

In 90 % of the plots tree and shrub regeneration was noted, all the regeneration being from seedlings. Hawthorn and ash seedlings were the most frequently encountered (see Table 5).

b. Remaining conifers

Most of these plots had an almost complete canopy cover, ( between 90 and 100%), although occasionally where plots were sited where there had been tree fall, canopy cover could be as low as 50%. Occasionally (in 40% of the plots ) there was a 'shrub' layer, to which both young trees and immature shrubs contributed, and in one plot the shrub layer gave as much as 50% cover. Hazel and ash saplings were seen most often, while in one plot honeysuckle scrambling through these shrubs also contributed to the shrub cover.

There was considerable variation in field layer cover, ranging from 5 to 90 %, although in most plots it was 70 % or more. However there seemed to be little correlation between the amount of light reaching the woodland floor and the extent of the vegetation cover.

All plots had some bryophyte cover, and in two plots it was more than 60%. *Eurhynchium praelongum* and *Thuidium tamariscinum* were noted in most plots. Bare ground was not visible although there could be a considerable amount of needle litter, and occasionally some brash or a cut stump.

There tended to be a greater number of species in the field layer of these plots (mean 13.8[4.4]) than those in the broad-leaved woodland (mean 7.8[2.7]) and the overall list is more extensive (forty species compared to twenty two), although most of the species (86%) occurring in the broad-leaved woodland plots are also found in these plots.

Dog's mercury, bramble and common dog-violet are encountered frequently, as they are in the broad-leaved woodland plots . In addition ground ivy and wood sedge occur frequently here too, and in contrast to the broad-leaved woodland plots ground ivy, described by Peterken as a fast colonising woodland species, often accounts for much of the vegetation cover. Honeysuckle, which is not recorded in the broad-leaved woodland plots, is also repeatedly seen ( 70 % of the plots).

There are nine ancient woodland indicators in the list of herbaceous species, with a mean of 4.3[0.8] indicators per 5m x 5 m plot, a similar value to that for the broad-leaved woodland plots. The list is very similar (Table 4) for the two treatments, although some species, particularly hairy St John's-wort and wood sedge occur more frequently in the conifer plots.

Three of the stress tolerant species found in these plots are also ancient woodland indicators. A fourth stress tolerant species, not in this category, is also present . This latter species was not found in the broad-leaved woodland plots but occurs in 20% of these plots ( Appendix 6), and the mean number

of stress tolerators per plot is slightly higher (Table 1).

The Group Two species present, seven in all, also overlap marginally with the ancient woodland indicator category. As in the broad-leaved woodland, dog's mercury and bramble are the most frequently encountered of this group. Honeysuckle, whose frequent presence in these plots and absence from the broad-leaved woodland has already been noted is another Group Two species, and one of Peterken's fast colonising woodland species, although generally the overall list for the two treatments is very similar. However the number of species in this group in any one plot is usually higher than those in the broad-leaved woodland plots.

As in the broad-leaved woodland plots no ruderal species were recorded in these plots, and only one competitor, creeping thistle, (one of Peterken's shade-bearing weeds), although in contrast to the broad-leaved woodland there was quite a list of Group One species, such as enchanter's nightshade, marsh thistle, creeping buttercup and hedge woundwort. Most were rather infrequent, with only wild angelica occurring in more than 50% of the plots (Appendix 6). The plot mean for this treatment was 2.3[2.0] compared with 0.7[0.7] for the broad-leaved woodland.

All the plots exhibited some tree and shrub regeneration (Table 5), mainly from seedlings, with occasionally coppice regrowth from ash. Overall the plots contained quite a range of species, similar to the list for the broad-leaved woodland. Hazel, hawthorn and rose seedlings were commonest, with the number of seedlings in each plot ranging from one to four (mean 2.3[1.3]).

### c. Restored area

The restored area had already started to develop a shrub layer, as a result of both coppice regrowth and seedling establishment, with occasional more mature ash trees amongst these shrubs. This is reflected in the recording in the plots, with one having both a "canopy" and shrub layer, and five others a shrub layer whose cover ranged from 10 to 50%.

Hazel, ash and goat willow are the most frequently encountered species, thus showing similarities with the composition of the broad-leaved woodland tree and shrub layers.

There is good ground cover in the plots (mean 97.7), and in contrast to the other two treatments, with very little litter or bare ground. Bryophyte cover is similar to that in the broad-leaved woodland plots and again is mainly composed of *Eurhynchium praelongum*.

