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Article *in* Quarterly Journal of Forestry · January 2005

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Clark, J. & Wilson, T. (2005) The importance of plus-tree selection in the improvement of hardwoods. *Quarterly Journal of Forestry.* **99**(1): 45-50.

THE IMPORTANCE OF PLUS-TREE SELECTION IN THE IMPROVEMENT OF HARDWOODS

Tree breeding is a key element in the improvement of productivity and timber quality of British hardwoods. **Jo Clark** and **Ted Wilson** explain the importance of plus-tree selection as the first step in an improvement programme.

British forestry has been moving in a new direction over recent years. The emphasis has evolved from the creation of large reserves of production forests, based primarily on the exploitation of exotic conifer species, to a multi-purpose woodland resource that meets a large number of management objectives and satisfies the broadest range of uses (Forestry Commission, 1999). With this development has come renewed interest in both the conservation of native trees and woodlands, and the use of high quality homegrown hardwood timbers.

Hardwood planting schemes in Britain are often established using cheap imports of seedlings from continental Europe, many of which are of unknown origin and genetic quality. While this material may show good initial productivity, it often proves not to be well adapted to the edaphic and climatic conditions in Britain (Cundall et al., 2003). To address this issue, new forest reproductive material (FRM) regulations were introduced in 2003 to govern the collection, labelling and transport of forest material (HMSO, 2002). These regulations place material into one of four categories, source identified, selected, qualified, and tested. Tested material is the result of long term progeny testing and yields the highest gains in productivity and timber quality.

Any breeding programme for the improvement of timber quality relies on the identification of the best parents. These will form the genetic base from which all subsequent improvements in form and vigour will be obtained. Such trees are usually found in forest conditions and may exhibit superior traits relative to neighbouring individuals of the same species. Selected trees are commonly referred to as superior phenotypes or plus-trees. Once selected, seed is collected for progeny testing to ascertain if the desired traits of the plus-tree have been inherited by the offspring.

This article outlines the steps involved in the identification and selection of plus-trees of hardwood species. Reference is made to current work focusing on ash. The principles discussed in this report will address phenotypic selection from the tree breeder's perspective, but also hold true for foresters selecting final crop trees in high value stands.

Table 1. Tree attributes to be taken into account during field assessment of plus-trees. Potential plus-trees are generally among the dominant individuals in a stand. Each trait is assessed relative to the average of neighbouring trees. Some traits are more important than others, depending on species and the objectives of the tree improvement programme.

Attribute	Considerations in selection
Stem straightness	A straight stem with little taper provides maximum volume and minimises waste in timber production. Straightness is essential for veneer bolts.
Timber height	This is the height to the first major fork. Good timber height maximises potential for long lengths of usable timber.
Diameter	Related to productivity and growth rates. An ideal tree will have superior volume increment and relatively little stem taper.
Forking	Forks usually result from breakage or damage to the leading shoot. Repeated forking is often due to a genetic pre-disposition in the tree (e.g., early bud burst in spring). A single fork is likely to be the result of frost damage or an insect pathogen.
Branch angle	Branches at or close to horizontal orientation produce less knot wood per unit length of the main stem.
Branch thickness	Heavy branching produces large knots which reduce the commercial grade and strength of timber.
Self-pruning	Self-pruning is where lower branches abscise cleanly in low light conditions. Early self-pruning reduces the risk of stem infection and increases timber quality.
Crown dimensions	A large healthy crown is essential to ensure maximum photosynthetic potential. The crown should be evenly distributed.
Fluting	Some trees produce irregular stem form, especially at the base. Any deviation from a concentric cross-section is undesirable.
Straight grain	A uniform and linear grain produces the cleanest wood. Spiral grain can often be noted in orientation of bark and produces wood that is more difficult to machine.
Disease	Trees exhibit variation in resistance to many diseases. Life threatening diseases, those that effect productivity and those that disfigure the stem are all to be avoided.
Epicormics	These are shoots that emerge from dormant buds along the stem in response to changes in light levels in the stand. Some species, such as oak, are especially susceptible to epicormics, after thinning operations.

