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Selecting the Right Provenance of Oak for Planting in Britain

INFORMATION NOTE

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SUMMARY

Two series of oak provenance trials were established in Great Britain in 1990 and 1992. These trials contain both European and British provenances and a mix of pedunculate and sessile oak. The trials have now been assessed twice for height, at years 6–8 and years 10–13. Analysis of the height and survival data has shown that British *selected seed stands have consistently good height growth and survival on all but the most testing sites. Near continental sources are generally average in performance whereas Danish and eastern European provenances have performed poorly. British provenances from non-selected stands have shown a range of performances. Those from Scotland, when moved south, have grown slowly but showed better survival on a frost prone Scottish site. On more testing Scottish sites, northerly provenances should be used to reduce the risk of frost damage. This Information Note summaries the trial data and provides recommendations for provenance selection.**

INTRODUCTION

Oak is the most important broadleaved tree species grown in Britain in terms of area and production. It is estimated to occupy 222 697 ha by the *National inventory of woodland and trees* (Forestry Commission, 2003).

Two species of oak are native to Britain: pedunculate oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* (Matt.) Liebl.). These two species have extensive but overlapping ranges across Europe and western Asia, and although there is a large overlap in geographical range, the two species show preferences for different site types. Pedunculate oak is dominant mainly in the lowlands of England, preferring base-rich sites and able to tolerate heavy soils that suffer seasonal waterlogging. Sessile oak is found more commonly to the north and west of Britain on more acid soils and is intolerant of flooding (Savill, 1991). However, in Britain there are many intermediate sites and it is not uncommon to find mixed stands where both species appear to be growing well.

The importance of correct seed choice when planting oak is increasing, with the growing emphasis on using native species for woodland creation, and the fact that most restocking of existing oak woodlands is by planting. However, growers are likely to source acorns from a variety of locations because oak is a masting species and the supply of acorns from any one stand is irregular. It is therefore important that growers are aware of the significance of provenance.

RECOMMENDATIONS

The following recommendations should be followed where good growth rates and/or rapid establishment are desired:

- Ensure that the species chosen matches the site characteristics.
- **First choice of provenance should be a British seed stand**, registered in the *selected** category, preferably growing in the same region of provenance as the planting site. This source will have been selected for its good phenotypic quality.
- If no such material is available then second choice would be seed from a *selected* seed stand in near continental Europe, preferably from Netherlands, northwest France or north Germany. The probability of late frosts should be considered when proposing to use this material in north Britain, in such circumstances more local provenances are less risky.
- Third choice is British seed from the *source-identified** category. This category does not require phenotypic quality nor precise information regarding location. However, material of good phenotypic quality may be available in this category and growers should seek precise information about the source of the seed. Good phenotypic quality is a more important criterion than geographical proximity alone.
- Seed from central and eastern European sources is **not recommended** and it would be better to delay planting rather than use such material.
- Good silvicultural practice is essential in order to obtain the best performance from the chosen provenance.

**Selected* and *source-identified* are defined by the Forest Reproductive Materials (FRM) regulations, see Samuel (2003) for more information.

Both oak species are covered by the Forest Reproductive Material (FRM) Regulations (2002). This ensures accurate labelling of planting stock supported by Supplier's Documents that provide an audit trail back through all production stages to the point of seed collection. Sources of seed registered throughout the European Union are classified into two categories: *source-identified* or *selected* (the latter showing phenotypic superiority). Growers should be aware of the support this provides in making decisions on the choice of planting stock. The Supplier's Document provides details of the provenance and, in addition to the category above, distinguishes whether the seed was collected from a specific stand or was a general collection from a region. This is key information for the grower to consider when purchasing oak seed or plants. General guidance is available in the Forestry Commission Information Note *Recent changes to the control of forest reproductive material* (Samuel, 2003).

