

Benefits and Challenges For Gene Conservation: a View From The UK National Tree Seed Project¹

Clare Trivedi² and Simon Kallow²

Abstract

Trees and woodlands in the United Kingdom are currently subject to a range of threats including loss and fragmentation of native woodland and escalating pest and disease outbreaks. The largely unknown impacts of climate change pose a number of questions when considering afforestation and reforestation. There are frequent calls to develop resilient woodlands, robust enough to deal with these challenges but there is uncertainty over what this means in terms of species mixes and use of local provenance versus non-local planting material. Conserving and making appropriate use of the current genetic diversity of native trees and shrubs should be an important element for meeting these challenges. For this reason, the United Kingdom National Tree Seed Project was launched by the Royal Botanic Gardens, Kew in 2013. Multi-provenance seed collections are being made, and conserved in Kew's Millennium Seed Bank. These genetic resources will be made available for research and conservation activities, ultimately facilitating access to appropriate planting materials for afforestation and reforestation.

Introduction

With one of the lowest rates of woodland cover in Europe, the United Kingdom's woodland resource is significantly impoverished. Woodland covers 12 percent of land area, of which only about one third can be considered native woodland (Atkinson and Townsend 2011). United Kingdom woodlands are also highly fragmented, and some are poorly managed. These issues are complicated by the significant rise in pest and disease outbreaks over the past decade and uncertain future climate change scenarios. For these reasons, protection, restoration and creation of woodlands are widely proposed (DEFRA 2012, Forestry Commission Scotland 2009, Welsh Assembly Government 2009, Woodland Trust 2016). For example, in England it is proposed that woodland habitat be enhanced through sustainable management, restoring ancient woodlands, and expanding tree cover with appropriate species (DEFRA 2012).

Reports frequently refer to the need to develop 'resilient woodlands' able to withstand varied challenges, but there is debate about what this means in terms of the benefits of native versus non-native species, and the use of local versus non-local planting material. One specific issue, highlighted by the 2012 ash dieback (caused by the pathogen *Hymenoscyphus fraxineus*) breakout, is that for many years much planting material was brought into the United Kingdom from continental Europe (Russell and Evans 2004). While there is now an increasing demand for homegrown planting material of native species, the supply can be difficult to maintain (Forestart 2014).

At the heart of these complex and intertwined issues is the need to maintain and utilize the full genetic diversity of native woodland resource. Coordinated gene conservation programs seek to address such challenges by conserving a genepool of genetically diverse, locally-adapted material which can be used for breeding for required traits, such as disease resistance, and facilitating the supply of appropriate native planting material.

A national gene conservation program to conserve forest genetic resources in the United Kingdom does not yet exist. Given that United Kingdom shares most of its woody flora with European neighbors, taking action to conserve its' own genetic resources will contribute to the wider conservation of European genetic resources. The islands of the United Kingdom are at the limit of the natural distribution range for a number of species and so may contain unique elements of natural variation worthy of conservation.

¹ A version of this paper was presented at the Gene Conservation of Tree Species – Banking on the Future Workshop, May 16-19, 2016, Chicago, IL.

² Royal Botanic Gardens, Kew, Millennium Seed Bank, Wakehurst Place, Haywards Heath, UK RH17 6TN.
Corresponding author: c.trivedi@kew.org.

It is in this context that in 2013, the Royal Botanic Gardens, Kew launched its United Kingdom National Tree Seed Project (UKNTSP), in order to establish an *ex situ* gene conservation program for the United Kingdom forest genetic resource. The aim of UKNTSP is to establish multi-provenance seed collections which in total will represent the majority of adaptive genetic diversity present. These collections are intended to provide a resource for science and practical efforts to meet the challenges outlined above.

The UK National Tree Seed Project

Based at Kew's Millennium Seed Bank (MSB), the project has a 5 year initial workplan with the following purpose:

'To provide a national repository of plant material and associated knowledge, for the purposes of long term conservation, and to make these resources available to users, in order to better understand and manage tree and shrub species in the United Kingdom landscape'.

The project will deliver three outputs by March 2018:

1. Establishment of an accessible, genetically representative, national seed collection of United Kingdom trees and shrubs.
2. Research to understand and overcome constraints to the *ex situ* conservation and use of United Kingdom tree species.
3. To raise public awareness of the project, and the role of *ex situ* conservation in general, to meet the challenges facing the conservation and management of United Kingdom trees, woods and forests. This output will not be discussed further in this paper.

