Effect of burning on the mycorrhizal fungi of Scots pine *Pinus sylvestris* at Boat of Garten, Inverness-shire, Scotland

MacKay J.W.B.
School of Biological Sciences, University of East Anglia, Norwich NR4 7TJ, UK

SUMMARY

In the Highlands of Scotland, low intensity burning would appear to be an effective way to encourage Scots pine *Pinus sylvestris* regeneration. As well as opening up the ground allowing seedlings to grow, low to moderate burns had no major impact on ectomycorrhizal communities; without a healthy ectomycorrhizal community pine seedlings struggle to become established.

BACKGROUND

Burning is being investigated as a method of encouraging the regeneration of Scots pine *Pinus sylvestris* on moorland outside existing areas of pinewood. Burning clears the land allowing increased seed germination but it may damage the ectomycorrhizal fungi that pines partly depend on for successful growth. Without a healthy ectomycorrhizal community, pine seedlings struggle to become established and several studies have shown that fire has a deleterious effect on ectomycorrhizal communities of pine.

In the first study of its kind in Scotland, the effect of burning on ectomycorrhizal communities of Scots pine seedlings was investigated.

ACTION

Study site: The study was undertaken at the Boat of Garten, Inverness-shire in the highlands of Scotland. Investigating the ectomycorrhizal (EM) communities of seedlings is a destructive process requiring the seedlings to be dug up. Because most of the remaining native Caledonian pinewood is protected by Site of Special Scientific Interest status, this study was conducted at a pine plantation (close to an expanse of old growth forest) where a wildfire burned an area of 12 ha in May 2000.

Sampling: The burn site was divided into two zones based on the level of fire intensity experienced. Seedlings were also collected from an area of unburned woodland (Zone 3) for comparison.

Stratification and sampling methods were as follows:

Zone 1 - a circle approximately 110 m in diameter in the centre of the burned area. The fire burned very intensely here and all trees were dead. Ground vegetation was patchy with large areas of bare ground or bryophyte (moss and liverwort) mats. Seedling distribution was very patchy and the area was sampled with an intensive fingertip search.

Zone 2 - the rest of the burn site (excluding Zone 1). The fire did not burn as intensely as in Zone 1, as a result most trees were still alive. The ground vegetation was better developed with less bare patches. Cowberry *Vaccinium vitis-idea* was the dominant plant. Tree seedlings were quite evenly distributed and randomly placed 5 m² quadrats were used to sample seedlings in this zone.

Zone 3 - an area of unburned forest on the opposite side of a forest track to the burned area. Apart from a few small dead trees, all trees were alive. The ground vegetation was dominated by 30-40 cm tall heather *Calluna vulgaris*. Clearings in the *Calluna* canopy were colonised by *Vaccinium* and bryophytes. Seedlings were found in the *Vaccinium* dominated clearings at quite high densities (8-9/m²) but none were found in the areas dominated by *Calluna*. Seedlings were taken from a number of representative areas in the clearings.

Only seedlings more than 1 m from their nearest neighbour were taken for mycorrhizal analysis. This was to ensure independence from other seedlings since mycorrhizal hyphae can spread some distance through the soil and link together nearby trees and seedlings. Selected seedlings were carefully excavated from the substrate, preserving as many root tips as possible, and were wrapped in tissue paper soaked with water and sealed in a plastic bag. Seedlings were stored in a cool box until processing took place at the Royal Botanic Gardens Edinburgh.

Mycorrhizal classification: Excess soil was washed from seedling roots under a jet of water. Further cleaning took place using tweezers and a dissecting needle under a dissecting microscope. The mycorrhizal communities of each seedling were then classified. Root tips were classified as mycorrhizal, non-mycorrhizal or dead. Mycorrhizal root tips belonged to a number of different morphotypes and these were recorded separately. Although some morphotypes were identified to species there was not enough time available to identify all the morphotypes found. Average number of morphotypes per seedling and percentage colonisation (proportion of root tips that were mycorrhizal) were calculated for each zone and compared.

CONSEQUENCES

Seedlings: Immediately after the fire there were large numbers of tree seedlings found at the site in the burned area, however, four years after the fire seedling numbers had decreased dramatically, particularly in Zone 1. Only 12 seedlings were recovered from this zone despite an intensive search of the area. Seedlings were at their highest density in the clearings in Zone 3. Possibly these gaps were caused during thinning operations – this could have been sufficient disturbance to reduce the dominance of *Calluna* and initiate a pulse of pine regeneration. The low ground vegetation in Zones 1 and 2 may have led to increased vulnerability of seedlings to grazing.

Mycorrhizal communities: Significant differences were found between the mycorrhizal communities of seedlings from each of the three zones. The average number of mycorrhizal morphotypes per seedling was clearly affected by fire. Seedlings in Zone 1 had far fewer morphotypes than those in Zones 2 and 3. Seedlings in Zone 1 also had a lower percentage colonisation than the other zones, although this was not statistically significant. This suggests that moderate burns do not have a large effect on the EM communities of pine seedlings whereas more intensive fires do.

Most morphotypes were not identified to species although one that was, was identified as *Piceirhiza bicolorata*. This mycorrhizal type is commonly found on many tree species and has been linked to a group of ericoid mycorrhizae known as the *Hymenoscyphus ericae* aggregate. Ericoid mycorrhizae were thought to be formed by different fungal species to the ectomycorrhizaes that pine species form but recent research has shown that isolates from the *Hymenoscyphus ericae* aggregate are able to form mycorrhizal relationships with both *Vaccinium* and *Pinus* roots. This suggests that pine seedlings may benefit from symbioses with a group of fungi previously thought to be unavailable to them. If this is the case pine seedlings should be able to establish on moorland some distance away from established woodland.

Results and site information are summarised in Table 1.

Conclusions: These results suggest that low intensity burning is an effective way to encourage pine regeneration as it clears the ground and moderate burns do not have a major effect on ectomycorrhizal communities. Attempts should be made to reduce seedling loss through grazing (e.g. by fencing or provision of tree collars) in areas where regeneration is a high priority.

Table 1. Effects of burning on mycorrhizal fungi of Scots pine, Boat of Garten, May 2000.

Zone	**1. Intense burn**	**2. Slight burn**	**3. Unburned**
Trees	All dead	Most alive, some smaller trees killed by fire	All alive apart from some very small trees, possibly due to stand self-thinning
Ground vegetation	Patchy. Large areas of bare ground & bryophytes. Some low growing *Calluna* & *Vaccinium*	*Vaccinium* dominant, patches of *Calluna*, bare ground, bryophytes & grasses	Dominated by 30-40 cm high *Calluna*. Clearings colonised by *Vaccinium* and bryophytes
Seedling distribution	Very infrequent, low numbers across whole zone	Moderate numbers spread evenly across zone	Only found in *Vaccinium*-dominated clearings
Sampling method	Intensive search of whole area	Randomly placed $5m^2$ quadrats	Representative areas of clearings selected and searched
Sample size	12	16	17
Average % colonisation / seedling	72%	86%	84%
Average no. of morphotypes /seedling	2.1	3.2	4.0
Effect of burning	Number of morphotypes reduced significantly, % colonisation reduced	Number of morphotypes slightly reduced, % colonisation highest	Not burnt