Forestry Commission

Research Note

Species preference of small mammals for direct-sown tree and shrub seeds

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Direct seeding can be a useful method for creating new woodland on former agricultural sites. However, the success of the technique is variable when it is used to restore conifer plantation sites to native species. Seed predation by small mammals, particularly the wood mouse (*Apodemus sylvaticus*), has been identified as a factor potentially limiting success. Small mammals are known to exhibit preferential predation when presented with a range of tree and shrub seeds. This research demonstrated that, when seeds used in the direct seeding of woodlands were presented on the soil surface, small mammals showed a preference for large-seeded species such as oak (*Quercus robur*), hazel (*Corylus avellana*) beech (*Fagus sylvatica*) and sycamore (*Acer pseudoplatanus*). In the case of oak, the removal of seeds by predators was rapid and total, usually in less than 24 hours. Smaller-seeded species and those with greater physical protection were significantly less likely to be taken. The results showed that the pattern of preference remained consistent between several different sites. The burial of seeds is known to reduce predation by reducing the chance of seeds being detected and increasing the time required for predators to find and remove them. In our experiments, burial restricted predation to just the highly-preferred species while less-preferred species were left almost untouched. However, burial also significantly reduced predation risk overall.

Introduction

Direct seeding has been recommended as a useful way of creating new native broadleaved woodlands on better quality lowland sites, such as former agricultural land (Willoughby *et al*. 2004). It is a relatively low-cost method of establishing broadleaved woodlands – particularly when using mixtures of species. The technique has several other advantages over planting: reduced establishment time, a more natural appearance, and the potential for reduced herbicide inputs.

However, although direct seeding would seem an attractive option for the restoration of native broadleaved woodland on former conifer plantation sites, the technique is not currently recommended for use in established woodland habitats because of excessive seed predation by small mammals such as the wood mouse (*Apodemus sylvaticus*), yellow-necked mouse (*Apodemus flavicolis*), bank vole (*Clethrionomys glareolus*), grey squirrel (*Sciurus carolinensis*) and, to a lesser extent, woodland birds.

The most common predator encountered at test sites in Britain was the wood mouse, which does not hibernate and needs to feed throughout winter to survive. Seeds form an important part of its winter diet and mice take seeds both for immediate consumption and to store underground for future use. Seed removal from test caches placed at clearfell sites in southern England was rapid and usually complete in one or two nights.

This Research Note reports the results of a series of studies with natural populations of mice designed to investigate predator preference amongst the tree and shrub seeds that are sown for creating native lowland woodland. These studies are part of wider research on issues such as site preparation and vegetation management to develop direct seeding for the restoration of conifer plantation sites to native broadleaved mixed woodlands.

Not all seeds are equal

Previous studies on seed predation have tended to focus on a few key species, such as oak and beech, that have often been sown as single species stands. However, when direct seeding new native woodlands, seed mixes are likely to contain at least six, and possibly up to twelve, different species – depending on the woodland type being established. Studies have shown that rodents, given a choice, tend to prefer the seeds of some species over others (e.g. Kollmann *et al*. 1998). Therefore it is highly likely that there will be differences in the relative predation risk of species included in direct-seeding mixes. Such differences might preclude direct sowing high-risk species, but still permit use of lower-risk species, either on their own or in combination with higher risk species. Alternatively, protection treatments such as repellents might be focused on seeds in the high-risk category.

Methods

To replicate surface sowing, individual seeds of 12 different species were attached to plastic-mesh mats with a minute spot of glue. The mats were placed on the ground in forest sites to allow foraging mice to remove or reject seeds of particular species. Additional seed mats were placed beneath two kinds of wire exclosure to establish the predominant seed predator: the first was designed to exclude birds but allow access by small mammals, the second to exclude both birds and small mammals. The numbers of seeds removed from the mats were counted daily because of the rapid uptake of seeds when predators are active (Jinks *et al*. 2012).

The same twelve species were used when when studying the removal of buried seeds on clearfell sites. We carefully plotted the position of each sown seed, and then regularly counted the number of sites with signs of digging to provide a measure of predator interest in different species. We also checked for signs of feeding, such as remains of shells (Figure 1). At the end of the experiment we dug up all sowing positions to check if seed had been removed or not. Sowing depth was investigated in a similar way at a second site, in this instance seeds were sown at two depths, deep or shallow.

