

A close-up photograph of tree catkins and leaves. The catkins are yellowish-green and elongated, hanging from a reddish-brown branch. The leaves are green and have a serrated edge. The background is a soft, out-of-focus green.

A Strategy for UK Forest Genetic Resources:

protecting the UK's unique diversity
of trees and shrubs

This strategy has been developed following two workshops on UK Forest Genetic Resources hosted by the Royal Botanic Gardens, Kew at the Millennium Seed Bank.

A wide stakeholder consultation was also carried out as part of the drafting process.

Full workshop reports, including lists of all attendees and are available at kew.org

- | | |
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Organisations that have endorsed this strategy



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Cover image: *Alnus glutinosa*, RBG Kew

Ministerial foreword

Trees and woodlands provide us with a wide range of benefits from improving human health and well-being, to supporting wildlife, absorbing carbon and delivering timber and other products. While most of us value these goods and services, the key role of genetic diversity for their ongoing provision is less widely appreciated.

Genetic diversity among individuals and populations allows tree species to adapt and evolve so that they are more likely to survive under the changing environmental conditions of our current times. Understanding and protecting genetic diversity also maintains more options for society to select and develop trees to provide different products or services in the future.

It is easy to imagine, for example, that we might be interested in trees with an ability to survive drought or to be tolerant to pest and diseases, or maybe to remove contaminants in soils or accumulate precious minerals. It is likely our trees harbour other traits that we have not yet even recognised as useful. This strategy for UK Forest Genetic Resources focuses attention on the populations of trees and shrubs that are uniquely adapted to UK growing conditions and the need to understand better, conserve and use them.

The publication of the strategy is the result of over two years of collaboration and consultation across a range of agencies and stakeholders involved in forestry, biodiversity conservation and woodland management across the UK. It fulfils a key achievement under Action 11 of the Tree Health Resilience Strategy published by Defra in May 2018 in encouraging diversification (including species and structural) and promoting processes that underpin genetic adaptation and resilience but this is just the start.

The Government strongly supports this initiative and looks forward to working with all the agencies and stakeholders involved to develop an action plan and for the implementation of the strategy which will manage better the genetic diversity in the UK's trees.



Lord Gardiner

Parliamentary Under Secretary of State for Rural Affairs and Biosecurity



The Strategy

The ability of UK woodlands and trees to meet present and future societal and environmental challenges depends on the availability of genetic diversity between and within tree species.

Within species, genetic diversity is the variation among individuals and populations, and it is needed to ensure that tree species can survive, adapt and evolve under changing environmental conditions and are resilient to stresses such as novel pests and diseases. Protecting genetic diversity also maintains the broadest possible options for future tree breeding, including the potential to develop traits that are not currently deemed to be important. Yet this vital genetic resource is poorly understood, undervalued, and threatened by direct and indirect human impacts. Whilst various efforts are underway to address these challenges, progress to date has been patchy, on a relatively small scale and insufficiently joined up or compatible in approach.

The objectives of this Strategy are to:

- catalyse collaboration for new research and better understanding of UK FGR
- guide *in situ* and *ex situ* conservation of UK FGR
- promote the value of UK FGR and support wider initiatives to make use of them

We aim to achieve these through working together to coordinate activity across the UK, developing a framework that encompasses current activities, identifies knowledge gaps, initiates new collaborations and helps to establish new research and conservation.

