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Vegetation Management

Controlling bramble within an oak woodland using herbicides

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Summary

Several foliar acting herbicides were applied to the ground flora of an oak woodland during the period of winter dormancy to investigate effects on the dense bramble (*Rubus fruticosus* agg.) thicket that was inhibiting the naturally regenerating oak seedlings. All herbicides visibly affected the bramble, reducing cover, height and biomass. The effect of paraquat was least persistent. Although survival was improved, the herbicides did not promote the growth of oak (*Quercus robur*) seedlings present at the time of application. The herbicides appeared to have no marked effect on many other species present in the groundflora. Reduction in bramble cover was accompanied by an increase in rosebay willowherb (*Chamerion angustifolium*) that became the dominant herbaceous species. Further investigations are required, but initial data suggest that application of 0.96 kg a.i. ha^{-1} triclopyr during the winter may be a useful treatment for the control of bramble without damaging dormant oak seedlings.

Key words: Oak, bramble, natural regeneration, groundflora, herbicides, triclopyr

Introduction

Bramble (*Rubus fruticosus* agg.) is a perennial, semi evergreen climbing shrub that forms a common component of many native woodland types and provides an important source of food through nectar, fruit and foliage to a diverse range of insects, birds and animals. However, its vigorous growth habit can make it a troublesome weed in some woodland situations, as it can prevent newly germinating tree seedlings from establishing, rapidly invade new areas, kill existing regeneration or planted nursery grown stock, and harbour rabbits and voles which can severely damage any remaining seedlings (Harmer, 2004). The direct adverse effects of bramble are not only due to competition for light, moisture and nutrients but also physical smothering of small trees.

In Britain, many land managers aspire to restock their woodland using natural regeneration, but this is a process often fraught with difficulties. A particular problem arises when the increased light levels produced by thinning the overstory encourages the growth of light demanding species such as bramble, at the expense of slower growing, more shade tolerant tree seedlings. Within oak and beech woodlands, an initially sparse cover of bramble can rapidly expand and colonise a site, effectively preventing tree regeneration and some form of control is therefore often required to help favour planted or naturally regenerated tree seedlings at the expense of bramble. Where necessary, bramble can be temporarily controlled through grazing, cutting or deep cultivation, but such operations are either very costly, or difficult to carry out without also damaging or disturbing existing tree seedlings or other ground flora. A tractor mounted spring tine cultivator has been used to successfully comb dense bramble thickets from amongst beech seedlings (Pakenham, 1996), but effects are likely to be short term (Harmer *et al*., 2000).

Foliar acting herbicides can give successful control of bramble within woodlands (Willoughby & Dewar, 1995), and may be the simplest and cheapest method of control in many situations. However, broad spectrum herbicides can also damage non-target vegetation or existing tree seedlings. Where nursery stock is often planted in discrete lines, or plants are protected from browsing using tree shelters, it is relatively easy to spray a targeted spot around the base of trees, to help promote growth of trees whilst confining herbicide damage only to the treated bramble. Conversely, on larger areas where irregularly spaced naturally regenerating trees are growing amongst dense bramble thickets, the only practical way to use a herbicide would be to make an overall spray on extensive areas, such as discrete lines or blocks of bramble. Therefore, to make such applications, it would be necessary to identify a selective herbicide that could control bramble whilst leaving tree seedlings unharmed. Ideally such a herbicide should neither damage nor prevent the subsequent establishment of more desirable components of the woodland ground flora, such as less competitive vegetation types or ancient woodland indicator species.