In order to look at differences in provenances at a European level and investigate which provenances might be suitable for Great Britain, two sets of provenance trials were established in collaboration with European partners. The first contains provenances from France, Germany, the Netherlands, Ireland and Great Britain and was planted in 1990 at five sites across GB and at an additional site in 1991. The second set of trials was organised by the International Union of Forest Research Organisations (IUFRO) and contains provenances from Belgium, Germany, Denmark, France, Hungary, Poland, Turkey and GB. This series was planted in 1992 at four sites in England, but one site failed and is not included here. Four British provenances (Dymock, Hereford; Blakeney, Dean; Sutton Bottom, Dean; Drummond Castle, Perthshire) and one French provenance (Fôret de Bercé) are common to both sets of trials, although it should be noted that the seed for each series was collected in different years and is therefore not directly comparable. Due to the European nature of the trials the majority of the provenances are of sessile oak, but some pedunculate provenances were also included from British provenances. The locations of the provenances and the trial sites are shown in Figure 1 and details are given in Table 1.

Figure 1 Trial sites used for the 1990 and 1992 series of oak provenance trials.

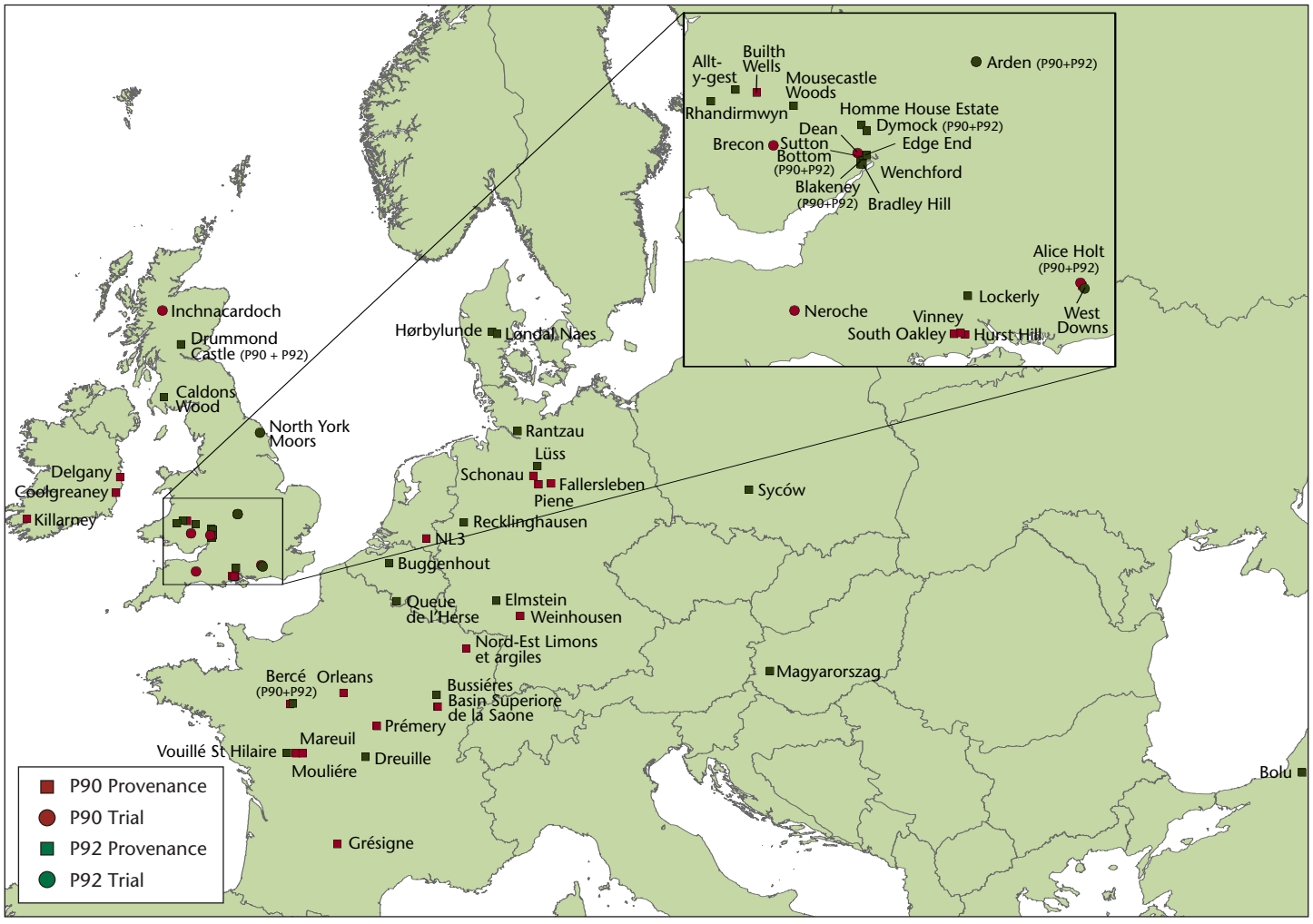

Table 1 Trial sites used for the 1990 and 1992 series of oak provenance trials.