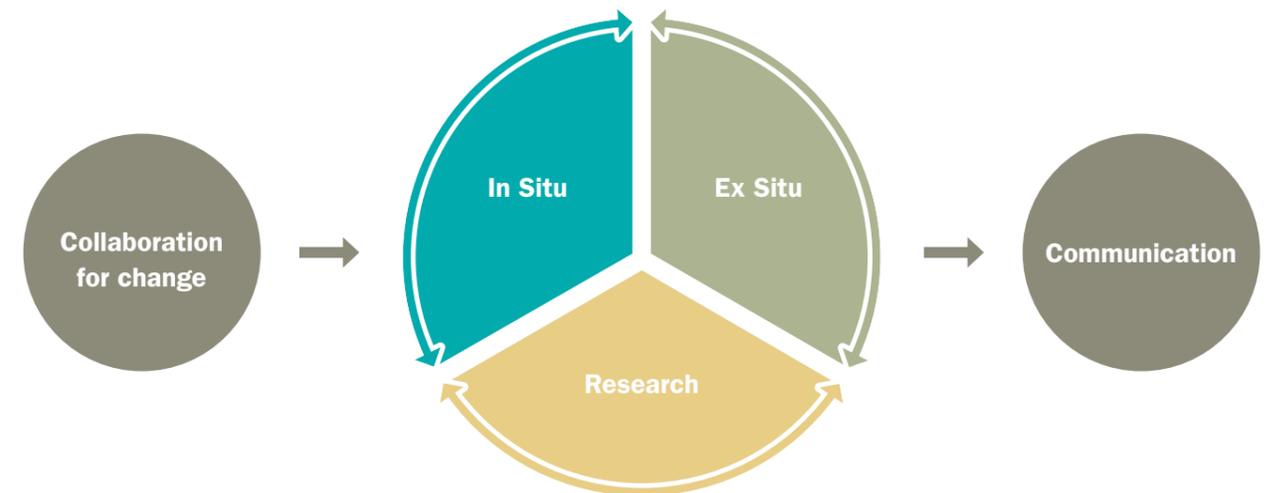
An Action Plan will be developed comprising the following elements:

- 1) Collaboration for change;
- 2) Communicating the value of UK FGR and promoting its use;
- 3) New research and coordination of existing knowledge on UK FGR;
- 4) *In situ* conservation via Gene Conservation Units; and
- 5) *Ex situ* conservation.

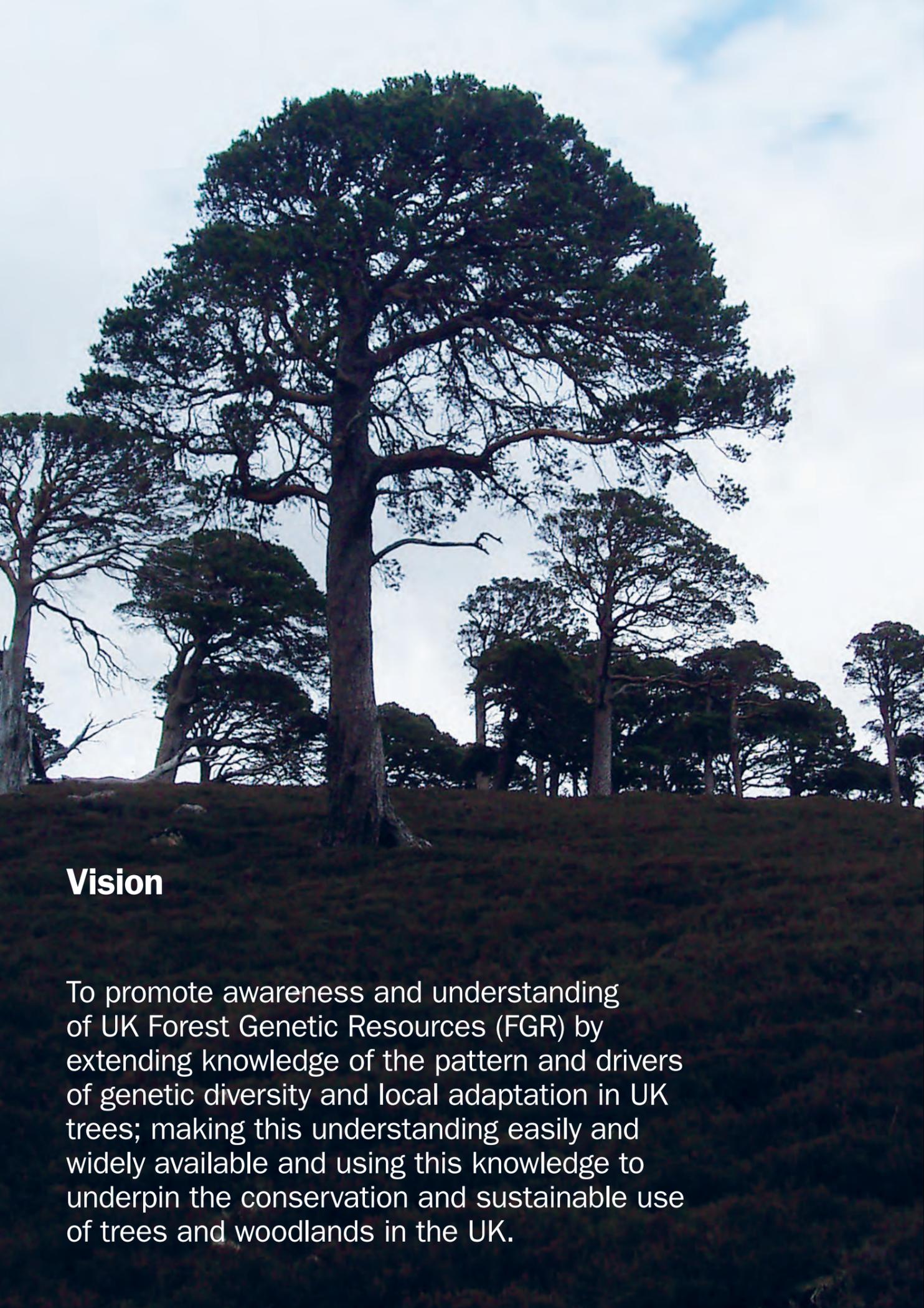
The Strategy will be linked to, and supportive of, other actions to protect and use UK FGR and to optimise resilience of UK woodlands and trees in the landscape.

