PRACTICAL METHODS FOR DISTINGUISHING THE TWO NATIVE BRITISH OAKS AND THEIR INTERMEDIATES

by S.M. Potter*

SUMMARY
Distinguishing with certainty British pedunculate oak (*Quercus robur*) from sessile oak (*Q. petraea*) is often difficult. Reasons for this are discussed and previous work aimed at resolving the confusion is summarised briefly. A relatively simple technique for determining the two species and their intermediates – using leaf characters – is proposed, and an alternative technique is described.

Introduction
It is ironic that British foresters, who have had to learn to identify a wide range of exotic trees, often experience difficulty in discriminating with certainty between the native sessile oak (*Quercus petraea*) and pedunculate oak (*Q. robur*). Such difficulties have practical implications; they are likely to hinder the development of understanding of the silvicultural differences between the two species, which, as Evans (1984) remarked, merit individual consideration in this respect, and to limit appreciation of the potential value of provenances and of hybrids on particular site types. The species’ reputation as ‘difficult plants’ (Nature Conservancy Council, 1981) has also hindered studies of their natural distribution, and has led at least one author of a county flora (Edees, 1972) to caution, correctly (Potter, 1990), that sessile oak is insufficiently recorded. Since the middle of the nineteenth century foresters and botanists have documented their suspicion that difficulties of identification result, at least in part, from hybridisation (Brown, 1851). There was, and still is, a need for a simple method by which non-specialists might identify the two species and intermediates relatively rapidly, and without reference to ephemeral characters such as flowers and fruit.

Studies of variation in the morphology of pedunculate and sessile oak populations in Britain (Cousens, 1962, 1963, 1965; Carlisle and Brown, 1965; Wigston, 1974, 1975), and in Continental Europe (Krahl-Urban, 1951; Johnsson, 1952), led to the general acceptance of the idea that gene exchange often takes place between the two species where they occur together (Gardiner, 1970). A mechanism by which that exchange might occur was first described by Anderson (1949), who named it introgressive hybridisation, or introgression. Where the ranges of two closely related species overlap, and other barriers to interbreeding have been eroded, occasional F1 hybrids may occur. Although many may be sterile, particularly with respect to other hybrids, some may be able to backcross with the parent species, which will be present in much greater numbers than the F1s. If the progeny of this and subsequent generations also backcross, the resulting population will be composed of individuals with genotypes similar to, but not identical with, one of the parent species, natural selection having favoured introgression of one of the parents in preference to the other.

*Principal Forestry Officer, Department of Planning and Economic Development, Staffordshire County Council, Martin St, Stafford ST16 2LE.
Cousens (1965), who extended his original studies of Scottish oak population to Eire, south-east England and Yugoslavia, noted evidence for introgression in each area. He concluded that *Q. robur* could have been introgressed by a number of related species during the last glaciations or earlier; it was a variable species when it arrived in post-glacial Britain, whereupon it was subject to some secondary introgression by *Q. petraea*. Introgression of *Q. petraea* by *Q. robur* is a variable phenomenon, increasing markedly in northern England and especially in Scotland where, according to Cousens, only 25 per cent of the oaks could be identified positively. Rushton (1979) identified a similar pattern of increasing introgression from east to west in England and Wales. Some studies in Continental Europe (e.g. Dupouey and Badeau, 1993; Aas, 1993; Bacilieri, Roussel and Ducousso, 1993) have disclosed a much lower proportion of hybrids in the sampled populations, and have led to speculation that the high levels of introgression reported from Britain may be due to particular local circumstances, or may be the consequence of the use of questionable methodologies (Dupouey and Badeau, 1993).

There is no single characteristic that can be used to distinguish each of the two species from the other, or either from the hybrid. Introgression can give rise to a range of intermediates displaying a continuous and smooth transition in morphology, from one parent species to the other. Consequently, the descriptions to be found in a standard flora are of limited value in identifying the two oaks and their hybrids. Methods that have been used previously to determine the taxonomic status of oak populations include developments of Anderson’s (1949) hybrid indices and pictorialised scatter diagrams (Carlisle and Brown, 1965; Cousens, 1962, 1963), theoretical species type and combination class analysis (Cousens, 1963, 1965), and multivariate statistical analyses (Rushton, 1979; Dupouey and Badeau, 1993; Aas, 1993; Elsner, 1993). Whilst all of these methods proved to be of value for the purposes for which they were used, they are not suitable for general use by non-specialists, either because of reliance on computer analysis of data or on the use of fruiting or other characters that are ephemeral.

