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Developments and Opportunities in Broadleaved Tree Improvement

– a call for plus trees and sites

Joseph L. Beesley and **Jo Clark** review the progress at Future Trees Trust, discuss the opportunities of new broadleaved species and invite readers to identify plus trees and host trial sites.

Figure 1. Sycamore plus tree. A dominant individual with high amounts of recoverable timber. (Photo: Jo Clark).

Tree improvement is a crucial strategy to enhance the quality and resilience of British timber. It is primarily achieved through traditional selective breeding whereby individuals are chosen based on desired physical traits, such as form and vigour or disease resistance, and brought together to produce seed and investigate genetics. For timber production, these superior trees are known as plus trees and are dominant, healthy individuals with straight and circular stems, good apical dominance and light branching (Figure 1). At Future Trees Trust (originally called BIHIP: The British and Irish Hardwoods Improvement Programme) we work with a range of native and naturalised broadleaved species commonly planted for commercial forestry: ash, birch, cherry, oak, sweet chestnut and sycamore. We partner with landowners across Britain and plant: i) orchards to produce seed, ii) field trials to assess parental performance through progeny testing, iii) provenance trials to investigate adaptation, and iv) clonal archives to conserve genetic resources.

Producing improved seed

The principle output of a breeding programme is improved seed. Once plus trees have been selected, scion material can be taken, and young grafts planted together in clonal seed orchards (CSOs). The improved seed produced at these orchards is considered *qualified* by Forest Reproductive Material (FRM) standards and is of higher quality (in terms of growth and form) than seed from a registered stand (which may be classified as source

identified or *selected*). If the trees within a CSO have been proven to be of superior quality then the produced seed is described as *tested* – the highest category of FRM (Forestry Commission, 2019). Our central objective at Future Trees Trust is to ensure *qualified* or *tested* seed is available to foresters for all our target species.

To this end, we are producing *qualified* seed for the majority of these species from CSOs across the UK, many established in the last decade (Figure 2, Table 1). Silver birch (*Betula pendula*) plus trees are represented in five orchards; three composed of plus trees from southern Scotland and northern England, and two of plus trees from northern Scotland (which will start producing shortly). Provenance trials established by Forest Research in 2001 have recently shown that more southerly material grows faster, and suggested the inclusion of provenances 2 degrees latitude south of a planting site (Lee et al., 2015). In light of these findings, and to establish new CSOs in these regions, we are about to begin selecting plus trees in central and southern England. Downy birch (*B. pubescens*) plus tree selection has also begun and successfully grafted scion material collected in Scotland will form the first seed orchard providing *qualified* material for this species.

> "One of our biggest and most exciting projects over the last decade has been the establishment of the first oak clonal seed orchards in the country."

Between 2009 and 2016 we helped establish five large CSOs of sycamore (*Acer pseudoplatanus*), which are in production, and three of sweet chestnut (*Castanea sativa*), which will start producing shortly, to help meet the increasing demand for these fast-growing broadleaves. As with silver birch, concurrent sycamore provenance trials have helped to understand local adaptation and provenance selection for this species (Cundall, Cahalan and Plowman, 1998; Whittet, Lopez and Rosique-Esplugas, 2020). The genetic diversity within our sweet chestnut plus tree collection has been investigated as part of a nationwide study and found to be a good representation of the high diversity found in the British population (Jarman et al., 2019).

One of our biggest and most exciting projects over the last decade has been the establishment of the first oak CSOs in the country. Once producing, these orchards will supply much-needed British seed and reduce the reliance on foreign imports. There will be three orchards for each of the two species native to the UK – pedunculate oak (*Quercus robur*) and sessile oak (*Q. petraea*) – and we have begun planting four sites. While the geographic distribution of selected pedunculate oak trees is good, we need additional sessile oak plus trees to improve the genetic diversity in these three orchards.