Stand Selection

In a typical UK programme, plus-trees are selected from across the entire UK and are recorded by region of provenance and seed zone (Herbert et al, 1999). The first step is to identify suitable stands. Typically, a stand should have a minimum of 30 individuals of good form, but it may be possible to select from a smaller population where the individuals are of exceptional quality. Having determined that the stand is suitable for plus-tree selection, it is then necessary to assess each tree to ensure that the best individual is chosen.

Tree selection

The tree's dominance within the stand, indicated by its superior height and diameter, are the first attributes to be assessed. Timber height (the amount of clear stem to the first fork or major branch) is very important. Timber is usually required in 2m sections. A minimum of three such sections (6m) of clear stem is desirable for a plus-tree, and obviously more are better. The degree of clean self-pruning and the shape of the bole are good indicators of the quality of the timber. A large healthy crown is essential for good growth potential (Figure 1).

The best tree may be the most dominant in a stand, but factors affecting form are also considered (Table 1). Branch angle and thickness are useful indicators of timber quality. The height to the first fork and the deepness of the fork should be considered. Hardwood species fork naturally, although some individuals show a greater predisposition to do this than others. Forking can occur as a single instance or it can be persistent throughout the crown. Where it occurs as a single fork, it is likely to be due to environmental factors and the tree need not be discarded on this account. However, where forking is persistent throughout the crown, it is much more likely to be genetic in origin and such trees should be avoided. Selected trees should be free of serious pests and disease.

A final consideration is the presence of any seed or flowers. In those trees that are dioecious, it is more desirable to select a female tree (if the objective is to collect seed) although males may be selected if graftwood is to be collected for clonal propagation.

For each species, the selection strategy is a little different. In oak, some trees are prone to shake (Savill et al., 1990) and epicormic shoots. It is thought that shake is associated with large vessel size and plus trees can be screened in the lab for this, prior to inclusion in progeny trials. Cherry (*Prunus avium*) exists in two forms, wild and sweet, and is susceptible to canker. Parents are screened to ensure they are true wild cherry and exhibit resistance to canker. Ash is a frost sensitive species and its avoidance strategy is to flush late. Individuals that flush early may be frost damaged and, given the opposing arrangement of buds, prone to forking.

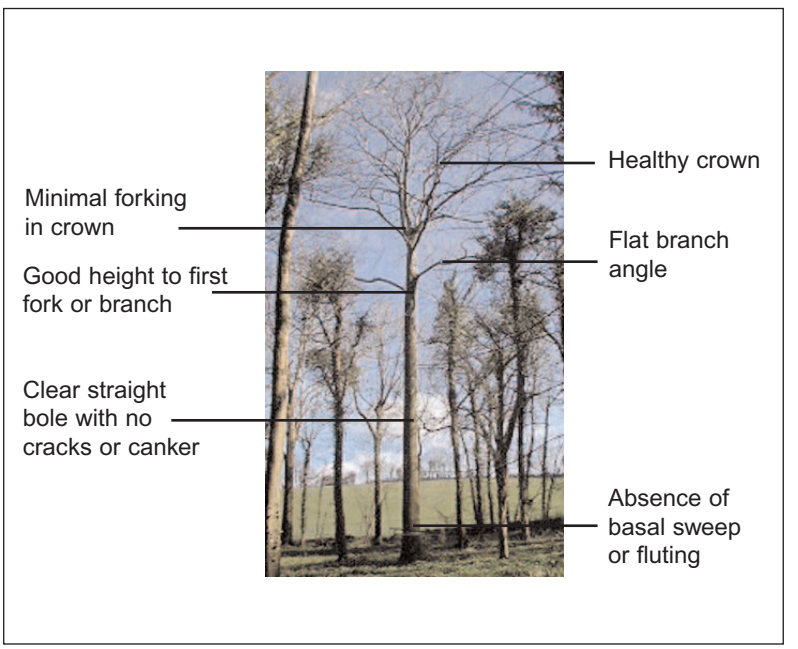

Figure 1. Example of an ash plus-tree at Dartington, Devon. This individual exhibits many desirable characteristics such as stem straightness, a flat branch angle, minimal forking and excellent volume and form.

