Restoration of lowland conifer PAWS

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Introduction

During much of the 20th century British forestry was driven by a policy that aimed to ensure a strategic supply of timber in case of war. This led to the successful development of silvicultural systems based predominantly on plantation forestry using fast growing, non-native conifer species. As a consequence there was a large expansion in forest cover due mainly to the afforestation of unwooded land in upland areas. However, the policy also resulted in the replacement of uneconomic, slow-growing, semi-natural broadleaved woodland with more productive conifers or more economically viable broadleaved trees such as beech. About 40% of ancient woodland that existed in the 1930s was converted to plantations, mostly between 1950 and 1980: these plantations on ancient woodland sites are commonly known as PAWS. Despite intensive silvicultural practices, the conversion of existing broadleaved woodland sites to conifers was often less successful than afforestation. The process of conversion became a contentious issue and was abandoned in 1985 when the government's policy for broadleaved woodlands was introduced. PAWS often retain a number of features characteristic of the preceding native woodland, including remnants of the ground flora, old coppice stools and veteran trees which can provide a nucleus around which a new broadleaved woodland can be created. Restoration of native broadleaved woodland is an important aim of current policy and a significant management objective of many PAWS. The aim of restoration is to create the conditions needed to promote the development of native woodland over the long term; it is a process which attempts to re-establish a functioning ecosystem by:

- Securing features from the former ancient semi-natural woodland.
- Removing introduced species of trees, shrubs and other plants.
- Encouraging the re-establishment of native species.
- Initiating and enhancing ecological processes which may be absent or damaged.

Figure 1 (a), (b) Examples of treatment plots immediately after felling and (c), (d) permanent quadrats after four years' growth (a, c = 20%; b, d = 80%).

It is generally accepted that restoring PAWS to native woodland will enhance woodland habitats for a range of plant and animal species, but the potential for success will vary with the remnant features present on the site and the methods used. Current guidance suggests that restoration should take place gradually using some form of continuous cover forestry to maintain woodland conditions while the planted species are removed and native broadleaves regenerate naturally. While this method may have a number of potential benefits (e.g. no major disturbance to fauna, retention of moist microclimates for epiphytes and deadwood invertebrates, control of ground vegetation by the presence of overstorey cover) it has never been adequately tested. This article briefly describes some of the studies within lowland PAWS that were established to examine current guidance and improve advice.

Sites and treatments

In 2001 experiments were established at Fineshade, Northamptonshire; Wakehurst Place, Sussex; and Chiddingfold, Surrey. All were within stands of *c.* 35-year-old Corsican pine growing on clay soil. The work at Chiddingfold, which is the largest, is described here. Although the initial treatments and the subsequent assessments varied slightly between sites the results obtained were similar.

The stand at Chiddingfold, which is managed by Forest Enterprise, was planted in 1966 and prior to treatment had 450 stems ha^{-1} with a basal area of 20 m^2. In autumn 2001 four thinning treatments were applied to remove 10, 20, 40 and 80% of basal area (Figure 1a–d); there were four replicates of each treatment. The site was unfenced and in all years the presence of deer was evident throughout the stand.

Assessments

Before thinning two permanent quadrats 2 x 2 m in size were established within each of the 16 treatment plots. After initial assessments the following have been observed annually within each quadrat:

- cover and height of ground flora present by species;
- growth and survival of a marked cohort of ash seedlings;
- species of trees regenerating and height of tallest seedlings;
- browsing damage.

Canopy cover above each quadrat was assessed using hemispherical photography both before thinning and in the following summer.

