

Understanding the Genetic Legacy of Past Caledonian Forest Decline

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British woodlands have experienced many centuries of management, including extensive selective felling and translocation. Such changes are highly likely to impact the genetic diversity of remaining natural tree populations altering the amount of diversity and/or its distribution within and among populations. Potential functional consequences can result, such as impacts on the capacity of tree populations to respond to disturbances such as habitat loss, pathogens or climate change. Understanding the extent to which woodland management practices have influenced patterns of genetic diversity can provide information on the current condition and potential resilience of British woodlands. This information can help decisions on how to manage tree genetic diversity and contribute to the development of sustainable woodland management plans.

A long history of change in the Caledonian forest

This project, co-funded by The Scottish Forestry Trust, The University of Stirling and The Centre for Ecology and Hydrology is focussed on remaining natural populations of Scots pine (*Pinus sylvestris* L.) the iconic species of the Caledonian forest, which in Britain still grows naturally in the Scottish Highlands. Currently, 84 pine forest fragments have been recognized as descendants of the more extensive pine forests that occupied the British Isles after the last ice age. The vast reduction in the number of pines has been attributed in part to past climate changes to wetter conditions, However,

natural causes explain only part of the story – with exploitation of pine for fuel and timber extraction being another major cause of the loss of the Caledonian forest. Felling practices were widespread in the Scottish Highlands and by the 20th Century, pine forests were reduced to a 1% of their estimated original area. The general decrease in the extent of these forests, together with poor natural regeneration caused by the subsequently high browsing pressure by deer and sheep, kept these forests at low tree density for centuries and strongly suppressed regeneration during the last 200 years. The remaining forests are typically designated as protected areas, and modern woodland management practices have moved to protect and expand what remains. Given the substantial historical changes in pine forest extent, we sought to determine how historical patterns of diversity developed and whether changes in historical woodland management have left an imprint on the diversity of the remaining Caledonian forest.

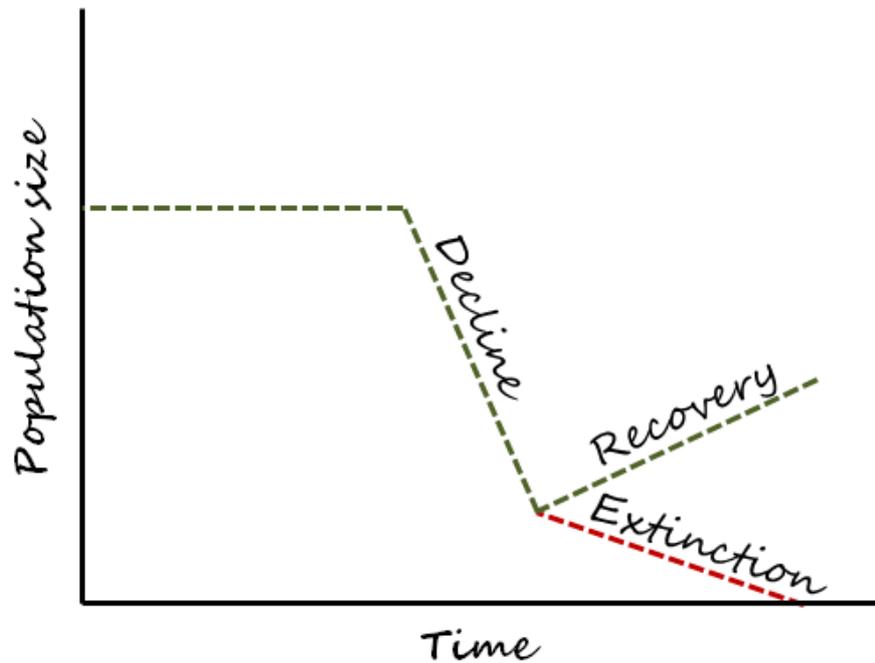
Did historical forest management influence pinewood genetic diversity?

Genetic diversity – the genetically based variability within individuals and populations of a species is the raw material for selection as trees adapt to changes in their environment. Maintaining diversity within natural populations can improve their chances of persistence under novel conditions and disturbance regimes such as climatic changes or pest and pathogen outbreaks. Previous studies on genetic diversity of the Scottish pine forest fragments have shown that populations are not genetically impoverished at the regional scale. However, to understand management impacts, we also need to explore how diversity is changing within populations.

Scots pine is a monoecious species, having both male and female flowers on the same tree. Scots pine pollen can travel long distances (from several meters up to 100 km), whereas its seeds will fall nearer to the mother tree. Consequently, in natural tree populations, individual trees typically receive male pollen from many different trees (both near and far trees), which will fertilize females flowers, leading to a highly genetically diverse crop of seeds within a tree. Pollen movement is, therefore, an important factor for spreading genes and key to the maintenance of genetic diversity of Scots pine at the local scale. Since historical woodland management has substantially reduced both the number of trees within Scottish pinewoods and pinewood area it may have impacted the number of pollen and seed donors, changing mating patterns and increasing the probability of mating between relatives.

By assessing the spatial distribution of genetic diversity of some of the remnant Caledonian pine forest fragments, we found that individuals are more genetically similar to each other than in unmanaged natural Scots pine forest elsewhere, a consequence of the extensive reduction in pine numbers. This increase of relatedness within native Scots pine populations could have negative impacts (e.g. reduced seed set and survival resulting in poorer regeneration and adaptability to change). Fortunately, however, the substantial recent efforts to conserve the remaining natural pine forest of Scotland and limit overgrazing have promoted natural regeneration of trees. This reversal of the recent trend of pine forest decline has considerably increased population sizes and therefore the number of pollen and seed donors within the remnant Caledonian forest patches. These changes are reflected in the new young pines, where genetic

similarity has decreased when comparing young individuals with the adult ones. Our findings suggest that current conservation management is being successful in supporting the recovery of genetic diversity at the local scale in the Caledonian Forest.



What can we learn from this?

Understanding the legacies of historical over-exploitation and current management practices is important. Excessive selective felling can lead to a point of no return, where individuals in remaining small populations mate frequently with their relatives and become increasingly genetically similar at the local scale. However, we have seen that Scots pine possess a relatively high capacity to recover when the population size is encouraged to increase. Our findings demonstrate that we should continue to manage the remaining natural Scottish pine forest fragments to increase population sizes. Such efforts will ensure that our iconic forests can be restored and their diversity maintained

– factors ever more important to ensure their persistence in a time of increasing risk of novel pests and pathogens and other rapid environmental changes.



Photographs show Caledonian forest at Abernethy with abundant natural regeneration.
Credits: P. González-Díaz.

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