Yorkshire fog, a highly efficient colonist of open habitats (Grime *et al* 1988) is a major contributor to ground cover in many of the plots, although in one is replaced in this capacity by creeping soft grass. Creeping soft-grass is exceedingly vigorous in lightly shaded and open habitats in woodland and may spread explosively after coppicing. There are quite a number of

additional herbaceous species in the plots, with a mean of 20.3 [2.9] species per 5m x 5 m plot.

Most of the additional species have low domin values, but occasionally they may give more extensive cover in one or two plots. Most notably pendulous sedge has a domin value of 7 ( 34-50 % cover) in one plot.

There is a relatively good degree of consistency overall in the plot composition. For example, of the total list of forty six herbaceous species fourteen occur in 80% or more of the plots. Creeping thistle , tufted hair-grass, and ground ivy are present in all the plots.

The plots therefore differ quite significantly from the ground layer in the broad-leaved woodland, both in having a significantly higher number of species per plot and in their major constituents. In particular dog's mercury, one of the main components of the field layer in the broad-leaved plots is only present in two of these plots, and at a low cover.

There are however some similarities between the overall lists for these treatments, with thirteen species common to both the broad-leaved woodland and the restored area plots. They include tufted hair-grass, ground ivy and bramble, each of which are frequently seen in all the treatments.

Some ancient woodland indicator species have persisted in the area with five recorded in the plots. All are found in one or both of the other treatment types ( Table 4), although dog's mercury and common dog violet are less frequent in this treatment compared with the broad-leaved woodland plots and pendulous sedge is more frequent. Hairy St John's-wort, which is not seen in the broad-leaved woodland plots, increases in frequency in this treatment compared with the conifers. The plot mean of 2.6[0.8] is lower than in the other treatment types.

Very few plots ( 20%) contained stress tolerant species, (Appendix 6) with only one species per plot. Group Two species were more in evidence with a plot mean of 4.4[1], which is higher than in any of the other treatment types. Several Group Two species were encountered frequently, particularly pendulous sedge and bramble, while both soft rush and conglomerate rush occurred relatively frequently.

As in the previous treatments none of the herbaceous species in the plots are categorised as ruderals , although some competitive species (see Appendix 6) are present, with one, creeping thistle occurring in all the plots. Competitive species were not present in the broad-leaved woodland plots, and in only one of the remaining conifer plots.

Similarly, in contrast to the broad-leaved woodland plots, there was quite a list of Group One species (six in all), although not as many as in the conifer plots. Of these only hedge woundwort and creeping buttercup were seen frequently. However the plot

mean for this treatment was higher than in the other treatments.

All the plots in this treatment contained regenerating trees and shrubs, with both coppice regrowth and establishment from seedlings in evidence. A more extensive list of regenerating species was recorded than in the previous two treatments and there was a higher number of regenerating species in individual plots with a plot mean of 3.2[1.6]. However the most frequently encountered species was pine ( in 50 % of the plots).

### III. Mortimer Forest

#### a. Broad leaved woodland

The almost closed canopy above the plots was dominated by sessile oak. Typically there was no shrub layer, although occasionally an immature beech formed an understory, and in one plot rowan was seen.

The field layer usually gave a cover of 95 % or more but in one plot cover was only 75%. Small amounts of litter or dead wood were often also present. In all the plots bilberry provided most of the ground cover, always accompanied by some wavy hair-grass. There were very few additional species, of which bracken was most frequently encountered. Often only a single frond was found. The mean number of herbaceous species in the plots was 3.4[0.7].

None of the herbaceous species present are regarded as ancient woodland indicators, although few would be anticipated in this type of community. The total list of seven species included two Group Two species, bilberry and wavy hair-grass, and one competitor, bracken which is shade tolerant( Appendix 6 ).

**Table 6 The frequency (%) with which regenerating trees and shrubs were encountered in the plots in Mortimer Forest.**

	Broad-leaved woodland	Remaining conifers	Restored area
<i>Betula sp.</i>	10	60	40
<i>Fagus sylvatica</i>	50	0	0
<i>Ilex aquifolium</i>	0	20	20
<i>Quercus sp.</i>	100	0	10
<i>Sorbus aucuparia</i>	30	0	30
<i>Tsuga heterophylla</i>	20	100	100
<b>Overall frequency</b>	<b>100</b>	<b>100</b>	<b>100</b>

Regeneration, almost always through seedling establishment, was

noted in all of the plots (Table 6), with oak occurring with a frequency of 100%. Beech was colonising too, in 50 % of the plots, and two hemlock seedlings were found.

