11 THE WIDE MARGINS EXPERIMENT

11.1 Introduction

The wide margins experiment was designed to evaluate the wildlife benefits, ease of management and potential for fodder cropping of two inexpensive grass leys suitable for use on fallowed arable land. One of these leys was a conventional mixture of *Phleum pratense* L. Cat's-tail with cultivars of *Lolium perenne* and *Trifolium repens* L. White Clover, designed to give high yields in high input systems. Such mixtures are generally considered to be of very low nature conservation value. They are nevertheless inexpensive and readily available to farmers and were therefore likely to be used for green cover on set-aside land. The composition of the second ley was based on 19th Century grass mixtures (The Lawson Seed and Nursery Company (Limited) 1877). It was more species rich and included a small proportion of forbs. Of these species, *Achillea millefolium* and *Rumex acetosa* have traditionally been used in so-called herbal leys because they improve the mineral nutrient content of the sward. We also included *Ranunculus acris* to improve the structural diversity and amenity value of the swards. We refer to these two leys as the 'conventional' and 'diverse' leys.

The experiment was designed before the regulations for the first set-aside scheme were formulated but at a stage when it was clear that there would be a requirement for fallowing or extensification to reduce EC surpluses. At that stage alternative cropping of land removed from arable production seemed a likely option and formed part of the thinking behind the choice of experimental treatments and the monitoring methods. Thus, the mowing regimes used were appropriate for hay and silage management and the productivity of the swards was measured in addition to their species composition. Fallowing of wide field margins was also mooted as a likely option in the scheme and we conducted the experiments on field margins rather than whole fields because of their potential benefits as wildlife corridors.

The experiment was nevertheless designed primarily to maximise understanding of relevant ecological processes rather than to test specific management systems tied to specific schemes (see Chapter 1.1). Thus, although the first set-aside scheme did not allow any agricultural use of green cover crops, the design of the experiment allowed us to evaluate many facets of the use of grass leys on set-aside within the scheme. More importantly, it also provided information that can be used to evaluate the conservation and management problems associated with future set-aside schemes, and with other schemes concerned with fallowed arable land and with extensified agriculture.

In this chapter we concentrate on results of the experiment that are relevant to set-aside. Results are presented from samples harvested from the experiment in the year in which the margins were sown, and three years later. In section 11.2.1 we evaluate the relative merits for nature conservation of the two leys under hay and silage management. Information from treatments with and without fertiliser is used to examine the role of fertility in controlling dominance and diversity in the two leys. Data concerned with the relative ease of managing the leys for set-aside green cover are presented in section

11.2.2. Management problems associated with both productivity and pernicious weed control are considered. In section 11.2.3 we present data on the importance of the wide margins to butterflies. Details of the grass leys and experimental methods are given in Chapter 2.3.

11.2 Results and discussion

11.2.1 THE RELATIVE NATURE CONSERVATION BENEFITS OF THE TWO LEYS

In this section we evaluate the effects of hay and silage management regimes and of the two fertiliser levels on the nature conservation merits of the two grass leys. Plant species richness and diversity are used as indicators of nature conservation value. We then examine the role of dominant species in determining species richness and diversity.

Analyses of the effects of treatment on total species richness and diversity are presented for both the establishment year (1988) and three years later. We then examine the relative contributions to observed treatment effects of the sown and naturally regenerating (unsown) components of the swards. Finally we look at the contributions to the sward of individual species in the seed mixtures. The relative abundance of the dominant species is examined in relation to the maintenance of diversity and analyses are presented of the effects of treatment on the individual dominant species.

Throughout this section it should be borne in mind that the design of the experiment did not allow direct statistical comparison of the results from the hay and silage margins because the two management regimes were imposed on different fields (Chapter 2.3.1). In 1988, management of the hay and silage regimes was identical prior to the time we harvested the samples. Very similar results were obtained from both regimes at that stage (below), suggesting that intrinsic differences between the fields were small relative to the effects of our treatments. We have therefore made qualitative comparisons between species richness and diversity under the two regimes. Such comparisons cannot, however, be made between our estimates of the abundance (measured as biomass) of individual species on the hay and silage margins in 1991. The samples from the former were harvested when productivity peaked, just before the hay was cut in June and, from the latter when productivity was lower, before the second silage cut in July (Chapter 2.3.2). Equally comparisons between the absolute biomass of species on the silage margins in 1988 and 1991 are not valid because although the harvest dates were similar, the sward had not been cut prior to the 1988 harvest.

Plant species richness and diversity

The analyses presented in this section are of the effects of treatment on species richness and diversity in 1988 and in 1991, and on the change in the variables between the two years. Analyses of both Simpson's index of diversity and the Shannon-Wiener function gave very similar results and so only the results from Simpson's index are presented. We used the individual species contributions to the biomass of each quadrat as a measure of their abundance in the estimation of diversity. An index of change in species richness and diversity between years was calculated as the ratio of the plot means for 1991 and 1988, and is expressed as a mean for each treatment. Thus, values near one indicate little or no change, values greater than one indicate an increase over time, and values less than one indicate a decline. Because of the variance in the data, the indices usually differ by varying amounts from rough estimates of the same quantity that can be made using the overall treatment means for 1988 and 1991 that are presented in the tables.

Margins managed for hay In both 1988 and 1991 there were significantly more plant species in the diverse ley than in the conventional ley (Table 11.1, and Figure 11.1). As expected from the relatively small amounts of fertiliser applied before the 1988 samples were harvested, fertiliser had no significant effect on the numbers of species that year (two applications, see Chapter 2.3.1). By 1991, although the differences between fertilised and unfertilised treatments were not significant, fertilised leys of both types had fewer species than unfertilised leys.

The numbers of species declined under all treatments between 1988 and 1991, with the smallest change in the unfertilised, diverse ley. However, the differences in the decline between treatments were not significant.

The results for diversity paralleled those for species richness. In both years, species diversity was significantly higher in diverse than in conventional leys (Table 11.2 and Figure 11.2). Fertiliser application had no significant effect on the diversity of either ley type in either year, although in 1991 the unfertilised plots of both ley types had higher diversities.

The diversity of the unfertilised, diverse ley showed almost no change between 1988 and 1991. Diversity declined substantially in all other treatments with the greatest decline in the fertilised conventional ley. The decline in diversity in this treatment was significantly greater than in the unfertilised, diverse ley and was proportionately greater than the decline in species richness. The decline was greater in conventional than in diverse leys and within both ley types was greater on fertilised than on unfertilised plots although these differences were not significant.

Margins managed for silage The effects of the four treatments on the species richness of the silage margins were similar to those on the hay margins. As on the hay margins, the unfertilised, diverse ley changed least between years, and in 1991 had significantly more species than the other treatments. The fertilised diverse ley also had significantly more species than either fertiliser treatment on the conventional ley (Table 11.3 and Figure 11.3).

In 1988 the species richness of the silage margins was similar to that of hay margins under each treatment. This was expected because at the stage the samples were taken the two types of margins had been managed in the same way (see Section 2.3.1). However, by 1991 the mean number of species per quadrat was conspicuously lower under each treatment on the silage than on the hay margins.

Diversity also declined in all treatments by 1991 (Table 11.4 and Figure 11.4). The unfertilised, diverse ley again showed least change between years. In 1991, it was significantly more diverse than the other three treatments, although the decline in its diversity on the silage margins was proportionately greater than on the hay margins (20% *cf* 1%). The application of fertiliser had more profound effects on the silage than on the hay margins: the diversity indices were approximately half those in the equivalent treatments on the hay margins. This difference was to be expected from the higher rates of fertiliser applied. The indices for the unfertilised treatments were also lower on the silage than on the hay margins, suggesting that the mowing regime also contributed to a reduction in diversity. We are unable to evaluate the significance of this effect because statistical comparison of the hay and silage regimes is not legitimate (see above).

Summary The species richness and diversity of both ley types declined over a three year period although the diverse ley remained more species rich than the conventional ley. This decline was exacerbated by the application of fertiliser in both ley types, under both hay and silage regimes. When unfertilised, the loss of species richness and diversity from the diverse ley over three years was negligible. By 1991 the treatments on the silage margins were poorer in species and less diverse than the equivalent treatments on the hay margins. Much of this effect was attributable to the higher rates of fertiliser application, although there was some evidence that the silage mowing regime also contributed to a loss of diversity.

The numbers of sown and unsown species

Margins managed for hay The diverse ley seed mixture contained nine species compared with only three in the conventional ley (Chapter 2.3.1) and in both years it retained significantly more sown species than the conventional ley (Table 11.5 and Figure 11.3). The mean number of sown species declined in all treatments. As for total species number (above) the decline in the unfertilised diverse ley was very small and it retained significantly more sown species than any other treatment.

In 1988 unsown species comprised about 40% of the total number of species in all treatments. The effect of fertiliser addition on the numbers of unsown species in the diverse ley in 1988 was not significant but the fertilised diverse ley had significantly more unsown species than conventional ley (Table 11.6 and Figure 11.1). Thus, in the year of establishment, the diverse ley tended to accommodate more unsown species that the conventional ley. In 1991 unsown species still comprised about 40% of all species in the conventional ley and 30% in the diverse ley. Neither the ley type nor the fertiliser application resulted in any significant difference in the numbers of unsown species.

Margins managed for silage As on the hay margins, the diverse ley managed for silage had significantly more sown species in both years than the conventional ley (Table 11.7 and Figure 11.2). In 1991 there were significantly more sown species in the unfertilised, diverse ley than in any other treatment. In this treatment the mean number of sown species remained virtually unchanged over the three year period but the numbers declined in all other treatments, with the greatest decline in the fertilised conventional ley.

In 1988, as on the hay margins, unsown species comprised about 40% of the total number of species in all treatments. Again, the diverse ley tended to accommodate the most unsown species in the establishment year. The numbers of unsown species in the two fertiliser treatments on the diverse ley did not differ significantly from one another but the diverse ley without fertiliser had significantly more unsown species than either fertiliser treatment on the conventional ley (Table 11.8 and Figure 11.2). The numbers of unsown species declined substantially in both leys by 1991 but, by then, the diverse ley was significantly more weedy than the conventional ley under both fertiliser regimes.

The silage regime was much more effective in excluding unsown species than the hay regime. The decline between 1988 and 1991 was proportionately greater with weedy species comprising less than 10% of the total in the conventional ley and about 20% in the diverse ley. Although part of this difference was attributable to the higher rates of fertiliser associated with silage management, the decline in unsown species was also substantially greater in unfertilised plots under silage management. It is likely that this was attributable to the timing of the two silage cuts, which prevented most species from setting seed.

Summary The numbers of sown species remained significantly higher in the diverse ley than the conventional ley over a three year period under both hay and silage regimes. During this period they remained at approximately their establishment level in the unfertilised, diverse ley but declined in all other treatments, under both hay and silage management. Fertiliser significantly increased the decline in the numbers of sown species in the diverse ley under silage management, but we were unable to detect any significant effect of the lower rate of fertiliser application under the hay regime.

In the year of establishment the diverse ley accommodated significantly more unsown species than the conventional ley. The numbers of unsown species declined in all treatments under both regimes after three years but the decline was very much greater under the silage than the hay regime. Under the hay regime the diverse ley retained more unsown species than the conventional ley but the difference was no longer significant. Under the silage regime, however, this difference was accentuated after three years, and the diverse ley had very significantly more unsown species than the conventional ley. Numbers of unsown species were thus determined primarily by the hay and silage management regimes, and secondarily by the ley type, which appeared to have most influence under silage management. The frequency and timing of mowing appeared to have more influence on the numbers of unsown species than the level of fertiliser application.

The diverse ley, cut in July only and grown without fertiliser, accommodated more sown and unsown species than any other treatment both in the establishment year and three years later.

The abundance of dominant species

In this section we examine the effects of the experimental treatments on the most abundant sown species in the two leys and on the remaining sown species, first on the hay and second on the silage margins. Live biomass is used as a measure of abundance.

Margins managed for hay In the conventional ley the three sown species, *Lolium perenne*, *Trifolium repens* and *Phleum pratense*, were more abundant than any unsown species. In the diverse ley, *Dactylis glomerata*, *Festuca pratensis* Hudson Meadow Fescue and *P. pratense* were the most abundant of the sown species but, by 1991, *T. repens*, which colonised the unfertilised leys from the conventional ley, had also become an important component. The remaining sown species in the diverse ley constituted only a minor fraction of the total biomass (Table 11.10, Figure 11.5).

Low diversity swards were highly associated with single strongly dominant species (Figure 11.2 *cf* Figure 11.5). In 1988 the conventional leys were dominated by *L. perenne* and *T. repens*. In the diverse leys, *D. glomerata*, *P. pratense* and *F. pratensis* were of similar importance but around 50% of the total biomass comprised other sown and unsown species. This difference was reflected in the higher diversity indices for diverse than conventional leys. Fertiliser had relatively little effect on species composition at this stage, although the relative amounts of *L. perenne* and *T. repens* in the conventional ley were affected by fertiliser. *T. repens* was more abundant than *L. perenne* in unfertilised plots, but in fertilised plots percentages of the total live biomass comprised by the two species were reversed (Table 11.9).

By 1991 the dominance of *L. perenne* in the conventional ley had increased at the expense of *T. repens*. The extreme dominance of *L. perenne* almost certainly accounted for the loss of species richness as well as the decline in abundance of *T. repens*. Both of these factors contributed to the decrease in diversity indices between the two years. The addition of fertiliser had relatively little effect on the dominance of *L. perenne*, although it decreased the abundance of *T. repens*. By contrast, the diverse leys were not dominated by any single species. In the absence of fertiliser, the three sown species that were important in the diverse leys in 1988 remained important but, in addition, *T. repens* from the conventional ley had colonised and become an important component. In the presence of fertiliser the three key sown species were still important, although the relative dominance of *Phleum pratense*, and more particularly of *Dactylis glomerata*, increased while colonisation by *T. repens* was negligible. These differences were reflected in significantly higher diversity indices for the diverse than the conventional ley, and for unfertilised than for fertilised plots on the diverse ley.

More detailed analyses of the abundance of the key dominant species in the hay margins are presented below:

1. *Trifolium repens* In both 1988 and 1991 *T. repens* was much less common in fertilised than unfertilised plots on the conventional ley, although the difference was not significant in either year (Table 11.11 and Figure 11.6). It declined substantially under both fertiliser treatments between the two years, as *L. perenne* increased. Turkington & Harper (1979) suggested that *T. repens* is likely to decline in this way in competition with *L. perenne*, which is able to exploit the increasing nitrogen levels resulting from nitrogen fixation by the *Rhizobium trifolii* bacteria in the *T. repens* root nodules. *T. repens* is suppressed more rapidly by the vigorous growth of *L. perenne* which results from the addition of fertiliser.

T. repens was not a component of the diverse ley seed mixture and in 1988 only a negligible amount colonised the swards. By 1991, however, it had colonised the unfertilised plots on the diverse ley while remaining at negligible densities on fertilised plots. Its biomass on the unfertilised plots was not significantly different from that on unfertilised plots on the conventional leys. Failure of *T. repens* to colonise fertilised plots on the diverse ley is attributable to its very poor ability to compete with *D. glomerata*. Chestnutt & Lowe (1970) showed that the productivity of *T. repens* grown in competition with five species of grasses was lowest when grown with *D. glomerata* and highest with *L. perenne*.

2. *Phleum pratense* *P. pratense* was the only species common to the two seed mixtures. It comprised 8.6 % by weight of the seeds in the conventional ley and 17% in the diverse ley. It established very badly in the conventional ley in 1988, comprising little over one percent of the biomass. It was significantly more abundant in the diverse ley (Table 11.11 and Figure 11.6).

By 1991 *P. pratense* had increased in the diverse ley but remained uncommon in the conventional ley. Its biomass was significantly lower in the unfertilised conventional ley than in all other treatments. There was some evidence that the biomass of *P. pratense* was increased by fertiliser. It was higher in fertilised than unfertilised plots on both ley types in both years, although the difference was significant only on the conventional ley in 1988, when the quantities involved were very small.

3. *Lolium perenne* In the conventional ley, in 1988, *L. perenne* established significantly better in the presence of fertiliser (Table 11.13 and Figure 11.6). By 1991 it had increased substantially, comprising about 75% of the total biomass of the sward on both fertilised and unfertilised plots. Its biomass remained greater on fertilised plots but the effect of fertiliser was no longer significant. It is likely that nitrogen released by *T. repens* in the unfertilised plots partially compensated for the lack of fertiliser.

4. *Dactylis glomerata* *D. glomerata* increased substantially in abundance in the diverse ley between 1988 and 1991. In both years, it was significantly more abundant in fertilised than unfertilised plots (Table 11.14 and Figure 11.6). In fertilised plots it comprised an average of around 50% of the biomass.

5. *Festuca pratensis* *F. pratensis* declined in the diverse leys between 1988 and 1991, as *P. pratense* and *D. glomerata* increased (Table 11.15 and Figure 11.6). Fertiliser had no significant effect on its biomass.

We have shown above that, by 1991, *D. glomerata*, *P. pratense* and *F. pratensis* together comprised a high proportion of the biomass of the diverse ley. The biomass of the remaining three sown grasses, *Cynosurus cristatus*, *Poa pratensis* and *Trisetum flavescens*, all of which are relatively slow growing species, was too low in our samples for formal analysis of treatment effects. Table 11.10 shows that these three species were minor contributors to the biomass of the swards although they all increased between 1988 and 1991 and were widely distributed in the swards. Their contribution to the biomass was also small in relation to their sowing density (data not presented). Although the biomass of all three species was greater in fertilised plots in the relatively open swards in the year of establishment, fertiliser had less effect on their biomass by 1991. The relatively poor performance of these species on the wide margins compared to that on the 2m margins experiment (Chapter 6) is likely to be attributable to the greater competitive abilities of the other grasses in the seed mixture. If soil fertility declines progressively on the unfertilised plots the relative abundance of these species may eventually increase.

The three forbs included in the seed mixture were sown at very low densities: the grass:forb ratio was 120:1 compared with 4:1 in the wild flower seed mixture on the 2m margins. These species were consequently recorded only at very low frequency and there are too few data for formal analysis (Table 11.10). More intensive sampling of these species and the rarer sown grasses is required to evaluate the effects of treatment on these species. Since their contribution to the biomass is extremely small, this information could be obtained rapidly by non-destructive sampling.

Margins managed for silage The same five sown species that were dominant on the hay margins were also dominant on the silage margins (Tables 11.16 and 11.17, Figure 11.7). The pattern of relative dominance was the same on the silage margins as on the hay margins in both years and for both fertiliser treatments. However, by 1991, the higher rates of fertiliser application on the silage margins were having more profound effects on species composition. The dominance of *L. perenne* in the conventional ley, and of *D. glomerata* in the diverse ley, was much greater in the fertilised treatments on the silage margins than on the hay margins. This was reflected by lower diversity indices for fertilised plots on the silage than on the hay margins (Figures 11.2 *cf* 11.4).

In the following accounts of the biomass of the dominant species we are unable to make direct comparisons between the absolute biomass of species in the hay and silage margins in 1991 (see above). Comparisons of the species abundance under the two regimes are therefore restricted to their abundance as a proportion of the sown biomass under each treatment.

More detailed analyses of the abundance of the key dominant species in the hay margins are presented below:

1. *T. repens* In 1988, as on the margins managed for hay, there was significantly more *T. repens* in the conventional than the diverse ley (Table 11.18 and Figure 11.8). Again, by 1991, the abundance of *T. repens* declined in both fertiliser treatments on the conventional ley and had colonised unfertilised plots on the diverse ley to the extent that its abundance did not differ significantly in any of these treatments. As on the hay margins it failed to colonise fertilised plots on the diverse ley. Although it was less abundant in the fertilised plots on the conventional ley in both years, this difference was not significant.