This Strategy aims to create a framework for collaboration to better understand, protect and use the genetic diversity in the UK's trees. It focuses on native species and introduced species where naturalisation has taken place or where important varieties or landraces have been developed in the UK. For ease of reference, we refer to such material as UK Forest Genetic Resources (UK FGR) throughout this document.

This scope will allow activity to focus on genetic diversity that is adapted to UK conditions, especially that which is unique to the UK.



Young Hazel leaves, RBG Kew



Vision

To promote awareness and understanding of UK Forest Genetic Resources (FGR) by extending knowledge of the pattern and drivers of genetic diversity and local adaptation in UK trees; making this understanding easily and widely available and using this knowledge to underpin the conservation and sustainable use of trees and woodlands in the UK.

Background

What are Forest Genetic Resources and why are they important?

Biological diversity, or 'biodiversity', is the variability among all living things and the ecosystems that they inhabit. It includes variation within species, between species and of ecosystems. The conservation and appropriate use of biodiversity is essential for sustainable development because human societies depend on the goods and services provided by biodiversity.

A particularly important aspect of biodiversity is the genetic material that is used by people or has potential value for human societies. These are known as Genetic Resources and include all living material that contains functional units of heredity such as living plants, seeds and propagules, tissue cultures and DNA samples. Those genetic resources that come from trees and other woody plant species are described as Forest Genetic Resources (FGR). They are crucial to the adaptation, evolution and protection of our ecosystems, landscapes and production systems and provide essential natural capital for benefits such as wood fuel, timber, carbon capture, soil and air quality protection, and recreation.

The ability of woodlands and trees to meet present and future societal, economic and environmental challenges depends on genetic diversity within tree species. Genetic diversity provides the potential for tree species to survive, adapt and evolve under changing environmental conditions and to be resilient to stresses such as novel pests and diseases. Furthermore, genetic diversity provides the building blocks for tree improvement and breeding to produce new varieties or to strengthen useful traits including those involved in pest and disease resistance. As we face the uncertainties of a changing world, genetic diversity will be essential to secure our forests and trees in all their roles when new challenges or opportunities emerge, and if different traits become desirable or necessary for survival.

Global and European context

Internationally, FGR have been recognised as a target for conservation action. The Convention on Biological Diversity commits states to reduce pressure, promote sustainable use, and improve the status of their biodiversity, explicitly including genetic diversity. More specifically, the Food and Agriculture Organisation's Global Plan of Action on Forest Genetic Resources, which aims to improve understanding, conservation and use of these resources, sets out an agreed list of strategic priorities.

Across Europe, there is a collective effort to organise knowledge on the genetic variation in Europe's trees. EUFORGEN is a network that coordinates the characterisation, documentation and protection of distinctive 'genetic units' within Europe's tree species under the umbrella of FOREST EUROPE, a ministerial-level, pan-European collaboration on sustainable management and protection of forests. EUFORGEN plays an important role in raising the profile and stimulating debate about the nature and value of FGR and how to protect them.