Bryophytes gave a small amount of cover in all the plots, with *Mnium hornum* and *Hypnum cupressiforme* noted in most plots.

Overall the stand is typical of the W16 *Quercus* sp. *Betula* sp.-*Deschampsia flexuosa* Woodland, sub-community b, *Vaccinium myrtillus*-*Dryopteris dilatata*.

#### b. Remaining conifers

The plots in the stand of western hemlock-spruce had a variable canopy cover ranging from 50 to 100% (Mean 76%). There was no understorey and the field layer cover was also rather variable, ( range 10%-60%, mean 21.6), but, in contrast to what might be anticipated, plots with a good ground cover did not necessarily correspond with those with a more open canopy.

In most plots a significant proportion of the ground was covered by deep needle litter and there was often dead wood, usually brash left when the stand had been thinned. Brash could account for as much as 90% cover in any one plot. Bryophytes were a constant feature of the plots, and in some gave a substantial cover(60%). *Mnium hornum* was again seen consistently in the plots, and *Plagiothecium undulatum*, a species not observed in the broad-leaved woodland plots, was also conspicuous in many.

In those plots where there was a reasonable field layer, bramble which is classed as a fast colonising woodland species by Peterken, and which occurs occasionally in W16, or bramble with broad buckler-fern, contributed significantly to this cover, although in one of these plots western hemlock-spruce seedlings, mostly between 60 and 90 cm tall, were the main contributors.

Bilberry, the main component of the field layer in the broad-leaved woodland plots was seen only infrequently in these plots, and had a low domin value. Its constant associate in the broad-leaved woodland plots, wavy hair-grass, and a community constant in W16, was not seen at all.

However there were additional species in these plots not found in the broad-leaved woodland plots, with only four of the total list of species for each of these treatments common to both. Overall more species were found in the conifer plots although there were a similar number of species in each plot ( Table 1).

One ancient woodland indicator species was present, great woodrush, but was found in only one plot. The total list of species also included four Group Two species, ( Appendix 6) two of which were also seen in the broad-leaved woodland plots. There were no ruderals and only three competitive species, stinging nettle, bracken, both of which can tolerate shade and rosebay willowherb. Group One species were also absent.

All the plots contained western hemlock-spruce seedlings, and birch seedlings were also quite frequent (Table 6). Occasionally holly seedlings were also found.

#### *c. Restored area*

Some of the plots in the restored area were partially overhung by young oak trees, forming a very incomplete shrub layer (5 - 20 % cover). In nearly all the plots there was either a significant amount of brash or of litter, through which or over which the field layer species were growing. In most plots the field layer cover was not extensive, although in three plots it was 80% or above.

As in the remaining conifer stand, bramble and broad buckler-fern were consistently recorded in the field layer, with bramble the main contributor. Rosebay willowherb and foxglove were also quite frequent constituents, although generally only a few immature specimens were present in each plot. Other associates were infrequent, but did include some of the species found in the field layer in the broad-leaved woodland, such as wavy hair-grass, honeysuckle and bracken, and additionally a little hard fern, which is described as occurring sparsely in the W16 community (Rodwell 1991). However bilberry whose establishment from seed is slow and infrequent and which was the dominant species in the broad-leaved woodland was absent from these plots. Overall the mean number of species in the field layer was of a similar order to that in the other treatments.

The full list of herbaceous species included one stress tolerator, heath bedstraw, which is more typically found in nutrient-poor grasslands, but which can be a component of W16, one ruderal, groundsel, and two competitors, one of which, rosebay willowherb was particularly frequent. There were also two Group Two species, neither of which were frequent.

All the plots contained regenerating trees or shrubs, (Table 6) although as in the remaining conifers the most frequently encountered species was western hemlock-spruce. Rowan and birch seedlings were seen quite frequently. All the regeneration was from seedlings, except in one plot where there was also regrowth from the cut stump of an oak.

Bryophytes occurred in most plots, although the percentage cover was low. *Mnium hornum* was most often encountered.

#### **IV. Eaton and Gamston Woods.**

##### *a. Broad-leaved woodland.*

The canopy and shrub layer combined, gave almost total cover, with very little open sky visible in most of the plots. The canopy was dominated by ash, whilst the understorey usually contained suckering wych elm, and often hawthorn and hazel.