There appear to be few options for using foliar acting herbicides to control bramble selectively whilst leaving actively growing trees unaffected (Willoughby & Dewar, 1995). However, application of some herbicides over deciduous trees in their dormant winter period may offer a safe means of controlling semi-evergreen species such as bramble. Paraquat has been regarded as safe as an overall spray of dormant fruit trees and bushes providing no green buds are present (Fryer & Makepeace, 1978), but Harmer *et al*. (2000) found this treatment applied in December caused tip die back of beech (*Fagus sylvatica*), possibly due to the greater susceptibility of seedlings grown under a canopy of trees and amongst weed vegetation. However, Willoughby *et al*. (2006) showed that paraquat could be generally safe over a wide range of deciduous species, and that weed competition or size of ash (*Fraxinus excelsior*) seedlings had no effect on tree tolerance. Several authors have reported tolerance of dormant trees to glyphosate (e.g. Garnett & Williamson, 1992; Willoughby, 1996; Harmer *et al*., 2000; Willoughby *et al*., 2006), but effects can vary with time of application and dose rate. When investigating options for the selective control of bramble amongst beech natural regeneration, Harmer *et al*. (2000) concluded that triclopyr offered the best combination of effective control and tree tolerance, but recommended that further observations were required with different species and on different sites. Hence the aim of the work reported here was to test the efficacy of a range of commercially available herbicides, approved for use within woodlands, on a bramble thicket that was suppressing naturally regenerating oak (*Quercus robur*) seedlings.

Materials and Methods

The experiment took place in Lea Bailey Wood in the Forest of Dean in south-west England (51°52'N, 2°31'W). The site was 164 m a.s.l., had an annual rainfall of 850 mm and a brown earth soil which was sandy silt loam in texture at pH 4.5. The woodland community was best described as NVC W10, an oak-bracken-bramble woodland (Rodwell, 1991). The stand comprised a mixture of 80% oak and 20% beech approximately 140 years old; there were a total of 75 stems ha^{-1} about 28–30 m tall with diameters of 60–70 cm at 1.3 m above ground. The ground flora was dominated by bramble with some patches of bracken (Pteridium aquilinum). Prior to establishing the experiment the site had been rabbit fenced to protect young oak seedlings that had arisen following a mast year in 1995. Occasional handweeding had also been carried out in parts of the stand to promote the survival and growth of seedlings. During winter 1999/2000 three experimental blocks each comprising six 30 m × 30 m plots were established and the treatments described in Table 1 were applied.

Table 1. *Treatment details*

Treatment Code	Herbicide	Rate (a.i. ha^{-1})	Product Name, Formulation and Manufacturer	Equivalent Product Rate (L ha^{-1})	Treatment Dates
Control	-	-	-	-	-
Gly	glyphosate	0.54	Roundup ProBiactive; 360 g L^{-1} glyphosate; Monsanto, (UK) Ltd	1.5	March 2000, January 2001, 2002
Para	paraquat	1.1	Gramoxone 100; 200 g L^{-1} paraquat; Syngenta	5.5	March 2000, January 2001, 2002
BS	2,4-D + dicamba + triclopyr	0.33 + 0.14 + 0.11	Broadsword; 200 g l^{-1} 2,4-D + 85 g L^{-1} dicamba + 65 g L^{-1} triclopyr; United Phosphorus Ltd	1.67	March 2000, January 2001, 2002
Tric	triclopyr	0.96	Timbrel; 480 g L^{-1} triclopyr; Dow AgroSciences	2.0	March 2000, January 2001, 2002
Tox	triclopyr + isoxaben	0.96 + 0.25	Timbrel; 480 g L^{-1} triclopyr, Dow AgroSciences Flexidor 125; 125 g L^{-1} isoxaben, Landseer Ltd	2.0 + 2.0	triclopyr :- March 2000, January 2001, 2002 isoxaben:- May 2000, March 2001, 2002