2. *P. pratense* In 1988, as on the hay margins, *P. pratense* established very badly as a proportion of the total biomass in the conventional ley. It was significantly more abundant in the diverse ley and in both ley types it was significantly more abundant in fertilised than in unfertilised plots (Table 11.19, Figure 11.8). By 1991, in contrast to the hay margins, its proportion of the total biomass of the sward had decreased in all treatments except the unfertilised diverse ley, where it increased slightly (Table 11.16). It was no longer significantly more abundant in fertilised plots on either ley type.

Although *P. pratense* responded positively to the levels of fertiliser applied to both hay and silage margins in 1988, and to the hay margins in 1991, its failure to respond to the higher levels applied to the silage margins in 1991 suggests that it was unable to compete with the sward dominants. The increased dominance of *L. perenne* in the fertilised conventional ley and of *D. glomerata* in the fertilised diverse ley is likely to account for the inability of *P. pratense* to respond to the fertiliser under these treatments. Its persistence in the unfertilised diverse ley, which was the least productive sward type (see Section 11.2.2 below), further suggests that its decline resulted from direct competitive effects.

3. *L. perenne* On the silage margins, in both 1988 and 1991, *L. perenne* was significantly more abundant on fertilised than unfertilised plots on the conventional ley, (Table 11.20 and Figure 11.8). On unfertilised plots on the conventional ley it increased between 1988 and 1991 to comprise a similar proportion of the sward on the silage margins to that on the hay margins (Tables 11.6 cf 11.9). On the fertilised plots the increase between the two years was greater than on the hay margins, with *L. perenne* comprising 94% of the biomass of the sward.

4. *D. glomerata* As on the margins managed for hay, *D. glomerata* in the diverse ley increased substantially as a proportion of the sward between 1988 and 1991 (Tables 11.9 and 11.16) and in both years was significantly more abundant on fertilised than on unfertilised plots (Table 11.21 and Figure 11.8). Its increase in fertilised plots on the silage margins was proportionately greater than on the hay margins. In 1991 it comprised 86% of the biomass of the fertilised plots on the silage margins but only 47% on the hay margins.

5. *F. pratensis* In 1988 *F. pratensis* was significantly more abundant in fertilised than in unfertilised plots on the silage margins (Table 11.22, Figure 11.8). By 1991, as on the hay margins, it had declined. The decline was proportionately greater on fertilised than on unfertilised plots to the extent that it became significantly less abundant on fertilised plots (Tables 11.9 and 11.16). This inability to respond to the increased rate of fertiliser application under the silage regime was likely to have been attributable to failure to compete successfully with *D. glomerata* (above).

In the absence of formal analysis, the data for other, less common sown species in the silage margins appear to be very similar to those for the hay margins (Table 11.17 cf Table 11.10). The only substantive difference is that *C. cristatus* decreased in the fertilised ley on the silage margins between 1988 and 1991, while it increased in the same treatment on the hay margins. We showed in Chapter 6 that *C. cristatus* is a poor competitor in tall, dense swards. Although it thrived in swards mown twice a year on the unfertilised 2m margins it was unable to persist in the very productive swards that resulted from the fertiliser levels associated with silage management.

Summary The relative abilities of the species included in the seed mixtures to respond to fertiliser addition were important influences in determining diversity. Under the hay regime no single species in the diverse ley became strongly dominant, even when fertiliser was applied. Under the higher fertiliser levels associated with the silage regime, however, *D. glomerata* became strongly dominant, resulting in substantial loss of diversity. In the conventional ley, addition of fertiliser promoted the dominance of *L. perenne* at the expense of *T. repens*. By 1991 *L. perenne* was strongly dominant under all treatments but this effect was most extreme under the fertiliser levels associated with the silage regime.

Inclusion of most perennial cultivars of *L. perenne* in grass seed mixtures is likely to result in low species richness, even in the absence of fertiliser application. This will be exacerbated by fertiliser addition and may also be exacerbated by the addition of *T. repens* cultivars. *D. glomerata* should not be included in seed mixtures for very fertile soils although it does not become strongly dominant in the absence of fertiliser.

11.2.2 MANAGEMENT PROBLEMS ASSOCIATED WITH THE USE OF THE LEYS FOR SET-ASIDE GREEN COVER

In this section we examine the problems associated with managing diverse and conventional leys for set-aside green cover. We present analyses of the effects of treatment on the total biomass of the leys and on the contributions of sown and unsown species to the total biomass. We then examine the effects of treatment on the abundance of pernicious weeds.

Productivity problems

Margins managed for hay In 1988 there were no significant differences between the four treatments in the mean biomass per quadrat, although the biomass of the unfertilised diverse ley was conspicuously lower than that of other treatments (Table 11.23 and Figure 11.9). By 1991, on both ley types, the biomass of the unfertilised plots was significantly lower than that of fertilised plots. There was no significant difference between the two ley types in the biomass of either the fertilised or the unfertilised plots, although the conventional ley had greater biomass than the diverse ley under both fertiliser regimes.

By 1991, there was a considerable amount of dead matter in the samples and this was recorded as dead biomass. Analyses of live biomass gave similar results to those of total biomass: it was significantly lower in unfertilised plots on the diverse ley than in the fertilised plots of on either ley-type (Table 11.24 and Figure 11.9). There was more dead matter in fertilised than unfertilised plots on both ley types but the difference was significant only on the conventional ley.

If the biomass of the sown and unsown species in the swards on the hay margins is examined separately (Figure 11.11, Tables 11.25 and 11.26) it can be seen that a much higher proportion of the biomass of the diverse than of the conventional ley comprised unsown species. In 1988, although the biomass of unsown species was conspicuously greater in the diverse than the conventional ley, none of the treatments differed significantly (Table 11.28). By 1991 the unsown biomass had decreased as a proportion of the total in all treatments but much the greatest decrease was in the fertilised diverse ley. There were no significant differences between fertiliser treatments within either ley type but the biomass of unsown species in the unfertilised diverse ley was significantly greater than in the unfertilised conventional ley.

These results for the biomass of unsown species in the swards parallel those for their species richness (Section 11.2.1 above). Thus, diverse leys had both more species and greater biomass of unsown species than conventional leys. Numbers and biomass of unsown species declined over a three year period. Fertiliser had relatively little effect on unsown species although they were both most abundant and greatest in number in the unfertilised diverse ley. This treatment thus had the greatest biomass of unsown species but the smallest biomass of sown species and smallest total biomass. Much of the unsown biomass in this treatment in 1991 was attributable to the colonisation by *T. repens* (section 11.2.1).

Margins managed for silage In 1988, as on the hay margins, the unfertilised, diverse ley had the lowest mean biomass. This was significantly lower than the mean biomass of fertilised plots on the conventional ley (Table 11.27 and Figure 11.10). By 1991, although the biomass of unfertilised plots was conspicuously lower than that of fertilised plots on both ley types, we were unable to detect significant differences between any treatments. The biomass of unfertilised plots on the diverse ley remained substantially lower than that of all other treatments. When live biomass only was considered, the biomass of this treatment was significantly lower than that of fertilised plots on the conventional ley but did not differ significantly from the other two treatments (Table 11.28).

In 1991, dead biomass was significantly greater in the fertilised, diverse ley than in all other treatments (Table 11.28). The large accumulation of litter under this treatment on the silage margins was attributable to dead basal leaves of *D. glomerata*.

Separate analysis of the sown and unsown components of the swards shows that, in 1988, as on the hay margins, the biomass of unsown species on the silage margins was greater in diverse than in conventional leys, although this difference was not significant (Table 11.30). By 1991 the biomass of remaining unsown species was very low in all treatments except the unfertilised diverse ley. This treatment had a significantly greater biomass of unsown species than either fertilised or unfertilised treatments on the conventional ley. Again, much of the unsown biomass on this treatment was attributable to colonisation by *T. repens*.

The main divergence in the results for sown species and for all species on the silage margins resulted from the removal from the analysis of the large unsown biomass in the unfertilised diverse ley. Whilst there were no significant differences between treatments in the total biomass in 1991, the biomass of this treatment was significantly and substantially lower than in any other treatment when only sown species were considered (Table 11.29).

Except in the unfertilised treatment on the diverse ley, the biomass of unsown species was a smaller proportion of the total biomass on the silage than on the hay margins in 1991. Again, this parallels the results for the numbers of unsown species, which were also lower under silage than under hay management (Section 11.2.1).

Summary Fertiliser increased the productivity of both leys under both hay and silage management. Although the diverse ley was less productive than the conventional ley under both fertiliser regimes, we were unable to detect any significant differences. The proportion of the total biomass contributed by unsown species was smaller in swards managed for silage than in those managed for hay. The unfertilised diverse ley was less productive than all other treatments under both hay and silage management. It contained a significantly smaller biomass of sown species than the other treatments but also contained a significantly greater biomass, as well as number, of unsown species than other treatments.

Pernicious weed problems

Pernicious weeds were not a major component of swards under any of the treatments, on either the hay or the silage margins in either year. The abundance of the pernicious weed species that occurred in more than three percent of the quadrats in any treatment either year are shown in Tables 11.31 and 11.32. We comment only on those for which there are sufficient data to suggest a clear pattern. Formal analyses of the data for these species are in progress.

In 1988 *Avena* species and *Alopecurus myosuroides* were the only pernicious weeds that occurred in all treatments on the hay margins (Table 11.31). They were both much more abundant in the diverse than the conventional ley. With the exception of *Avena* species in the conventional ley, they were also more abundant in fertilised than unfertilised plots on both ley types. By 1991 their abundance was very low in fertilised plots and they had virtually disappeared from unfertilised plots. Their pattern of abundance was thus similar to that in sown plots in the 2m margins experiment, with a rapid decline after the establishment year as a result of competition from the perennial swards (Chapter 5). Although the diverse ley was less effective than the conventional ley in excluding these species in 1988, it is likely that this resulted from the very dense growth of *T. repens* in the latter (Section 11.2.1) rather than to differences in the effectiveness of the grassy components of the swards.

On the silage margins in 1988 the pattern of abundance of *Avena* species and *A. myosuroides* was the same as that on the hay margins. In 1991 neither species was recorded on the silage margins but since the samples were harvested after the first cut it is likely that any plants present early in the season had died by that stage. It is likely that the first silage cut in late May effectively prevented these species from seeding, while hay cut in early July allowed them to flower and seed. However, since both of these species have a persistent seed bank (see Chapter 5) sampling prior to the first silage cut is required to assess the real extent to which they have persisted under the silage regime.

Bromus sterilis was not recorded on the wide margins in 1988. As on the 2m margins (Chapter 5) its seedlings were destroyed when the margins were tine-harrowed prior to sowing in April 1988 (see Section 2.3.1). By 1991 it had increased in abundance on the hay margins. Neither ley type appeared to be as effective in controlling this species as the wild flower seed mixture used on the 2m margins (Chapter 5). There was also some evidence that *B. sterilis* was more abundant in the conventional than in the diverse ley on the hay margins. It was recorded in only one percent of quadrats on the silage margins in 1991 but any growth in that year would have been removed by the first cut. Plants would have been coming into flower at that stage and regrowth following the cut would have been unlikely. As with the previous two annual species, recording before the first silage cut is needed to assess the real abundance of this species. However, *B. sterilis* was much more likely than *Avena* species or *A. myosuroides* to have been eradicated by the early date of the first silage cut because its seed bank is short lived.

Elymus repens also increased substantially in abundance in the hay margins by 1991. Like *B. sterilis* it achieved higher biomass in the conventional than in the diverse ley and in fertilised than in unfertilised plots with both ley types. It was recorded at a much lower frequency on the silage margins (its lower biomass on the silage margins is attributable in part to the first silage cut). Although the significance of this difference cannot be evaluated it is possible that it was less favoured by the silage cutting regime.

Summary Although the unfertilised diverse ley contained both greater biomass and numbers of unsown species, it tended to harbour less persistent pernicious weeds than other treatments. This result is to some extent predictable because the success of these weedy species in modern agriculture is attributable to their ability to utilise high soil nutrient levels. However, the demonstration that species rich grass leys can accommodate more naturally regenerating species than conventional leys without at the same time accommodating more pernicious weeds is an important tool in making the use of more diverse leys on set-aside land acceptable to farmers and landowners.

11.2.3 THE EFFECT OF WIDE MARGIN MANAGEMENT ON BUTTERFLIES

Transect recordings were made on five dates in 1991 (Chapter 2.3.2). Because the width of the wide margins varied from 7.2m to 9.6m (see Chapter 2.3.1), records were not made for the total width of each margin. To make the data comparable with those from the two metre margins, all butterflies seen on approximately the 2m width along the middle of each plot were recorded. Transects on the wide margins were occasionally, but not always, conducted on the same day as on the 2m margins, but the same criteria for transect recording were fulfilled on each recording occasion (Chapter 2.2.3).

The abundance of butterflies

Butterfly abundances on the different treatments on the margins managed for hay and silage were analyzed over the five transect dates, with data grouped to analyze distribution before and after the crops were cut.

Hay margins There was a highly significant effect of treatment on butterfly abundance before the hay cut ($P=0.0001$; Table 11.33) with significantly more butterflies recorded on the unfertilised plots of the diverse ley, than any other plot type. No butterflies were recorded on fertilised plots of the conventional ley. A two-way ANOVA showed that there was a significant effect of fertiliser ($P=0.0001$) but not of seed mixture ($P=0.584$; Table 11.33). There was a significant interaction between fertiliser and seed mixture ($P=0.0001$), with fertiliser having a greater effect on the diverse than the conventional ley. Treatment still had a significant effect on butterfly distribution after the hay cut, but the effect was less pronounced ($P=0.0344$; Table 11.34). The unfertilised plots of the diverse ley had the greatest butterfly abundance, but it was significantly greater only than fertilised plots of the conventional ley (Table 11.34). The effect of seed mixture was not significant (2-way ANOVA, P=0.2073) but, again, there was a significant effect of fertiliser (P=0.0078).

Silage margins Prior to the silage cut, butterfly abundance showed a significant treatment effect (P=0.0315) although this was less pronounced than on the hay margins. The highest mean number of butterflies was recorded on the unfertilised plots of the diverse ley, but this was significantly higher only than on unfertilised plots of the conventional ley (Table 11.35). A 2-way ANOVA showed that seed mixture, but not fertiliser, had a significant effect on butterfly abundance (P=0.0267). The interaction between these two factors was not significant.

After the silage cut, there was no significant treatment effect overall (P=0.071), although mean butterfly numbers were highest on the unfertilised plots of both leys. A 2-way ANOVA showed there to be a significant effect of fertiliser (P=0.0089) but not of seed mixture (Table 11.36).

The species richness of butterflies

Hay margins Eight species were recorded on both the hay and silage margins in 1991 (*Maniola jurtina*, *Pyronia tithonus*, *Coenonympha pamphilus*, *Melanargia galathea*, *Aglais urticae*, *Polyommatus icarus*, *Pieris napae*, and *Ochlodes venata*). A further three species (*Pieris brassicae*, *Pieris rapae* and *Vanessa atlanta*) were recorded only on the hay margins. Prior to the cut, there was a highly significant effect of treatment on the number of species recorded (P=0.0001; Table 11.37). The highest numbers of species were recorded on unfertilised plots of the diverse ley, followed by unfertilised plots of the conventional ley and fertilised plots of the conventional ley. Significantly fewer species were recorded on fertilised plots of the diverse ley. A 2-way ANOVA showed the effect of ley type to be non-significant (P=0.165), but fertiliser application had a highly significant effect (P=0.0001). There was a significant interaction between the two factors (P=0.0002) attributable to the effect of fertiliser on the diverse ley. After the hay cut the overall effect of treatment on the number of butterfly species recorded was no longer significant (P=0.157; Table 11.38). A 2-way ANOVA showed a significant effect of fertiliser application (P=0.0257; Table 11.38), but not of mixture.

Silage margins Eight species were recorded on the silage margins during the five transects. There was a significant effect of treatment on the number of butterfly species recorded before the silage was cut in July (P=0.0066; Table 11.39). Significantly more species were recorded on unfertilised plots of the diverse ley than on either fertiliser treatment on the conventional ley (Table 11.39). A 2-way ANOVA showed a significant effect of seed mixture on the number of species recorded (P=0.0077) but no effect of fertiliser (P=0.1046; Table 11.39). The interaction between mixture and fertiliser approached significance (P=0.0578) due to the effect of fertiliser on the diverse ley. After the silage cut there was no significant effect of treatment on the number of species recorded (P=0.3934; Table 11.40), and no significant effect of fertiliser or seed mixture (P=0.1440 and P=0.3162 respectively).

Butterfly diversity

Hay margins Shannon-Wiener diversity indices were calculated for the hay margins before and after the hay was cut, and ranked using Wilcoxon Scores (Table 11.41 and 11.42). There was no significant difference in diversity between treatments before the cut (Kruskal-Wallis Test, P=0.1026) but there was a significant difference in diversity after the cut (Kruskal-Wallis Test, P=0.0285). Unfertilised plots of the diverse and conventional leys had the highest diversity (Table 11.42).

Silage margins There was a significant difference in diversity between treatments on the silage margins before the cut (Kruskal-Wallis Test, P=0.0216; Table 11.43). The highest diversity was recorded on unfertilised plots of the diverse ley, followed by fertilised plots of the diverse ley. After the silage cut, there was no longer a significant difference in diversity between treatments (Kruskal-Wallis Test, P=0.6849; Table 11.44).

Summary Both the type of grass ley and the addition of fertiliser affected the abundance, species richness and diversity of butterflies recorded on the wide margins. The diverse ley was more attractive to butterflies than the conventional ley and higher abundances were recorded on unfertilised than on fertilised plots. Fertilised plots under the conventional ley were least attractive to butterflies. In general, the wide margins attracted fewer individuals and species of butterflies than the two metre margins.

11.3 Conclusions and practical implications

Our results show clearly that relatively species rich grass mixtures can have considerable advantages over conventional agricultural grass leys for set-aside green cover. Although they are likely to be slightly more expensive, they are less productive, and consequently easier to manage. The smaller biomass is easier to cut, requires less frequent cutting and, if cut material is left lying, it is less likely to kill the underlying sward. Our data further suggest that both unfertilised swards, and more species rich mixtures, are more effective in excluding persistent, pernicious agricultural weeds than are fertilised swards and conventional *Lolium/Trifolium* leys. These advantages are likely to be lost to farmers who put high priority on maintaining soil fertility under set-aside by using green cover containing legumes.

More species rich mixtures also have substantial benefits for wildlife conservation. In addition to the contribution of the sown species to creating a more diverse community, these leys allow significantly more naturally regenerating species to colonise. In the absence of either direct fertiliser application or fertiliser drift, the numbers of these species and of the sown species, were maintained for at least three years. This relatively high plant species richness was accompanied by relatively high butterfly species richness. Part of this effect on butterflies was attributable to the diversity of grasses suitable for oviposition by Satyrid butterflies but the abundance of *Trifolium repens*, which was the major nectar source on the wide margins, was also an important contributory factor. Increasing soil fertility initially increased the dominance of a few of the sown species at the expense of the numbers of sown and unsown species. Further increase resulted in extreme dominance by *Dactylis glomerata* but such extreme dominance effects are unlikely to be problems on unfertilised set-aside land. The relatively low abundance of *T. repens* on these plots, as well as the lower plant species richness, was likely to account for the reduced abundance of butterflies on these plots.

The conventional grass ley mixture not only comprised very few plant species but also accommodated very few naturally regenerating species. The numbers and abundance of unsown species declined to negligible levels after three years because of the dominance initially of both *L. perenne* and *T. repens* and later of *L. perenne* alone. Unsown species were lost from unfertilised as well as fertilised plots on this ley. Conventional leys of this kind are thus unlikely to have any more interest for wildlife when grown without fertiliser on set-aside land than when grown under high input systems. The relatively low numbers and abundances of butterflies on this ley were attributable both to the low plant species richness and, particularly on the fertilised plots, to the suppression of white clover, the dominant nectar source.