The field layer cover in the plots ranged from 30% to 95%, although in most plots it was 70% or above. There were only small amounts of bare ground visible, but usually a substantial bryophyte cover (over 50%), with *Eurhynchium praelongum* in most plots. Small amounts of leaf litter were also present and often a little dead wood, such as decaying tree stumps where trees had toppled.

**Table 7** The frequency (%) with which ancient woodland indicator species were encountered in the plots in Eaton and Gamston Woods.

	Broad-leaved woodland	Remaining conifers	Restored area
<i>Carex sylvatica</i>	10	0	0
<i>Hyacinthoides non-scripta</i>	0	0	30
<i>Hypericum hirsutum</i>	0	0	30
<i>Mercurialis perennis</i>	100	0	80
<i>Potentilla sterilis</i>	0	0	10
<i>Stellaria holostea</i>	10	0	0
<i>Veronica montana</i>	10	0	0
<i>Viola riviniana</i>	10	0	10

A combination of dog's mercury and bramble, in varying proportions, accounted for most of the cover in the plots, and nearly all also contained some cleavers, (one of Peterken's shade-bearing weeds), red campion and wood avens.

The total number of species recorded in the plots was not high and the mean number in each plot was 6.4[1.1]. Only five ancient woodland indicators were included in this list, with generally only 1 or 2 in individual plots (mean 1.4[0.7]). Of these indicators only dog's mercury occurred frequently (Table 7).

The list also included two stress tolerant species (Appendix 6), both also ancient woodland indicators and four Group Two species. Of these only bramble and dog's mercury, which are the main components of the community, occurred frequently.

Ruderals were not recorded and there was only one competitor, stinging nettle, which Peterken describes as a fast colonising woodland species. Group One species were also uncommon although one of these, cleavers, was particularly frequent.

Tree and shrub regeneration was always from seedling establishment. It was not however a frequent phenomenon in the plots, occurring in only 50% with often only one species exhibiting regeneration in each plot (mean 0.6[0.7]). A number of species were noted (see Table 8).

b. Remaining conifers.

The plots in the conifer stand also had an almost closed canopy often with very little open sky visible through it. In two stands shrubs were found beneath the canopy though the extent of their cover was limited.

The field layer was very variable ranging from no cover in one plot to a maximum of 95%. Most plots were covered with a deep layer of needle litter, in some cases above which bramble was scrambling. Small amounts of dead wood were present too, and most plots had a cover of bryophytes, though this was never very extensive.

**Table 8 The frequency (%) with which regenerating trees and shrubs were encountered in the plots in each treatment at Eaton and Gamston Woods.**

	Broad-leaved woodland	Remaining conifers	Restored area
<i>Acer campestre</i>	10	0	50
<i>Acer pseudoplatanus</i>	10	0	0
<i>Betula sp.</i>	0	0	20
<i>Cornus sanguinea</i>	10	0	10
<i>Corylus avellana</i>	0	0	50
<i>CraLaegus monogyna</i>	0	0	80
<i>Fraxinus excelsior</i>	30	0	70
<i>Ilex aquifolium</i>	0	10	0
<i>Rosa sp.</i>	0	0	10
<b>Overall Frequency</b>	<b>50</b>	<b>10</b>	<b>100</b>

Bramble was the main component of the field layer. There were only a limited number of associates, (Mean No. species per plot 4.1[1.9]), and most had only a low domin value. Of these broad buckler fern and male fern, both listed by Peterken (1981) as fast colonising woodland species, were seen most frequently, neither of which were common in the broad-leaved woodland plots. Dog's mercury one of the characteristic species of the broad-leaved woodland plots was not recorded at all in this treatment, and overall only two of the herbaceous species recorded were common to both treatments.

Ancient woodland indicators and stress tolerant species were not included in the total list of nine herbaceous species, although some Group Two species were in evidence. Only one other type of strategist was noted, the competitor bracken, which is shade tolerant.

There was very little evidence of any regeneration in this

treatment, with only one plot containing a single holly seedling.

*c. Restored area.*

The areas from which conifers had been removed were not extensive and distributed unevenly through a broad-leaved stand. The plots in the restored area were consequently often partially shaded by ash or oak or occasionally both species, and in these plots tree cover ranged from 20 to 50%.