Applications were made using a Cooper Pegler CP3 knapsack sprayer fitted with a blue Polijet nozzle, giving an output of 1800 ml $minute^{-1}$ at a pressure of 100 kPA and a volume rate of 200 l ha^{-1}. Damage to adjacent plots was avoided through carefully targeting sprays and making applications only in still, dry conditions. The advanced regeneration present at the time of spraying was assessed for herbicide damage in July 2000 by observing leaf disfigurement and death. Up to 30 oak seedlings per plot were then identified at random, and permanently marked for further observations which comprised assessment of height (cm) and stem diameter (mm) 5 cm above ground level initially and at the end of each growing season until 2002, and a further assessment of herbicide damage in June 2001. The percentage cover of vegetation present in the ground flora was observed in permanent 2 m × 2 m quadrats located in the centre of the plots. The cover of bramble within the whole treatment plots was assessed using 15 temporary 2 m × 2 m quadrats placed at *c*. 5 m intervals along three transects across the plots; the transects were *c*. 10 m apart. The biomass of live bramble was measured by destructive sampling of randomly located 1 × 1 m quadrats in May, July and September 2000: three quadrats were harvested from each plot at each date. The material was weighed after drying overnight at 90°C. Total number of seedlings, which included both the advanced regeneration present at the start of the experiment and any naturally regenerated seedlings, was assessed within the 2 m × 2 m quadrats at the end of 2003. All analyses were carried-out using Genstat statistical software (Genstat, 1993): vegetation cover in 2 m × 2 m quadrats and whole plot bramble were investigated using REML; herbicide damage and survival were investigated by Generalised Linear Models using a poisson distribution and seedling number using a binomial distribution; Analysis of Variance was used to investigate seedling growth data with initial values as covariates; all other analyses were carried out using regression. Data for vegetation cover and bramble biomass were transformed to logarithms prior to analysis. Plant nomenclature follows Stace (1991).

Results

Visible effects of herbicides on vegetation health

In July 2000 the leaves of some oak seedlings showed deformities typical of those associated with glyphosate damage (Derr & Appleton, 1988), but similar symptoms of disfigured leaves that were puckered or peculiarly crinkled were found in all treatments, including the control. This apparent damage was mainly restricted to leaves produced during the first flush of growth and most of those formed during the second flush appeared as typical oak leaves. About 40% of seedlings in the Gly and BS treatments appeared to be damaged which compares with 3% and 19% in Para and Control respectively (Table 2). Analyses indicated that although Para differed significantly from Gly, BS and Tox there were no differences between most treatments. Few of the marked seedlings were visibly damaged in June 2001, and although some seedlings had died these were scattered throughout the treatments and no significant differences between treatments were found (data not shown). Similarly, with the exception of bramble, the herbicides appeared to have little effect on the groundflora with obvious damage being seen to wood anemone (*Anemone nemorosa*) and bluebell (*Hyacinthoides non-scripta*) in May 2000 on only one Tox plot (data not shown). Observations in May 2000 found that all herbicides had affected the bramble. The paraquat treatment had killed old leaves and some of the thinner shoots, but vigorous new growth was occurring on leafless shoots that were producing new shoots similar in appearance, but shorter, than those in the control treatment. Plots treated with glyphosate retained a dense cover of dark blue-green leaves on over-wintered shoots many of which showed no signs of spring growth; the new shoots that were being produced had leaves that were a pale yellow-green in colour and were much shorter than the control. The BS, Tric and Tox treatments had produced dramatic effects on the bramble, almost all old shoots had died shedding all of their leaves and any new shoots had died whilst they were very small.