Although the diverse ley, when unfertilised, was clearly most beneficial to both management and wildlife conservation, it is possible that some of these benefits will eventually be curtailed by the invasion of *T. repens*. In 1991 the patches of *T. repens* added visual and structural diversity to the swards but continued increase is likely to have deleterious effects on species richness. Turkington & Harper (1979) postulate that *T. repens* goes through a regeneration cycle in which its nitrogen production results in dominance by tall grasses. As *T. repens* is out-competed, the nitrogen status of the soil declines and the grasses are replaced by slower-growing species. *T. repens* can then re-invade the community and the cycle starts again. Further monitoring is required to test this prediction and to ascertain the extent and time-scale on which *T. repens* may result in reduction in diversity. Although the extent of invasion by *T. repens* was to a large extent an artefact of our experimental situation, in which swards containing high densities of *T. repens* were interspersed with those that did not, it illustrates that *T. repens* cultivars, which are very common on farmland, can increase very rapidly indeed in unfertilised grassland sown with species rich grass mixtures.

Comparisons between the unfertilised plots under the two regimes suggested that the mowing regime, as well as the fertiliser levels, associated with management for hay was likely to be more beneficial to the maintenance of species richness than that associated with silage. Although we demonstrated on the 2m margins experiment that diversity was greater in plots cut twice a year than in those cut once, we also showed that the timing as well as the frequency of cutting was important. The timing of the two silage cuts, which were likely to remove, first, the main flowering shoots of most species and, second, any regrowth, were likely to have prevented the majority of species from producing seed. The timing of the hay cut allowed some species to seed before the cut and others to seed on regrowth later in the season. Cutting twice during the main summer flowering period thus appears to be detrimental to the maintenance of plant species richness. In Chapter 9 we showed that a single cut during the summer was detrimental to populations of many species of butterflies. Two cuts during this period are likely to have devastating effects.

Some of the results of our experiment may have differed from those that would be obtained in a typical set-aside situation, where cut material is left *in situ* rather than removed from the site. We suggested above that the lower productivity of the diverse ley has considerable advantages in this context because it would be less likely than the conventional ley to result in die-back of the underlying sward. However, the implications for the development and maintenance of diversity, and for pernicious weed problems, are more difficult to assess. Although leaving cut material lying is likely to maintain high soil nutrient status at the expense of species richness, there is little information available on the time-scale on which collection of cuttings is likely to influence species richness on high fertility soils. In the 2m margins experiment, collection of cut material had no significant effects on species richness over a three year period (Chapter 4) although it affected the relative abundance of some species (Chapter 5). As suggested in Chapter 4, measurement of soil nutrient status within the rigorous framework of the 2m margins experiment is important to the proper evaluation of this problem which is central to many conservation-management decisions on former agricultural land.

There is no reason to predict that the outcome of any aspect of the experiment would have been very different had it been conducted on whole fields rather than on field margins, although it is likely that the numbers of unsown species in the swards would be lower towards the centres of the fields.

In this chapter we have evaluated the performance of the leys primarily in terms of their suitability for ungrazed green cover on set-aside land. However, the diverse, as well as the conventional ley were also designed for their forage qualities (Section 11.1). We were unable to evaluate properly their relative quality for forage cropping and for grazing because we had insufficient resources to measure palatability and digestibility. Although the conventional ley was more productive than the diverse ley, and both leys were more productive when fertilised, most of the differences in productivity were relatively small. Thus, in 1991, the diverse and conventional leys only differed by around 5% in mean biomass harvested from the hay margins, and by 11% in that harvested from the silage margins. The loss in productivity of the conventional ley when unfertilised was around 20% and that in the diverse ley around 30%. The smaller differential in the conventional ley was likely to have resulted from the greater biomass of clover in the unfertilised treatment partially compensating for the lack of fertiliser. However, even leys which have low productivity when unfertilised, such as our diverse ley, may have agricultural potential in areas such as ESAs, where wildlife conservation and amenity interests are best served by extensified stock management. Herbal grass leys, containing grasses with good forage properties, but excluding *L. perenne*, and containing forbs which increase the mineral nutrient content of the forage, may have considerable benefits in these situations.

With the exception of *R. acris*, the forb species included in our diverse ley were chosen for their forage qualities. *R. acris* was sown at very low density and its contribution to the biomass and visual appearance of the sward during the first three years after sowing was negligible. *Achillea millefolium* and *Rumex acetosa* were also uncommon but on the hay margins, on which they flowered before the was hay cut, they were an attractive feature of the swards. In addition, the *R. acetosa* in the swards was host to a breeding population of *Lycaena phlaeas* Small Copper butterflies. We suggest in Chapter 6 that addition of one or more species of forbs to a grass seed mixture can contribute disproportionately to its wildlife and aesthetic value. Although two of the species used in this mixture were sown at rates recommended for improving the mineral nutrient content of fodder, higher rates would have more substantial benefits in the context of set-aside and amenity. Both the fact that *T. repens* was the main nectar source available to butterflies on these margins, and much lower numbers of butterflies recorded than on the two metre margins, illustrate the potential importance to wildlife conservation of careful selection of forbaceous components of grass leys for fallowed arable land.

If species rich grass leys on ex-arable land are used for forage cropping and/or grazing, a different range of forb species should be considered from those most likely to be included in wild flower seed mixtures for smaller, uncropped areas. Forb species traditionally used in such mixtures include *Achillea millefolium*, *Rumex acetosa* and *Sanguisorba officinalis* L. Great Burnet. Legumes including *Lotus corniculatus* L. Common Birdsfoot Trefoil, *Onobrychis viciifolia* Scop. Sainfoin, *Medicago lupulina* L. Black Medick, *Trifolium pratense* L. Red Clover and *T. repens* were also included. It is unlikely that these species would proliferate to the same potentially deleterious extent as the cultivars of *T. repens* that colonised unfertilised plots on the diverse ley on our experiment.

Cultivars of the non-leguminous as well as the leguminous species are used in commercially available herbal leys. The use of some non-leguminous cultivars should be considered seriously in some set-aside situations where the forage quality of the sward is important and re-creation of a sward that faithfully imitates a semi-natural grassland type is not the primary aim. Their price is likely to be lower than that of the wild species and it is unlikely that the value of the sward, either for other species, or for amenity, would be diminished. The use of cultivars of some of these species and of other wild flowers on ex-arable land is an anathema to many conservationists. However, the debate about the appropriateness of their use should take into account the long history of use of some these species in permanent pasture seed mixtures. Thus, for example, in 1877, the Lawson Seed and Nursery Company were recommending that 'on warm dry banks cowslip seed may be scattered at the rate from 1/4 to 1/2 lb. per acre' as a constituent of seed mixtures for establishing permanent pasture.

Table 11.1 The effect of treatment on the number of plant species in margins managed for hay

Treatment	Mean number of species per quadrat and mean index of change[1]					
	1988[2]		1991[3]		Index of change[4]	
Conventional-fertiliser	5.28	B	3.78	B	0.75	A
Conventional+fertiliser	5.16	B	3.56	B	0.71	A
Diverse-fertiliser	9.56	A	8.59	A	0.90	A
Diverse+fertiliser	9.75	A	7.14	A	0.74	A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=1.65, 1991 MSD=1.81, Index of change MSD=0.27
[2]1-way ANOVA, $F_{(3,27)}$=36.27, P=0.0001
[3]1-way ANOVA, $F_{(3,27)}$=29.27, P=0.0001
[4]1-way ANOVA, $F_{(3,27)}$=1.56, P=0.2231

Table 11.2 The effect of treatment on species diversity in margins managed for hay

Treatment	Mean index per quadrat and mean index of change[1]					
	1988[2]		1991[3]		Index of change[4]	
Conventional-fertiliser	0.53	B	0.36	BC	0.70	AB
Conventional+fertiliser	0.50	B	0.28	C	0.55	B
Diverse-fertiliser	0.67	A	0.65	A	0.99	A
Diverse+fertiliser	0.65	A	0.49	AB	0.76	AB

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=0.08, 1991 MSD=0.19, Index of change MSD=0.34
[2]1-way ANOVA, $F_{(3,27)}$=17.46, P=0.0001
[3]1-way ANOVA, $F_{(3,27)}$=11.87, P=0.0001
[4]1-way ANOVA, $F_{(3,27)}$=4.49, P=0.0111

Table 11.3 The effect of treatment on the number of plant species in margins managed for silage

Treatment	Mean number of species per quadrat and mean index of change[1]					
	1988[2]		1991[3]		Index of change[4]	
Conventional-fertiliser	5.14	B	2.61	C	0.51	B
Conventional+fertiliser	5.25	B	2.33	C	0.46	B
Diverse-fertiliser	10.1	A	7.64	A	0.76	A
Diverse+fertiliser	9.21	A	5.04	B	0.55	AB

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=1.85, 1991 MSD=1.63, Index of change MSD=0.21
[2]1-way ANOVA, $F_{(3,23)}=30.92$, P=0.0001
[3]1-way ANOVA, $F_{(3,23)}=35.52$, P=0.0001
[4]1-way ANOVA, $F_{(3,23)}=5.93$, P=0.0038

Table 11.4 The effect of treatment on plant species diversity in margins managed for silage

Treatment	Mean index per quadrat and mean index of change[1]					
	1988[2]		1991[3]		Index of change[4]	
Conventional-fertiliser	0.51	B	0.31	B	0.61	A
Conventional+fertiliser	0.44	B	0.12	B	0.38	A
Diverse-fertiliser	0.70	A	0.56	A	0.80	A
Diverse+fertiliser	0.70	A	0.25	B	0.35	A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=0.11, 1991 MSD=0.24, Index of change MSD=0.47
[2]1-way ANOVA, $F_{(3,23)}=20.32$, P=0.0001
[3]1-way ANOVA, $F_{(3,23)}=9.22$, P=0.0003
[4]1-way ANOVA, $F_{(3,23)}=3.10$, P=0.0466

Table 11.5 The effect of treatment on the number of sown species in margins managed for hay[1]

Treatment	Ln mean number of sown species per quadrat and mean index of change[2] Arithmetic means in brackets		
	1988[3]	1991[4]	Index of change[5]
Conventional-fertiliser	1.07 B (2.91)	0.77 B (2.16)	0.74 AB
Conventional+fertiliser	1.11 B (3.00)	0.74 B (2.13)	0.71 B
Diverse-fertiliser	1.81 A (6.16)	1.78 A (5.97)	0.98 A
Diverse+fertiliser	1.70 A (5.54)	1.54 A (4.89)	0.90 AB

[1]Analyses performed on ln-transformed data, index of change calculated using arithmetic means
[2]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=0.12, 1991 MSD=0.29, Index of change MSD=0.24
[3]1-way ANOVA, $F_{(3,27)}=159.30$, $P=0.0001$
[4]1-way ANOVA, $F_{(3,27)}=51.39$, $P=0.0001$
[5]1-way ANOVA, $F_{(3,27)}=4.22$, $P=0.0143$

Table 11.6 The effect of treatment on the number of unsown species in margins managed for hay

Treatment	Mean number of unsown species per quadrat and mean index of change[1]		
	1988[2]	1991[3]	Index of change[4]
Conventional-fertiliser	2.38 B	1.63 A	0.96 A
Conventional+fertiliser	2.13 B	1.44 A	0.94 A
Diverse-fertiliser	3.41 AB	2.63 A	0.85 A
Diverse+fertiliser	4.21 A	2.25 A	0.55 A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=1.70, 1991 MSD=1.40, Index of change MSD=0.99
[2]1-way ANOVA, $F_{(3,27)}=4.67$, $P=0.0094$
[3]1-way ANOVA, $F_{(3,27)}=2.37$, $P=0.0927$
[4]1-way ANOVA, $F_{(3,27)}=0.51$, $P=0.6816$

Table 11.7 The effect of treatment on the number of sown species in margins managed for silage[1]

Treatment	Ln mean number of sown species per quadrat and mean index of change[2]. Arithmetic means in brackets		
	1988[3]	1991[4]	Index of change[5]
Conventional-fertiliser	1.09 B (2.96)	0.88 C (2.43)	0.82 AB
Conventional+fertiliser	1.10 B (3.00)	0.74 C (2.13)	0.71 B
Diverse-fertiliser	1.76 A (5.82)	1.75 A (5.79)	0.99 A
Diverse+fertiliser	1.80 A (6.07)	1.33 B (3.89)	0.65 B

[1]Analyses performed on ln-transformed data, index of change calculated using arithmetic means
[2]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=0.07, 1991 MSD=0.29, index of change MSD=0.22
[3]1-way ANOVA, $F_{(3,23)}$=480.87, P=0.0001
[4]1-way ANOVA, $F_{(3,23)}$=37.46, P=0.0001
[5]1-way ANOVA, $F_{(3,23)}$=7.68, P=0.0010

Table 11.8 The effect of treatment on the number of unsown species in margins managed for silage

Treatment	Mean number of unsown species per quadrat and mean index of change[1]		
	1988[2]	1991[3]	Index of change[4]
Conventional-fertiliser	2.18 B	0.18 B	0.11 B
Conventional+fertiliser	2.25 B	0.21 B	0.15 AB
Diverse-fertiliser	4.32 A	1.86 A	0.47 A
Diverse+fertiliser	3.14 AB	1.14 A	0.39 AB

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=1.79, 1991 MSD=0.85, index of change MSD=0.34
[2]1-way ANOVA, $F_{(3,23)}$=4.84, P=0.0094
[3]1-way ANOVA, $F_{(3,23)}$=14.12, P=0.0001
[4]1-way ANOVA, $F_{(3,23)}$=4.31, P=0.0150

Table 11.9 Live biomass comprised by key species in margins managed for hay

Treatment	1988		1991	
	biomass[1] (g)	%total[2] biomass	biomass[1] (g)	%total[2] biomass
a) *T. repens*				
Conventional-fertiliser	21.35	52	9.28	19
Conventional+fertiliser	14.48	33	2.35	4
Diverse-fertiliser	0.15	0.5	11.74	29
Diverse+fertiliser	0.08	0.2	0.70	1
b) *P. pratense*				
Conventional-fertiliser	0.49	1	0.52	1
Conventional+fertiliser	1.35	3	5.82	9
Diverse-fertiliser	4.25	14	7.73	19
Diverse+fertiliser	8.59	18	15.66	29
c) *L. perenne*				
Diverse+fertiliser	12.87	32	36.97	74
Diverse-fertiliser	23.33	53	46.55	76
d) *D. glomerata*				
Diverse-fertiliser	3.59	12	10.46	26
Diverse+fertiliser	6.74	14	25.74	47
e) *F. pratensis*				
Diverse-fertiliser	7.33	24	3.84	10
Diverse+fertiliser	9.23	19	3.87	37

[1] Mean live biomass per quadrat
[2] Percentage of the total live biomass

Table 11.10 Mean biomass per quadrat of species[3] sown in the diverse ley on margins managed for hay

Treatment	1988		1991	
	biomass[1] (g)	%total[2] biomass	biomass[1] (g)	%total[2] biomass
a) *Cynosurus cristatus*				
Diverse-fertiliser	0.1782	0.59	0.6933	1.75
Diverse+fertiliser	0.1867	0.39	0.5441	1.00
b) *Poa pratensis*				
Diverse-fertiliser	0.1626	0.54	1.3663	3.44
Diverse+fertiliser	0.2346	0.49	1.2873	2.36
c) *Trisetum flavescens*				
Diverse+fertiliser	0.0556	0.19	1.3480	3.40
Diverse-fertiliser	0.1241	0.26	2.0774	3.81
d) *Achillea millefolium*				
Diverse-fertiliser	0.0050	0.02	0.4492	1.13
Diverse+fertiliser	0.0067	0.01	0.1114	0.20
e) *Ranunculus acris*				
Diverse-fertiliser	0.0000	0	0.0055	0.01
Diverse+fertiliser	0.0002	0	0.0000	0
f) *Rumex acetosa*				
Diverse-fertiliser	0.0109	0.04	0.0041	0.01
Diverse+fertiliser	0.0250	0.05	0.0368	0.07

[1] Mean live biomass per quadrat
[2] Percentage of the total live biomass
[3] data for *D. glomerata, F. pratensis* and *P. pratense* are given in Table 11.9

Table 11.11 The effect of treatment on the biomass of *T. repens* in margins managed for hay[1]

Treatment	Ln mean biomass of *T. repens* per quadrat (mg)[2]. Arithmetic means (g) in brackets					
	1988[3]			1991[4]		
Conventional-fertiliser	9.94	A	(21.3)	8.93	A	(9.28)
Conventional+fertiliser	9.56	A	(14.5)	6.03	AB	(2.35)
Diverse-fertiliser	2.82	B	(0.15)	9.06	A	(11.7)
Diverse+fertiliser	2.33	B	(0.08)	2.81	B	(0.70)

[1]Analyses performed on ln-transformed data
[2]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=2.76, 1991 MSD=3.52
[3]1-way ANOVA, $F_{(3,28)}$=33.85, P=0.0001
[4]1-way ANOVA, $F_{(3,28)}$=10.47, P=0.0001

Table 11.12 The effect of treatment on the biomass of *P. pratense* in margins managed for hay[1]

Treatment	Ln mean biomass of *P. pratense* per quadrat (mg)[2]. Arithmetic means (g) in brackets					
	1988[3]			1991[4]		
Conventional-fertiliser	5.63	C	(0.49)	2.87	B	(0.52)
Conventional+fertiliser	6.96	B	(1.35)	6.47	AB	(5.82)
Diverse-fertiliser	8.20	A	(4.25)	8.78	A	(7.73)
Diverse+fertiliser	9.01	A	(8.59)	9.12	A	(15.7)

[1]Analyses performed on ln-transformed data
[2]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=1.10, 1991 MSD=3.73
[3]1-way ANOVA, $F_{(3,28)}$=26.85, P=0.0001
[4]1-way ANOVA, $F_{(3,28)}$=8.90, P=0.0003

Table 11.13 The effect of treatment on the biomass of *L. perenne* on margins managed for hay (conventional ley only)

Treatment	Mean biomass of *L. perenne* per quadrat (g)[1]	
	1988[2]	1991[3]
Conventional-fertiliser	12.9 B	37.0 A
Conventional+fertiliser	23.3 A	46.5 A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=7.88, 1991 MSD=11.05
[2]1-way ANOVA, $F_{(1,14)}$=8.10, P=0.0129
[3]1-way ANOVA, $F_{(1,14)}$=3.46, P=0.0842

Table 11.14 The effect of treatment on the biomass of *D. glomerata* on margins managed for hay (diverse ley only)

Treatment	Mean biomass of *D. glomerata* per quadrat (g)[1]	
	1988[2]	1991[3]
Diverse-fertiliser	3.59 B	10.5 B
Diverse+fertiliser	6.74 A	25.7 A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=2.15, 1991 MSD=12.1
[2]1-way ANOVA, $F_{(1,14)}$=9.86, Pr>F=0.0072, MSD=2.15
[3]1-way ANOVA, $F_{(1,14)}$=7.33, Pr>F=0.0170, MSD=12.1

Table 11.15 The effect of treatment on the biomass of *F. pratensis* on margins managed for hay (diverse ley only)

Treatment	Mean biomass of *F. pratensis* per quadrat (g)[1]	
	1988[2]	1991[3]
Diverse-fertiliser	7.33 A	3.84 A
Diverse+fertiliser	9.23 A	3.87 A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=4.49, 1991 MSD=4.11
[2]1-way ANOVA, $F_{(1,14)}$=0.83, P=0.3784
[3]1-way ANOVA, $F_{(1,14)}$=0.00, P=0.9893

Table 11.16 Live biomass comprised by key species in margins managed for silage

Treatment	1988		1991	
	biomass[1] (g)	%total[2] biomass	biomass[1] (g)	%total[2] biomass
a) *T. repens*				
Conventional-fertiliser	15.97	51	8.73	25
Conventional+fertiliser	9.40	24	1.95	5
Diverse-fertiliser	0.11	0.7	10.20	43
Diverse+fertiliser	0.08	0.3	0.04	0.1
b) *P. pratense*				
Conventional-fertiliser	0.35	1	0.38	1
Conventional+fertiliser	1.24	3	0.28	0.7
Diverse-fertiliser	2.12	13	3.71	16
Diverse+fertiliser	6.63	22	2.20	7
c) *L. perenne*				
Diverse+fertiliser	12.57	40	25.22	73
Diverse-fertiliser	25.36	65	39.77	94
d) *D. glomerata*				
Diverse-fertiliser	1.98	12	5.39	23
Diverse+fertiliser	7.41	24	28.20	86
e) *F. pratensis*				
Diverse-fertiliser	4.44	27	2.36	10
Diverse+fertiliser	9.55	32	0.80	2