Ash Tree Data Sheet

AH 404-19

Estate ID a-59 WOW A

Estate Name	Telephone
Owner Forest Enterprise	Manager
Owners Address FE (3)	Managers Address Forest Enterprise

Tree Location Seed Zone 404

Wood Mailscot Wood	Selected By J. Clark	Date 5/9/02
Grid Ref SO 556 143	Map Ref 162	County Gloucestershire

Comments on tree and stand
Stand of predominantly beech/ash. few oak, yew, elm, hazel. fairly open woodland, quite light.
This tree very good & straight, excellent timber length, but very deep steep fork. Good healthy crown.

Stand and Site Characteristics

Stand ID a-59-3	Stand Age	Stand Type Mixed deciduous
Aspect 300° NW	Slope/deg 7°	Alt/m 50M
Soil Type Sandy loam	Texture	Drainage Good
Ppt/mm p.a	Yield Class	NVC Class

Vegetation Type
Geum urbanum, Rubus fruticosus, Geranium robertianum, ajuga reptans Carex pendula, clematis vitalba, Veronica montana, Oxalis acetosella, Circea lutetiana, Potentilla reptens, Rubus ideaus, hedera helix Conopodium majus.

Tree Characteristics

Tree ID agls 04		
Height (m) 30.9	Timber height (m) 16.5	DBH (cm) 37
Straightness to 10m 0 1 2 3 4 5 6 7 8 9 10 (Good)		
Bark grain Vertical	Basal sweep No	Fluting No
Circularity OK	Est. branch diameter (cm) 20	
Bark defects/disease No		
Flowering/seed No		

Figure 2. Plus-tree data sheet. A map, directions and history of the tree are recorded on the reverse.

Recording the tree

Having decided which tree is to be selected on a visual basis, it is then necessary to make notes on the tree using a standard data form (Figure 2). Detailed and accurate notes are essential as they will be of value over a period of decades. Designation of breeding orchards under FRM regulations requires details of the parent trees and their locations. Some general observations on the stand are useful to note such as species composition, what component the selected species plays, and any statutory designations that the woodland may have.

Tree characteristics such as total height, timber height, estimated branch diameter of the lowest branch, and diameter at breast height (taken at 1.3m above ground level) are recorded. Factors that contribute to the form of the tree are also scored. These include the circularity of the bole, the bark grain (which may be spiral and thus undesirable), the presence of any basal sweep, fluting and stem straightness. Any bark defects should also be noted, including slight mechanical damage. Other more serious bark defects such as cavities or cankers will have prevented the tree from being selected in the first place.

