Policy Advice Note - Genetic considerations for provenance choice of native trees under climate change in England

1. Background and objectives

Government, conservation bodies and the commercial forestry sector are committed to protecting, enhancing and expanding the resource of woods, trees and forests for the multiple benefits they provide, and doing so under conditions of a changing climate and increasing pest and disease threats. For a considerable time now, the Forestry Commission has advocated 'the right tree in the right place' as a standard philosophy for tree planting, but how should this be interpreted when adapting to future environmental and climatic conditions? A variety of views have been expressed upon discussion of this topic, particularly concerning appropriate provenance selection for native woodland planting. A lack of knowledge of the evidence-base underpinning those views has become apparent and, as a response, the Forestry Commission, Natural England and the Woodland Trust commissioned a report '*Genetic considerations for provenance choice of native trees under climate change in England*' from Forest Research during 2018 to answer the research question: What is the evidence around provenance choice and adaptation to climate change when planting native woodland?

2. Approach and methods

The report identified, collated and analysed the available evidence to determine if using different provenances of native tree planting stock confers an adaptive advantage. A clear and concise explanation of tree genetics and adaptation, as presented in the report, provides clarity of understanding of the evidence and highlights particular areas requiring further research. However, the report only indirectly addresses the related issue of whether new native woods and trees should be established by planting or by natural regeneration to confer greater adaptive advantage. Natural England, the Woodland Trust and other conservation bodies frequently promote natural regeneration as the preferred mechanism for establishment, wherever feasible. The report does not compare the adaptive qualities of planted material with natural regeneration; rather, its explicit focus is upon planting material, and contrasting adaptation to projected climate change of more southerly provenance with local provenance. In addition, the evidence is drawn solely from tree provenance performance in different situations and does not extend to a consideration of the ecosystem impacts of alternative provenance choices. The Forestry Commission, Natural England and the Woodland Trust have used this body of evidence to review existing policies and to inform this Policy Advice Note on suitable actions for those seeking to build resilience to climate change into their woods and other tree planting situations.

3. Key findings

- Genetic variation in populations of trees is very high, typically exceeding the variation between populations.
- Different populations within a species show adaptive differences as a result of generations of spatially variable natural selection. Factors causing adaptive genetic variation can include temperature and precipitation regimes, and local pest and pathogen pressures.
- The geographical pattern of adaptive variation varies among species and among traits within species.

- The effect of site is often larger than the effect of provenance. This reflects phenotypic plasticity, the ability of trees to modify their phenotype[1] *in situ*.
- Provenances transferred from warmer to colder environments often show greater early vigour than local provenance, although survival and stem form can be compromised if the transfer distance is too large or if transfer is made from an area with a continental climate.
- Local provenance often shows average growth due to conservative adaptation to the local growing season and, consequently, can be hardier than provenances transferred from warmer environments.
- Stressful growing environments can produce results which contrast with expectation, revealing or exposing puzzling or cryptic genetic variation. This is when individuals and populations which do not differ greatly in the absence of stress produce very different phenotypes under conditions of stress.
- The evidence-base is incomplete, especially for the less widely planted native species, so any conclusions should recognise this limitation.

4. Key recommendations

Maintaining genetic variation in our tree species is important; we don't know with certainty the environmental pressures our trees will face, but the greater the variation, the more likely it is that populations are able to survive and even thrive in the new and changing conditions.

Natural selection, via natural regeneration, is important and can drive site-based adaptation. If there is very limited natural regeneration, for example due to a lack of seed trees or grazing and browsing impacts, then adaptation will not take place. If these issues cannot be addressed, then appropriate tree stock will need to be brought in to help drive site-based adaptation.

Planting appropriate southerly provenance is a valid choice for maintaining and enhancing timber production, but is not proven for enhancing resilience by increasing the genetic diversity on site, since most tree populations are already genetically diverse. There is some evidence that shows reduced susceptibility to drought but also an increased frost risk from some more southerly choices.

The projected rate of climate change we are facing is unprecedented; there is a risk that natural selection processes may not be able to keep pace with environmental change. Consequently, management interventions may need to be more frequent to enable more natural regeneration, or to make use of assisted migration[2] where this is shown to be effective and meets the management objectives.

A "portfolio approach" (for example, using natural regeneration, local planting stock, and planting stock from appropriate, more southerly provenances), using species matched to site characteristics and managers' objectives could help to spread the risks associated with making any one provenance choice and increase the likelihood that some trees will thrive.

On sites of high biodiversity interest, for example ancient woodlands or SSSIs, we do not know from this work whether there are unintended negative consequences of using assisted migration (for example biosecurity breaches or mismatched phenology issues), as ecosystem interactions have not been a part of this research. Care also needs to be taken not to bring additional material onto sites which have unique genotypes from a long period of genetic isolation where this is important from a conservation perspective.

We do know that selective pressures on sites will mean that any unsuitable material brought in through planting will usually fail before it reaches reproductive age; limiting the amount of any non-local provenance stock to only a small proportion addresses this risk.

[1] The physical and biochemical characteristics of an organism as determined by the interaction of its genetic constitution and the environment.

[2] Introducing provenances from more southerly regions in anticipation of climate change.