[1] Mean live biomass per quadrat
[2] Percentage of the total live biomass

Table 11.17 Mean biomass per quadrat of species[3] sown in the diverse ley on margins managed for silage

Treatment	1988		1991	
	biomass[1] (g)	%total[2] biomass	biomass[1] (g)	%total[2] biomass
a) *Cynosurus cristatus*				
Diverse-fertiliser	0.0959	0.60	0.2691	1.14
Diverse+fertiliser	0.1873	0.62	0.0303	0.09
b) *Poa pratensis*				
Diverse-fertiliser	0.1005	0.62	0.6036	2.55
Diverse+fertiliser	0.3122	1.03	0.8835	2.68
c) *Trisetum flavescens*				
Diverse+fertiliser	0.0729	0.45	0.2523	1.07
Diverse-fertiliser	0.1792	0.59	0.2604	0.79
d) *Achillea millefolium*				
Diverse-fertiliser	0.0011	0.01	0.1449	0.61
Diverse+fertiliser	0.0257	0.09	0.0032	0.01
e) *Ranunculus acris*				
Diverse-fertiliser	0.0061	0.04	0.0007	0
Diverse+fertiliser	0	0	0.0016	0
f) *Rumex acetosa*				
Diverse-fertiliser	0.0061	0.04	0.0080	0.03
Diverse+fertiliser	0.0052	0.02	0.0045	0.01

[1] Mean live biomass per quadrat
[2] Percentage of the total live biomass
[3] data for *D. glomerata, F. pratensis* and *P. pratense* are given in Table 11.16

Table 12.18 The effect of treatment on the biomass of *T. repens* in margins managed for silage[1]

Treatment	Ln mean biomass of *T. repens* per quadrat (mg)[2]. Arithmetic means (g) in brackets					
	1988[3]			1991[4]		
Conventional-fertiliser	9.47	A	(16.0)	8.54	A	(8.73)
Conventional+fertiliser	8.92	A	(9.40)	5.43	A	(1.95)
Diverse-fertiliser	2.91	B	(0.11)	8.41	A	(10.2)
Diverse+fertiliser	1.61	B	(0.08)	1.86	B	(0.04)

[1]Analyses performed on ln-transformed data
[2]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=3.11, 1991 MSD=3.49
[3]1-way ANOVA, $F_{(3,23)}$=26.12, P=0.0001
[4]1-way ANOVA, $F_{(3,23)}$=12.97, P=0.0001

Table 11.19 The effect of treatment on the biomass of *P. pratense* in margins managed for silage[1]

Treatment	Ln mean biomass of *P. pratense* per quadrat (mg)[2]. Arithmetic means (g) in brackets					
	1988[3]			1991[4]		
Conventional-fertiliser	5.79	D	(0.35)	4.13	B	(0.38)
Conventional+fertiliser	7.08	C	(1.24)	5.05	AB	(0.28)
Diverse-fertiliser	7.63	B	(2.12)	7.84	A	(3.71)
Diverse+fertiliser	8.75	A	(6.63)	6.87	AB	(2.20)

[1]Analyses performed on ln-transformed data
[2]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=0.51, 1991 MSD=2.84
[3]1-way ANOVA, $F_{(3,23)}$=93.12, P=0.0001
[4]1-way ANOVA, $F_{(3,23)}$=5.54, P=0.0052

Table 11.20 The effect of treatment on the biomass of *L. perenne* in margins managed for silage (conventional ley only)

Treatment	Mean biomass of *L. perenne* per quadrat (g)[1]			
	1988[2]		1991[3]	
Conventional-fertiliser	12.6	B	25.2	B
Conventional+fertiliser	25.4	A	39.8	A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=8.50, 1991 MSD=10.15
[2]1-way ANOVA, $F_{(1,11)}=10.96$, P=0.0069
[3]1-way ANOVA, $F_{(1,11)}=9.95$, P=0.0092

Table 11.21 The effect of treatment on the biomass of *D. glomerata* on margins managed for silage (diverse ley only)

Treatment	Mean biomass of *D. glomerata* per quadrat (g)[1]			
	1988[2]		1991[3]	
Diverse-fertiliser	1.98	B	5.39	B
Diverse+fertiliser	7.41	A	28.2	A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=4.14, 1991 MSD=10.16
[2]1-way ANOVA, $F_{(1,12)}=8.17$, P=0.0144
[3]1-way ANOVA, $F_{(1,12)}=23.92$, P=0.0004

Table 11.22 The effect of treatment on the biomass of *F. pratensis* on margins managed for silage (diverse ley only)

Treatment	Mean biomass of *F. pratensis* per quadrat (g)[1]			
	1988[2]		1991[3]	
Diverse-fertiliser	4.44	B	2.36	A
Diverse+fertiliser	9.55	A	0.80	B

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=3.41, 1991 MSD=0.98
[2]1-way ANOVA, $F_{(1,12)}=10.69$, P=0.0067
[3]1-way ANOVA, $F_{(1,12)}=12.00$, P=0.0047

Table 11.23 The effect of treatment on total biomass in margins managed for hay

Treatment	Mean total biomass per quadrat (g)[1]			
	1988[2]		1991[3]	
Conventional-fertiliser	40.8	A	53.6	BC
Conventional+fertiliser	43.9	A	67.2	A
Diverse-fertiliser	30.0	A	43.9	C
Diverse+fertiliser	47.6	A	59.5	AB

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=19.5, 1991 MSD=13.1
[2]1-way ANOVA, $F_{(3,28)}=2.25$, P=0.1047
[3]1-way ANOVA, $F_{(3,28)}=8.45$, P=0.0004

Table 11.24 The effect of treatment on live and dead biomass in margins managed for hay (1991 only)

Treatment	Mean biomass per quadrat (g)[1]			
	Live biomass[2]		Dead biomass[3]	
Conventional-fertiliser	49.7	AB	3.90	B
Conventional+fertiliser	61.0	A	6.24	A
Diverse-fertiliser	39.7	B	4.22	B
Diverse+fertiliser	54.5	A	4.94	AB

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=12.9, 1991 MSD=1.33
[2]1-way ANOVA, $F_{(3,28)}=7.22$, P=0.0010
[3]1-way ANOVA, $F_{(3,28)}=9.10$, P=0.0002

Table 11.25 The effect of treatment on the biomass of sown species in margins managed for hay

Treatment	Mean biomass of sown species per quadrat (g)[1]	
	1988[2]	1991[3]
Conventional-fertiliser	34.7 AB	46.8 A
Conventional+fertiliser	39.2 A	54.7 A
Diverse-fertiliser	15.6 C	25.9 B
Diverse+fertiliser	25.3 BC	51.2 A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=11.0, 1991 MSD=14.7
[2]1-way ANOVA, $F_{(3,27)}$=13.98, P=0.0001
[3]1-way ANOVA, $F_{(3,27)}$=11.89, P=0.0001

Table 11.26 The effect of treatment on the biomass of unsown species in margins managed for hay[1]

Treatment	Ln mean biomass of unsown species per quadrat (mg)[2] Arithmetic means (g) in brackets	
	1988[3]	1991[4]
Conventional-fertiliser	7.99 A (6.15)	6.90 B (2.97)
Conventional+fertiliser	7.95 A (4.76)	7.17 AB (6.27)
Diverse-fertiliser	9.00 A (14.4)	9.39 A (13.8)
Diverse+fertiliser	9.32 A (23.4)	8.19 AB (4.23)

[1]Analyses performed on ln-transformed data
[2]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=1.94, 1991 MSD=2.25
[3]1-way ANOVA, $F_{(3,27)}$=1.92, P=0.1499
[4]1-way ANOVA, $F_{(3,27)}$=3.90, P=0.0194

Table 11.27 The effect of treatment on total biomass in margins managed for silage

Treatment	Mean total biomass per quadrat (g)[1]			
	1988[2]		1991[3]	
Conventional-fertiliser	31.4	AB	38.6	A
Conventional+fertiliser	39.0	A	46.8	A
Diverse-fertiliser	16.1	B	29.6	A
Diverse+fertiliser	30.2	AB	44.3	A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=15.9, 1991 MSD=17.3
[2]1-way ANOVA, $F_{(3,23)}=5.48$, P=0.0055
[3]1-way ANOVA, $F_{(3,23)}=2.97$, P=0.0528

Table 11.28 The effect of treatment on live and dead biomass in margins managed for silage (1991 only)

Treatment	Mean biomass per quadrat (g)[1]			
	Live biomass[2]		Dead biomass[3]	
Conventional-fertiliser	34.5	AB	4.09	B
Conventional+fertiliser	42.2	A	4.58	B
Diverse-fertiliser	23.6	B	5.99	B
Diverse+fertiliser	32.9	AB	11.4	A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=15.0, 1991 MSD=3.97
[2]1-way ANOVA, $F_{(3,23)}=3.85$, P=0.0229
[3]1-way ANOVA, $F_{(3,23)}=11.15$, P=0.0001

Table 11.29 The effect of treatment on the biomass of sown species in margins managed for silage

Treatment	Mean biomass of sown species per quadrat (g)[1]			
	1988[2]		1991[3]	
Conventional-fertiliser	28.9	A	34.3	A
Conventional+fertiliser	36.0	A	42.0	A
Diverse-fertiliser	8.81	B	12.7	B
Diverse+fertiliser	24.3	A	32.4	A

[1]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=13.1, 1991 MSD=14.1
[2]1-way ANOVA, $F_{(3,23)}$=11.67, P=0.0001
[3]1-way ANOVA, $F_{(3,23)}$=11.90, P=0.0001

Table 11.30 The effect of treatment on the biomass of unsown species in margins managed for silage[1]

Treatment	Ln mean biomass of unsown species per quadrat (mg)[2]. Arithmetic means (g) in brackets					
	1988[3]			1991[4]		
Conventional-fertiliser	7.56	A	(2.51)	2.86	B	(0.21)
Conventional+fertiliser	7.36	A	(2.99)	2.64	B	(0.21)
Diverse-fertiliser	8.42	A	(7.29)	8.56	A	(10.9)
Diverse+fertiliser	8.54	A	(5.91)	5.69	AB	(0.53)

[1]Analyses performed on ln-transformed data.
[2]Tukey's studentized range test, within columns means with the same letter are not significantly different. 1988 MSD=1.49, 1991 MSD=3.61
[3]1-way ANOVA, $F_{(3,23)}$=2.42, P=0.0921
[4]1-way ANOVA, $F_{(3,23)}$=9.19, P=0.0004

Table 11.31 The abundance and frequency of pernicious weeds in margins managed for hay

Treatment	Mean biomass per quadrat (g x 10^{-3}). Percentage of quadrats infested in brackets			
	1988		1991	
a) *Alopecurus myosuroides*				
Conventional-fertiliser	9.38	(3%)	0	(0%)
Conventional+fertiliser	696.00	(16%)	127.27	(6%)
Diverse-fertiliser	1421.47	(19%)	0.63	(3%)
Diverse+fertiliser	4642.41	(28%)	21.34	(9%)
b) *Avena* species (*A. fatua* and *A. sterilis* subsp. *ludoviciana* combined)				
Conventional-fertiliser	617.63	(11%)	23.71	(11%)
Conventional+fertiliser	155.53	(8%)	0	(0%)
Diverse-fertiliser	218.70	(7%)	2.59	(7%)
Diverse+fertiliser	2004.38	(11%)	0	(0%)
c) *Bromus sterilis*				
Conventional-fertiliser	0	(0%)	2118.54	(56%)
Conventional+fertiliser	0	(0%)	545.01	(19%)
Diverse-fertiliser	0	(0%)	16.88	(34%)
Diverse+fertiliser	0	(0%)	339.26	(25%)
d) *Cirsium arvense*				
Conventional-fertiliser	0	(0%)	0	(0%)
Conventional+fertiliser	0	(0%)	0	(0%)
Diverse-fertiliser	0	(0%)	9.53	(3%)
Diverse+fertiliser	0	(0%)	128.13	(3%)
e) *Convolvulus arvensis*				
Conventional-fertiliser	0	(0%)	1.34	(3%)
Conventional+fertiliser	0	(0%)	0	(0%)
Diverse-fertiliser	0	(0%)	0	(0%)
Diverse+fertiliser	19.05	(3%)	16.88	(9%)
f) *Elymus repens*				
Conventional-fertiliser	0	(0%)	373.63	(13%)
Conventional+fertiliser	0	(0%)	3149.53	(19%)
Diverse-fertiliser	0	(0%)	39.53	(3%)
Diverse+fertiliser	114.66	(3%)	1995.63	(0.28%)
g) *Galium aparine*				
Conventional-fertiliser	0	(0%)	13.91	(3%)
Conventional+fertiliser	0.86	(3%)	0	(0%)
Diverse-fertiliser	0	(0%)	5.03	(6%)
Diverse+fertiliser	20.28	(3%)	6.81	(3%)

Table 11.32 The abundance and frequency of pernicious weeds in margins managed for silage

Treatment	Mean biomass per quadrat (g x 10^{-3}). Percentage of quadrats infested in brackets			
	1988		1991	
a) *Alopecurus myosuroides*				
Conventional-fertiliser	113.85	(18%)	0	(0%)
Conventional+fertiliser	653.31	(25%)	0	(0%)
Diverse-fertiliser	1150.80	(25%)	0	(0%)
Diverse+fertiliser	967.09	(21%)	0	(0%)
b) *Avena* species (*A. fatua* and *A. sterilis* subsp. *ludoviciana* combined)				
Conventional-fertiliser	1129.37	(14%)	0	(0%)
Conventional+fertiliser	941.67	(8%)	0	(0%)
Diverse-fertiliser	0	(0%)	0	(0%)
Diverse+fertiliser	251.18	(11%)	0	(0%)
c) *Bromus sterilis*				
Conventional-fertiliser	0	(0%)	0	(0%)
Conventional+fertiliser	0	(0%)	0	(0%)
Diverse-fertiliser	0	(0%)	0	(0%)
Diverse+fertiliser	0	(0%)	7.02	(4%)
d) *Cirsium arvense*				
Conventional-fertiliser	16.12	(7%)	0	(0%)
Conventional+fertiliser	0	(0%)	0	(0%)
Diverse-fertiliser	0	(0%)	0	(0%)
Diverse+fertiliser	377.86	(4%)	35.57	(4%)
e) *Convolvulus arvensis*				
Conventional-fertiliser	0	(0%)	0	(0%)
Conventional+fertiliser	0	(0%)	0	(0%)
Diverse-fertiliser	0	(0%)	0	(0%)
Diverse+fertiliser	0	(0%)	0	(0%)
f) *Elymus repens*				
Conventional-fertiliser	1.09	(4%)	133.05	(7%)
Conventional+fertiliser	0	(0%)	211.72	(8%)
Diverse-fertiliser	0	(0%)	0	(0%)
Diverse+fertiliser	20.18	(4%)	7.00	(4%)
g) *Galium aparine*				
Conventional-fertiliser	0	(0%)	0	(0%)
Conventional+fertiliser	0	(0%)	0	(0%)
Diverse-fertiliser	0	(0%)	0	(0%)
Diverse+fertiliser	103.57	(4%)	0	(0%)

Table 11.33 Butterfly abundance on hay margins before the cut

1-way treatment ANOVA

Treatment	Mean abundance[1] per plot	Grouping[2]
Diverse - fertiliser	4.20 (1.56)	A
Conventional - fertiliser	1.50 (0.73)	B
Conventional + fertiliser	1.22 (0.654)	B
Diverse + fertiliser	0.00 (0.000)	B

Main Effect	d.f.	*F* value	*P*	Sig.
Treatment	3	18.11	0.0001	***

2-way mixture and fertiliser ANOVA

Mixture	Mean abundance[1]	Fertiliser	Mean abundance
Diverse	2.100 (0.780)	Minus	2.850 (1.149)
Conventional	1.368 (0.698)	Plus	0.579 (0.309)

Main Effects	d.f.	*F* value	*P*	Sig.
Mix	1	0.31	0.5839	ns
Fertiliser	1	29.11	0.0001	***
Mix*Fertiliser	1	23.48	0.0001	***

[1] ANOVA performed on log transformed means, shown in parentheses.
[2] Tukey's studentised range test; means with the same letter do not differ significantly ($P \leq 0.05$).

Table 11.34 Butterfly abundance on hay margins following the cut

1-way treatment ANOVA

Treatment	Mean abundance[1] per plot	Grouping[2]
Diverse - fertiliser	1.08 (0.599)	A
Conventional - fertiliser	0.92 (0.476)	A B
Diverse + fertiliser	0.58 (0.332)	A B
Conventional + fertiliser	0.29 (0.202)	B

Main Effect	d.f.	*F* value	*P*	Sig.
Treatment	3	3.01	0.0344	*

2-way mixture and fertiliser ANOVA

Mixture	Mean abundance[1]	Fertiliser	Mean abundance
Diverse	0.833 (0.466)	Minus	1.000 (0.554)
Conventional	0.604 (0.339)	Plus	0.438 (0.408)

Main Effects	d.f.	*F* value	*P*	Sig.
Mix	1	1.61	0.2073	ns
Fertiliser	1	7.40	0.0078	**
Mix*Fertiliser	1	0.00	0.9736	ns

[1] ANOVA performed on log transformed means, shown in parentheses.
[2] Tukey's studentised range test; means with the same letter do not differ significantly ($P \leq 0.05$).

Table 11.35 Butterfly abundance on silage margins before the cut

1-way treatment ANOVA

Treatment	Mean abundance[1] per plot	Grouping[2]
Diverse - fertiliser	1.86 (0.811)	A
Diverse + fertiliser	0.71 (0.376)	A B
Conventional + fertiliser	0.43 (0.265)	A B
Conventional - fertiliser	0.42 (0.227)	B

Main Effect	d.f.	*F* value	*P*	Sig.
Treatment	3	3.19	0.0315	*

2-way mixture and fertiliser ANOVA

Mixture	Mean abundance[1]	Fertiliser	Mean abundance
Diverse	1.286 (0.593)	Minus	1.143 (0.519)
Conventional	0.423 (0.244)	Plus	0.577 (0.324)

Main Effects	d.f.	*F* value	*P*	Sig.
Mix	1	5.27	0.0267	*
Fertiliser	1	1.87	0.1976	ns
Mix*Fertiliser	1	2.42	0.1263	ns

[1] ANOVA performed on log transformed means, shown in parentheses.
[2] Tukey's studentised range test; means with the same letter do not differ significantly ($P \leq 0.05$).

Table 11.36 Butterfly abundance on silage margins following the cut

1-way treatment ANOVA

Treatment	Mean abundance[1] per plot	Grouping[2]
Conventional - fertiliser	0.54 (0.320)	A
Diverse - fertiliser	0.48 (0.289)	A
Diverse + fertiliser	0.14 (0.099)	A
Conventional + fertiliser	0.11 (0.077)	A

Main Effect	d.f.	*F* value	*P*	Sig.
Treatment	3	2.44	0.071	ns

2-way mixture and fertiliser ANOVA

Mixture	Mean abundance[1]	Fertiliser	Mean abundance
Diverse	0.309 (0.193)	Minus	0.512 (0.305)
Conventional	0.350 (0.211)	Plus	0.128 (0.089)

Main Effects	d.f.	*F* value	*P*	Sig.
Mix	1	0.00	0.9535	ns
Fertiliser	1	7.21	0.0089	**
Mix*Fertiliser	1	0.11	0.7414	ns

[1] ANOVA performed on log transformed means, shown in parentheses.
[2] Tukey's studentised range test; means with the same letter do not differ significantly ($P \leq 0.05$).