Trial site	Altitude (m)	Average rainfall (mm y^{-1})	Aspect (slope)	Soil (geology)	Previous land use	Region of provenance*
P90						
Alice Holt	50	750	Southwest (moderate exposure)	Weald clay (Lower Cretaceous)	Norway spruce felled 1989	40(5)
Arden (P91)	90	650	West (gentle slope)	Mixed clays (Keuper Marl)	ASNW** mixed oak/ash/birch/hazel felled in 1984	40(3)
Brecon	270–310	1300	Northeast (steep slope, moderate to severe exposure)	Upland Brown Earth (Old Red Sandstone Devonian)	Oak wood then Sitka spruce YC24	30(4)
Dean	167	850	South (gentle slope moderate exposure)	Upland Brown Earth (Upper Westphalian, Silesian, Carboniferous)	European larch felled 88/89	40(4)
Inchnacardoch	40	1300	Level	Basic Brown Earth (Moine)	Sheep grazing and arable	20(1)
Neroche	130	900	Northwest (gentle slope, moderate exposure)	Lower Lias Clay (Jurassic, Lower Lias Shales)	Agricultural	30(5)
P92						
Alice Holt (P93)	45	675	South-southwest (nearly level, moderate exposure)	Denchworth series clay (Jurassic and Cretaceous clay)	Pine and spruce windblow in 1987	40(5)
Arden	90	650	West (gentle slope)	Mixed clays (Keuper Marl)	ASNW** mixed oak/ash/birch/hazel woodland felled in 1984	40(3)
North York Moors	145	788	Southeast (level, moderate exposure)	Calcareous Brown Earth (soft limestone)	Cultivated, ex-forest nursery	40(1)

*As defined by the FRM Regulations; the native seed zone includes the number in brackets (See Herbert *et al.*, 1999).
**Ancient semi-natural woodland.

The trials have been assessed for height growth on at least two occasions since planting and it is now possible to comment on the vigour and survival of the provenances. These are key features for establishment success and have a strong impact on the level of inputs required from the grower for a successful crop. It should not be forgotten that good silviculture is also essential when growing good quality oak. Form has not been assessed in these trials yet and therefore recommendations based on form cannot be made. However, in general, the better performing provenances are also showing good apical dominance. It is also too soon to assess for important timber properties such as 'shake', a problem that should always be considered when planting on light soils.

RESULTS FOR HEIGHT GROWTH

The trials were assessed for height at six years after planting and again at 10–13 years. Comparing the rankings for each provenance at the two different ages showed that those provenances of approximately mean height for each experiment changed rank whereas the best and the worst performing provenances tended to be the same at each assessment. The provenances were therefore placed into categories based on an analysis of whether the mean height of a selected provenance was statistically significantly different from the mean height for all provenances at the site or the mean height of the tallest or shortest provenance.

The results of the P90 and P92 series are summarised in Tables 2a and 2b using these categories. The provenances are ranked in order of overall performance at all sites, with increasing vigour from red to green:

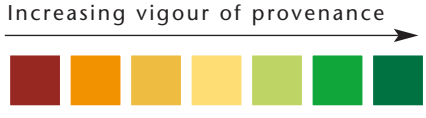

Table 2a and b

Summary of height assessments at two ages for the P90 and P92 series.