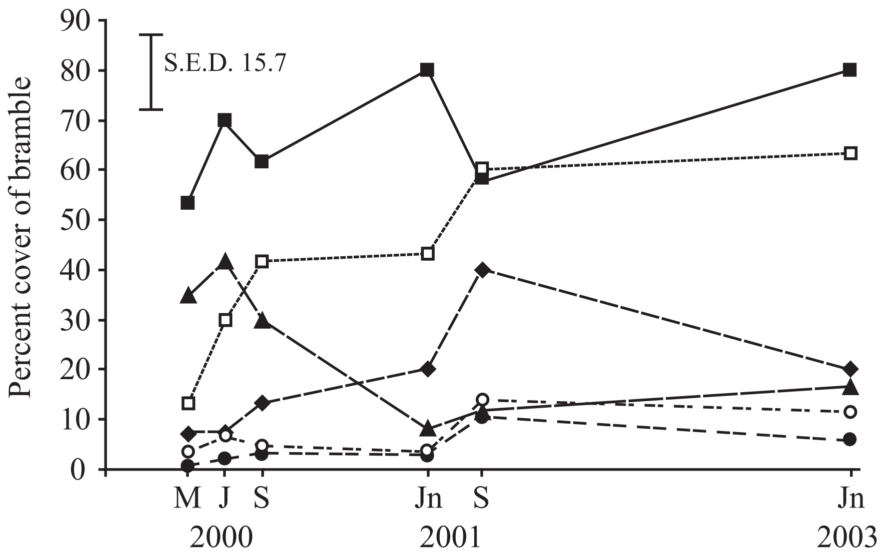

Fig. 1 Percentage cover of bramble in different herbicide treatments at each month and year of assessment. Herbicides: ■ = Control; ▲ = Gly; ● = Tric; ♦ = BS; □ = Para; ○ = Tox. Dates: M = May; Jn = June; J = July; S = September.

Bramble

The cover of bramble in the 2 m × 2 m quadrats was significantly reduced by the application of herbicides. There were significant interactions between treatment and date of observation. During 2000 the bramble cover in the control was significantly greater than in any of the treated plots (Fig. 1), and overall BS, Tric and Tox had significantly lower cover than Gly and Para. Data are not shown for bramble height but the differences were very similar. The trend was similar in subsequent years, but by 2003 the cover in Para plots was significantly greater than in the other herbicide treatments, 60% compared with 20% or less. (Fig. 1). Bramble cover over the whole of the treatment plots reflected that in the 2 m × 2 m quadrats: there were significant differences between treatments (5 df) and significant treatment × date interactions (25 df), both of which were significant at $P < 0.001$. Cover in the controls was consistently highest (55–70%), Gly was initially high and declined (50% down to 15%), Para rose from 15% to 40% and by 2003 all other treatments were below 20%. Cover of bramble in the 2 m × 2 m quadrats was a good reflection of that present on the whole plots: using general linear modelling it was possible to predict cover in 2 m × 2 m quadrats from whole plot bramble cover, with the model including whole plot bramble, date of observation, treatment and interactions explaining 86% of the variation ($P < 0.001$, df = 71).

Live biomass of bramble was difficult to assess on plots where there had been a significant herbicide effect, and bramble stems were only included if they had any green leaf material or new shoot growth. Parts of live stems that were obviously dead were removed. Overall the dry biomass in controls was *c*. 200 g m^{-2} whereas that in the herbicide plots varied between 150 g m^{-2} for Gly and less than 10 g m^{-2} for Tric and Tox treatments. The changes in biomass observed in 2000 were generally similar to those for cover and height with BS, Tric and Tox being lower than for the other treatments (Fig. 2). The biomass in control plots was never significantly different from the Gly treatment and only different from Para in July and September. This may reflect the method of assigning live / dead shoots and the dose and mode of the herbicides action. The Para treatment killed leaves effectively, but as large, robust stems remained alive and sprouted new shoots they were included in the harvest. The glyphosate treatment had visible effects on bramble foliage, and although it was unhealthy, it remained alive: this may reflect the relatively low quantity of glyphosate applied. In contrast, the other three herbicides killed leaves and stem completely.