Table 11.37 Species richness on hay margins before the cut

1-way treatment ANOVA

Treatment	Mean no. species per plot	Grouping[1]
Diverse - fertiliser	1.250	A
Conventional - fertiliser	0.875	A
Conventional + fertiliser	0.750	A
Diverse + fertiliser	0.000	B

Main Effect	d.f.	*F* value	*P*	Sig.
Treatment	3	15.88	0.0001	***

2-way mixture and fertiliser ANOVA

Mixture	Mean no. species	Fertiliser	Mean no. species
Diverse	0.625	Minus	1.063
Conventional	0.813	Plus	0.375

Main Effects	d.f.	*F* value	*P*	Sig.
Mix	1	2.03	0.1650	ns
Fertiliser	1	27.32	0.0001	***
Mix*Fertiliser	1	18.29	0.0002	***

[1] Tukey's studentised range test; means with the same letter do not differ significantly ($P \leq 0.05$).

Table 11.38 Species richness on hay margins following the cut

1-way treatment ANOVA

Treatment	Mean no. species per plot	Grouping[1]
Diverse - fertiliser	2.000	A
Conventional - fertiliser	1.875	A
Diverse + fertiliser	1.125	A
Conventional + fertiliser	1.125	A

Main Effect	d.f.	*F* value	*P*	Sig.
Treatment	3	1.87	0.1570	ns

2-way mixture and fertiliser ANOVA

Mixture	Mean no. species	Fertiliser	Mean no. species
Diverse	1.563	Minus	1.937
Conventional	1.500	Plus	1.125

Main Effects	d.f.	*F* value	*P*	Sig.
Mix	1	0.03	0.8575	ns
Fertiliser	1	5.55	0.0257	*
Mix*Fertiliser	1	0.03	0.8575	ns

[1] Tukey's studentised range test; means with the same letter do not differ significantly ($P \leq 0.05$).

Table 11.39 Species richness on silage margins before the cut

1-way treatment ANOVA

Treatment	Mean no. species per plot	Grouping[1]
Diverse - fertiliser	1.571	A
Diverse + fertiliser	0.714	A B
Conventional + fertiliser	0.500	B
Diverse - fertiliser	0.429	B

Main Effect	d.f.	*F* value	*P*	Sig.
Treatment	3	5.24	0.0066	**

2-way mixture and fertiliser ANOVA

Mixture	Mean no. species	Fertiliser	Mean no. species
Diverse	1.143	Minus	1.000
Conventional	0.462	Plus	0.615

Main Effects	d.f.	*F* value	*P*	Sig.
Mix	1	8.52	0.0077	**
Fertiliser	1	2.85	0.1046	ns
Mix*Fertiliser	1	3.99	0.0578	ns

[1] Tukey's studentised range test; means with the same letter do not differ significantly ($P \leq 0.05$).

Table 11.40 Species richness on silage margins following the cut

1-way treatment ANOVA

Treatment	Mean no. species per plot	Grouping[1]
Diverse - fertiliser	1.143	A
Conventional - fertiliser	1.000	A
Diverse + fertiliser	0.857	A
Conventional + fertiliser	0.400	A

Main Effect	d.f.	*F* value	*P*	Sig.
Treatment	3	1.04	0.3934	ns

2-way mixture and fertiliser ANOVA

Mixture	Mean no. species	Fertiliser	Mean no. species
Diverse	1.000	Minus	1.066
Conventional	0.786	Plus	0.692

Main Effects	d.f.	*F* value	*P*	Sig.
Mix	1	1.05	0.3162	ns
Fertiliser	1	2.29	0.1440	ns
Mix*Fertiliser	1	0.29	0.5966	ns

[1] Tukey's studentised range test; means with the same letter do not differ significantly ($P \leq 0.05$).

Table 11.41 Butterfly diversity on hay margins before the cut

Treatment	Mean SW Index	Mean Wilcoxon score[1]
Conventional - fertiliser	0.0000	15.5
Diverse - fertiliser	0.1154	19.5
Diverse + fertiliser	0.0000	15.5
Conventional + fertiliser	0.0000	15.5

[1] Kruskal-Wallis Test (Chi-Square Approximation): $\chi^2_{(3)} = 6.19$, $P=0.103$.

Table 11.42 Butterfly diversity following the hay cut

Treatment	Mean SW Index	Mean Wilcoxon score[1]
Conventional - fertiliser	0.7068	20.31
Diverse - fertiliser	0.6313	21.63
Diverse + fertiliser	0.1662	12.75
Conventional + fertiliser	0.0866	11.31

[1] Kruskal-Wallis Test (Chi-Square Approximation): $\chi^2_{(3)} = 9.0636$, $P=0.0285$.

Table 11.43 Butterfly diversity before the silage cut

Treatment	Mean SW Index	Mean Wilcoxon score[1]
Diverse - fertiliser	0.2658	19.28
Diverse + fertiliser	0.0909	13.36
Conventional - fertiliser	0.0000	11.50
Conventional + fertiliser	0.0000	11.50

[1] Kruskal-Wallis Test (Chi-Square Approximation): $\chi^2_{(3)} = 9.67$, $P=0.0216$.

Table 11.44 Butterfly diversity after the silage cut

Treatment	Mean SW Index	Mean Wilcoxon score[1]
Conventional - fertiliser	0.1998	14.92
Diverse + fertiliser	0.0990	13.42
Diverse - fertiliser	0.1445	13.57
Conventional + fertiliser	0.0000	11.50

[1] Kruskal-Wallis Test (Chi-Square Approximation): $\chi^2_{(3)} = 1.48$, $P=0.6849$.

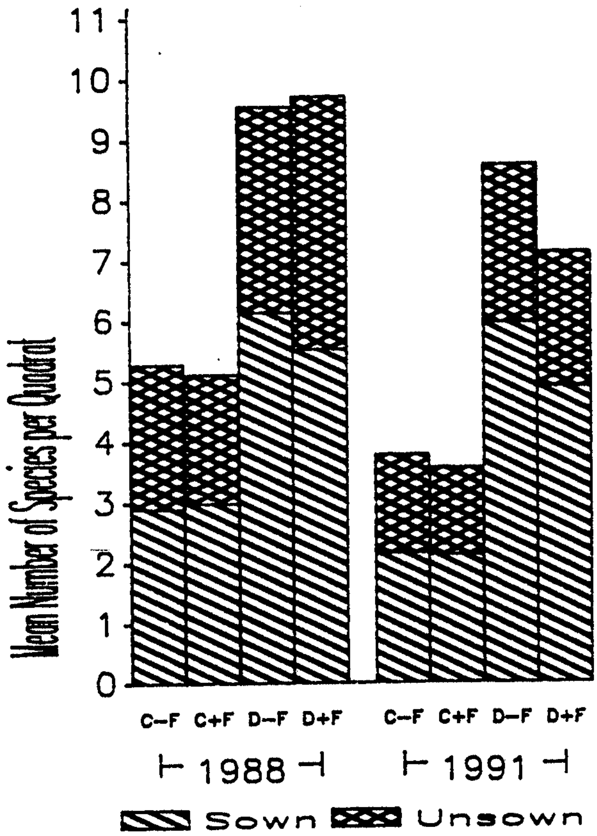

Figure 11.1 The mean numbers of sown and unsown species per 25x25 cm quadrat on the hay margins

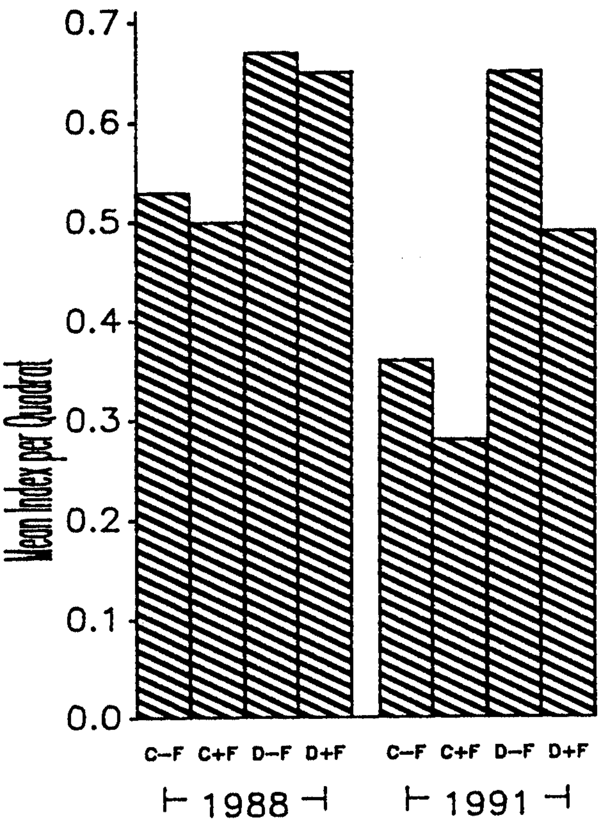

Figure 11.2 The mean values of Simpson's diversity index for plant species on the hay margins

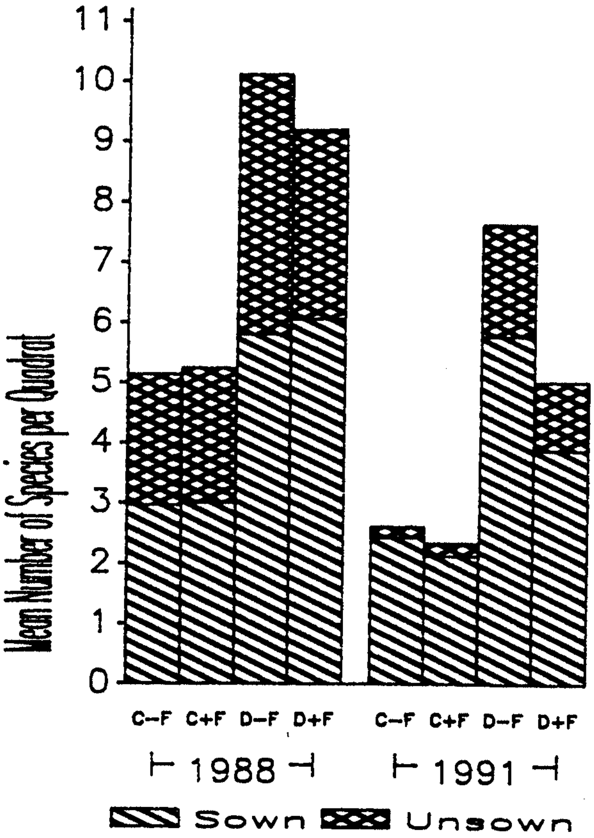

Figure 11.3 The mean numbers of sown and unsown species per 25x25 cm quadrat on the silage margins

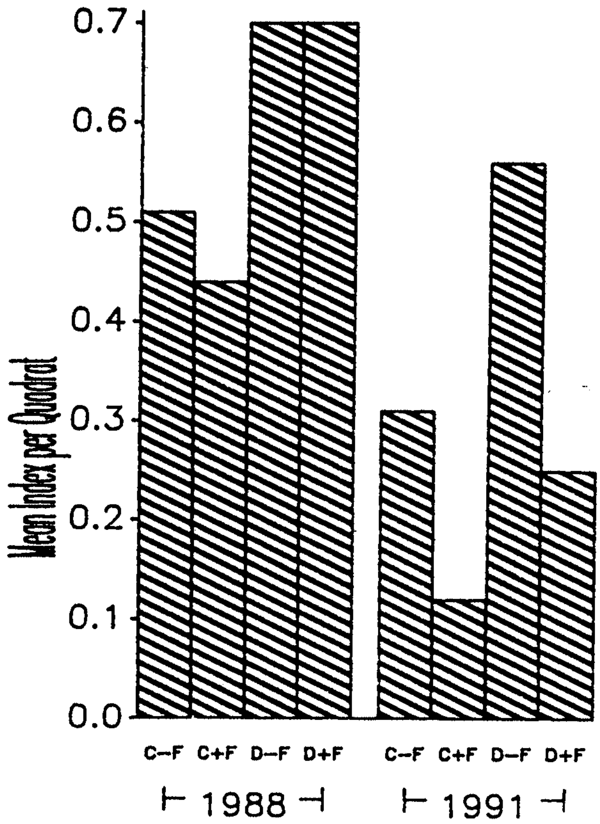

Figure 11.4 The mean values of Simpson's diversity index for plant species on the silage margins

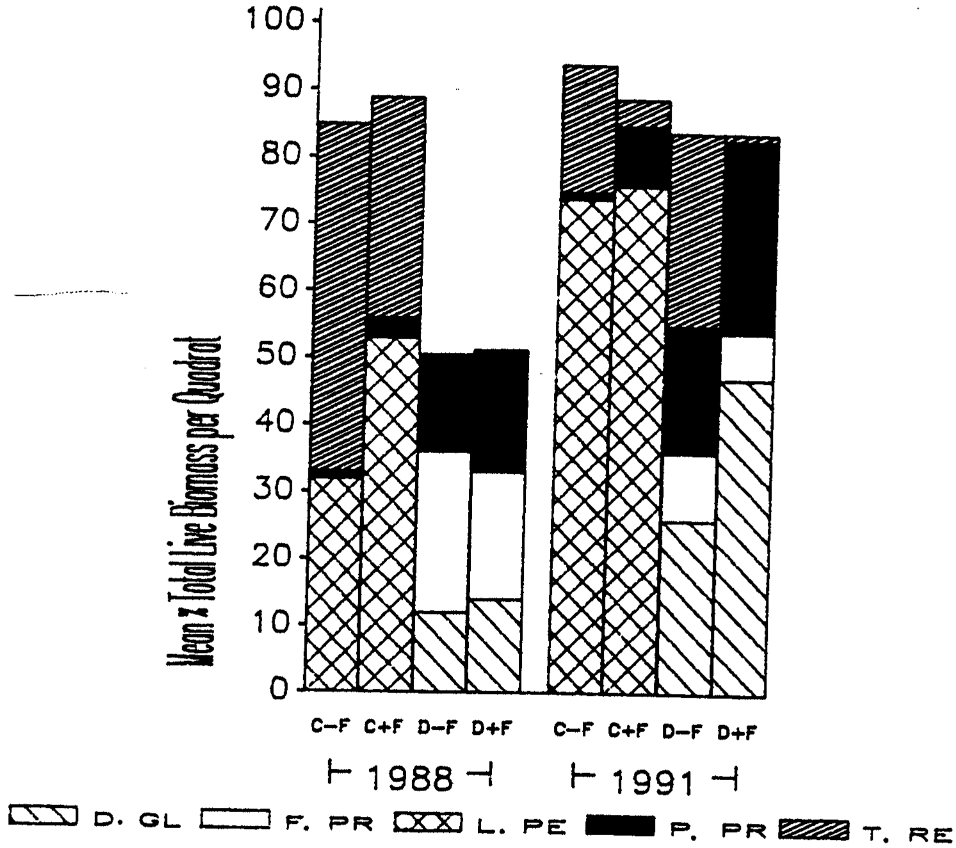

Figure 11.5 The proportion of the sward biomass comprised by the five most abundant species in the hay margins

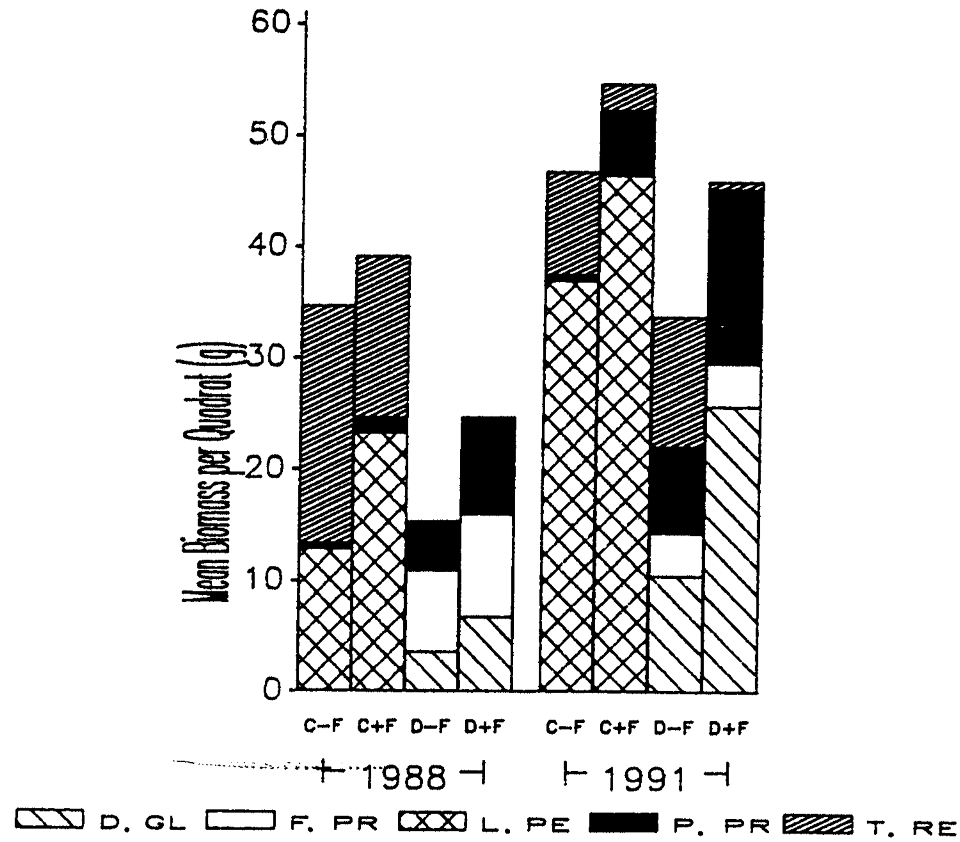

Figure 11.6 The effect of treatment on the five most abundant species on the hay margins

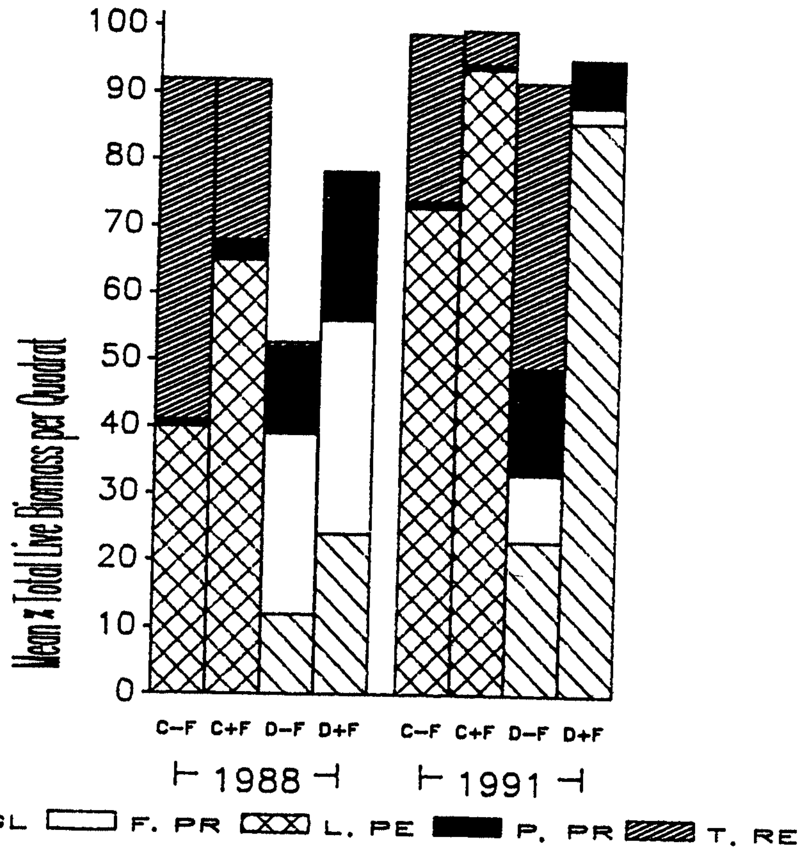

Figure 11.7 The proportion of the sward biomass comprised by the five most abundant species in the silage margins