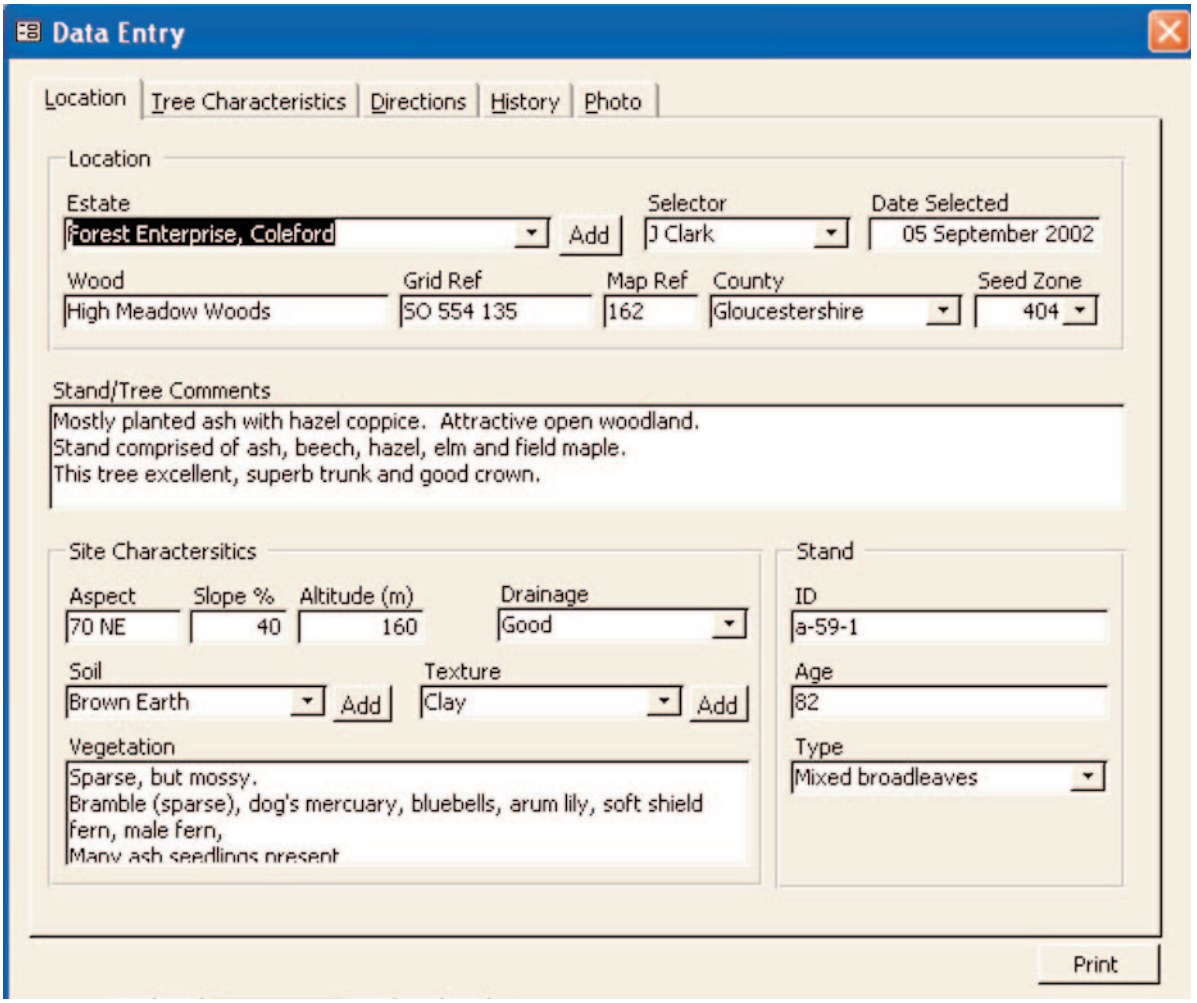

Figure 3. First data entry screen for the ash plus tree database. Data is added to one of five tabs and includes a photo and map (1:20,000) of the tree location.

Once selected, it is helpful to identify the tree with tree marking paint. This ensures that in future visits, the right tree is located. In some cases, a global positioning system (GPS) reading may be obtained, although this is not always possible under dense tree canopies.

Database development and management

Data from selected trees is held within a database managed by a single research organisation to ensure upkeep of records. Ownership of the tree is of course retained by the landowner. In the past, many of the best trees have been removed as they fetch the highest prices. When a tree is added to the database, it is expected that it will not be felled in the near future, at least until seed can be procured or scion material held in a clonal gene bank.

The database for ash is held by the National School of Forestry, University of Central Lancashire, Newton Rigg (Figure 3). A technical report has been published (Clark and Wilson, 2003) which details plus-tree selection protocol in greater detail than described here and is linked to the database. For data protection reasons, the database is not available to the public, although copies of the report can be obtained from the authors. Databases for other hardwood species also exist (oak, birch and cherry). Details can be obtained, from the relevant species group of the British and Irish Hardwoods Improvement Programme (www.bihip.com).

Conclusion

The selection of plus-trees is the essential first step in the process of improving our hardwood resource. In the past, the best trees have been felled, leaving poorer individuals as founders of the next generation. These are the woodlands from which we select plus-trees today. By adopting tree breeding programmes, it is hoped that the quality of planting stock for future forests may be improved, so that we can restore a truly sustainable supply of quality hardwood timber in Britain.

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