The ground vegetation was generally well developed and bryophytes were always present, although percentage cover was never very high. Some litter and brash was present in most plots although there was very rarely bare ground visible.

Bramble attained a high cover in 90% of the plots, and was usually accompanied by dog's mercury. There were a variety of associates many of which were also found in the broad-leaved woodland plots, so that the community was rather similar to that in the semi-natural stand. The mean number of species per plot was 4.5[1.5], which was not significantly different from the other two treatments.

Ancient woodland indicator species were rather infrequent in these plots (Table 7), and the plot mean was similar to that for the broad-leaved woodland. Although some of the indicators were common to both treatments there were differences e.g. hairy St. John's-wort was not found in the broad-leaved woodland plots but was found in 30% of these plots. Two stress tolerant species were recorded both of which are also ancient woodland indicators.

Four Group Two species were noted, the most frequently encountered of which were dog's mercury, also an ancient woodland indicator and bramble, one of Peterken's fast colonising woodland species ( Appendix 6). The other two species, ivy and honeysuckle, are also described similarly by Peterken.

Only one ruderal was present, at a low frequency, although three competitors were encountered, of which rosebay willowherb was seen in 50% of the plots. Five Group One species were noted, including cleavers in 80% of the plots and enchanter's nightshade in 70% of the plots. The former is a shade-bearing weed while the latter is a fast colonising woodland species, according to Peterken. Only two of these species were also encountered in the broad-leaved woodland plots and none in the conifer plots.

Regeneration was occurring in all of the plots, from both seedling establishment and to a lesser extent from coppice regrowth. The list of regenerating species was rather higher in this treatment type, with ash and hawthorn being encountered particularly frequently ( Table 8).

## **DISCUSSION**

### **Restoration of a semi-natural tree cover.**

There are indications that at least at some of the sites the restored areas will regain a semi-natural tree cover. This process seems to be progressing particularly well at Foxley Wood, where the conifers have been removed longest, and a community similar to that in the semi-natural broad-leaved stand is developing. Felling seems to have been undertaken selectively at this site, with broad-leaves which had established amongst the planted conifers being retained, a practice which has contributed to this successful restoration. However pine is also regenerating well and it will be necessary to remove these seedlings, if they continue to thrive.

At Eaton and Gamston Wood where conifers were removed from a mixed stand, there is good regeneration too, particularly of the species characteristic of the semi-natural community. At Castor Hanglands where felling was undertaken last winter ('96) regeneration has begun, although the frequency with which species typical of the semi-natural stand are encountered is rather low and with additional species, such as birch and willow, which are often early colonists of bare ground producing large quantities of mobile seeds, more abundant. Birch seedlings were frequently seen in the restored area at Mortimer Forest, where felling had recently occurred, although the most commonly encountered seedlings were western hemlock-spruce. Oak the canopy dominant in the semi-natural stand where it was regenerating freely, was very rarely seen. Consequently restoration of a semi-natural tree cover appears to be less likely to be successful at this site without intervention.

Good regeneration in the remaining conifer stands at some sites, also gives an indication that restoration may be successful if the conifers were removed. However success seems less assured at Eaton and Gamston Woods where there is very little evidence of regeneration in the conifer stand, possibly because of the deep layer of needle litter and the heavy shade, as has been found elsewhere (Kirby and May 1989), and at Mortimer Forest where there is a significant amount of conifer regeneration.

### **Effects of conifer planting on the field layer**

#### *Field layer cover.*

Planting of conifers at the sites has generally resulted in a substantial reduction in field layer cover compared to the semi-natural stand, although there is considerable variation between plots in the conifer stands at each site, in some instances related to amounts of light reaching the woodland floor. However at Foxley Wood the extent of the field layer cover is similar beneath both stand types. Some of the plots in the conifer stand are less densely shaded than the majority in the broad-leaved stand where there is very little open sky visible through the

combined shrub layer and canopy which may account for this. Good ground flora survival under pine has been found at other sites, such as the Wyre Forest, where the extent of field layer cover was similar under a 35 year old Scot's pine stand to that in an 80 year old oak stand, which was attributed to the open nature of the canopy in older pine plantations (Kirby 1988).

#### *Species composition*

Although overall cover is suppressed the number of herbaceous species in the plots has usually remained similar in the broad-leaved and conifer stands, and at two sites a similar range of species was encountered in each stand type, although abundance did vary. For example, at Foxley Wood ground ivy was more abundant beneath the conifers than in the broad-leaved stand. However there was less correlation between the species lists from the two stand types at both Mortimer Forest and at Eaton and Gamston Woods.