Results

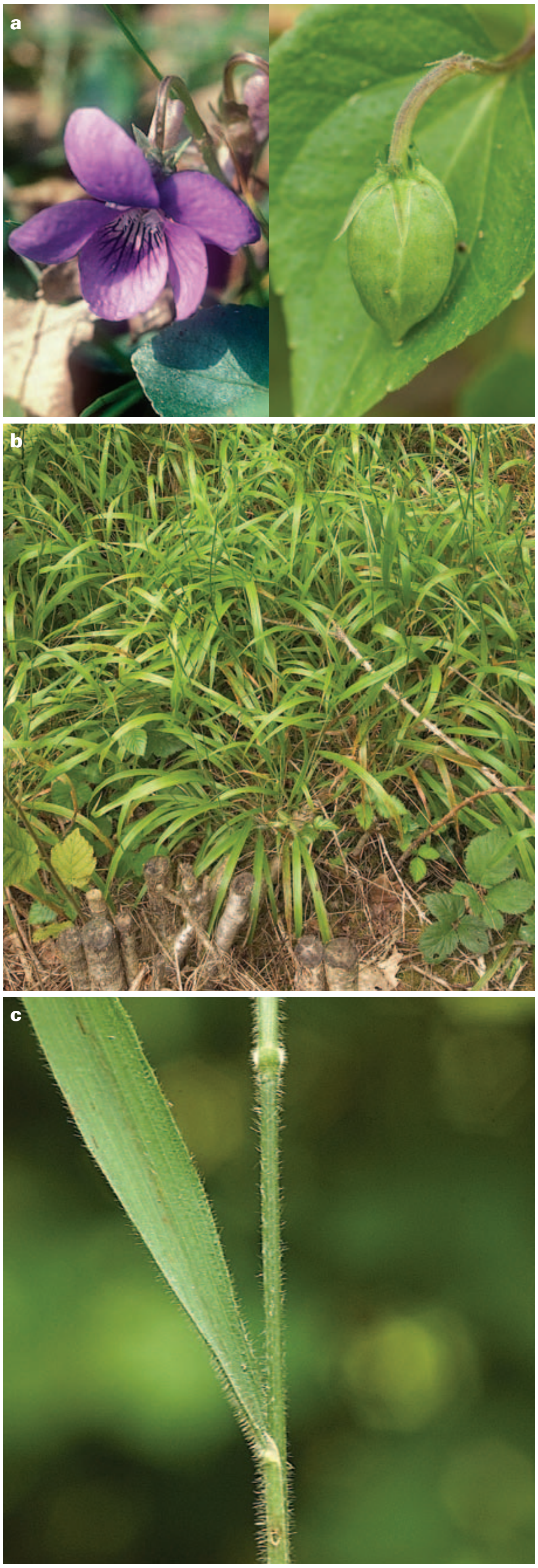
Observations are ongoing and the following is an interim résumé of some of the data collected.

Changes in the ground flora vegetation

In 2001, before thinning, there was a total of 50 species present in the ground flora of the permanent quadrats: four years after thinning there were the same number. However, there appeared to have been a change in the species composition, with 20% of the species initially present being replaced by a similar number of new species. More than half the species present occurred in only one or two quadrats, but a few including common violet *(Viola riviniana)* and wood false-brome *(Brachypodium sylvaticum)* were present in more than 60% of quadrats (Figure 2a, b and c); in 2005 bramble *(Rubus fruticosus)* occurred in all quadrats.

The abundance of most species was low and only nine species ever exceeded 5% cover on any quadrat on which they were present. Bramble was the most abundant species and by 2005 the site was becoming dominated by a dense thicket. More than half of the quadrats had 50% or more bramble cover but this varied with treatment. The height of the bramble thicket increased with time: by 2005 the height of that in the 80% thinning plots was twice that in the 20% plots (Figure 3). The response of bramble was expected and detailed studies to investigate its growth have been made in all thinning treatments (see Box 1).

Figure 2 (a) Common violet flower and seed pod, (b) wood false-brome and (c) close up showing node and fine hairs on stem which can be useful in identification.



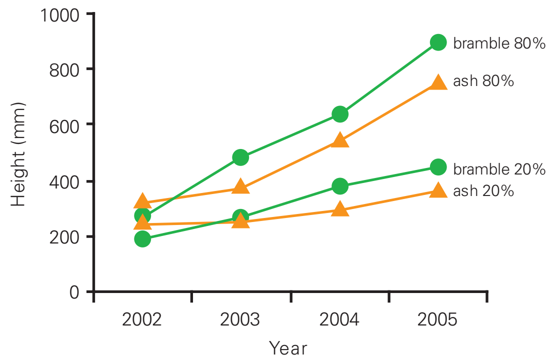


Figure 3 Mean height of tallest ash seedlings and bramble thicket in the 20% and 80% thinning treatments between 2002 and 2005.