Although the UK played a leading role in the initiation and development of the EUFORGEN network and in the establishment of agreed minimum criteria for designation of *in situ* gene conservation units (GCUs), it has been slow to identify and register any GCUs of its own. Establishment of these GCUs is vital to support coordinated protection of genetic diversity in Europe's tree species at a range-wide scale, to which the UK brings a unique contribution due to its northern oceanic climate and island character.

Understanding and conserving UK FGR: current status and what is required

The UK is home to a range of native, non-native and naturalised tree and shrub species that have adapted in various ways to their growing environments. Some of this genetic diversity has evolved naturally over generations as species have adapted at a fine scale to local conditions. In other cases, diversity is the product of deliberate efforts over many years to develop varieties that are productive in UK conditions, such as the Sitka spruce lines. However, for most species, the distribution and spatial structure of genetic variation is currently poorly understood and lacks a coherent management strategy.

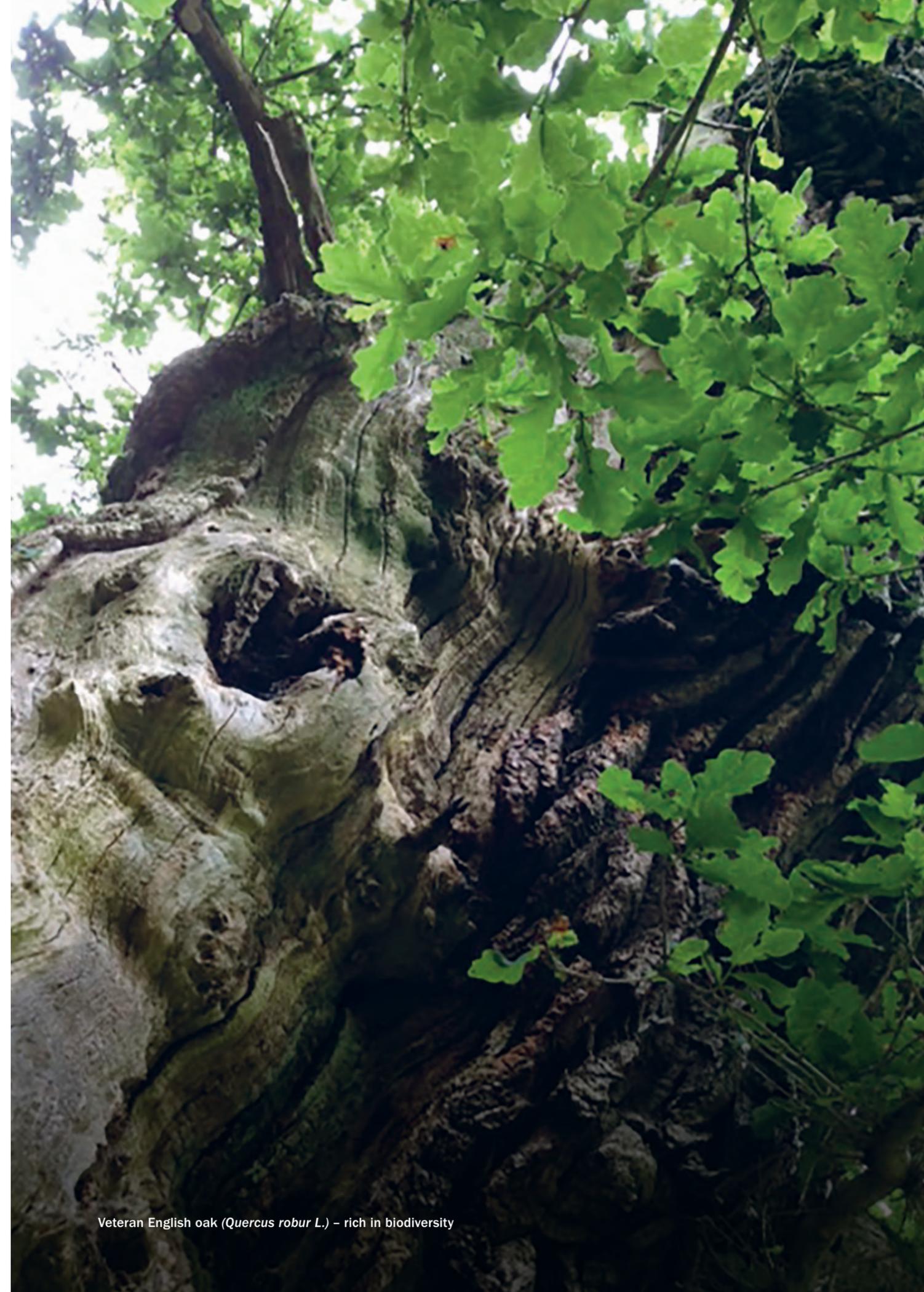
Environmental factors, like climate, soils and pathogens vary widely across the UK. We know that adaptation to distinct local combinations of these factors results in genetic differences in the trees that grow in different places. Currently, we do not have a comprehensive picture of which of these factors are the most important, at what spatial scale local adaptation operates, or how these patterns vary among species. Similarly, we know generally that gene dispersal, through pollen and seed, is a vital process for maintaining genetic resources but we do not know precisely how genetically connected our tree populations are and how this interaction varies over time, for example among climatically different years.