(a) Height assessments at two ages for the P90 series

Experiment	Species P/S*	Alice Holt		Dean		Neroche		Brecon		Arden	
Age		8	12	6	12	6	13	6	13	6	11
NL3, Netherlands	P										
West Downs, Surrey, GB	S										
Sutton Bottom, Gloucs., GB	P										
South Oakley, Hampshire, GB	S										
Weinhousen, Germany	P										
Vinney, Hampshire, GB	S										
Hurst Hill, New Forest, GB	P										
Coolgreany, Wexford, Ireland	S										
Blakeney, Gloucs., GB	P										
Dymock, Hereford, GB	S										
Fallersleben, Germany	P										
Fôret de Bercé, France	S										
Piene, Germany	S										
Orleans, France	S										
Killarney, Kerry, Ireland	S										
Basin Superior de la Saone, France	S										
Prémery, France	S										
Grésigne, France	S										
Builth Wells, Powys, GB	P										
Fôret de Mareuil, France	S										
Fôret de Moulière, France	S										
NE Limons et Argiles, France	S										
Delgany, Wicklow, Ireland	S										
Drummond Castle, Perthshire, GB	P										
Schonau Floren-berg, Germany	S										
Elgin, Morayshire, GB	P										
Belgium	S										

(b) Height assessments at two ages for the P92 series

Experiment	Species P/S*	North York Moors		Arden		Alice Holt	
Age		6	11	6	11	5	10
Blakeney, Gloucs., GB	S						
Lockerley, Hampshire, GB	P						
Wenchford, Gloucs., GB	P						
Fôret de Bercé, France	S						
Sutton Bottom, Gloucs., GB	S						
Edge End, Gloucs., GB	S						
Homme House Estate, Herefordshire, GB	P						
Dymock, Herefordshire, GB	S						
Bradley Hill, Gloucs., GB	S						
Elmstein-N, Germany	S						
Recklinghause, Germany	S						
Drummond Castle, Perthshire, GB	P						
Fôret de Bussières, France	S						
Fôret de Vouillé St. Hilaire, France	S						
Mousecastle Woods, Herefordshire, GB	P						
Buggenhout, Belgium	S						
Rantzau, Germany	S						
Løndal Naes, Denmark	S						
Lüss, Germany	S						
Hørbylunde, Denmark	S						
Queue de l' Herse, Belgium	S						
Caldons Wood, Galloway, GB	S						
Syców, Poland	S						
Allt-y-gest, Powys, GB	S						
Fôret de Dreuille, France	S						
Bolu (Ayikayasi), Turkey	S						
Magyarorszag, Hungary	S						
Rhandirmwyn, Dyfed, GB	S						

Significantly taller than the experiment mean height.

Taller than the experiment mean height but significantly shorter than the tallest.

Equivalent to mean height but not significantly shorter than the tallest.

Mean height and significantly shorter than the tallest and taller than the shortest.

Equivalent to mean height but not significantly taller than the shortest.

Shorter than the experiment mean height but significantly taller than the shortest.

Significantly shorter than the experiment mean height.

* Species: P = pedunculate oak; S = sessile oak.

Provenances in bold were GB registered seed stands when seed was collected.

The tables are split into those provenances planted at two or more sites (above thick white line) and those only at one.

Table 3 provides a summary of the difference between the height of the tallest and the shortest provenances for each of the trials.

The results of these trials highlight the importance of provenance choice when growing oak. The height difference between the best and worst provenances is of the order of 1.5–2 m in 12 years. In practical terms this is the difference between the oaks closing canopy and dominating the site or still suffering from weed competition by this stage. The tallest provenances also move more quickly through the stage where frost and herbivore damage can threaten the establishment success and quality of a crop.

The differences between the sites are also noteworthy. The relatively poor overall performance of the oak at the Dean P90 and Alice Holt P93 sites is due, in the most part, to strong weed competition with bracken – plus the presence of deer at the Dean, and gorse at Alice Holt. Even the best provenances will struggle if the necessary silvicultural management is not applied.

Both series of trials provide a consistent overall picture for provenance choice for planting oak in Britain. Provenances from *selected* British seed stands are generally the best, consistent performers for height growth across all the sites.

However, this is in contrast to the performance of British provenances from non-selected seed stands which show a wide range of performance. This suggests that for oak it is better to select provenance on the basis of good phenotype than on geographical proximity to the planting site when good initial height growth is required. In general, the poorest performing British provenances were those that were moved south and their slower growth is likely to be linked to adaptation to a shorter growing season. They do however show high survival on difficult sites.