Tree seedlings

In all years the same eight species of broadleaved trees have been found regenerating on the site. The only notable change that occurred following thinning was an increase in the frequency of willow *(Salix* sp.*)* and birch *(Betula* sp.*)* seedlings. Subsequently there has been little recruitment of any species. Ash *(Fraxinus excelsior)* has always been the most common species occurring on all quadrats; by 2005 birch, willow and oak *(Quercus* sp.*)* were found in about half of the quadrats; holly *(Ilex aquifolium)*, wild cherry *(Prunus avium)*, hazel *(Corylus avellana)* and hawthorn *(Crataegus monogyna)* all occurred on less than 15% of quadrats.

Thinning had a positive influence on the growth of the tree seedlings, those in the heaviest thinning treatment growing more than those in the lighter thinnings. For example, between 2002 and 2005 the mean height of the tallest ash seedling present on a quadrat increased by about 120 mm in the 20% treatment compared with an increase of about 400 mm in the 80% treatment (Figure 3). After 2002 the mean heights of the tallest ash seedlings were less than those of the bramble thickets in which they were growing whatever the thinning treatment (Figure 3).

Should advice on methods of restoration be changed?

Woodland regeneration and restoration may take many years and it is difficult to draw definitive conclusions from four years of observation. The results described are representative of those from the two other experimental sites which suggests that the changes observed may be typical of sites similar to those studied. However, a decision on whether the current advice needs modifying may depend on the criteria used to assess success. Although maintaining canopy cover by using light thinning reduced bramble growth to some extent, it did not allow tree seedlings to establish any better than under heavy thinning. Similarly, light thinning did not promote the growth and establishment of herbaceous species in the woodland ground flora; the only species that flourished was bramble. If short-term observations of tree seedling establishment and ground flora development can be used as criteria to assess the merit of gradual restoration, then on sites similar to those studied, they indicate that light thinning over a long period of time may have little benefit relative to rapid clearance of trees.

Additional experiments to aid both understanding of woodland development and management practice have been established to investigate the development of tree seedlings and ground flora. These studies are taking place in a variety of coniferous and broadleaved woodlands and include: the development of bramble thicket from the seed-bank with and without competition from other ground flora plants in a beech PAWS; the development of naturally regenerating trees and ground flora after thinning neglected ash woodland; management of bramble and enrichment planting in conifer PAWS; woodland development on windblown and clearfelled conifer sites.

Box 1 Summary of detailed studies.

Bramble is a very common native species found in the ground flora of almost all woodland and scrub communities described by the National Vegetation Classification. Although it is typical of lowland deciduous woodlands it is found almost everywhere in Great Britain growing at altitudes of up to about 450 m. It grows on a wide variety of soil types being most frequent on well-drained, fertile, moderately acid soils. Best growth occurs in the open and, although its flowering will be suppressed, bramble grows well in semi-shaded conditions. The flowers are an important source of nectar and pollen, and the fruits are eaten by a variety of animals. The structure of the habitat provided by bramble provides important shelter for some birds and small mammals. However, bramble can present significant problems for woodland managers especially during regeneration.

The vigorous growth of bramble to form dense thickets following thinning or felling operations can make it a troublesome weed on many sites; it can inhibit the growth of both naturally regenerating and planted tree seedlings, and suppress other species in the ground flora. The impenetrable nature of dense thickets may protect young saplings against browsing by deer, but it also provides shelter for small mammals which can consume tree seeds and severely damage tree seedlings.

Although the general pattern of bramble growth following thinning is understood there is insufficient knowledge of its response to canopy opening that can be used predictively to guide management. Several investigations were made to improve understanding of bramble thickets. Growth, flowering and fruiting were observed between June 2002 and August 2004 within 5 x 1 m permanent transects located in each of the different thinning treatments.

Vegetative growth

Results of non-destructive observations of vegetative growth reflect those for permanent quadrats and showed that bramble cover, height and shoot length increased steadily over three years of observation in all thinning treatments. Most bramble was recorded in the 80% thinning treatment with final cover being almost 60% at an average height of 60 cm; this compares with about 45% bramble cover at 45 cm height in the 20% thinning treatment.

Flowering and fruiting

Flowering and fruiting of bramble was assessed by counting numbers of inflorescences and recording fruit development using ten categories from an unopened bud to a ripe blackberry (Figure 4). Seeds were extracted by mashing the fruits through a sieve and their quality was assessed by cutting them in half and observing them under a microscope. A seed was either filled with live embryonic and storage tissue or it contained a collapsed embryo whose tissue was dry and shrivelled (Figure 5).