Effective protection of FGR will need both *ex situ* and *in situ* action. For the former, the UK National Tree Seed Project, led by the Millennium Seed Bank, Royal Botanic Gardens Kew, has established extensive collections of seed from our native tree species. Separately, Forest Research, Future Trees Trust and Earth Trust, as well as several private companies, have established provenance and progeny trials, and clonal seed orchards for some broadleaved and conifer species. Coordination and extension of *ex situ* activities is needed in order to develop an integrated genebank of UK FGR and ensure it is genetically comprehensive and accessible to users.

Also, some key problems have yet to be solved, for example options for recalcitrant seed of species such as oak are needed. More urgently, *in situ* conservation is lagging well behind the *ex situ* efforts. To date, few GCUs have been designated to manage genetically distinctive living stands of target species in the UK.

Currently, there is no comprehensive formal policy specific to FGR in the UK, although several related policies are in place or planned. From a forestry perspective, sustainable forest management is guided by the UK Forestry Standard, a comprehensive, cross-government framework that sets out standards and requirements as well as monitoring and reporting procedures. Other advice is provided in specific policies, for example the new 'Action Plan for Climate Change Adaptation in forests, woods and trees in England', delivered by the Forestry Climate Change Working Group. Initiatives on tree improvement and breeding have been brought together under the recently agreed National Tree Improvement Strategy, whilst new measures to manage and enhance the supply of UK-origin forest reproductive material are in development. From a conservation perspective, policy is shaped by the international Convention on Biological Diversity's 'Strategic Plan for Biodiversity 2011-2020' and its 'Aichi Targets'. Conservation policy and legislation are devolved matters and country-level biodiversity strategies apply, although they are linked by the 'UK post-2010 Biodiversity Framework'. Each nation in the UK has also developed strategies for managing risks associated with pests and diseases, which often refer to the need to manage UK FGR, such as DEFRA's Tree Health Resilience Strategy 2018.

Throughout these initiatives, genetic diversity is recognised as needing protection, however in practice this has remained largely an aspiration. A national strategy to support these initiatives is needed to promote understanding and conservation of UK FGR and to promote their use in tree planting of all types.



Veteran English oak (*Quercus robur L.*) – rich in biodiversity



Investigating adaptation to climate change in a beech (*Fagus sylvatica L.*) provenance trial

Key Elements of the Strategy

Collaboration for change

Current Situation: There are many individuals and organisations working to better understand, conserve and use UK FGR. They range from individual academic research studies to large projects such as the UK National Tree Seed Project and initiatives such as the National Tree Improvement Strategy. However, these efforts are not currently co-ordinated or set within a single unifying framework.

In order to deliver the aspirations of this strategy a UK FGR Steering Group will be established to act as a central reference point and forum for discussion, and to oversee development of the Strategy and delivery of its action plan. This Group will also work to ensure that the Strategy will align with wider efforts to manage UK FGR, such as the UK Forestry Standard, the FRM register, the National Tree Improvement Strategy and the Biodiversity Strategies.

Aspiration: Create and maintain a steering group to co-ordinate activities and facilitate collaboration in order to achieve the objectives of the UK FGR Strategy.