After each run the count data were analysed using a statistical model to measure the relative preference for one species over another. Species were then ranked by preference. By comparing the species ranks from tests across a range of sites and years, we can determine how consistent the observed preferences are, and so inform strategies for managing the problem.

Figure 1 (a) Characteristically precise holes dug by wood mice to remove direct-sown hazel nuts; (b) occasional empty shells are all that remain after seed discovery.

Results

When predators are given a choice of uncovered seeds of different species they tend to remove species in distinct phases or sequences, with seed removal during any period being focused on particular species or groups of species. The most preferred seeds are the first to be removed and are nearly always completely taken, while less preferred species are removed later and are often only partially taken. Combining the preference results from several experiments using the same seed lots of 12 species shows that the most highly preferred species is oak (Table 1 and Figure 2). Whenever a patch of mixed seeds was encountered, the acorns were always removed first and completely (Figure 3). The next three species ranked in order of preference are beech, sycamore and hazel; these are usually removed after the acorns, and are often (but not always) removed completely. At the other end of the preference scale come ash and hawthorn seeds which often remain untouched, or when they are partially removed, they are the last species to go. Preference for seeds of the other species is more variable in terms of the order and extent to which they are removed.

Table 1 The average preference ranking from three separate experiments for seeds of 12 species (Jinks *et al.* 2012).

Common name	Scientific name	Rank
English oak	*Quercus robur*	1.50
Beech	*Fagus sylvatica*	2.00
Sycamore	*Acer pseudoplatanus*	3.25
Hazel	*Corylus avellana*	4.00
Guelder-rose	*Viburnum opulus*	6.75
Field maple	*Acer campestre*	7.25
Wayfaring tree	*Viburnum lantana*	7.25
Dogwood	*Cornus sanguinea*	8.50
Blackthorn	*Prunus spinosa*	8.50
Wild cherry	*Prunus avium*	9.00
Hawthorn	*Crataegus monogyna*	9.25
Ash	*Fraxinus excelsior*	11.50

Figure 2 The seeds and fruits of trees and shrubs used in these studies. Top row (left to right): English oak, beech, sycamore, hazel; bottom row: wayfaring tree, guelder-rose, dogwood, wild cherry, blackthorn, field maple, hawthorn, ash.

These results suggest that species producing large nuts, and also sycamore, are likely to be much more vulnerable to predation than other tree and shrub seeds (Figure 4). We have found, for nearly all species studied, that the degree of preference for a particular seed is related to its weight tempered by the size (weight or thickness) of any protective coating (Figure 5). Thus large seeds are more preferred than small seeds, and for species with the same seed weight, those with thinner protective coats are preferred over ones with thick coats. An exception is ash, which is consistently less-preferred than would be expected for

Figure 3 Removal of the seeds of 12 species over a 13-day period.

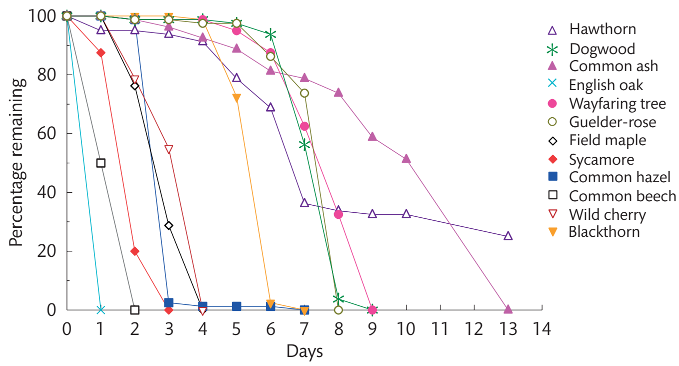
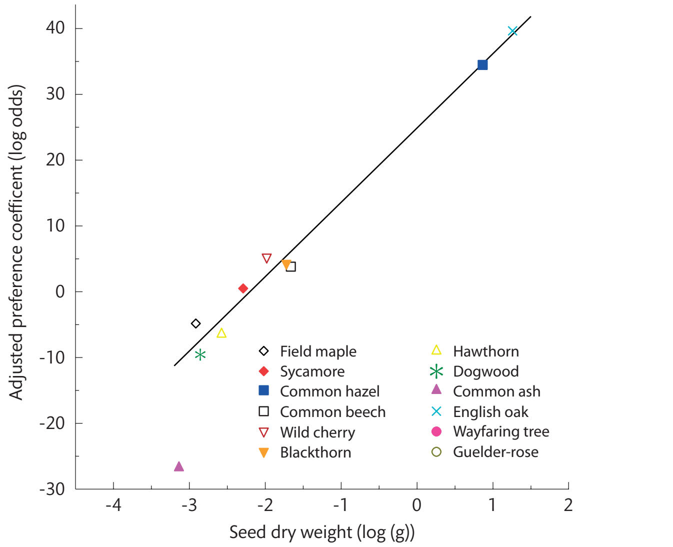