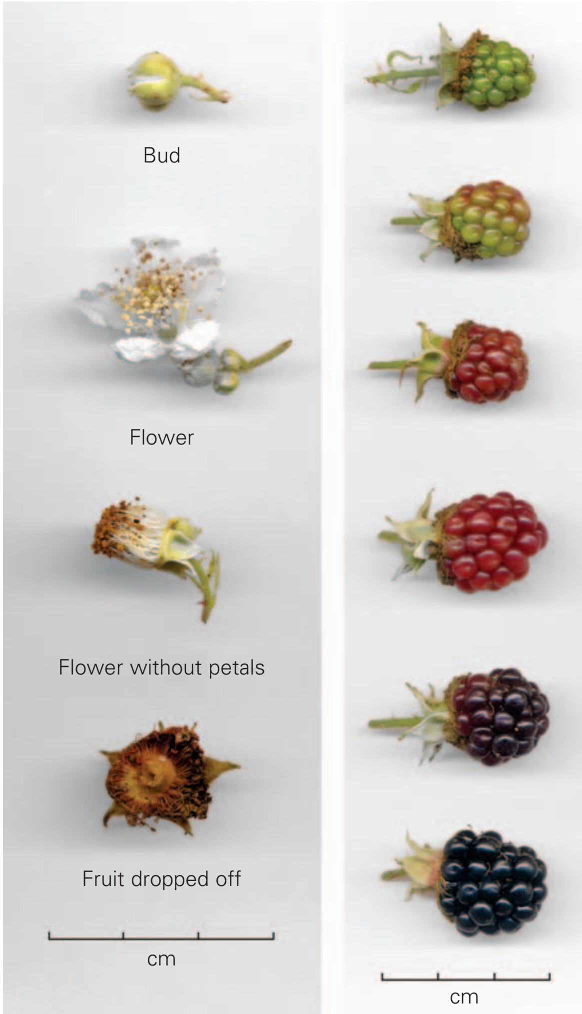


Figure 4 Different stages of flower and fruit development in bramble.

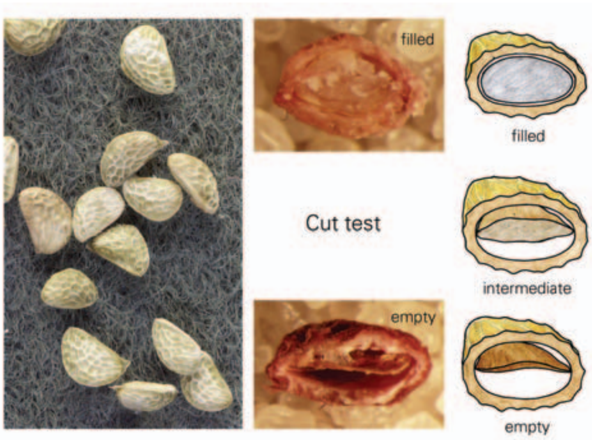


Figure 5 Entire bramble seed after extraction with examples of full and empty seed after cutting.

Box 1 Summary of detailed studies (continued).

Both the numbers of inflorescences and berries were affected by the thinning treatments; there were considerably more inflorescences and berries in the 80% thinning treatment. In 2002 there was about 1 inflorescence per m^2 which increased to 7 in the 10% thinning treatment and to 23 in the 80% treatment by 2004. Similarly, the berries increased from an initial number of about 4 per m^2 to 43 in the 10% thinning and 188 in the 80% thinning (Table 1).

Fruit development was fastest in the 80% thinning, but the ripeness stage of a berry had no influence on the number of seeds within it or the proportion of filled seeds. Similarly, the different thinning treatments had little effect on either the number of seeds in the berries or the proportion of filled seeds.

Table 1 Characteristics of bramble fruiting under different canopy covers in 2004.

	Thinning treatment			
	80%	**40%**	**20%**	**10%**
No. of inflorescences (m^{-2})	23	16	10	7
No. of berries (m^{-2})	188	114	66	43
No. of seeds/berry	18	15	13	9
Proportion of filled seeds	28%	27%	31%	22%

References and further reading

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