Communicating the value of UK FGR and promoting its use

Current situation: There is low awareness and little promotion of the need to characterise and conserve FGR in the UK. Although tree breeders are already making use of genetic variation to produce trees with good vigour, timber quality and elevated resistance to pests and diseases, beyond this community there is much lower awareness of the potential to make use of genetic diversity to support resilience in our forests. For forests planted with production objectives and for those planted with alternative aims there is much to be gained from better understanding of UK. It is a priority to raise awareness of the value and risk to UK FGR, the importance of research to understand UK FGR and the benefits of *in situ* and *ex situ* conservation.

Aspiration: create an outreach programme that will promote the value of UK FGR and efforts to understand, protect and manage them. Support wider initiatives to make full use of UK FGR in tree planting. Highlight the need for new research and funding.

New research and coordination of existing knowledge on UK FGR

Current situation: For most UK tree species, there is little or no hard information on the extent of genetic diversity, the scale and drivers of local adaptation or the patterns and processes of gene movement in the landscape. Where knowledge exists, it is often fragmentary, based on incomplete sampling, obtained using different tools and study designs, and poorly archived. For good reasons, much previous work has been driven by commercial production objectives and as a consequence, generally does not consider other adaptively-important variation that doesn't fit a production forestry profile. As a matter of urgency we need to collate existing knowledge, promote the case for new research, and provide the means to present and make accessible all available data.

Aspiration: Highlight knowledge gaps and stimulate new primary research: to determine the amount, spatial pattern and main drivers of genetic variation within tree species from a molecular and phenotypic point of view; to predict patterns of genetic diversity by relating spatial variation in climate and other factors to genetic adaptation; and to characterise mechanisms and scale of gene movement in diverse landscapes. Establish an on-line resource collating and providing easy access to knowledge on UK FGR.

In situ conservation

Current Situation: Due to the extensive historical deforestation of the country, many UK tree species persist as single trees or small, semi-natural, fragmented populations. However, research indicates that many extant populations are likely to have persisted *in situ* for long periods of time, some since the initial post-glacial colonisation, and show adaptation to local conditions at various spatial scales. To varying extents, these locally adapted units represent distinctive genetic diversity that merits protection, but to date few *in situ* GCUs have been designated in the UK according to the EUFORGEN process. Such units would complement existing efforts to maintain genetic diversity throughout the landscape, as outlined in the UK Forestry Standard. Formal establishment of UK GCUs within the EUFORGEN network would also contribute to range-wide genepool conservation for our tree species and allow recognition and evaluation of the distinctiveness of UK genetic variation within a wider European context.

GCUs are simply woodlands, identified as being representative of distinct genetic variation for a particular species, in which dynamic conservation is a primary management objective. Dynamic conservation is a regime that, alongside other management objectives, aims to permit adaptive change within species. Declaring a woodland as a GCU does not prevent other uses, such as timber production, so a wide range of forest types can be considered for designation. However, there should be an undertaking to monitor the units to assess regeneration and population size every five to 10 years to spot early signs of decline, and to allow comparison with GCUs elsewhere in Europe.

Both research and *ex situ* conservation activities can guide the identification of appropriate sites for GCUs, and to support wider management of UK FGR across the landscape.

Aspiration: Using the UK's existing network of protected sites as a starting point, establish a dynamically managed and directly characterised set of GCUs for UK FGR that conform to the EUFORGEN database entry criteria in order to conserve genetic diversity in the landscape whilst allowing tree populations to evolve and adapt to changing conditions.

Ex situ conservation

Current Situation: *Ex situ* conservation plays a complementary role to *in situ* conservation by safeguarding genetic diversity away from the risks it encounters in the landscape, and by making it easily accessible for research and conservation. A significant proportion of native UK FGR has been captured through the UK National Tree Seed Project (UKNTSP) and through tree improvement programmes and their associated provenance and breeding trials. Further material exists as living collections in botanic gardens and arboreta, in clone banks, in tissue culture and in DNA banks. Seed orchards might also be viewed as *ex situ* conservation collections in some cases. Some significant gaps remain, such as the *ex situ* conservation of oak, horse chestnut and sweet chestnut which do not tolerate the drying conditions applied during standard seed banking operations.