Figure 4 A wood mouse, caught on CCTV, selectively removing acorns from a plot.

Figure 5 The preference of wood mice for seeds of different species is related to seed weight (coat weight is held constant in the fitted model): the heaviest seeds being most preferred.



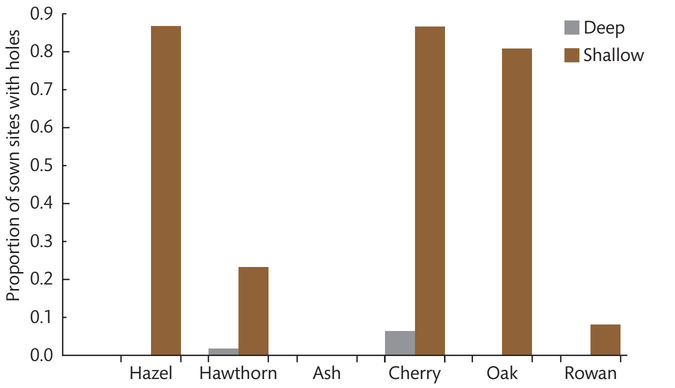
the size of the seeds; this is probably because ash samaras rely on chemical rather than physical defences to deter predators.

Results from experiments on buried seeds of species mixtures show that predation becomes confined to the highly-preferred species, with the less-preferred ones often left untouched. For example, using seeds of the same 12 species buried in sand, only oak, beech and hazel were removed; the remaining species were left untouched, despite exploratory digging.

Burying seed reduced predation in two ways. Firstly, it reduced the chances of the seeds being detected by predators (by masking smell, for example). Secondly, it increased the time needed for predators to locate and remove seeds, compared with freely-available seed on the surface. This extra time can increase vulnerability of small mammals to predation, and also increases enegy expenditure – potentially reducing net energy gain. Effectiveness depended on factors such as burial depth and soil porosity.

Burial depth was a key factor in protecting seeds of vulnerable species (Figure 6). On a clearfell conifer site with a large population of wood mice in southern England, seeds of oak, hazel and, unexpectedly, cherry, sown just below the soil surface were nearly all removed, whereas predation of less-preferred hawthorn, ash and rowan was much lower. Burial considerably reduced predation of the highly-preferred species.

Figure 6 The effect of burial depth* on the predation of seeds of six species sown on a clearfell conifer site.



*Shallow seeds were sown just below the soil surface; deep-sown seeds were sown at 2 cm depth, except hazel and oak which were sown at 10 cm depth (Jinks *et al*. 2012).

In a larger-scale trial using direct-sown beech, hazel, field maple, ash, hawthorn and dogwood, excavation of sown seeds was confined principally to hazel and beech. On average 70% of sowing positions were dug up, compared with less than 15% for the other species. These differences were reflected in seedling emergence where only a tiny proportion of sown hazel and beech eventually emerged, compared with 30% of the other species.

Conclusions

Our results show that of the 12 species investigated, large-seeded species such as oak, hazel, and beech are the most vulnerable to predation by small mammals. Species with smaller seeds or with seeds that have greater physical protection are much less preferred and so are more likely to persist when sown on regeneration sites; any losses are likely to be small, localised, and tolerable. In contrast, larger seeds, if freely available, are rapidly and completely removed. However, burial appears to be a simple method to significantly reduce predation risk.

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