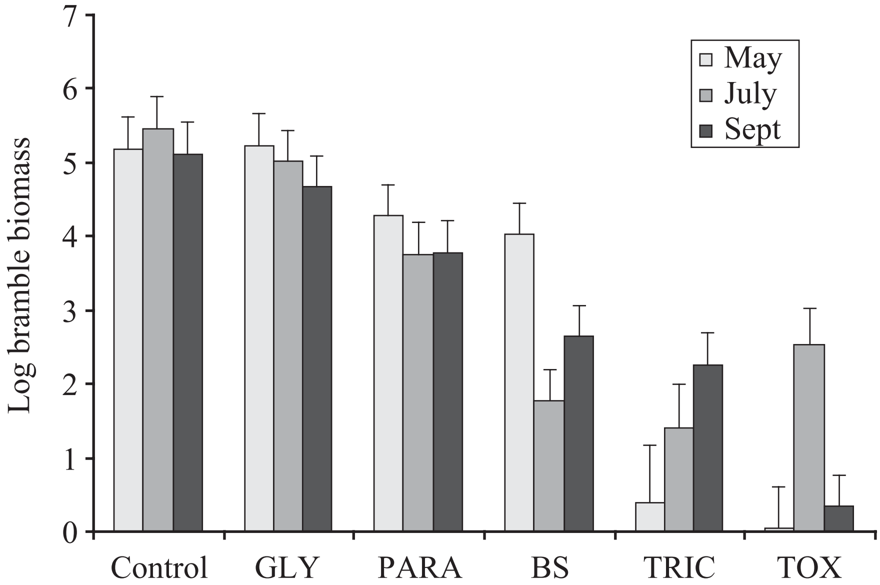

Fig. 2 Live biomass (g m^{-1}) of bramble in each herbicide treatment in summer 2000. Standard error bars are shown.

Other vegetation in the groundflora

There was a turnover of species present in the quadrats. A total of 31 were recorded during the 3 years of observation, but there were only 20 present initially in May 2000 and 25 in June 2003. Only two species, Yorkshire fog (*Holcus lanatus*) and dock (*Rumex* sp.) disappeared from the quadrats. Several species appeared and remained present until the end of the observations, these included hemp nettle (*Galeopsis tetrahit*), foxglove (*Digitalis purpurea*) and wood avens (*Geum urbanum*); others such as nipplewort (*Lapsana communis*) and wall lettuce (*Mycelis muralis*) appeared and disappeared: none of these new species occurred in more than three quadrats. The frequency of most species already present on site remained more or less constant, such species included characteristic woodland plants such as wood anemone, bluebell, creeping soft grass (*H. mollis*) and yellow archangel (*Lamiastrum galeobdolon*). In contrast, wood millet (*Milium effusum*) increased in frequency, being found initially in only 10% of quadrats, but by June 2003 it was present on 90%. Ten species were found on more than 25% of quadrats, the most common species and their frequencies in 2003 were bramble (100%), ivy (*Hedera helix*) (95%), rosebay willowherb (*Chamerion angustifolium*) (90%), and wood millet (90%). There were six species of regenerating trees and shrubs included in the groundflora: the most frequent of these was oak which was found on 60% of quadrats, all others including beech and holly *(Ilex aquifolium*) were found in less than 20%. Broom (*Cytisus scoparius*) was the only new species of shrub to be recruited during the study. Mean species diversity (excluding bramble) calculated using Simpson's index (Magurran, 2004) varied between 0.32 and 0.42 but there was no significant difference between treatments. Whilst loss of bramble reduced the total amount of vegetation present, the cover of most species remained low and the amount of each rarely exceeded 5%. The most notable exception was rosebay willowherb which increased in cover until it became the dominant herbaceous species present with covers of 5–70% in 90% of quadrats. Although there was considerable variability there was a significant inverse relationship between covers of bramble and rosebay willowherb at all assessment dates (Fig. 3; $P < 0.001$, $R^2 = 40\%$, df =101).