In an attempt to devise a method of identification that relies only on leaf characters that can be assessed easily, two ancient semi-natural oak woods in Staffordshire were studied. Brocton Coppice, on Cannock Chase, which is thought to be the last surviving fragment of the pre-medieval Cankwood (Staffordshire County Planning Department, 1981) was cited by Jones (1959), although not by name, as an example of an ancient population of sessile oak, unlikely to have been disturbed by planting. The soil type is a humo-ferric podzol, formed over Sherwood Series Sandstones. Forest Banks, in eastern Staffordshire, demarcates the northern boundary of the ancient Forest of Needwood. Pedunculate oaks are found there on a steep scarp slope, growing in stagnogleys, calcareous pelosols and argillic gleys, over Triassic mudstones.

Each population was sampled to ensure that it comprised non-introgressed individuals on the basis of criteria given by Jones (1959), Wigston (1975), Cousins (1963), and Carlisle and Brown (1965). Subsequently some residual introgression came to light in Brocton Coppice; five trees were so identified using Cousins’ (1963) secondary character combining class analysis and were excluded from the sample population.

About 12 per cent of the individuals in each sample population were selected at
random, and leaf samples were collected from spring shoots of the lower crown, as described below. For each leaf the petiole per centage was calculated and the number of leaf lobe pairs noted. Scores of +1, 0 or -1 were assigned for depth and regularity of lobing, presence/absence of auricles and presence/absence of abaxial pubescence.

The sum of the scores for the three secondary characters of any tree will lie somewhere between +3 (Theoretical Species Type (TST) for Q. petraea) and -3 (TST for Q. robur); this 'total leaf character score' can therefore be used as a continuous variable, albeit an artificial one that gives no information about the nature of the variation and arbitrarily assigns equal significance to each character. When the reference populations were plotted on a scatter diagram with petiole percentage and average number of lobe pairs as axes there was no clear separation between the two species. When a third axis, for total leaf character score, was added, separation was achieved, as Figure 1 shows.

Three-dimensional diagrams are difficult to work with. Figure 2 shows the same
information in two elevations, as P plotted against C, and L against C. The
boundaries delimiting each species are derived from the 98 per cent confidence
limits of the mean values of each variable. This diagram is the basis of the first of
the proposed methods of identification, described below.

An alternative method has recently been described. Dupouey and Badeau (1993)
studies the morphological variability of 800 oaks in 80 strands in Lorraine, northeaster
France. Eighty foliar and fruiting variables were measure or calculated for
each tree, and analysed mainly by factoria correspondence analysis. Some of the
variables were found to be redundant, and the character set could be reduced to 29,
all of which related to leaves and shoots. The analysis demonstrated that sessile and
pedunculate oaks were clearly separated morphologically, with intermediates
representing only 3.5 per cent of the sample population. The authors state that:
"Length of the petiole and number of intercalary veins are sufficient to separate the
two species *Q. robur* and *Q. petraea* with 99 per cent success rate. The discriminant function for tree recognition is: \( I = (407 \times nint) - (130 \times 1pet) + 357 \), where:
- number of intercalary veins (mean of 10 leaves per tree); 1pet: length of petiole in mm (mean of 10 leaves per tree); I: species index; positive for *Q. robur* and negative for *Q. petraea*. Values between -1000 and +1000 indicate an intermediate tree.” Intercalary veins are those running to the sinus, between lobes.

Practical details for the application of each of these methods are as follows.

*Potter’s Method*

1. Collect 15 leaves from the tree to be identified. These should be taken from the most accessible part of the lower crown, but epicormic shoots or coppice growth should be avoided. Young trees less than about 4 m in height may still have predominantly juvenile foliage which cannot be reliably identified. If possible the 15 leaves should be made up of three samples of five, taken from equidistant points around the crown. Select undamaged leaves from the middle part of the shoot; avoid leaves which have resulted from the second (Lammas) flush of growth from late July onwards, as these can exhibit excessive variability. Pack the leaves in polyethylene bags.

2. If the leaves cannot be measured immediately they should be stored in a refrigerator or preferably in a freezer to prevent mildew or damage by the insects that are likely to harbour.

3. Take one leaf at a time and make the following measurements: (i) the length of the petiole - \( a \) on Figure 3; (ii) the length of the lamina - \( b \) on Figure 3. The petiole per centage \( p \) for that leaf, is calculated as 100a/b. Note the value of \( p \).

