and (iii) new planting or restocking of woodlands elsewhere with a significant emphasis on timber production. Where silver birch is planted away from ancient woodlands and the major purpose is timber production, there may be significant yield advantages in selecting planting stock from further south. The results here suggest that material from the Lake District (NSZ 301), Yorkshire (NSZ 401) or lowland south-eastern Scotland (NSZ 204) would be options that forest managers should consider in preference to local provenances on sites in mid- to northern Scotland.

A generally less prescriptive approach is adopted in England and Wales. This is primarily due to the perceived maladaptation of local provenances according to predicted changes in future climate. In recent years the concept of human-assisted provenance movement in anticipation of climate change has been proposed, where planting material is moved from areas further south (e.g. southern England, France or Italy) that are believed to display a present-day climate comparable to that predicted for the planting site in 2050 or beyond.

While it could be argued that the results from the 2003 collection recommends the use of provenances from the south of England (NSZ 405) or even northern France on some sites in northern Scotland, caution over large-scale northward transfer is required if the risk of early autumn frost damage is to be avoided. Hubert and Cundall (2006) suggested care in moving birch provenances over distances greater than 2° latitude or approximately 200 km. This would equate to a northward shift from east Yorkshire in northern England to Fife in central Scotland; or from Berwickshire in southern Scotland to Aberdeenshire in northern Scotland. These findings are consistent with similar silver birch provenance studies in Finland (Worrell, 1992; Worrell *et al*., 2000). Data from the study reported here suggest a 2° latitude northern transfer distance should be safe and perhaps conservative under current climatic conditions. If future predictions of climate change are then considered, sourcing planting stock from between 2° and 5° latitude south – as suggested for woodlands in England by Ray *et al*. (2010) – should be considered.

Variation between provenances for stem form and stem diameter remains to be assessed in these trials. Malcolm and

Worrell (2001) found an excellent correlation (r = 0.86) between 12-year height and stem diameter in a birch progeny trial of mixed provenance growing in northern Scotland, and a tendency for the more vigorous trees to have better stem form. This is encouraging, but it is important that future assessments in the trials reported here include stem form and diameter.

Climate change implications

Managers need to be confident that the silver birch planting stock they select now will perform satisfactorily under the climate that will occur during the next 30–60 years, which roughly equates to the rotation length for silver birch. In most upland areas where silver birch is a likely choice of broadleaved species for productive forestry, the British climate is anticipated to become warmer and drier in summer. There is less certainty over the future occurrence of early autumn and late spring frosts (Broadmeadow and Ray, 2005). The pre-identification of silver birch material from the north of England which appears to perform consistently well at sites across Scotland, or from southern England which performs well in northern England, offers growers a potential opportunity to 'future proof' their planting choices. Over the short time these trials have existed, there is no evidence of greater frost damage risk leading to poorer survival of more southerly material from as far away as northern France. Continued monitoring of the trials will be required to detect possible climatic effects with longer return periods that might yet kill or damage provenances translocated northwards.

An interesting feature of the results from this study is the mediocre performance of locally sourced provenances. While the local NSZ may display adaptation to severe climatic events with very long return periods, they do appear to be conservative in relation to current mean climatic conditions. Provenances translocated from further south may be expected to be better adapted to future northerly climates in due course.

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