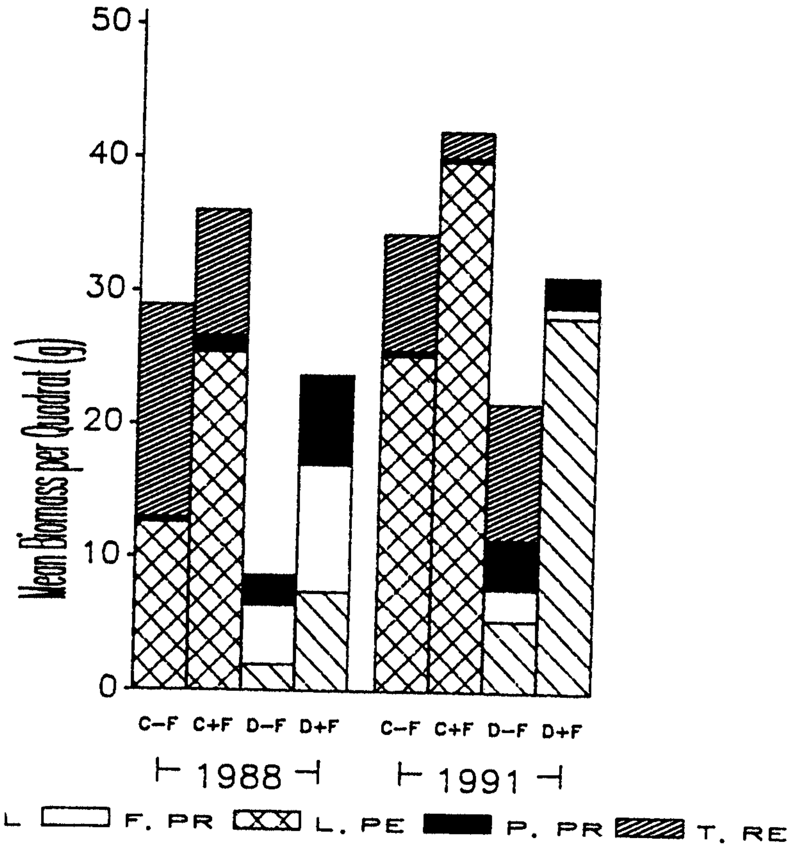

Figure 11.8 The effect of treatment on the five most abundant species on the silage margins

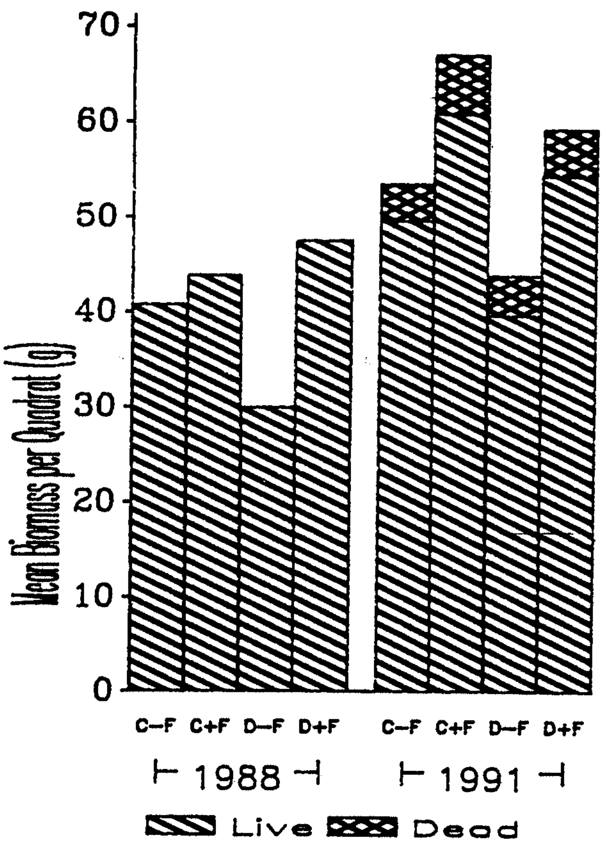

Figure 11.9 The mean biomass per 25x25cm quadrat of the swards on the hay margins

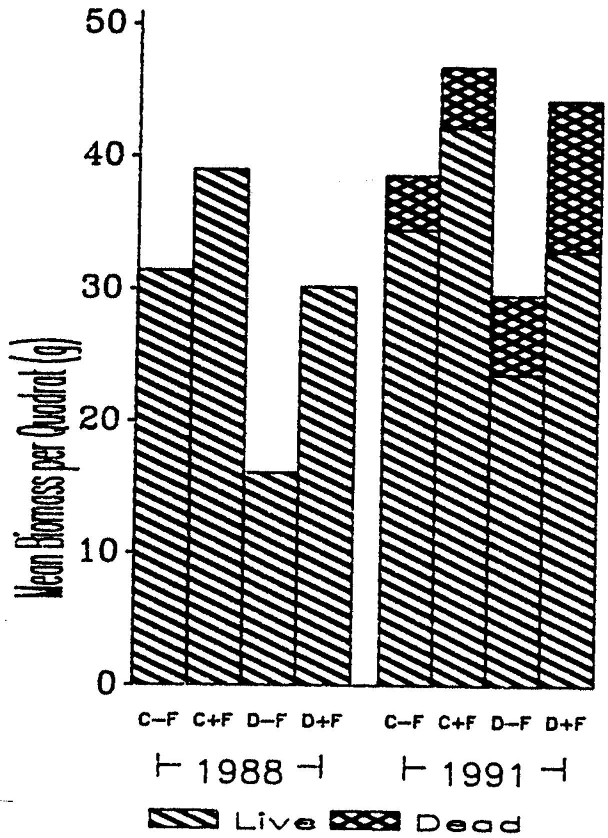

Figure 11.10 The mean biomass per 25x25cm quadrat of the swards on the silage margins

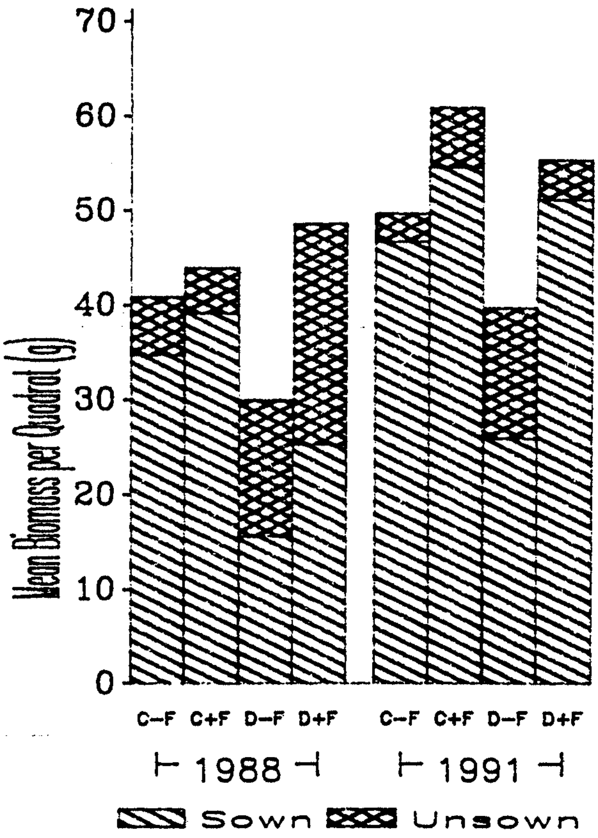

Figure 11.11 The mean biomass of sown and unsown species per 25x25cm quadrat on the hay margins

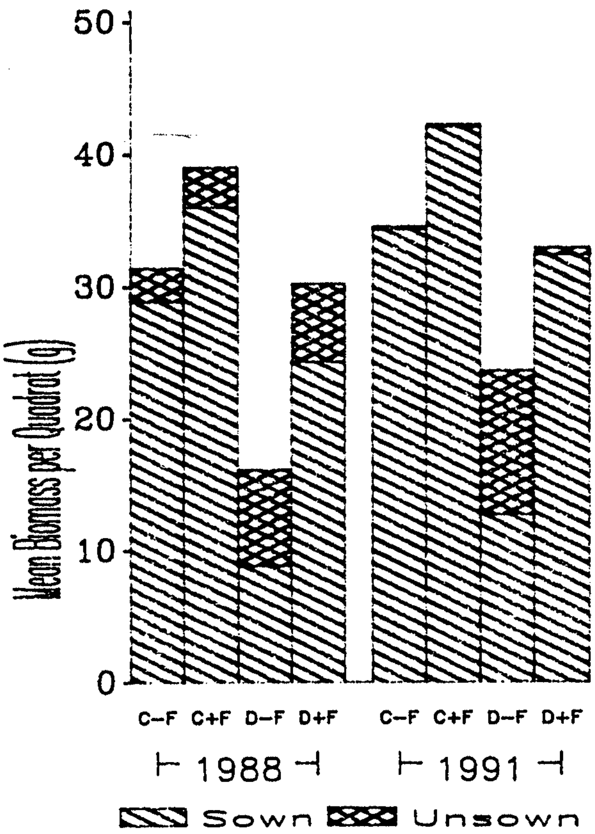

Figure 11.12 The mean biomass of sown and unsown species per 25x25cm quadrat on the silage margins

12 DISCUSSION

12.1 Field margin restoration

A central theme in this report has been that integrated solutions to the problems of weed control and the restoration of wildlife interest on degraded field margins can be best achieved by establishing and maintaining predominantly perennial, grassy swards. It is vital that these two problems are addressed simultaneously because nature conservation measures must be 'carried' by other practical and financial benefits to agriculture if they are to be acceptable to the majority of farmers. The objectives for conservation management of field boundaries must themselves be simple and flexible if they are to be realistic and to accommodate the farmer's own aspirations. Only in exceptional circumstances would the conservation of rare species or the restoration of species richness to levels comparable with those in high-quality semi-natural habitats, be feasible or appropriate aims. More suitable targets are likely to include increasing species richness and establishing or increasing populations of the many, still widespread, but declining species of plants and animals which were once ubiquitous and attractive features of the agricultural countryside.

Our experiments showed that both nature conservation and weed management objectives can be achieved on expanded field margins by employing simple, relatively inexpensive management techniques. We further showed that some of these techniques can be more effective in controlling weeds than the still-common practise of using broad-spectrum herbicides to manage field boundary vegetation. In this chapter we discuss the broad principles of field margins management that emerge from the results presented in this report. These principles are useful and robust guides to devising management strategies to fulfil a variety of objectives for field margin use. We also, however, draw attention to examples of the many more detailed results in the report, particularly relating to individual species' responses to management, understanding of which should enable much finer tuning of prescriptions to fulfil particular objectives in specific agricultural situations. We then discuss the problems of applying this sort of detailed information to the varying requirements for field margins at farm level (Section 12.2). Finally we discuss the contribution that our conclusions can make to the provision of advice for conservation management of more extensive areas of arable land fallowed under the various incentive schemes.

Our results provided a clear demonstration that the common practise of using broad-spectrum herbicides to control weeds on field margins is not only detrimental to wildlife but also perpetuates weed problems. Annual spraying with glyphosate resulted in species-poor, annual dominated swards (Chapter 4) which were less attractive to most of the invertebrate groups examined (Chapter 8), and particularly to nectar-feeding species such as butterflies (Chapters 9 & 10), than completely unmanaged field margins. In the medium-term spraying is unlikely to be a more cost-effective method of weed control than establishing dense, perennial grass swards in which weedy species are unable to compete.

The aims of establishing weed-free, attractive perennial swards, supporting a diversity of invertebrates, were most rapidly, easily and comprehensively achieved by sowing a wild-flower seed mixture on the extended field margins. Even in the absence of management over a four-year period, these swards effectively excluded annual weeds and prevented the spread of perennial weeds (Chapter 5). However, wild-flower seed mixtures have two draw-backs which have tended to lead both farmers and conservationists to reject their use on field margins.

First, from the perspective of the farmer, they are expensive. This means that they must be grown in a way that is likely to ensure successful establishment and subsequent growth. We showed clearly that sowing seed mixtures into existing field margin vegetation resulted in extremely poor establishment, while sowing into a well prepared seed bed, in the same way as other grass crops, resulted in good establishment, particularly of the grass species. The components of the mixture must also be chosen carefully. They must be suited to the prevailing soil-type: we recommend the use of species common in near-by, semi-natural grassland, thus ensuring not only that they are likely to be suited to local soils, but also that they are in keeping with the local flora. They must be appropriate both for the farmer's objectives for the field margin swards and for the management regime that is intended. This requires detailed understanding of individual species. Thus, we showed that some common components of wildflower seed mixtures die out rapidly when managed once a year or less, while other do badly when mown twice a year (Chapter 6). Swards including a continuity of favoured nectar source species can attract a large and diverse assemblage of butterflies (Chapter 9), while inclusion of larval food plants of specialist-feeders can help to establish breeding populations (Feber & Smith 1993). Other studies have shown that inclusion of grass species, such as *Dactylis glomerata*, with tussocky growth can encourage large overwintering populations of crop-pest predators (Thomas *et al* 1992). These detailed studies provide the basis of tailoring seed mixtures to particular situations and requirements. Such fine-tuning not only capitalises most effectively on the investment by ensuring success but can also reduce the cost by limiting the number of species included. In general we recommend the use of the simplest possible mixtures that fulfil these essential requirements. Inclusion of as few as two or three forbs with four or five species of fine-leaved grasses can ensure swards with excellent weed control properties that are visually attractive. Although their plant species richness is low, they can support rich invertebrate assemblages if managed appropriately.

The second draw-back of wild-flower seeded swards is that they tend to exclude species from the local flora. We showed in Chapter 4 that the numbers of species from the local flora present in sown swards was only around 35% of that in naturally-regenerating swards. Whilst this is precisely the property that resulted in effective weed control, it is undesirable for nature conservation objectives in circumstances where an attractive local flora, with semi-natural elements, could be conserved. Our data provide robust guidance on the circumstances in which allowing natural regeneration is likely to result in an acceptably species rich flora. Most of the perennial flora colonising fallowed field margins is likely to be a sub-set of the species present in floras only in the immediate vicinity of margin, usually in adjacent hedge bottoms or ditch banks (Chapter 3). Although the colonisation rate is most rapid in the very early years of succession, the proportion of species in the adjoining floras which are represented in the new flora is likely to continue to increase gradually for many years. Thus, if the flora available in the immediate vicinity of the newly fallowed field margins is considered very depauperate relative to what is considered desirable on the new field margins, the use of seed mixtures should be considered. This situation is likely to occur commonly in many very intensively farmed areas of lowland England, where field boundary management by close ploughing and herbicide use has long been practised.

The presence of an acceptably species rich flora in the vicinity of a newly-fallowed field margin does not, however, guarantee satisfactory results from natural regeneration. In the first year of fallow agriculturally alarming results are predictable. Fallowing a crop edge and leaving it unsprayed inevitably results in a proliferation of annual crop weeds present as seeds in the soil (Chapter 3). Although, on field margins, annual dominance is likely to last for only one year, until dominance by perennials is established, its inevitably and short-term nature should be clearly explained to farmers embarking on field margin extension or more extensive set-aside. Failure to do this in the context of set-aside has been clearly shown by the horrified reactions to set-aside weed problems catalogued in the farming press.

Even in the second and subsequent years of fallow, when the sward is perennial-dominated and may be reasonably species-rich, the fertility of the soil and relative abundance of propagules of desirable and weedy species is likely to ensure dominance by a few, usually aggressive, weedy species (Chapter 3). The results in this report show that simple mowing regimes can be used to manipulate the species composition and richness of these swards and the persistence of annual weeds beyond the first year of fallow (Chapters 4 & 5).

Mowing twice a year, in spring and autumn, maximised the species richness of both naturally regenerating and sown swards. This regime was more effective than twice annual mowing in spring and summer, and substantially more effective than mowing once a year or not at all (Chapter 4). The effectiveness of spring and autumn mowing appeared to result both from the opportunities it gave for many species to set seed during the summer and the germination and establishment opportunities that it created by opening up the swards in the autumn (Chapter 5). This regime also optimised butterfly species richness by allowing nectar continuity during the main flight period of most species (Chapters 9 & 10). Although butterflies were equally abundant on uncut treatments, on which nectar supply was also continuous, we predicted that the progressive decline in plant species richness on these swards would result in diminished nectar supply in the medium term. Any mowing during the summer months was very deleterious to invertebrate species richness and abundance (Chapter 8).

The advantages to nature conservation objectives of mowing in spring and autumn must be balanced in the early years of succession by the deleterious effects of this regime on annual weed control. The same factors that promote overall diversity (allowing species to set seed and creating germination and establishment opportunities) also allow annual weed species to persist under this regime. Control of both *Avena* species and *Bromus sterilis* were significantly worse under this regime than in swards which were left uncut (Chapter 5). Spring and autumn-cut swards were the only ones in which *Avena* species persisted for several years. *Avena* species even persisted at low density in sown swards under this regime. This conflict of interest between the development of diversity and annual weed control can be resolved by using management regimes that optimise weed control in the first instance and later relaxing the regime to favour the development of diversity. Weed control must be a priority if the field margins are to remain an acceptable proposition to the farmer. This compromise is likely to involve mowing in spring and at some point during the summer (below), a regime that was only slightly less favourable to plant species richness, if much less favourable to butterflies, than spring and autumn mowing. This regime may also have to be entertained, at least on limited areas of the field margins, where heavy public access is required.

Although most species of annual weeds decline dramatically even in naturally regenerating swards in the second year of fallow, control of these species by carefully timed mowing is likely to be an important element of field margin management. The problems created by badly timed mowing were discussed above. In the first year of fallow mowing can be used to prevent both the agricultural embarrassment of overtly weedy field margins and shedding of seed by tall-growing species into the crop edge. If the fallowed swards are not intended to be permanent (as in set-aside, for example) it is also important to prevent species such as *Avena* with long-lived seeds, from shedding. In subsequent years mowing is most likely to be useful to control *Bromus sterilis* which we demonstrated can persist at high densities in perennial swards if it is allowed to seed (Chapter 5). We suggest that control of problem annual species by mowing is likely to be most successful when timed to coincide with the period when most panicles are flowering, and when late-summer mowing is avoided to reduce establishment opportunities for any seeds shed and seeds already present in the seed bank. This conflicts with advice from other sources which suggests that frequently repeated mowing throughout the summer is the best annual weed control strategy (see Chapter 5.3). The most effective annual weed control strategies are likely to be based on understanding the interactions between mowing and the flowering and germination phenologies and seed longevities of the species at a particular site, in the ways described in this report.

None of the mowing regimes employed in this experiment resulted in the successful control of perennial weeds in naturally regenerating swards within four years of establishing the extended field margins (Chapter 5). It is likely that more frequent mowing would control these species, although late summer mowing should again be avoided during the periods when the seeds of any of the species concerned germinate and establish. Where natural regeneration is the preferred option for sward establishment, and frequent mowing is not considered desirable or practical, spot treatment of problem perennials with selective herbicides should be considered. Any such herbicide use should be targeted when clumps are small because of the risk of allowing annual weed species to re-establish in the resulting bare ground. This is one example of a recurring theme in the conclusions throughout this report, that mixed strategies of field margin management are likely to yield the best results for nature conservation and best integration of nature conservation with weed control and other agricultural interests, such as access or game rearing.

It is also possible that the spread of weedy perennials may be curtailed in the medium term if mowing and hay removal reduce the soil nutrient status of the field boundary (see Chapter 5.3). Our results suggest that this is at best likely to be a slow process.

Comparison of swards in which hay cut twice annually was removed with those in which it was left lying, revealed few differences over a four year period. However, although no effects on diversity were detectable over this period (Chapter 4), *Urtica dioica* was significantly more abundant in swards in which the hay was left lying by the fourth year after fallowing (Chapter 5). This suggests that field margin soils may be sufficiently isolated from lateral movement of soil nutrients from the field, for mowing and hay removal eventually to have an impact on their soil nutrient status and plant species composition. The problem of perennial weed control is central to assessing the medium and long-term viability of natural regeneration in field margin restoration on fertile soils. In the first four years of the experiment the perennial weed problem rarely looked very severe but the sustained rate of increase by key species suggested that it was likely to become severe within the next few years. Equally, the issue of the importance of collecting cut hay must be definitively resolved if the expense and difficulty of achieving this is to be justified (Chapter 5.3). To these ends it is vital that measurements of soil nutrient status under the contrasting treatments and longer-term monitoring of the flora are carried out.