The majority of the European provenances come from registered *selected* seed stands and have shown generally average performance in the trials. The main exception to this is the single Dutch provenance, NL3, from south Netherlands that has shown exceptionally good growth on all sites in the P90 series except at Brecon. However, care should be taken when using Dutch material since it is more likely to suffer from shake and should not be used on sites that are prone to drought or fluctuating water tables (Hubert and Savill, 1999). The two Danish provenances in the P92 series, however, show surprisingly poor height growth considering the latitudinal similarity to north England. This poor performance may be due to the fact that the stands were selected on the basis of Danish native origin rather than for registration in the *selected* category. At the mildest site in the trials, Neroche in Devon, it is interesting to note the improving performance of two otherwise poor French provenances, Fôret de Moulière and northeast Limons et Argiles. The provenances from eastern Europe and Turkey are below average for growth, but since they are only planted at one site each it is impossible to draw any firm conclusions. However it could be highly risky to buy this material for planting in Britain.

Table 3

A comparison of the mean height of the tallest and shortest provenances for the P90 and P92 series of trials. (Percentages are given relative to the experiment mean height for all provenances in the same trial.)

Trial location	P90 series of trials					P92 series of trials		
	Alice Holt	Arden	Brecon	Dean	Neroche	Alice Holt	Arden	North York Moors
Assessment age	12	11	13	12	13	10	11	11
Tallest provenance (cm)	537.6 (112.9%) Sutton Bottom (Gloucs.)	461.6 (128.4%) NL3 (Netherlands)	556.0 (121.9%) Vinney (Hampshire)	291.3 (146.7%) NL3 (Netherlands)	395.7 (117.5%) NL3 (Netherlands)	290.8 (117.7%) Lockerley (Hampshire)	471.2 (120.4%) Blakeney (Gloucs.)	330.7 (122.8%) Blakeney (Gloucs.)
Experiment mean height (cm)	476.2	359.4	456.2	198.6	336.9	247.1	391.2	269.2
Shortest Provenance (cm)	406.2 (83.3%) Drummond Castle (Perthshire)	308.7 (85.9%) Drummond Castle (Perthshire)	338.3 (74.2%) Fallersleben (Germany)	122.4 (61.6%) Delgany (Ireland)	243.4 (72.2%) Drummond Castle (Perthshire)	191.8 (77.6%) Magyarorszag (Hungary)	298.2 (76.2%) Caldons Wood (Galloway)	223.3 (83.0%) Bolu (Turkey)

SURVIVAL

Tables 4a and 4b provide a summary of the mean survival at the most recent assessment for each trial.

The survival at the North York Moors site has been uniformly excellent. The very high survival rates are likely to be due to the fact that the experiment was established on an ex-nursery site where early weed control was more straightforward. On the other suitable oak sites it appears that good survival is also possible almost regardless of provenance. This is perhaps not surprising since oak is a flexible pioneer species with a large natural range.

However, on more demanding sites the general trend observed is better survival using the GB provenances. For example, Inchnacardoch, near Fort Augustus (Scottish Highlands), is arguably not a site to grow quality oak being very prone to summer frosts. For this reason this site was dropped from the analysis of height growth. However, this testing site has highlighted that only Drummond Castle and Builth Wells survive well under these conditions, these provenances therefore showing signs of adaptation to such frost-prone sites. Deans and Harvey (1996) observed similar differences in a test of the frost hardiness of 16 European sessile oak provenances. This adaptation – late flushing and early senescence – leads to a shorter growing season, and therefore slower growth, compared with southerly provenances on southern sites. However, this slower growth is potentially a problem if weed competition is strong, and this could explain the poor survival of Allt-y-gest (Powys) and Caldons Wood (Galloway) provenances at Arden P92. It is also important to note the particularly poor survival of the Hungarian provenance at Alice Holt P92.

PEDUNCULATE OR SESSILE OAK?