Aspiration: An integrated and genetically comprehensive genebank for UK FGR including seed banking, cryopreservation, clone banking and living plant collections, as appropriate. The collections and associated field data, seed viability data and propagation protocols to be easily accessible and widely used for research and conservation.



Collecting seed for the UK National Tree Seed Project, RBG Kew

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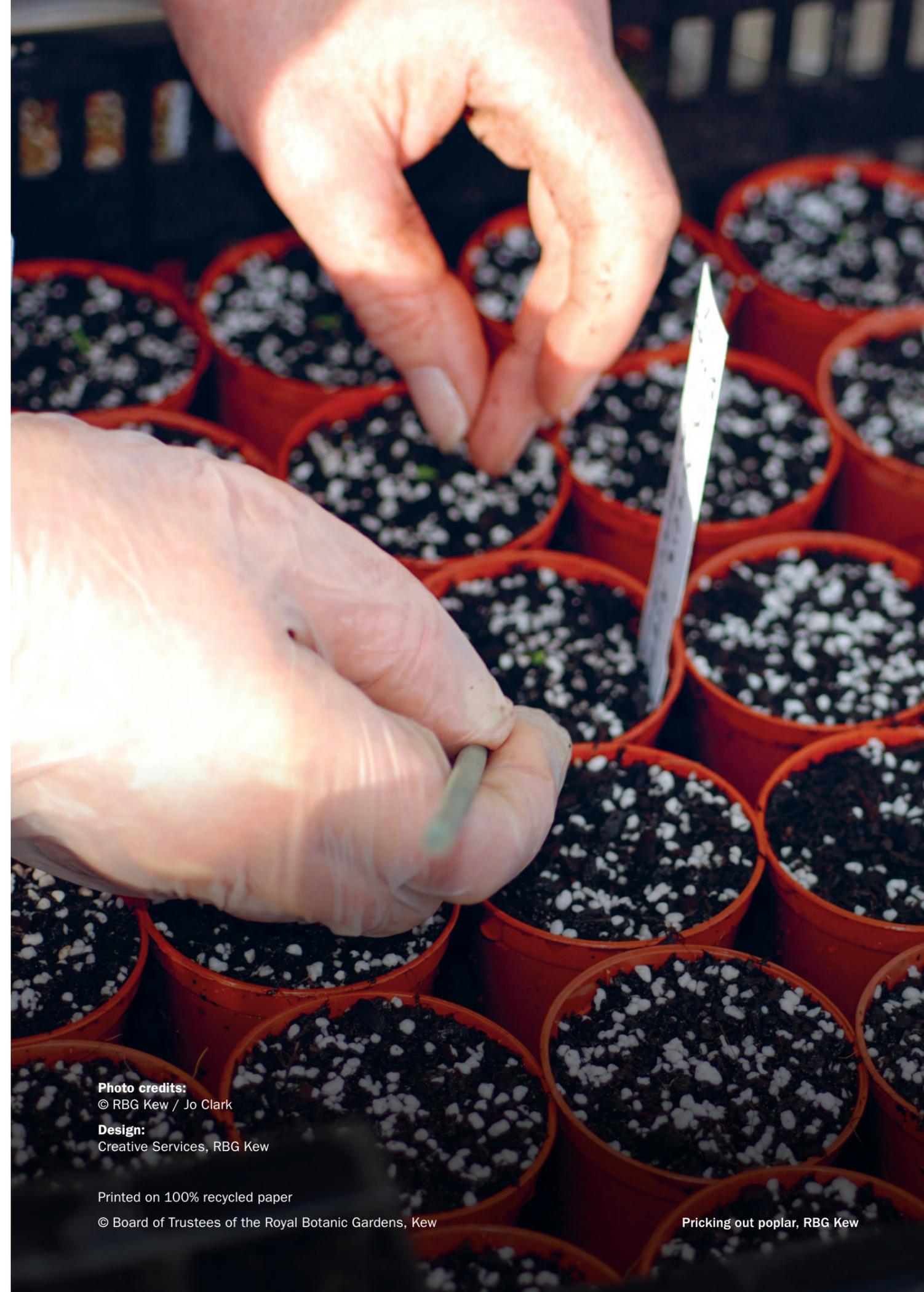


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Pricking out poplar, RBG Kew

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