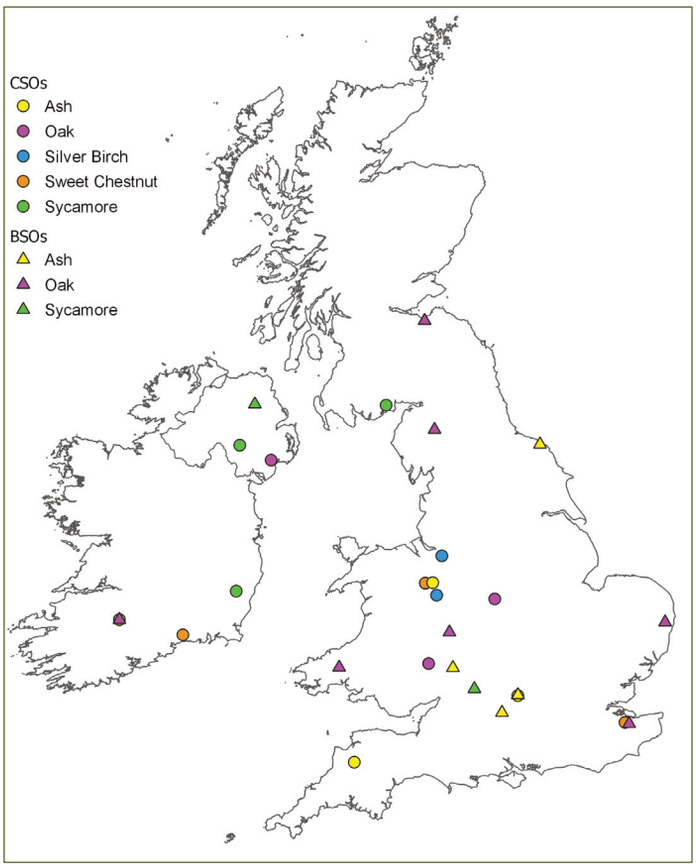

Figure 2. Map of the British Isles showing the location of Future Trees Trust's seed production sites: clonal seed orchards (CSOs; circles) and breeding seedling orchards (BSOs; triangles).

Table 1. Approximate timeframe of seed availability for Future Trees Trust target species.

Common name	Species	Time to *qualified* seed	Time to *tested* seed
Silver birch	*Betula pendula*	Available	20 years
Downy birch	*Betula pubescens*	5 years	
Sycamore	*Acer pseudoplatanus*	Available	20 years
Sweet chestnut	*Castanea sativa*	5 years	
Pedunculate oak	*Quercus robur*	15 years	10 years
Sessile oak	*Quercus petraea*	15 years	10 years
Cherry	*Prunus avium*	Available	

A summary of our current and projected seed production is shown in Figure 2 and Table 1. Our next steps involve expanding several of our existing CSOs and planting new orchards. We are currently selecting plus trees of silver birch in central and southern England, downy birch in Scotland and northern England, and sessile oak from across Britain (Table 2). We are also looking for sites of approximately 1ha on which to plant our final two pedunculate oak orchards.

Testing plus tree progeny

Alongside collecting graftwood for CSOs, the progeny of plus trees can be studied in field trials to investigate the genetic component of their superior characteristics. Poorly performing individuals can then be removed from the CSOs, improving the quality of the seed being produced and promoting their FRM status from *qualified* to *tested*. One type of progeny trial we frequently establish is the breeding seedling orchard (BSO) (Barnes, 1995). Here, plus tree progeny are assessed regularly for health, growth, form and timing of budburst and once completed can be thinned themselves to give additional *tested* seed orchards.

We currently have active progeny trials for oak, sycamore and ash (*Fraxinus excelsior*) (Figure 2). Planted in 2003, the eight oak BSOs continue to provide a detailed insight into family and species performance at highly varied sites across the British Isles. These trials will inform our selection of plus trees in the CSOs and then be thinned to leave the best families and function as small seed orchards. In time, both our BSOs and CSOs will start to produce the first ever *tested* British acorns available to forestry.

Two small sycamore progeny trials were planted in 2016 that will guide plus tree selection in the CSOs. Seed is currently being collected for a series of larger BSOs containing many more parent trees that will support the findings of the small trials, and can be thinned and managed as *tested* seed orchards.