At Mortimer Forest bilberry the main component of the semi-natural ground layer was seen very infrequently in the conifer plots and wavy hair-grass a constant associate of the bilberry was not seen at all. Bilberry is thought to be susceptible to damage during extraction (Kirby and May 1989), which may explain the reduction in frequency. Dog's mercury one of the main components of the semi-natural field layer at Eaton and Gamston Woods was not recorded at all in the conifer plots.

At Eaton and Gamston Wood ancient woodland indicators were not included in the list of species from the conifers stands, although at the other sites they did persist beneath the conifers, with similar numbers of indicators in the conifer plots to those located in the broad-leaved stands. Ruderals were very rarely seen in the conifer plots and few competitors were present. It would appear that these types of strategists, which would have been likely colonists when the broad-leaved stands were felled and the conifers first planted have not been able to persist in the dense shade of the fully developed conifer canopy.

It can be inferred, therefore, that at least at some of the sites where the species characteristic of the semi-natural community including ancient woodland indicators persist, and there are low levels of competitors, restoration of a semi-natural ground flora will be successful after felling of the conifers.

#### **Effects of conifer removal.**

##### *Ground cover*

Removal of the conifers has allowed a considerable expansion in ground cover in the restored stands, assuming the ground cover was previously suppressed as has been found in the remaining conifer stands.

## *Species composition*

### a. Herbs characteristic of the semi-natural community

This expansion can only partially be attributed to an increase in cover of the herbs characteristic of the semi-natural community, and at some sites these species remain at a low cover in the restored area. The species which do respond tend to vary from site to site; some species exhibit recognisable trends but not necessarily consistently across all the sites.

At Castor Hanglands, for example, false wood-brome, a fast colonizing woodland species and a major constituent of the semi-natural ground layer, has persisted beneath the conifers, though is much reduced. Generally in the restored area it has begun to expand, although does not as yet make a substantial contribution to the cover in every plot. However dog's mercury an ancient woodland indicator and a stress tolerant competitor, which is the other main component of the semi-natural ground layer, occurs frequently beneath the conifers but is much less conspicuous in the restored area. There is some evidence that dog's mercury is susceptible to trampling and disturbance which may account for this. It exhibits a similar response at Foxley Wood where it is also one of the main components of the semi-natural stand.

Bramble, also a stress tolerant competitor, and the other main component of the semi-natural field layer at Foxley Wood, persists beneath the conifers and is present in the restored area, although it has not expanded here in comparison with the conifer plots.

At Eaton and Gamston Woods, where bramble and dog's mercury are again the main components of the semi-natural field layer, bramble persisted beneath the conifers although dog's mercury did not occur. However bramble was a major contributor to the field layer in the restored area and had expanded considerably in comparison to the conifer plots. It was usually accompanied by dog's mercury.

Bramble was a very infrequent associate in the ground layer of the broadleaf stand at Mortimer Forest, but occurred more often beneath the conifers and had spread substantially in the restored area.

Other than at Mortimer Forest the characteristic herbs of the semi-natural community occurring in the restored areas include ancient woodland indicators, with a similar number of indicators to those in the other stand types at each site. One indicator, dog's mercury, is the main component of the community at all three sites, although most indicators occur rather infrequently in the semi-natural stands. However the frequency with which some indicators are encountered increases in the restored areas. This trend is seen at all three sites for hairy St John's-wort. It produces numerous small seeds which require areas of bared ground for establishment, a condition which would best be met in the restored plots. It also forms a persistent seed bank, which

allows it to persist during the closed phases of coppice cycle.

b. Additional species found in the restored areas.

In most instances there has been an increase in the overall number of species compared with the semi-natural stand, the exception being Mortimer Forest. The additional species have usually contributed substantially to the expansion of the ground flora in the restored plots. The new colonists are often competitive ruderals or strategists intermediate between competitive ruderals and ruderals etc. (Group One species), such as creeping bent, lesser burdock, spear thistle, creeping buttercup and coltsfoot or competitors such as rosebay willowherb and great hairy willowherb. At Castor Hanglands, where restoration had occurred very recently and there were still very occasional patches of bare ground or bare ground with a light cover of leaf litter, there was also a significant ingress of ruderal species, such as common poppy, shepherd's purse, chickweed and scentless mayweed.