An alternative approach to parts of the perennial weed problem may lie in attempts to change farming attitudes to those species that are considered undesirable, but which are unlikely to present problems in the crops. Species such as *Urtica dioica* and *Cirsium vulgare*, for example, are frequently targeted for herbicide application in field margins although they are not crop pests and are both valuable hosts for attractive and also agriculturally beneficial invertebrates.

The Wytham experiments also provide important guidance on the feasibility of restoring existing, degraded field margins. As discussed above, sowing wildflower seed mixtures into existing swards is likely to result in extremely poor establishment and therefore poor return on the investment (Chapter 4). When sown swards are desired, or are necessary because of lack of other suitable sources of propagules, existing field margins should be cultivated first before sowing. In cases where they are infested with pernicious, rhizomatous, perennial weeds, broad spectrum herbicide use prior to cultivation and sowing should be considered. This should be unnecessary where annual, rather than perennial weeds are a problem.

Where the flora of the existing field margin or adjacent field boundary is an acceptable basis for restoration by mowing management, our data show that improvements in weed control and species richness should be expected to be much slower than in the secondary successional vegetation of extended field margins. A gradual increase in species richness on the old field margins was attributable to the exclusion of fertilisers and herbicides rather than to management (Chapter 3). Mowing twice annually, with removal of the cut material, had no detectable effects on the species richness of existing field margins over a four year period (Chapter 4). Slow change is inevitable in this type of vegetation, because establishment opportunities are likely to be few and changes in the size and number of established perennial plants are likely to be slow. Nevertheless, exclusion of agrochemicals from existing field boundaries, together with twice-annual mowing is likely to bring about short-term improvements in the visual acceptability and accessibility of the margins, as well as medium to long-term improvements in their nature conservation value.

12.2 The provision of advice

The above discussion highlights the importance of applying simultaneously both robust general principles of field margin management and much more detailed information relevant to particular sites, suites of species and objectives. The ease with which simple, blanket prescriptions, can be disseminated is attractive, and may bring about some general improvement in standards of field margin management. However, the necessity of finding reliably successful solutions is critical to the acceptability and credibility of any moves to encourage restoration of this extremely important habitat. Tailored advice, given by advisors with an understanding both of the general principles and how to apply them under specific conditions, is much more likely to result in management prescriptions that are perceived as successful by both farming and nature conservation interests. We therefore believe that effective dissemination of the wealth of detailed advice now available from this and other studies should be achieved by training advisors, rather than leafleting farmers. As well as resulting in more successful advice for individual sites, dissemination through this route is likely to be the most effective way of achieving the mixed strategies of field margin management, which we suggest above are most likely to optimise benefits to nature conservation. The nature of the information available, and the complexity of objectives likely to be sought for field margins by both farmers and conservationists, suggest that dissemination as an expert system should be considered.

Despite the enormous potential of field margins for nature conservation in the wider countryside (see Chapter 1), little attention has been given to field margin management in the various schemes designed to improve conservation management on farmland. We believe that our conclusions show that the weed control benefits of simple improvements to field margin management, make better nature conservation management a viable proposition for many farmers in the absence of additional incentives. However, incentive schemes would undoubtedly play an important role in encouraging the initiation of field margin restoration on a much larger-scale, particularly where capital investment in seed mixtures or new cutting equipment is required. Many of the potential benefits of field margins as landscape corridors are likely to require improvements in management over large areas, if they are to be realised. It is to be hoped that the information now available, as a result of this study, will both encourage recognition of the role of this habitat and increase enormously the chances of success of any subsidy scheme by the provision of effective advice.

12.3 Set-aside and other incentive schemes

We have shown throughout this report that many of our conclusions, from both the two metre and wide margins experiments (Chapter 11), are of direct relevance to the management of set-aside and other subsidised schemes for farmland habitat restoration. We have also indicated the ways in which some areas of our results are likely to differ from those for whole fields, although most of these differences are likely to be quantitative rather than qualitative. The information contained in this report constitutes some of the most robust advice now available on the effects of differing mowing regimes on weed species common in set-aside, on the ways in which mowing can be used to optimise diversity, on effects of different mowing regimes on different taxonomic groups, and on the use of non-agricultural seed mixtures to establish green cover on fallowed arable land.

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APPENDIX 1 THE PLANT SPECIES RECORDED ON THE EXPERIMENTAL FIELD MARGINS BETWEEN 1987 AND 1991

Complete species lists are provided for the field boundaries (including the hedges, hedge bottoms, ditches, ditch banks and tracks: A1.1), the old zone of the field margins (A1.2), the new field margins (A1.3) and the crop (A1.4). An equivalent list of the species recorded from the seed bank samples is given in A1.5.

A1.1 SPECIES RECORDED IN THE FIELD BOUNDARIES ADJACENT TO THE EXPERIMENTAL FIELD MARGINS

Acer campestre	L.	Field Maple
Acer pseudoplatanus	L.	Sycamore
Achillea millefolium	L.	Yarrow
Agrimonia eupatoria	L.	Agrimony
Agrostis capillaris	L.	Common Bent
Agrostis stolonifera	L.	Creeping Bent
Ajuga reptans	L.	Bugle
Alliaria petiolata	L.	Garlic Mustard
Allium vineale	L.	Wild Onion
Alopecurus pratensis	(Bieb)Cavara & Grande	Meadow Foxtail
Anagallis arvensis	L.	Scarlet Pimpernel
Angelica sylvestris	L.	Wild Angelica
Anthriscus sylvestris	(L.)Hoffm.	Cow Parsley
Apium nodiflorum	(L.)Lag.	Fool's Water-cress
Arctium lappa	L.	Greater Burdock
Arctium minus	(Hill) Bernh	Lesser Burdock
Armoracia rusticana	P.Gaertner, B.Meyer & Scherb	Horse-radish
Arrhenatherum elatius	(L.)Beauv.	False Oat-grass
Arum maculatum	L.	Lords-and-Ladies
Atriplex patula	L.	Common Orache
Avena fatua	L.	Wild Oat
Avena sterilis	L.	Winter Wild-oat
Ballota nigra	L.	Black Horehound
Bellis perennis	L.	Daisy
Betula pendula	Roth	Birch
Brachypodium sylvaticum	(Hudson)Beauv.	False Brome
Brassica nigra	(L.)Koch	Black Mustard
Bromus commutatus	Schrader	Meadow Brome
Bromus hordeaceus	L.	Soft-brome
Bromus ramosus	Hudson	Hairy Brome
Bromus sterilis	L.	Barren Brome
Bryonia cretica	L. ssp. *dioica*	White Bryony
Calamagrostis epigejos	(L.)Roth	Wood Small-reed
Calystegia sepium	(L.)R.Br.	Hedge Bindweed
Capsella bursa-pastoris	Medic	Shepherd's Purse
Cardamine hirsuta	L.	Hairy Bittercress
Carduus acanthoides	L.	Welted Thistle
Carex flacca	Schreber	Glaucous Sedge
Carex hirta	L.	Hairy Sedge
Carex otrubae	Podp.	False Fox-sedge
Carex pendula	Hudson	Pendulous Sedge
Carex remota	L.	Remote Sedge

Centaurea scabiosa	L.	Greater Knapweed
Cerastium fontanum	Baumg.	Common Mouse-ear
Chaerophyllum temulentum	L.	Rough Chervil
Chamaenerion angustifolium	(L.)Scop	Rosebay Willowherb
Chenopodium album	L.	Fat-hen
Chenopodium polyspermum	L.	Many-seeded Goosefoot
Cirsium arvense	(L.)Scop.	Creeping Thistle
Cirsium palustre	(L.)Scop.	Marsh Thistle
Cirsium vulgare	(L.)Scop.	Spear Thistle
Clematis vitalba	L.	Traveller's-joy
Convolvulus arvensis	L.	Field Bindweed
Cornus sanguinea	L.	Dogwood
Coronopus squamatus	(Forskal)Acherson	Swine-cress
Corylus avellana	L.	Hazel
Crataegus monogyna	Jacq.	Hawthorn
Crepis capillaris	(L.)Wallr	Smooth Hawk's-beard
Cynosurus cristatus	(L.)Wallr.	Crested Dog's-tail
Dactylis glomerata	L.	Cock's-foot
Dactylorhiza fuchsii	(Druce)Soo	Common Spotted-orchid
Deschampsia cespitosa	(L.)Beauv	Tufted Hair-grass
Dipsacus fullonum	L.	Teazel
Elymus repens	(L.)Gould	Common Couch
Epilobium hirsutum	L.	Great Willowherb
Epilobium parviflorum	Schreb.	Small-flowered Willowherb
Equisetum arvense	L.	Field Horsetail
Equisetum telmateia	L.	Great Horse-tail
Erophila verna	(L.)Chevall	Whitlow-grass
Euonymus europaeus	L.	Spindle
Eupatorium cannabinum	L.	Hemp-agrimony
Euphorbia exigua	L.	Dwarf Spurge
Festuca arundinacea	Schreb.	Tall Fescue
Festuca gigantea	(L.)Vill.	Giant Fescue
Festuca rubra	L.	Red Fescue
Filipendula ulmaria	(L.)Maxim.	Meadowsweet
Fraxinus excelsior	L.	Ash
Galium aparine	L.	Cleavers
Galium mollugo	L.	Hedge-bedstraw
Geranium dissectum	L.	Cut-leaved Crane's-bill
Geranium pyrenaicum	Burm.fil.	Hedgerow Crane's-bill
Geranium robertianum	L.	Herb-Robert
Geum urbanum	L.	Wood Avens
Glechoma hederacea	L.	Ground-ivy
Glyceria fluitans	(L.)R.Br.	Sweet-grass
Glyceria plicata	Fries	Plicate Sweet-grass
Hedera helix	L.	Ivy
Heracleum sphondyllium	L.	Hogweed
Holcus lanatus	L.	Yorkshire-fog

Holcus mollis	L.	Creeping Soft-grass
Hordeum murinum	L.	Wall Barley
Hordeum secalinum	Schreb.	Meadow Barley
Humulus lupulus	L.	Hop
Hyacinthoides non-scriptus	(L.)Chouard ex Rothm.	Bluebell
Hypericum hirsutum	L.	Hairy St.John's-wort
Hypericum perforatum	L.	Perforate St.John's-wort
Hypericum tetrapterum	Fr.	Square-stalked St.John's-wort
Juncus articulatus	L.	Jointed Rush
Juncus conglomeratus	L.	Compact Rush
Juncus effusus	L.	Soft-rush
Juncus inflexus	L.	Hard Rush
Kickxia spuria	(L.)Dumort	Round-leaved Fluellen
Knautia arvensis	(L.)Coulter	Field Scabious
Lamium album	L.	White Dead-nettle
Lamium purpureum	L.	Red Dead-nettle
Lapsana communis	L.	Nipplewort
Lathyrus pratensis	L.	Meadow Vetchling
Leontodon autumnalis	L.	Autumn Hawkbit
Leucanthemum vulgare	Lam.	Oxeye Daisy
Ligustrum vulgare	L.	Wild Privet
Lolium perenne ssp. *perenne*	L.	Perennial Rye-grass
Lotus corniculatus	L.	Common Bird's-foot-trefoil
Lotus uliginosus	Schkuhr	Greater Bird's-foot-trefoil
Malus sylvestris	Miller	Crab Apple
Malva sylvestris	L.	Common Mallow
Matricaria matricariodes	(Less.)Porter	Pineappleweed
Medicago lupulina	L.	Black Medick
Mentha aquatica	L.	Water Mint
Mercurialis perennis	L.	Dog's Mercury
Myosotis arvensis	(L.)Hill	Field Forget-me-not
Papaver rhoeas	L.	Common Poppy
Phalaris arundinacea	L.	Reed Canary-grass
Phleum pratense	L. ssp. *bertolonii* (Bornm.)DC.	Small Timothy
Phleum pratense	L.	Timothy
Phragmites australis	(Cav.)Trin ex Steudel	Common Reed
Picris echioides	L.	Bristly Oxtongue
Plantago lanceolata	L.	Ribwort Plantain
Plantago major	L.	Greater Plantain
Poa annua	L.	Annual Meadow-grass
Poa pratensis	L.	Smooth Meadow-grass
Poa trivialis	L.	Rough Meadow-grass
Polygonum amphibium	L.	Amphibious Bistort
Polygonum aviculare agg.	L.	Knotgrass
Polygonum persicaria	L.	Redshank
Potentilla anserina	L.	Silverweed

Potentilla reptans	L.	Creeping Cinquefoil
Primula veris	L.	Cowslip
Prunella vulgaris	L.	Selfheal
Prunus avium	L.	Cherry
Prunus spinosa	L.	Blackthorn
Pulicaria dysenterica	(L.)Bernh.	Common Fleabane
Quercus robur agg.	L.	Penduncnulate Oak
Ranunculus acris	L.	Meadow Buttercup
Ranunculus auricomus	L.	Goldilocks
Ranunculus ficaria	L.	Lesser Celandine
Ranunculus repens	L.	Creeping Buttercup
Rhamnus catharticus	L.	Buckthorn
Ribes uva-crispa	L.	Gooseberry
Rosa arvensis	Hudson	Field-rose
Rosa canina	L.	Dog-rose
Rubus caesius	L.	Dewberry
Rubus fruticosus	L.	Bramble
Rumex acetosa	L.	Common Sorrel
Rumex conglomeratus	Murray	Clustered Dock
Rumex crispus	L.	Curled Dock
Rumex obtusifolius	L.	Broad-leaved Dock
Rumex sanguineus	L.	Blood-veined Dock
Sagina procumbens	L.	Procumbent Pearlwort
Salix alba	L.	White Willow
Salix caprea	L.	Goat Sallow
Salix cinerea	L. ssp. *oleifolia*	Great Sallow
Salix fragilis	L.	Crack Willow
Sambucus nigra	L.	Elder
Scrophularia auriculata	L.	Water Figwort
Senecio erucifolius	L.	Hoary Ragwort
Senecio jacobea	L.	Common Ragwort
Senecio squalidus	L.	Oxford Ragwort
Senecio vulgaris	L.	Groundsel
Silene dioica	(L.)Clariv.	Red Campion
Silene latifolia	Poiret ssp. *alba* (Miller)Greut.& Burd.	White Campion
Sinapis arvensis	L.	Charlock
Sison amomum	L.	Stone Parsley
Sisymbrium officinale	(L.)Scop	Hedge Mustard
Solanum dulcamara	L.	Bittersweet
Sonchus arvensis	L.	Perennial Sow-thistle
Sonchus asper	(L.)Hill	Prickly Sow-thistle
Sonchus oleraceus	L.	Smooth Sow-thistle
Stachys sylvatica	L.	Common Comfrey
Stellaria graminea	L.	Lesser Stitchwort
Stellaria holostea	L.	Greater Stitchwort
Stellaria media	(L.)Vill.	Common Chickweed
Tamus communis	L.	Black Bryony

Taraxacum officinale agg.	Wigg.	Common Dandelion
Torilis japonica	(Houtt.)DC.	Upright Hedge-parsley
Tragopogon pratensis	L.	Goat's-beard
Trifolium pratense	L.	Red Clover
Trifolium repens	L.	White Clover
Tripleurospermum inodorum	Schultz Bip.	Scentless Mayweed
Trisetum flavescens	(L.)Beauv.	Yellow Oat-grass
Tussilago farfara	L.	Colt's-foot
Ulmus minor	Mill.	Smooth Elm
Urtica dioica	L.	Common Nettle
Veronica anagallis-aquatica	L.	Blue Water-speedwell
Veronica arvensis	L.	Wall Speedwell
Veronica beccabunga	L.	Brooklime
Veronica chamaedrys	L.	Germander Speedwell
Veronica hederifolia	L.	Ivy-leaved Speedwell
Veronica persica	Poiret	Common Field-speedwell
Veronica polita	Fr.	Blue Field Speedwell
Viburnum lantana	L.	Wayfaring Tree
Viburnum opulus	L.	Guelder Rose
Vicia cracca	L.	Tufted Vetch
Viola odorata	L.	Sweet Violet
Viola riviniana	Rchb.	Dog Violet

A1.2 SPECIES RECORDED ON THE OLD ZONE OF THE FIELD MARGINS

Acer campestre	L.	Field Maple
Achillea millefolium	L.	Yarrow
Aethusa cynapium	L.	Fool's Parsley
Agrimonia eupatoria	L.	Agrimony
Agrostis stolonifera	L.	Creeping Bent
Alliaria petiolata	L.	Garlic Mustard
Allium vineale	L.	Wild Onion
Alopecurus geniculatus	L.	Marsh Foxtail
Alopecurus myosuroides	Hudson	Black-grass
Alopecurus pratensis	(Bieb)Cavara & Grande	Meadow Foxtail
Anagallis arvensis	L.	Scarlet Pimpernel
Angelica sylvestris	L.	Wild Angelica
Anthriscus sylvestris	(L.)Hoffm.	Cow Parsley
Apium nodiflorum	(L.)Lag.	Fool's Water-cress
Arctium lappa	L.	Greater Burdock
Arctium minus	(Hill) Bernh	Lesser Burdock
Armoracia rusticana	P.Gaertner, B.Meyer & Scherb	Horse-radish
Arrhenatherum elatius	(L.)Beauv.	False Oat-grass
Arum maculatum	L.	Lords-and-Ladies
Avena fatua	L.	Wild Oat
Avena sterilis	L. ssp. *ludoviciana*	Winter Wild Oat
Avenula pubescens	Dumort	Downy Oat-grass
Ballota nigra	L.	Black Horehound
Bellis perennis	L.	Daisy
Brachypodium sylvaticum	(Hudson)Beauv.	False Brome
Bromus erectus	Hudson	Upright Brome
Bromus hordeaceus	L.	Soft-brome
Bromus sterilis	L.	Barren Brome
Bryonia cretica	L. ssp. *dioica*	White Bryony
Calystegia sepium	(L.)R.Br.	Hedge Bindweed
Cardamine hirsuta	L.	Hairy Bittercress
Carduus acanthoides	L.	Welted Thistle
Carex hirta	L.	Hairy Sedge
Centaurea nigra	L.	Common Knapweed
Centaurea scabiosa	L.	Greater Knapweed
Centaurium erythraea	Rafn.	Common Centaury
Cerastium fontanum	Baumg.	Common Mouse-ear
Chaerophyllum temulentum	L.	Rough Chervil
Chenopodium album	L.	Fat-hen
Chenopodium polyspermum	L.	Many-seeded Goosefoot
Cirsium arvense	(L.)Scop.	Creeping Thistle
Cirsium eriophorum	(L.)Scop.	Woolly Thistle
Cirsium vulgare	(L.)Scop.	Spear Thistle