Our work with ash has changed dramatically in the last decade. A series of BSOs was planted in 1993 and, after thinning, produced the first ever *tested* broadleaved British seed in 2012. That same year restrictions were implemented in response to the presence of ash dieback (caused by the fungus *Hymenoscyphus fraxineus*) in the UK and the seed could not be sold. Despite this misfortune, the BSOs have become a fantastic resource to investigate the disease and we have been working closely with partners (Forest Research, Earth Trust and Sylva Foundation) to locate and graft trees that show tolerance to ash dieback (Clark and Webber, 2017). We also lead the Living Ash Project with Forest Research, Fera and Royal Botanic Gardens, Kew to further characterise these individuals and create CSOs that will produce tolerant seed to restore devastated woodlands.

Along with the new sycamore trials described above, we are also collecting seed to establish progeny trials for silver birch. These BSOs will test the plus trees and promote seed from the CSOs from *qualified* to *tested*. We are currently looking for sites of 1-1.5ha in which to host either the sycamore or silver birch progeny trials.

With improved seed available for a number of target species we are also planning to establish demonstration plots across the country. These will be small trials of approximately 0.25-0.5ha that will visibly show the increased growth rate and better form of improved seed. We are looking to partner with landowners who would like host one of these plots.

> "We are interested in starting improvement programmes with currently underused species that could provide real economic opportunities for foresters."

Partnerships and strategies

There have been a number of important strategies written recently that bring together organisations to support research that utilises forest genetics. Of high importance is the National Tree Improvement Strategy (NTIS). Jointly written in 2017 by Confor, Forest Research and Future Trees Trust, this document details how organisations involved in broadleaved and conifer tree improvement can work in close partnership on shared challenges over the next 25 years.

In 2019 we worked with the UK Centre for Ecology and Hydrology, Forest Research, Woodland Trust and Royal Botanic Gardens, Kew to formulate a practical strategy for conserving the Forest Genetic Resources (FGR) of the UK (Trivedi et al., 2019). Through collaboration and communication, the strategy aims to guide the conservation and promote the value of our FGR. Both these strategy documents can be found on our website

Figure 3. One-year old sweet chestnut clonal seed orchard in Co. Waterford, October 2016. (Photo: Jo Clark)

www.futuretrees.org

Furthermore, we have developed an interactive, map-based platform that will facilitate this open attitude between organisations and countries. UK Forest Genetic Resources (www.ukfgr.co.uk) is a freely accessible database that contains information on all our orchards, trials and archives, and details of the research data that we have collected at each. We encourage other organisations to include their active field trials and hope to incorporate additional layers, such as Genetic Conservation Units, in the future.

Expanding the scope of hardwood tree improvement

Alongside the progress we are making with our core species, we are interested in starting improvement programmes with currently underused species that could provide real economic opportunities for foresters. These are species for which there are no breeding programmes in the UK and few or no registered seed stands, but a growing demand for their timber. They can also be planted to diversify woodlands and build resilience against potential new pests and diseases. Such demand is often met through the import of foreign material that may be maladapted to the British climate or act as a vector for disease.

We worked with the Woodland Trust and Forestart on the Sustainable Seed Source Project in 2015 to audit existing seed stands, identify species of future interest and locate potential seed stands for two of these species. Information on the distribution, stand availability and timber demand of 15 candidate species was collated and ranked. Aspen (*Populus tremula*), common alder (*Alnus glutinosa*), hornbeam (*Carpinus betulus*), small-leaved lime (*Tilia cordata*) and wild apple (*Malus sylvestris spp. sylvestris*) were considered the highest priority.

As many of these species have few or no registered seed stands, work was undertaken in 2016 and 2017 to identify potential new seed stands of small-leaved lime and hornbeam. After visiting 45 sites across England, 16 stands of small-leaved lime and 15 stands of hornbeam were recommended for registration. This is an essential step in improving the availability of seed for these lesser-used species. The next stage is to begin identifying plus trees for the five highest priority species listed above and we are asking for recommendations of good individuals or stands (Table 2).

Summary and next steps

At CSOs across the country improved seed is being produced for silver birch, sycamore, cherry and, in several years' time, for sweet chestnut (Figure 3, Table 1). To increase the genetic diversity within existing orchards and plant CSOs in new regions of the country we are selecting additional plus trees for silver birch, downy birch and

Table 2. Species and regions for which Future Trees Trust is selecting plus trees.