Output 1

A detailed account of the process for developing the project's target species list and sampling strategy is provided in Kallow and Trivedi (Collecting genetic material on a small island, these proceedings). In summary, a list of 70 native taxa were chosen as target species, based on a scoring system that took into account tree health risks, conservation status, and prevalence in the landscape. Species which are prevalent in the landscape were scored highly to reflect the likely greater impacts of their loss.

Tree seed zones had already been developed for the United Kingdom (Herbert et al. 1999). In the absence of species-specific genetic knowledge, these biogeographic zones were adopted by the project to provide a framework for the establishment of seed collections that represented the majority of adaptive genetic variation in Britain for each target taxon. It was decided to ensure at least one collection was made within each seed zone in the native distribution of each targeted taxon, with collections at both high and low elevation where populations are present above 300 m above sea level. Botanical records, provided by the Botanical Society of Britain and Ireland, were mapped against the seed zones, leading to an initial list of 946 target collections. Over time, desk studies and ground-truthing reduced this target list to 663, illustrating the importance of both local and species-specific knowledge when planning seed collecting.

In order to meet the ambitious targets with limited resources, seed collecting is being carried out by more than 30 governmental and non-governmental agencies, and many trained volunteers. Guidance for tree seed collecting typically advocates the collection of 30 to 60 genetically distinct individuals (e.g., OECD 2013, Thomas et al. 2014) from a population. The highly fragmented nature of United Kingdom woodlands means it is rarely possible to meet such expectations. Collectors must then consider making collections from dispersed sites across a seed zone. Furthermore, the project is seeking several thousand seeds per collection, collected from across the canopy of each mother tree, in order to capture the genetic diversity associated with a range of fathers. Such seed collecting is extremely time consuming. Our experience shows a team of four can generally collect from a maximum of 15 trees in one day.

Seed from individual mother trees is stored separately as this will allow heritability estimates to be calculated for important adaptive traits. Each mother tree is geo-referenced and tagged. As of July 2016, 465 collections have been made, achieving 278 collecting targets.

Output 2

Output 2 seeks to identify and overcome constraints to seed banking the United Kingdom native woody flora. It is split into 2 parts:

2.1: Studies to better understand the population genetics of United Kingdom species and how to sample and use collections.

The project adapted a desk-based decision tree approach to identify what is known about the genetic structure and diversity of the target species (Neaves and Hollingsworth, personal communication). Overall, this approach confirmed there is not enough fine detail known at the United Kingdom level to inform species-specific sampling strategies. However, it did identify priority species for future studies such as *Juniperus communis* and *Taxus baccata*.

2.2: To identify and overcome constraints to the storage and germination of the United Kingdom woody flora.

Literature reviews and viability data from MSB collections were used to identify potential constraints and solutions. This assessment indicated there are few significant constraints to seed-banking, with the exception of *Quercus* species, which are recognised as recalcitrant.

To date, germination protocols are established for 64 target species, and these will be made publicly available. Studies are identifying species likely to be short-lived in conventional seed bank conditions, and these are prioritized for cryopreservation in order to ensure their long term availability. Particular attention is being paid to developing collecting and processing protocols for the Salicaceae to enable optimal storage of this difficult family. Studies to optimize seed maturity at the time of collection are planned for *Fagus sylvatica*.

Benefits and Challenges for the UKNTSP

The UKNTSP collections will conserve a representation of the genetic diversity present in the United Kingdom woody flora at this point in time. The collections will be available for a wide range of research studies, many of which we cannot anticipate at present. They will allow future researchers to understand changes that occurred due to climate change and disease and pest events which may change the composition of the United Kingdom genetic resource. Through its gene conservation approach, the UKNTSP can also make a significant contribution to meeting the contemporary challenges outlined previously.

Some of the seed collecting sites found by the UKNTSP could be suitable for exploitation as registered seed sources. This could facilitate an improved commercial supply of planting material of known provenance for afforestation and reforestation.

Furthermore, the project is enhancing skills and knowledge in tree seed collecting and storage. It is also raising awareness of issues of genetic diversity and seed quality. So, alongside commercial supply chains, a culture of high quality seed collecting and use of appropriate genetic material is developing among many non-government organizations who lead United Kingdom habitat management.