There is no clear trend apparent between the performance of the two oak species in either series of trials. However, it is interesting to note the drop in performance of the top pedunculate oak provenances for each series at the more northern and western sites, namely: Lockerley and Wenchford at North York Moors P92, and NL3 at Brecon P90. This poorer performance of the pedunculate oak provenances suggests that these two sites are potentially better suited to sessile oak.

COMPARISON WITH OTHER TRIALS

Worrell (1992) analysed four sessile oak experiments and noted only a small difference in height growth between GB and continental provenances. However the GB provenances did have faster growth rates in nine out of ten datasets available. There is no information as to whether the GB material came from registered seed stands or not. As in this study he noted that the lowest growth rates came from Danish provenances, but in contrast he found French provenances from northwest France appeared to out-perform GB ones. Worrell also reported slightly better form for the French material.

Coillte Teoranta, the Irish Forest Board, also have two trials as part of the P90 series (Lally and Thompson, 2000). Their recommendations for planting in Ireland, after six-year height and form assessments, are for Dutch, British and German material. In particular, NL3, Sutton Bottom and Blakeney performed well for height and form after six years. These are very similar results to those found here.

On a broader scale, Madsen *et al.* (in prep.) analysed the P92 series using all the trials across Europe. Only three British provenances, Sutton Bottom, Blakeney and Dymock, were planted elsewhere in Europe, but good performance for height was observed for all three at year six, particularly when looked at within an 'Atlantic' subset of trial sites. German provenances grew well, the French were more mixed, but the Danish, Turkish and Hungarian provenances were all very poor. The one Polish provenance performed better at the 'Continental' sub-set of sites.

CONCLUSIONS

There are significant differences between the performance of oak provenances that have important practical implications for growers. Poor provenance choice can compromise the success of the crop from the start. Good silviculture in the form of weed and herbivore control is also required to maximise the potential of the selected provenance.

Registered seed stands from GB in the *selected* category are the best sources of oak for planting in Britain – judged on the basis of growth and survival in GB. Planting these provenances is likely to be lead to higher establishment success and lower establishment inputs required.

Table 4a

Percentage survival for the P90 series ranked by mean survival.

Provenance	Species	Alice Holt	Arden	Brecon	Dean	Neroche	Inchna-cardoch	Mean (all sites)
Drummond Castle, Perthshire	P	91.7	87.5	98.2	97.2	95.4	83.3	92.2
Builth Wells, Powys	P	83.3	79.2	98.2	88.0	89.8	78.7	86.2
South Oakley, Hampshire	S	89.6	95.8	95.4	84.3	90.7	50.0	84.3
Hurst Hill, Hampshire	P	87.5		99.1	84.3	96.3	47.2	82.9
NL3, Netherlands	P	83.3	95.8	92.6	80.6	96.3	48.2	82.8
Vinney, Hampshire	S	93.8		99.1	91.7	92.6	25.9	80.6
Sutton Bottom, Gloucs.	P	83.3	85.4	97.2	75.0	93.5	19.4	75.7
West Downs, Surrey	S	77.1		98.2	85.2	59.3	54.6	74.9
Delgany, Wicklow, Ireland	S	87.5		94.4	62.0	87.0	18.5	69.9
Fôret de Moulière, France	S	87.5		97.2	75.9	85.2	0.9	69.4
Dymock, Hereford	S	81.3	64.6	99.1	79.6	88.0	2.8	69.2
Blakeney, Gloucs.	P	85.4		96.3	72.2	83.3	8.3	69.1
NE Limons et Argiles, France	S	72.9		98.2	65.7	97.2	3.7	67.6
Coolgreany, Wexford, Ireland	S	89.6	56.3	96.3	65.7	91.7	4.6	67.4
Basin Superior de la Saone, France	S	75.0		96.3	76.9	81.5	0.0	65.9
Fôret de Mareuil, France	S	97.9			73.2		0.0	57.0
Weinhousen, Germany	P	95.8			88.0	98.2		94.0
Fallersleben, Germany	P	81.3		87.0	78.7	92.6		84.9
Piene, Germany	S	81.3	81.3		84.3			82.3
Prémery, France	S	77.0			85.2			81.1
Fôret de Bercé, France	S	97.9	81.3		63.9			81.0
Orleans, France	S	89.6	72.9		75.9			79.5
Grésigne, France	S	85.4			59.3	92.6		79.1
Killarney, Kerry, Ireland	S	66.7	87.5		81.5			78.6

Table 4b

Percentage survival for the P92 series ranked by mean survival.