Common name	Species	Regions of interest	Purpose
Silver birch	*Betula pendula*	Central and southern England	Establish CSO for these regions
Downy birch	*Betula pubescens*	Southern Scotland and northern England	Establish first CSO
Sessile oak	*Quercus petraea*	Nationwide	Increase diversity within current CSOs
Aspen	*Populus tremula*	Nationwide	Begin improvement programme
Common alder	*Alnus glutinosa*	Nationwide	
Hornbeam	*Carpinus betulus*	Southern England	
Small-leaved lime	*Tilia cordata*	England & Wales	
Wild apple	*Malus sylvestris spp. sylvestris*	Nationwide	

sessile oak (Table 2). Progeny testing is ongoing for oak and sycamore (Figure 2), and we are collecting seed to establish new progeny trials for sycamore and silver birch. We are also looking for landowners who wish to participate in broadleaved tree improvement and host a pedunculate oak seed orchard (1ha), progeny trial (1ha) or demonstration plot (0.25-0.5ha). In the coming decade we are also expanding our research programme to include new species that could be hugely beneficial to British foresters. We are at the beginning of the improvement programme for these species and are looking for plus trees (Table 2). If the reader is aware of any high-quality individuals or stands of any of the species discussed in this article or is interested in hosting a trial or orchard, we would be very grateful if they could contact joe.beesley@futuretrees.org

References

Barnes, R. (1995) The breeding seedling orchard in multiple population breeding strategy. *Silvae Genetica*, **44**:81-87.

Clark, J. & Webber, J. (2017) The ash resource and the response to ash dieback in Great Britain. *Dieback of European Ash*, 228-237.

Cundall, E.P., Cahalan, C.M. & Plowman, M.R. (1998) Early results of sycamore (*Acer pseudoplatanus*) provenance trials at farm-forestry sites in England and Wales. *Forestry*, **71**:237-245.

Forestry Commission (2019) *Forest reproductive material: regulations controlling seed cuttings and planting stock for forestry in Great Britain*. Forestry Commission, Edinburgh, 1-33.

Jarman, R. et al. (2019) DNA analysis of *Castanea sativa* (sweet chestnut) in Britain and Ireland: Elucidating European origins and genepool diversity. *PLoS ONE*, **14**:1-26.

Lee, S.J. et al. (2015) Early height growth of silver birch (*Betula pendula* Roth) provenances and implications for choice of planting stock in Britain. *Forestry*, **88**:484-499.

Trivedi, C. et al. (2019) *A Strategy for UK Forest Genetic Resources*, Royal Botanic Gardens, Kew.

Whittet, R., Lopez, G. & Rosique-Esplugas, C. (2020) Mid-rotation variation in growth, form and phenology of sycamore (*Acer pseudoplatanus* L.) provenances in field trials in England. in preparation.

Further reading from the *QJF* archive

These articles can be accessed online by logging into the members' area of the RFS website, then following links to the *Quarterly Journal of Forestry*.

Clark, J. & Wilson, E. (2005) The importance of plus-tree selection in the improvement of hardwoods. *QJF*, **100**(1):45-50.

Clark, J. & Hemery, G. (2009) Outcomes from 15 years of hardwood research at the Northmoor Trust. *QJF*, **104**(3):212-219.

Clark, J. (2014) The Living Ash Project: A new breeding programme for ash. *QJF*, **108**(3):185-187.

Clark, J. & Fennessy, J. (2014) Oak breeding in the Netherlands. *QJF*, **108**(1):38-42.

Clark, J. (2017) Ash Trees for the Future? *QJF*, **111**(2):117-119.

Jo Clark is Head of Research at Future Trees Trust. She has over 30 years in forestry research, and leads the Living Ash Project, recently funded by Defra for a further five years.

Joe Beesley recently joined Future Trees Trust as Researcher after obtaining his doctorate in Biochemistry. He brings his experience in genetics and disease to forestry research.

Email: joe.beesley@futuretrees.org