These new colonists are species which have developed regenerative strategies which allow them to take advantage of disturbance. Some have persistent seed banks, including all the ruderals encountered at Castor Hanglands, and some of the Group One species such as creeping bent, lesser burdock, creeping buttercup, broad-leaved dock and brooklime which allows, for example, temporary stability during periods when they are excluded by perennial species (Grime *et al* 1988). Others have widely dispersed seeds or spores such as the group one species American willowherb and coltsfoot and the competitor rosebay willowherb and can exploit situations where disturbance occurs as an exceptional event in an environment of high productivity. Several have adopted a combination of these strategies and produce widely dispersed seeds which may persist in the soil for over five years and often much longer. They include ruderal species such as groundsel, competitors such as creeping thistle and great hairy willowherb and the Group One strategist prickly sow-thistle ( R/CR).

However because these strategists do not thrive in conditions where levels of stress are high they are unlikely to persist once a canopy cover develops.

There are some new colonists which are not ruderals, competitors or Group One species, and which occur relatively frequently in the restored areas. These include jointed rush, seen at Castor Hanglands and Yorkshire fog which was encountered at Foxley Wood. Both have a persistent seed bank like the other new species and in addition are capable of vegetative regeneration making them effective colonists. Yorkshire fog has only restricted tolerance of shaded habitats (Grime *et al* 1988) and its vigour may reduce as the canopy develops. Similarly jointed rush is not usually found in shaded habitats.

Occasionally the new colonists are species included on Peterken's list of fast colonising woodland herbs most of which are also

characteristic of undisturbed communities in ancient woods. They include herb robert, broad-leaved willowherb and ivy. A few are ancient woodland indicators such as common valerian, barren strawberry and bluebell. New colonists from these groups are most often seen at Eaton and Gamston Woods, where the conifers have been selectively removed from a mixed stand.

#### *Mortimer Forest*

At Mortimer Forest there was not a substantial increase in species numbers in the restored area compared with the semi-natural stand and field layer cover had increased only marginally following removal of the conifers. A small number of new species are present, including rosebay willowherb and Yorkshire fog, both colonists of the restored areas at other sites. Most of these new species are also found, although very infrequently, in the conifer stand at this site.

The soils at Mortimer Forest are acidic and consequently would not be expected to support as diverse assemblage of species as more calcareous substrata. However the substantial brash cover in the restored area may also be a factor, reducing the opportunities for seedling establishment, with only one ruderal, groundsel, present. Some of the species which have responded, such as heath bedstraw and foxglove are typical of the W16 community, but are often limited to scattered individuals when there is substantial ericoid cover and may become more prominent in gaps and clearings or after coppicing (Rodwell 1991). Bramble, in which the response was most marked, is also noted as an occasional component of the community that may thicken up when grazing is relaxed or after coppicing. Rosebay willowherb too is described as typical, with persistent clumps marking localised areas of disturbance or fire.

#### **CONCLUSIONS**

The restored sites will probably regain a semi-natural tree cover, although some intervention may be required at some sites to remove undesirable species, principally conifers.

There are also indications that a characteristic ground flora will be successfully restored at most sites. Species typical of the semi-natural stands, including ancient woodland indicators where appropriate, have generally been recorded in the restored areas, although often with a reduced frequency. At most sites there has been a significant amount of colonisation by additional herbs, many of which are not woodland specialists but which currently contribute substantially to vegetation cover. However it is anticipated that as the canopy develops these species, which are generally competitive ruderals or intermediate between competitors and competitive ruderals or are ruderals and which are not tolerant of stress, will decline. It is probably reasonable to assume that this type of strategist colonised the area at the time when the broad-leaved trees were felled and the conifers first planted. These strategists now appear very infrequently in the conifer stands, adding weight to this

supposition.

The vigour of bramble, which has responded positively to felling, may also be reduced as shade increases allowing other characteristic herbs to expand, thus restoring the balance in some communities. However at Mortimer Forest where bramble has replaced bilberry as the main component of the community, it is uncertain whether bilberry will be able to respond. It is not found in the restored area and its establishment from seed is slow and infrequent, and is probably restricted to bare areas of soil. In addition a persistent soil seed bank has not been found in Britain. Regeneration is mainly from rhizome growth. Occasional plants growing on the edges of the rides adjacent to the restored area may eventually spread into it.

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