Institution: The University of Edinburgh

Unit of Assessment: UoA5: Biological Sciences

Title of case study:

10. Tree seeds are sourced from local, adapted populations to improve the health of woodlands.

1. Summary of the impact

Impact on public policy and services: The use of well-adapted sources of forest tree seed for planting in the UK is embedded in native woodland planting policy. This policy is enforced through payment of planting grant only when appropriately adapted seed is utilised.

Impact on the environment: The new native woodland derived from locally adapted stock is not only more likely to show increased establishment, but also to be more resilient to native and introduced diseases.

Impact on commerce: 67% of native woodland seed is now locally-sourced, representing £4 million of the total trade of £8.2 million in British native trees.

Beneficiaries: Woodland owners and seed suppliers in the UK, who have an interest in ensuring maximum establishment and long-term tree health. Populations of wild animals reliant on the health of woodlands. Society as a whole benefits from a more sustainable environment and preserved biodiversity.

Significance and Reach: The policy and practice play important roles in maintaining a healthy, sustainable woodland environment with maximum biodiversity. On average 40 million trees of native species are planted annually in the UK.

Attribution: All the original research was undertaken at the University of Edinburgh, led by Professor Richard Ennos.

2. Underpinning research

UoE work led by Richard Ennos between 1997 and 2000 focused on molecular and adaptive variation in native populations of Scots pine [1, 2, 3] and silver birch [4]. Using mitochondrial DNA analysis, the research showed that native Scots pine (*Pinus sylvestris*) populations in Scotland were derived from more than one European refugium after the last glaciation, whilst silver birch (*Betula pendula*) shows no evidence of more than one provenance. The research demonstrated, through experimental evidence of local adaptation of Scots pine and birch within the UK, that seed source significantly affected establishment and growth [1, 4], linked to these provenance issues. The research also provided confirmation of the ubiquity of local adaptation of native trees to environmental conditions.

This development of an evolutionary narrative for understanding the genetic variability of forest trees was made accessible and relevant to the community of practicing foresters in the UK through a policy paper published in 1998 in the international journal Forestry [5], the official journal of the Institute of Chartered Foresters in the UK. This narrative drew on a variety of published research that included the original UoE research. A major objective was to demystify the subject of genetics so that an informed debate could be had on issues such as the regulation of seed sourcing, and the capacity of forest tree populations to adapt to climate and other environmental change.

All UoE when research was undertaken: Prof. Richard Ennos (School of Biological Sciences, UoE 1983-present) and Dr William Sinclair (PDRA 1993-1997) (population genetics), Dr. Douglas Malcolm (Senior Lecturer 1961-1997) (forest management), and Dr. Richard Worrell (Research Associate 1994-2000) (forest policy).

3. References to the research

1. Ennos, R. A., Sinclair, W. T. & Perks, M. T. (1997). Genetic insights into the evolution of Scots pine, *Pinus sylvestris* L., in Scotland. Bot. J. Scotl., 49: 257-265. doi:10.1080/03746609708684871 **14 citations at 19/09/2013**
2. Sinclair, W. T., Morman, J. D. & Ennos, R. A. (1998). Multiple origins for Scots pine (*Pinus sylvestris* L.) in Scotland: Evidence from mitochondrial DNA variation. Heredity, 80: 233-240. doi:10.1046/j.1365-2540.1998.00287.x **36 Scopus citations at 19/09/2013**
3. Sinclair, W. T., Morman, J. D. & Ennos, R. A. (1999). The postglacial history of Scots pine (*Pinus sylvestris* L.) in Western Europe: Evidence from mitochondrial DNA variation. Molecular Ecology, 8: 83-88. doi: 10.1046/j.1365-294X.1999.00527.x **104 Scopus citations at 19/09/2013**
4. Worrell, R., Cundall, E.P., Malcolm, D.C. & Ennos, R.A. (2000). Variation among seed sources of silver birch in Scotland. Forestry, 73, 419-435. doi:10.1093/forestry/73.5.419 **5 Scopus citations at 19/09/2013**
5. Ennos, R. A., Worrell, R., Malcolm, D. C. (1998). The genetic management of native species in Scotland. Forestry, 71, 1-23. doi: 10.1093/forestry/71.1.1 **24 Scopus citations at 19/09/2013.** This paper was awarded the Institute of Chartered Foresters' Silvicultural Prize in 1999 as the **best paper in Forestry during the year 1998**.