4. Calculate the number of pairs of leaf lobes. As the leaf may not be symmetrical count the total number of lobes, exclusive of the tip of the leaf, and divide by two to give \( l \) for the leaf. It may sometimes be difficult to distinguish between a small lobe and a crenate leaf margin, especially near the petiole. Note whether a vein extends from the mid-rib to the margin at that point: if it does this should be counted as a lobe. Note the value of \( l \).

5. Assess the depth and regularity of lobing. A more or less symmetrical leaf has regular lobing, whilst that in Figure 3 would count as irregular. The depth of lobing can usually be assessed by eye, or the measurement shown in Figure 3 can be used. If \( X1 + X2 = 0.5Y \) or less the lobing is shallow; if more than 0.5Y it is deep. If the lobes are shallow and regular, score +1; if deep and irregular, score -1; if intermediate, ie shallow and irregular or deep and regular, score 0.

6. Assess whether auricles are present at the base of the lamina. Figure 4 gives some examples of ‘strong’ and ‘weak’ auricles. If auricles are absent or present only as a single weak one the leaf scores +1; if two strongly developed auricles, score -1; if intermediate, ie two weak auricles or one, strongly developed, score 0.

7. Look at the underside of the leaf. If there are clusters of silvery-white hairs on each side of the lower third of the mid-rib, visible with the naked eye, score +1. If the mid-rib is completely glabrous, score -1. If there are hairs present but they are thinly scattered and/or scarcely visible without a lens, score 0 (NB ignore the presence of any hairs on the lamina).

8. Add together the three scores obtained in steps 5, 6 and 7 to give a total Leaf Character Score \( c \), which can vary from +3 to -3. Note the value of \( c \).

9. This completes the measurement of the first leaf. The process is repeated for
each of the remaining 14 leaves, and the values of \( p, l \) and \( c \) summed and divided by 15 to give average values, \( P, L \) and \( C \).

10. Plot the position of the tree with respect to \( P, L \) and \( C \) on each elevation of Figure 2. In most cases the specific status of the tree will be obvious; where it is not the following rules of interpretation apply:

(i) If the tree falls within the \( Q. petraea \) area on both elevations of the diagram it is sessile oak; if within \( Q. robur \) on both elevations it is pedunculate oak; if within the Intermediate area on both it is a hybrid.

(ii) If the tree falls within the \( Q. robur \) or \( Q. petraea \) area on one elevation but in the Intermediate area on the other it is a hybrid. The pattern of introgression of hybrid trees can be inferred, to some extent, from their plotted positions relative to the parent species.

Dupouey and Badeau’s Method

1. Collect 10 leaves from the outer part of the canopy, on its southern aspect. Choose leaves from the middle part of the spring shoot, avoiding Lamma growth. Store as described above.

2. For each leaf measure and record the length of the petiole in mm. (a in Figure 3), and count and record the number of intercalary veins running to sinuses.

3. Repeat for the sample of 10 leaves, calculate average values for ‘\( p \)’ and ‘\( l \)’ and calculate the species index value \( I \) using the expression given above.

Discussion

The first method described above has been independently tested (Edwards and Edwards, 1984, pers. comm.), and has proved to be of value in determining the composition of a number of mixed and hybrid oak populations (Potter, 1990). Specific applications have included: analysis of parent trees to ensure that seed collected from them would be representative of the genotypic range of the population; mapping the distribution of the parent species and hybrids, and relating the patterns of introgression to variations in soil characteristics; verifying the description of an ancient semi-natural mixed and hybrid oak wood in a Site of Special Scientific Interest notification; determining whether a woodland was planted, by comparing the pattern of introgression with that of known ancient semi-natural woods on the same soil type. The method requires only a ruler, although a
hand lens and a pocket calculator are also useful. The measurements, calculations and plotting of a single tree can be completed in 20 to 30 minutes.

Dupouey and Badeau’s simplified method has not, as far as is known, been tested widely in Britain. However, a preliminary comparison by the author suggests that both methods yield similar results. Dupouey and Badeau’s approach has some practical advantages: as fewer characters are assessed, using fewer leaves, it yields a result more quickly and simply than does Potter’s method, and leaves which have been slightly damaged by insects can be used, provided that the veins and petiole are intact, although it may sometimes be difficult to decide whether a particular vein is truly ‘intercalary’. Dupouey and Badeau’s method has the disadvantage that it yields less information about the nature of variation than does Potter’s method, but this is unlikely to be of consequence to practical foresters.

The use of one or both of these relatively simple methods for discriminating between the parent species and the range of hybrid forms which may be encountered in our woods is commended. A wider knowledge of the occurrence and distribution of hybrid oaks could stimulate interest in, and debate on, their silvicultural potential.

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REFERENCES