Provenance	Species	Alice Holt	Arden	North York Moors	Mean (all sites)
Homme House, Herefordshire	P	98.1	62.7	99.1	86.6
Fôret. de Vouillé St. Hilaire, France	S	93.5	62.3	100.0	85.3
Recklinghausen, Germany	S	92.6	62.7	100.0	85.1
Edge End, Gloucs.	S	92.6	60.7	100.0	84.4
Wenchford, Gloucs.	P	88.9	63.3	100.0	84.1
Dymock, Herefordshire	S	94.4	55.0	100.0	83.1
Lockerley, Hampshire	P	88.0	60.7	100.0	82.9
Blakeney, Gloucs.	S	83.3	61.7	100.0	81.7
Sutton Bottom, Gloucs.	S	82.4	60.7	98.1	80.4
Elmstein-N, Germany	S	78.7	60.0	100.0	79.6
Mousecastle Woods, Herefordshire	P	79.6	56.3	100.0	78.7
Løndal Naes, Denmark	S	95.4	40.0	100.0	78.5
Bradley Hill, Gloucs.	S	74.1	60.7	97.2	77.3
Lüss, Germany	S	80.6	44.0	100.0	74.9
Rantzau, Germany	S	87.0	36.0	100.0	74.3
Hørbylunde, Denmark	S	81.5	38.7	100.0	73.4
Caldons Wood, Galloway	S	75.0	38.7	100.0	71.2
Drummond Castle, Perthshire	P	86.1		100.0	93.1
Fôret de Bercé, France	S		60.0	100.0	80.0
Fôret de Bussières, France	S		59.3	100.0	79.7
Queue de L' Herse, Belgium	S	67.6	56.3		62.0
Buggenhout, Belgium	S	63.9	58.0		60.9
Fôret de Dreuille, France	S			100.0	100.0
Syców, Poland	S			99.1	99.1
Bolu (Ayikayasi), Turkey	S			97.2	97.2
Rhandirmwyn, Dyfed	S	81.5			81.5
Allt-y-gest, Powys	S		36.3		36.3
Magyarorszag, Hungary	S	32.4			32.4

Note:

Table 4a is split between provenances planted at the Scottish site (Inchnachardoch) and those absent.

Table 4b is split (thick white line) between those provenances planted on all, two or one site.

P = pedunculate oak (*Q. robur*)
S = sessile oak (*Q. petraea*)

GB registered stands in bold.

If seed from British *selected* stands were not available then collecting seed from stands of high phenotypic quality would be preferable to stands chosen on the basis of close geographical proximity to the proposed planting site alone. This would therefore also include *selected* seed stands on the near continent. These trials suggest that material from the Netherlands, northern and western France, and northern Germany is suitable for British conditions. Material not in the *selected* category is defined as *source identified*. This does not require phenotypic selection nor precise geographic location for inclusion into this category, but nevertheless there is the potential to obtain *source identified* material of good phenotypic quality. However, growers will need to demand more precise information about the seed when considering the use of *source identified* material.

For faster growth it is possible to move material from south to north but this involves increasing risk. Although oak appears to show good levels of survival on good sites regardless of provenance, on more testing sites there is evidence of adaptive variation of northern provenances to late frosts.

Material from central and eastern Europe is not recommended. If this were the only stock on offer it would be better to delay planting until a better provenance was available.

The list of British *selected* seed stands for oak is still far from being comprehensive. Increasing the supply of this high quality material is an excellent way of supporting the growing of oak in Britain and growers who think they have good quality stands are urged to consider registration.

Details of registration can be found at:
www.forestry.gov.uk/frm

An application form with details of the criteria used to judge a stand can be downloaded from the National Register section. Alternatively, contact Cathleen Baldwin at:

Forest Research, Northern Research Station, Roslin EH25 9SY. Email: cathleen.baldwin@forestry.gsi.gov.uk.

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