4. Details of the impact

The *Forestry* paper [5] took the apparently academic issues of population genetic theory and forest genetics and explained their relevance to forest managers in terms both of how seed should be sourced, and how the genetic resources of our native forests should be managed and conserved. After the publication of this paper, the Forestry Commission commissioned an additional Technical Paper on the topic, for circulation within the wider Forestry community [Ennos, R. A., Worrell, R., Arkle, P., Malcolm, D. C. (2000) Genetic variation and conservation of British native trees and shrubs. *Forestry Commission Technical Paper* 31. Forestry Commission, Edinburgh. 38pp. ISBN 0 85538 412 3]. In his foreword to this Technical paper, the Head of Policy & Practice Division, Forestry Commission observed that the *Forestry* publication [5]:

> '*is the first attempt at setting a comprehensive framework for the development of knowledge and policies for the genetic conservation of our native trees and shrubs….we very much welcome the main message … and have decided to publish the report in full as a Technical Paper in order to stimulate wider discussion of this important topic'.*

The UoE publication [5] stimulated a debate in the UK about the regulation of seed sources for planting in native woodland regeneration schemes. This was followed rapidly by the production of a Practice Note [a] on the topic by the Forestry Commission in 1999. This note, which is still best practice, recommends that when planting native tree species, seed should be used only from populations that are adapted to the environmental conditions present at the planting site. Often, though not always, this involves planting seed from populations in the local area. These are key recommendations from the *Forestry* paper [5]. The Practice Note recommends utilising seed from within the same seed zone, or a neighbouring seed zone as a means of ensuring that seed is adapted to the planting site. Experimental evidence of local adaptation of Scots pine and birch within the UK [1, 4] underpinned this policy, and confirmation of the ubiquity of local adaptation of native trees to environmental conditions was provided by [5]. A number of policy and standards documents produced between 2000 and 2008 reinforced this approach: the UK Forestry Standard (Forestry Commission, 2004) encourages the use of local stock for planting native species and the Woodland Assurance Standard (UKWAS) also encourages use of local provenance (UKWAS Steering Group, 2006). These guidelines are based on the principle that locally-sourced planting stock is likely to represent the best-adapted material available for a site. A specific Guidance Note for seed sourcing of native trees and shrubs in Scotland, laying emphasis on sourcing locally

adapted seed, was published by Forestry Commission Scotland in 2006 [b]. In this note, which again remains current policy, the technical paper [Ennos et al. 2000] was specifically cited as underpinning the policy advice.

Originally put forward as recommendations, the Forestry Commission seed sourcing policy outlined above has now become common practice thanks to the dissemination and acceptance of the position papers and frameworks outlined above, with a commensurate impact during the REF impact period. For instance, the seed provenance policies have been widely enforced in the REF period by linking the payment of planting grant to the use of adapted seed sources. A typical example of this is from the Scottish Government's current Native Woodland Creation grant scheme, introduced in 2009, where a condition of grant is that:

> *"The woodland must be comprised of native species and* ***provenance appropriate to the site****."* [c]

Guidance published by the EU and the Forestry Commission in 2008 [d] advised nursery operators on appropriate sourcing of seed. In the UK, forest tree planting stock is produced by approximately 25 nurseries. In 2008 approximately 67% of native species plantings were sourced from British populations as a result of the policy and guidance change. £4 million of the total annual trade of £8.2 million in British native trees now comes from local, adapted sources [d].

The Programme Group Manager at Forest Research's Northern research station states that:

> *"[Professor Ennos'] paper in Forestry [5] and his Forestry Commission Technical paper (Ennos et al.2000) provided clear and comprehensive reviews of the major determinants of genetic diversity in woodlands in Britain. These publications have underpinned much of the subsequent policy that relates to the sourcing of planting stock of our native tree and shrub species in Britain today. …Such information is vital for the development of appropriate future policy as Britain's contemporary forests are facing unprecedented uncertainty from threats relating to climate change as well as novel pests and diseases."*

Beyond the immediate changes to practice and the commercial impact of this, the ultimate impact of the research is that the native woodlands created since the change in policy, comprise populations that are better adapted than they would otherwise have been. This means that widespread dieback and failure of inappropriately planted continental sources, e.g. Finnish silver birch in Scotland [4], has been averted. Local seed sourcing is likely to have also reduced the rate of inadvertent transport of exotic pathogens into the UK on imported seed and planting stock. Finally the populations which establish from well-adapted planting stock and populations are likely to show greater long term resilience and adaptability to native and introduced diseases and to climate change than maladapted plantings, ensuring that our investment in woodland planting will deliver the expected long term benefits for associated wildlife and biodiversity [e].

5. Sources to corroborate the impact

a) Herbert, R., Samuel, S., Patterson, G. (1999) Using local stock for planting native trees and shrubs. Forestry Commission Practice Note 8. http://www.forestry.gov.uk/pdf/fcpn8.pdf/$file/fcpn8.pdf or copy available on request

b) Forestry Commission Scotland (2006) Seed sources for planting native trees and shrubs in Scotland. Forestry Commission Scotland Guidance Note. http://www.forestry.gov.uk/pdf/seedsourcefcfc151.pdf/$file/seedsourcefcfc151.pdf or copy available on request

c) Scottish Govt Native Woodland creation grant policy: http://www.scotland.gov.uk/Topics/farmingrural/SRDP/RuralPriorities/Options/WoodlandCreation/NativeWoodlands or copy available on request

d) Buckley, P., Blakesley, D. 2008. Sourcing local native plants for nursery production. Guidance for seed suppliers and growers. Joint report for CRFF, Wildlife Landscapes, EU and Forestry Commission England. [copy available on request]

e) Corroboration that UoE research has underpinned policy relating to the sourcing of planting stock of native tree and shrub species in Britain can be provided by the Programme Group Manager, Forest Research, Northern Research Station.