For several species, collecting directly from seed sources is unlikely to be efficient, either because sufficiently large native stands simply do not exist or they rarely produce seed (Karen Russell, personal communication). The UKNTSP collections could provide the founder stock for establishing seed orchards. For some species, an option would be to screen collections for traits such as disease resistance, ultimately aiming for the development of disease resistant seed orchards to supply material for reforestation of areas decimated by pests or disease.

The UKNTSP collections also provide useful material to better understand how to adapt United Kingdom woodland conservation and management to climate change. They are an ideal source of experimental material for provenance trials to measure the performance of materials from different seed sources across different parts of the United Kingdom. Of particular importance are adaptive traits such as drought resistance. Collections of known provenance from across the United Kingdom will also be useful for studies of seed physiology in support of natural regeneration of populations. Examples include

understanding gradients in seed viability, and varying requirements for cold stratification before germination.

Finally, the collections will be available for wider studies to better understand the interactions of trees with pests and diseases, which in turn will provide management solutions. For example, the seeds could be used to assess the efficacy of new treatments or preventive measures and the impact of these on related and associated species.

These likely benefits of the collections mostly fall outside the scope of the project itself. It is incumbent on the project staff to engage constructively with a wide range of researchers, foresters and conservation agencies to ensure the resource is used to its fullest advantage and sits within a coherent wider gene conservation framework. The key challenge remaining for the project team is to ensure the collections are sufficiently large and genetically representative to meet the needs of users. We need to make the best use of available resources to collect enough seed from sufficient trees to ensure the collection is representative of the adaptive genetic diversity contained by the United Kingdom native forest resource, and that it meets the needs of those who will use it in the future.

Acknowledgments

Funding for the UKNTSP has been kindly provided by the players of People's Postcode Lottery. Thank you to Kevin Potter, Joan Cottrell, Karen Russell and Roberta Garguila for comments on drafts of this paper.

Literature Cited

- Atkinson, S.; Townsend, M. 2011.** State of the UK's forests, woods and trees: perspectives from the sector. Lincolnshire: Woodland Trust. 98 p. <https://www.woodlandtrust.org.uk/mediafile/100229275/stake-of-uk-forest-report.pdf?cb=58d97f320cab43d78739766e71084f76>. (11 May 2017).
- Department for Environment, Food and Rural Affairs [DEFRA]. 2012.** The Independent Panel on Forestry: final report. <https://www.gov.uk/government/publications/independent-panel-on-forestry-final-report>. (11 May 2017).
- Forestart. 2014.** FRM registered 'selected' seed stand audit commissioned by Forestry Commission England undertaken by Forestart Limited. <http://www.futuretrees.org/files/uploads/FTT-seed-stand-audit-Stage-1-report-V2.pdf>. (11 May 2017).
- Forestry Commission Scotland. 2009.** The Scottish government's rationale for woodland expansion. <http://scotland.forestry.gov.uk/images/corporate/pdf/ForestExpansion.pdf>. (11 May 2017).
- Herbert, R.; Samuel, S.; Patterson, G. 1999.** Using local stock for planting native trees and shrubs. Forestry Commission Practice Note 8. Edinburgh: Forestry Commission.
- Organisation for Economic Co-operation and Development [OECD]. 2013.** OECD guidelines on the production of forest reproductive materials. <http://www.oecd.org/tad/code/forestreproductivematerial.htm>. (11 May 2017).
- Russell, K.; Evans, K. 2004.** Nursery survey report 2003 – report for participating nurseries, August 2004: to identify the problems experienced by the nursery industry in sourcing and providing local stock of native trees and shrubs. Kent: EMR. 17 p.
- Thomas, E.; Jalonon, R.; Loo, J.; Boshier, D.; Gallo, L. [et al.]. 2014.** Genetic considerations in ecosystem restoration using native tree species. *Forest Ecology and Management*. 333: 66–75.
- Welsh Assembly Government. 2009.** Woodlands for Wales: the Welsh Assembly Government's strategy for woodlands and trees. <http://gov.wales/docs/dra/publications/090324-woodlands-for-wales-strategy-en.pdf>. (11 May 2017).
- Woodland Trust. 2016.** www.woodlandtrust.org.uk. (11 May 2017).