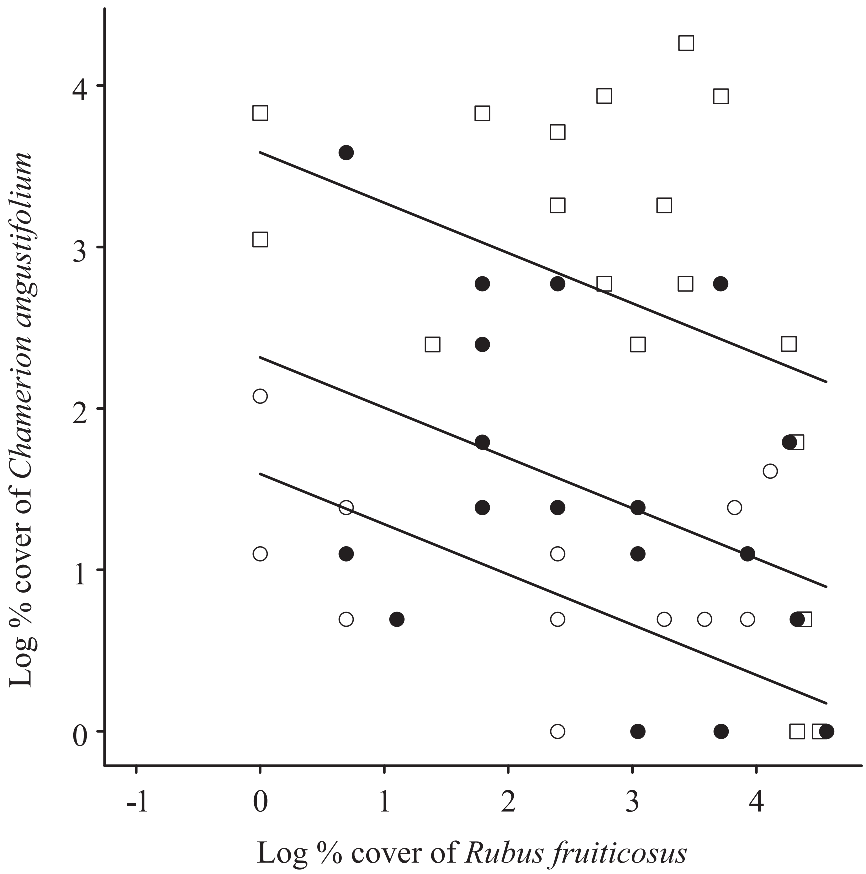

Fig. 3 Relationship between cover of rosebay willowherb and bramble. Regression lines are of the form: Log %cover rosebay willowherb = constant -0.3113*(log % cover bramble); $P < 0.001$, $R^2 = 40\%$, df =101. Symbols used and values of constants are: May 2000(□), 1.595; June 2001(●), 2.317 and June 2003 (○), 3.586.

Tree seedlings

There were significant differences between treatments in the survival of the marked tree seedlings ($P < 0.001$, df = 28). Only 50% survived in the control plots whereas in general more than 60% survived in the herbicide treatments (Table 2). Growth of marked seedlings was very poor regardless of treatment: plants were initially 20–40 cm tall with stem diameters of 2–4 mm, in 2002 they were of similar stature and there were no significant differences between treatments (Table 2). At the final assessment in 2003 no new naturally regenerated oak seedlings were found in the control, whereas there were about ten new seedlings in the Tric and Tox plots with fewer in other treatments (Table 2).

Table 2. *Herbicide damage, performance of marked oak seedlings at the end of 2002 and total number oak of seedlings on permanent quadrats in 2003*

Treatment Code	Damage (%)	Survival (%)	Height (cm)	Diameter (mm)	Total seedlings
Control	19	60	27	3.5	None
Gly	45	81	32	2.8	3.0
Para	3	68	35	3.2	1.7
BS	42	66	35	3.4	0.7
Tric	29	57	27	4.1	9.3
Tox	34	70	23	1.9	11.7
df	11	28	26	25	12
Average SED	11.5	6.9	-	-	5.5
P	0.023	<0.001	NS	NS	0.005

Damage = Percentage of sprayed seedlings (advanced regeneration) suffering apparent herbicide damage in July 2000. Survival = percentage of advance regeneration that survived after spraying, based on permanently marked seedlings. Diameter = Diameter 5 cm above ground level of permanently marked seedlings (advanced regeneration). Height = height of permanently marked advanced regeneration. Total seedlings = Total number of oak seedlings, both advanced and new regeneration, in 2 m × 2 m quadrats. NS = not significant.

Discussion

In general, all of the herbicides tested reduced the amount of bramble present. Long-term control was poorest for paraquat, as would be expected of a essentially non-translocated herbicide. The most effective treatments appeared to be those containing triclopyr. Little additional control over triclopyr alone appeared to be gained from the proprietary mixture which contained the additional translocated foliar acting woody weedkillers 2,4-D and dicamba. Isoxaben is a residual soil acting herbicide which, in some circumstances, has been shown to be capable of preventing the germination of new bramble seedlings (Dixon *et al*., 2006). In our work, there was some suggestion that total bramble biomass was reduced by the end of the first year through the addition of isoxaben following the triclopyr applications, but over a three year period there was little difference between treatments.

Although there were some initial signs of damage, survival of the marked seedlings was greater than the control in all the herbicide treatments, suggesting that any negative impacts from the repeated herbicide sprays were outweighed by the beneficial effects of a release from bramble competition. Growth response was poor, but this may result from the amount of canopy cover due to the high number of trees present on site relative to the 20–25 ha^{-1} recommended by Evans (1988). Despite the presence of overstory trees there were few apparent long term effects on the existing tree seedlings from applications of paraquat, echoing the reports of tolerance by Willoughby *et al*. (2006), but contrasting with those of Harmer *et al*. (2000).

More newly germinating tree seedlings survived in the Tric and Tox treatments than in others. This suggests that either very small young seedlings were negatively affected by the Gly, Para and BS treatments or, more likely given the lack of seedlings in the control plots, that the improved bramble control in the Tric and Tox plots favoured the natural regeneration of new tree seedlings.

The herbicide applications in our work were all made between January and March, and as seedling tolerance is likely to depend on dormancy status, more studies are required to determine a range of alternative safe times of application within the year for different tree species. Similarly, bramble susceptibility will also vary depending on time of application. In semi-natural habitats one of the major constraints on the use of herbicides for the control of competitive species that inhibit tree establishment is the effect that the chemicals may have on non-target species. With the exception of bramble, the herbicide treatments used in this experiment appeared to have little adverse effect on the other species present in the groundflora, some of which can be classified as ancient woodland indicators (Rose, 1999); these include wood millet which increased in frequency following herbicide addition. Whilst these results are encouraging and suggest that use of herbicides during the dormant season may be possible, the ground cover provided by the bramble thicket at this site was initially high and insufficient quantities of herbicide may have penetrated to cause damage to smaller plants. Further studies are necessary to test the effects of dormant season application of herbicides on a range of herbaceous species at sites where the cover of bramble is low or absent.

During the course of the experiment the ground flora on many of the treated plots changed from one that was dominated by bramble to one dominated by rosebay willowherb. Previous work has indicated that use of Triclopyr within a beech wood during the dormant season favoured the development of remote sedge (*Carex remota*) (Harmer *et al*., 2000). Such changes in vegetation following the use of herbicide should not be unexpected, but whether this is a problem may depend on the characteristics of the species that occupy the site. They may be a problem if they are competitive species with the potential to inhibit the establishment of small seedlings – remote sedge could fall into this category if it produces a dense sward. Although rosebay willowherb is often regarded as a weed species it is probably less competitive than the bramble that it replaced: over the year it allows more light to reach the forest floor as it produces shoots that grow in spring and die in autumn, and in contrast to dense vigorous bramble its shoots are unlikely to suppress tree seedling growth by physical smothering causing plants to collapse. However, replacing bramble with rosebay willowherb may have other effects, as it can produce very large numbers of wind-dispersed seed that can invade sites disturbed after management, and in addition it is probably much less beneficial for wildlife than bramble which provides valuable food and habitat for a wide variety of animals (Harmer, 2004). Initial indications from this work suggest that 0.96 kg a.i. ha^{-1} triclopyr applied between January and March, when existing tree seedlings are deeply dormant but bramble retains live green (not very dark green or brown) leaves, may offer a safe and effective method of freeing oak natural regeneration from bramble competition. However, if treatment is to favour growth and further seedling recruitment, then it will be necessary to ensure that the site is suitable for establishment, allowing seedlings to take advantage of the improved conditions. Before such a treatment could be widely recommended for releasing natural regeneration from bramble competition further investigations are required into the impacts of herbicides on overwintering non-target ground flora, their effects on different tree species treated at alternative times of year, and the influence of competing weed vegetation on the tolerance of tree seedlings to herbicides.

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