Clematis vitalba	L.	Traveller's-joy
Clinopodium vulgare	L.	Wild Basil
Convolvulus arvensis	L.	Field Bindweed
Cornus sanguinea	L.	Dogwood
Coronopus squamatus	(Forskal)Acherson	Swine-cress
Crataegus monogyna	Jacq.	Hawthorn
Crepis capillaris	(L.)Wallr	Smooth Hawk's-beard
Crepis vesicaria	L.	Beaked Hawk's-beard
Cynosurus cristatus	(L.)Wallr.	Crested Dog's-tail
Dactylis glomerata	L.	Cock's-foot
Daucus carota	L.	Wild carrot
Deschampsia cespitosa	(L.)Beauv	Tufted Hair-grass
Dipsacus fullonum	L.	Teazel
Elymus repens	(L.)Gould	Common Couch
Epilobium hirsutum	L.	Great Willowherb
Equisetum arvense	L.	Field Horsetail
Eupatorium cannabinum	L.	Hemp-agrimony
Euphorbia exigua	L.	Dwarf Spurge
Euphorbia helioscopa	L.	Sun Spurge
Fallopia convolvulus	(L.)A Love	Black Bindweed
Festuca arundinacea	Schreb.	Tall Fescue
Festuca gigantea	(L.)Vill.	Giant Fescue
Festuca pratensis	Hudson.	Meadow Fescue
Festuca rubra	L.	Red Fescue
Filipendula ulmaria	(L.)Maxim.	Meadowsweet
Fraxinus excelsior	L.	Ash
Fumaria officinale	L.	Common Fumitory
Galium aparine	L.	Cleavers
Galium mollugo	L.	Hedge-bedstraw
Galium verum	L.	Lady's Bedstraw
Geranium dissectum	L.	Dove's-foot Crane's-bill
Geranium robertianum	L.	Herb-Robert
Geum urbanum	L.	Wood Avens
Glechoma hederacea	L.	Ground-ivy
Hedera helix	L.	Ivy
Heracleum sphondyllium	L.	Hogweed
Holcus lanatus	L.	Yorkshire-fog
Holcus mollis	L.	Creeping Soft-grass
Hordeum murinum	L.	Wall Barley
Hordeum secalinum	Schreb.	Meadow Barley
Hordeum vulgare	L.	Barley
Hyacinthoides non-scriptus	(L.)Chouard ex Rothm.	Bluebell
Hypericum hirsutum	L.	Hairy St.John's-wort
Hypericum perforatum	L.	Perforate St.John's-wort
Knautia arvensis	(L.)Coulter	Field Scabious
Lactuca serriola	L.	Prickly Lettuce
Lamium album	L.	White Dead-nettle

Lamium amplexicaule	L.	Henbit Dead-nettle
Lamium purpureum	L.	Red Dead-nettle
Lapsana communis	L.	Nipplewort
Lathyrus pratensis	L.	Meadow Vetchling
Leontodon hispidus	L.	Rough Hawkbit
Leucanthemum vulgare	Lam.	Oxeye Daisy
Ligustrum vulgare	L.	Wild Privet
Lithospermum arvense	L.	Field Gromwell
Lolium perenne ssp. *perenne*	L.	Perennial Rye-grass
Lotus corniculatus	L.	Common Bird's-foot-trefoil
Matricaria matricariodes	(Less.)Porter	Pineappleweed
Malva sylvestris	L.	Common Mallow
Medicago lupulina	L.	Black Medick
Mercurialis perennis	L.	Dog's Mercury
Myosotis arvensis	(L.)Hill	Field Forget-me-not
Odontites verna	(Bellardi)Dumort	Red Bartsia
Papaver rhoeas	L.	Common Poppy
Phalaris arundinacea	L.	Reed Canary-grass
Phleum pratense	L. ssp. *bertolonii* (Bornm.)DC.	Small Timothy
Phleum pratense	L.	Timothy
Phragmites australis	(Cav.)Trin ex Steudel	Common Reed
Picris echioides	L.	Bristly Oxtongue
Plantago lanceolata	L.	Ribwort Plantain
Plantago major	L.	Greater Plantain
Poa annua	L.	Annual Meadow-grass
Poa pratensis	L.	Smooth Meadow-grass
Poa trivialis	L.	Rough Meadow-grass
Polygonum amphibium	L.	Amphibious Bistort
Polygonum aviculare agg.	L.	Knotgrass
Potentilla reptans	L.	Creeping Cinquefoil
Primula veris	L.	Cowslip
Prunella vulgaris	L.	Selfheal
Prunus spinosa	L.	Blackthorn
Quercus robur agg.	L.	Pendunculate Oak
Ranunculus acris	L.	Meadow Buttercup
Ranunculus bulbosus	L.	Bulbous Buttercup
Ranunculus ficaria	L.	Lesser Celandine
Ranunculus repens	L.	Creeping Buttercup
Rosa canina	L.	Dog-rose
Rubus caesius	L.	Dewberry
Rumex acetosa	L.	Common Sorrel
Rumex conglomeratus	Murray	Clustered Dock
Rumex crispus	L.	Curled Dock
Rubus fruticosus	L.	Bramble
Rumex obtusifolius	L.	Broad-leaved Dock
Rumex sanguineus	L.	Blood-veined Dock
Sambucus nigra	L.	Elder

Scrophularia auriculata	L.	Water Figwort
Senecio jacobea	L.	Common Ragwort
Senecio vulgaris	L.	Groundsel
Silene dioica	(L.)Clariv.	Red Campion
Silene latifolia	Poiret ssp. *alba* (Miller)Greut.& Burd.	White Campion
Silene vulgaris	(Moench)Garcke	Bladder Campion
Sinapis arvensis	L.	Charlock
Sison amomum	L.	Stone Parsley
Sisymbrium officinale	(L.)Scop	Hedge Mustard
Solanum dulcamara	L.	Bittersweet
Solanum tuberosum	L.	Potato
Sonchus arvensis	L.	Perennial Sow-thistle
Sonchus asper	(L.)Hill	Prickly Sow-thistle
Sonchus oleraceus	L.	Smooth Sow-thistle
Stachys sylvatica	L.	Hedge Woundwort
Stellaria holostea	L.	Greater Stitchwort
Stellaria media	(L.)Vill.	Common Chickweed
Tamus communis	L.	Black Bryony
Taraxacum officinale agg.	Wigg.	Common Dandelion
Torilis japonica	(Houtt.)DC.	Upright Hedge-parsley
Tragopogon pratensis	L.	Goat's-beard
Trifolium pratense	L.	Red Clover
Trifolium repens	L.	White Clover
Tripleurospermum inodorum	Schultz Bip.	Scentless Mayweed
Trisetum flavescens	(L.)Beauv.	Yellow Oat-grass
Triticum aestivum	L.	Wheat
Tussilago farfara	L.	Colt's-foot
Ulmus minor	Mill.	Smooth Elm
Ulmus procera	Salisb.	English Elm
Urtica dioica	L.	Common Nettle
Veronica arvensis	L.	Wall Speedwell
Veronica chamaedrys	L.	Germander Speedwell
Veronica hederifolia	L.	Ivy-leaved Speedwell
Veronica persica	Poiret	Common Field-speedwell
Veronica polita	Fr.	Blue Field Speedwell
Vicia faba	L.	Field Bean
Vicia sativa (ssp. *nigra*)	L.	Common Vetch
Viola hirta	L.	Hairy violet
Viola odorata	L.	Sweet Violet
Viola riviniana	Rchb.	Dog Violet

A1.3 SPECIES RECORDED ON THE NEW ZONE OF THE FIELD MARGINS

Acer campestre	L.	Field Maple
Acer pseudoplatanus	L.	Sycamore
Achillea millefolium	L.	Yarrow
Aethusa cynapium	L.	Fool's Parsley
Agrimonia eupatoria	L.	Agrimony
Agrostis stolonifera	L.	Creeping Bent
Alliaria petiolata	L.	Garlic Mustard
Allium vineale	L.	Wild Onion
Alopecurus geniculatus	L.	Marsh Foxtail
Alopecurus myosuroides	Hudson	Black-grass
Alopecurus pratensis	(Bieb)Cavara & Grande	Meadow Foxtail
Anagallis arvensis	L.	Scarlet Pimpernel
Angelica sylvestris	L.	Wild Angelica
Anthriscus sylvestris	(L.)Hoffm.	Cow Parsley
Apium nodiflorum	(L.)Lag.	Fool's Water-cress
Arctium lappa	L.	Greater Burdock
Arctium minus	(Hill) Bernh	Lesser Burdock
Arenaria serpyllifolia	L.	Thyme-leaved Sandwort
Arrhenatherum elatius	(L.)Beauv.	False Oat-grass
Artemesia vulgaris	L.	Mugwort
Arum maculatum	L.	Lords-and-Ladies
Atriplex patula	L.	Common Orache
Atriplex prostrata	Boucher ex.DC.	Spear-leaved Orache
Avena fatua	L.	Wild Oat
Avena sterilis	L. ssp. *ludoviciana*	Winter Wild-oat
Ballota nigra	L.	Black Horehound
Barbarea vulgaris	R. Br.	Wintercress
Bellis perennis	L.	Daisy
Brachypodium sylvaticum	(Hudson)Beauv.	False Brome
Brassica napus	L.	Oilseed Rape
Brassica nigra	(L.)Koch	Black Mustard
Bromus commutatus	Schrader	Meadow Brome
Bromus erectus	Hudson	Upright Brome
Bromus hordeaceus	L.	Soft-brome
Bromus sterilis	L.	Barren Brome
Bryonia cretica	L. ssp. *dioica*	White Bryony
Calystegia sepium	(L.)R.Br.	Hedge Bindweed
Capsella bursa-pastoris	Medic	Shepherd's Purse
Cardamine hirsuta	L.	Hairy Bittercress
Carduus acanthoides	L.	Welted Thistle
Carex otrubae	Podp.	False Fox-sedge
Carex pendula	Hudson	Pendulous Sedge
Centaurea nigra	L.	Common Knapweed

Centaurea scabiosa	L.	Greater Knapweed
Cerastium fontanum	Baumg.	Common Mouse-ear
Chaerophyllum temulentum	L.	Rough Chervil
Chenopodium album	L.	Fat-hen
Chenopodium polyspermum	L.	Many-seeded Goosefoot
Chenopodium rubrum	L.	Red Goosefoot
Cirsium arvense	(L.)Scop.	Creeping Thistle
Cirsium eriophorum	(L.)Scop.	Woolly Thistle
Cirsium vulgare	(L.)Scop.	Spear Thistle
Clematis vitalba	L.	Traveller's-joy
Clinopodium vulgare	L.	Wild Basil
Convolvulus arvensis	L.	Field Bindweed
Cornus sanguinea	L.	Dogwood
Coronopus squamatus	(Forskal)Acherson	Swine-cress
Corylus avellana	L.	Hazel
Crataegus monogyna	Jacq.	Hawthorn
Crepis capillaris	(L.)Wallr	Smooth Hawk's-beard
Crepis vesicaria	L.	Beaked Hawk's-beard
Cynosurus cristatus	(L.)Wallr.	Crested Dog's-tail
Dactylis glomerata	L.	Cock's-foot
Deschampsia cespitosa	(L.)Beauv	Tufted Hair-grass
Dipsacus fullonum	L.	Teazel
Elymus repens	(L.)Gould	Common Couch
Epilobium ciliatum	Rafin.	American Willowherb
Epilobium hirsutum	L.	Great Willowherb
Epilobium montanum	L.	Broad-leaved Willowherb
Epilobium parviflorum	Schreb.	Small-flowered Willowherb
Epilobium tetragonum	L.	Square-stalked Willowherb
Equisetum arvense	L.	Field Horsetail
Eupatorium cannabinum	L.	Hemp-agrimony
Euphorbia exigua	L.	Dwarf Spurge
Euphorbia helioscopa	L.	Sun Spurge
Euphorbia peplus	L.	Petty Spurge
Fallopia convolvulus	(L.)A Love	Black Bindweed
Festuca gigantea	(L.)Vill.	Giant Fescue
Festuca rubra	L.	Red Fescue
Fraxinus excelsior	L.	Ash
Fumaria officinale	L.	Common Fumitory
Galium aparine	L.	Cleavers
Galium mollugo	L.	Hedge-bedstraw
Galium verum	L.	Lady's Bedstraw
Geranium dissectum	L.	Cut-leaved Crane's-bill
Geranium pusillum	L.	Small Crane's-bill
Geranium robertianum	L.	Herb-Robert
Geum urbanum	L.	Wood Avens
Glechoma hederacea	L.	Ground-ivy
Glyceria fluitans	(L.)R.Br.	Sweet-grass

Glyceria plicata	Fries	Plicate Sweet-grass
Gnaphalium uliginosum	L.	Marsh Cudweed
Hedera helix	L.	Ivy
Heracleum sphondyllium	L.	Hogweed
Holcus lanatus	L.	Yorkshire-fog
Holcus mollis	L.	Creeping Soft-grass
Hordeum murinum	L.	Wall Barley
Hordeum secalinum	Schreb.	Meadow Barley
Hordeum vulgare	L.	Barley
Hypericum hirsutum	L.	Hairy St.John's-wort
Hypericum perforatum	L.	Perforate St.John's-wort
Juncus bufonius	L.	Toad Rush
Juncus effusus	L.	Soft-rush
Juncus inflexus	L.	Hard Rush
Kickxia spuria	(L.)Dumort	Round-leaved Fluellen
Knautia arvensis	(L.)Coulter	Field Scabious
Lactuca serriola	L.	Prickly Lettuce
Lamium album	L.	White Dead-nettle
Lamium amplexicaule	L.	Henbit Dead-nettle
Lamium purpureum	L.	Red Dead-nettle
Lapsana communis	L.	Nipplewort
Lathyrus pratensis	L.	Meadow Vetchling
Legousia hybrida	(L.)Delarbre	Venus's-looking-glass
Leontodon autumnalis	L.	Autumn Hawkbit
Leontodon hispidus	L.	Rough Hawkbit
Leucanthemum vulgare	Lam.	Oxeye Daisy
Ligustrum vulgare	L.	Wild Privet
Lithospermum arvense	L.	Field Gromwell
Lotus corniculatus	L.	Common Bird's-foot-trefoil
Lolium perenne ssp. *perenne*	L.	Perennial Rye-grass
Malva sylvestris	L.	Common Mallow
Matricaria matricariodes	(Less.)Porter	Pineappleweed
Medicago lupulina	L.	Black Medick
Mentha arvensis	L.	Field Mint
Myosotis arvensis	(L.)Hill	Field Forget-me-not
Odontites verna	(Bellardi)Dumort	Red Bartsia
Papaver rhoeas	L.	Common Poppy
Phalaris arundinacea	L.	Reed Canary-grass
Phragmites australis	(Cav.)Trin ex Steudel	Common Reed
Phleum pratense	L. ssp. *bertolonii* (Bornm.)DC.	Small Timothy
Phleum pratense	L.	Timothy
Picris echioides	L.	Bristly Oxtongue
Plantago lanceolata	L.	Ribwort Plantain
Plantago major	L.	Greater Plantain
Poa annua	L.	Annual Meadow-grass
Poa pratensis	L.	Smooth Meadow-grass
Poa trivialis	L.	Rough Meadow-grass

Polygonum amphibium	L.	Amphibious Bistort
Polygonum aviculare agg.	L.	Knotgrass
Polygonum lapathifolium	L.	Pale Persicaria
Polygonum persicaria	L.	Redshank
Potentilla reptans	L.	Creeping Cinquefoil
Primula veris	L.	Cowslip
Prunella vulgaris	L.	Selfheal
Prunus spinosa	L.	Blackthorn
Quercus robur agg.	L.	Pendunculate Oak
Ranunculus acris	L.	Meadow Buttercup
Ranunculus bulbosus	L.	Bulbous Buttercup
Ranunculus ficaria	L.	Lesser Celandine
Ranunculus repens	L.	Creeping Buttercup
Reseda luteola	L.	Weld
Ribes uva-crispa	L.	Gooseberry
Rosa canina	L.	Dog-rose
Rubus caesius	L.	Dewberry
Rubus fruticosus	L.	Bramble
Rumex acetosa	L.	Common Sorrel
Rumex conglomeratus	Murray	Clustered Dock
Rumex crispus	L.	Curled Dock
Rumex obtusifolius	L.	Broad-leaved Dock
Rumex sanguineus	L.	Blood-veined Dock
Sambucus nigra	L.	Elder
Scrophularia auriculata	L.	Water Figwort
Scrophularia nodosa	L.	Figwort
Senecio erucifolius	L.	Hoary Ragwort
Senecio jacobea	L.	Common Ragwort
Senecio vulgaris	L.	Groundsel
Sinapis arvensis	L.	Charlock
Silene dioica	(L.)Clariv.	Red Campion
Silene latifolia	Poiret ssp. *alba* (Miller)Greut.& Burd.	White Campion
Silene vulgaris	(Moench)Garcke	Bladder Campion
Sisymbrium officinale	(L.)Scop	Hedge Mustard
Solanum dulcamara	L.	Bittersweet
Solanum nigrum	L.	Black Nightshade
Solanum tuberosum	L.	Potato
Sonchus arvensis	L.	Perennial Sow-thistle
Sonchus asper	(L.)Hill	Prickly Sow-thistle
Sonchus oleraceus	L.	Smooth Sow-thistle
Stachys sylvatica	L.	Hedge Woundwort
Stellaria holostea	L.	Greater Stitchwort
Stellaria media	(L.)Vill.	Common Chickweed
Tamus communis	L.	Black Bryony
Taraxacum officinale agg.	Wigg.	Common Dandelion
Thlaspi arvense	L.	Field Penny-cress
Torilis japonica	(Houtt.)DC.	Upright Hedge-parsley

Tragopogon pratensis	L.	Goat's-beard
Trifolium pratense	L.	Red Clover
Trifolium repens	L.	White Clover
Tripleurospermum inodorum	Schultz Bip.	Scentless Mayweed
Trisetum flavescens	(L.)Beauv.	Yellow Oat-grass
Triticum aestivum	L.	Wheat
Tussilago farfara	L.	Colt's-foot
Urtica dioica	L.	Common Nettle
Urtica urens	L.	Small Nettle
Veronica anagallis-aquatica	L.	Blue Water-speedwell
Veronica arvensis	L.	Wall Speedwell
Veronica beccabunga	L.	Brooklime
Veronica chamaedrys	L.	Germander Speedwell
Veronica hederifolia	L.	Ivy-leaved Speedwell
Veronica persica	Poiret	Common Field-speedwell
Veronica polita	Fr.	Blue Field Speedwell
Vicia faba	L.	Field Bean
Vicia sativa (ssp. *nigra*)	L.	Common Vetch
Viola arvensis	Murray	Field Pansy
Viola odorata	L.	Sweet Violet
Vulpia myuros	(L.)C.Gmelin	Rats-tail Fescue

A1.4 SPECIES RECORDED IN THE CROP ADJACENT TO THE EXPERIMENTAL FIELD MARGINS

Acer campestre	L.	Field Maple
Acer pseudoplatanus	L.	Sycamore
Aethusa cynapium	L.	Fool's Parsley
Agrostis stolonifera	L.	Creeping Bent
Alliaria petiolata	L.	Garlic Mustard
Alopecurus geniculatus	L.	Marsh Foxtail
Alopecurus myosuroides	Hudson	Black-grass
Alopecurus pratensis	(Bieb)Cavara & Grande	Meadow Foxtail
Anagallis arvensis	L.	Scarlet Pimpernel
Angelica sylvestris	L.	Wild Angelica
Anthriscus sylvestris	(L.)Hoffm.	Cow Parsley
Aphanes arvensis	L.	Parsley Piert
Apium nodiflorum	(L.)Lag.	Fool's Water-cress
Arctium lappa	L.	Greater Burdock
Arctium minus	(Hill) Bernh	Lesser Burdock
Arenaria serpyllifolia	L.	Thyme-leaved Sandwort
Arrhenatherum elatius	(L.)Beauv.	False Oat-grass
Arum maculatum	L.	Lords-and-Ladies
Atriplex patula	L.	Common Orache
Atriplex prostrata	Boucher ex.DC.	Spear-leaved Orache
Avena fatua	L.	Wild Oat
Avena sterilis	L. ssp. *ludoviciana*	Winter Wild-oat
Ballota nigra	L.	Black Horehound
Brassica napus	L.	Oilseed Rape
Brassica nigra	(L.)Koch	Black Mustard
Bromus hordeaceus	L.	Soft-brome
Bromus sterilis	L.	Barren Brome
Bryonia cretica	L. ssp. *dioica*	White Bryony
Calystegia sepium	(L.)R.Br.	Hedge Bindweed
Capsella bursa-pastoris	Medic	Shepherd's Purse
Cardamine hirsuta	L.	Hairy Bittercress
Carduus acanthoides	L.	Welted Thistle
Centaurea nigra	L.	Common Knapweed
Cerastium fontanum	Baumg.	Common Mouse-ear
Chaerophyllum temulentum	L.	Rough Chervil
Chenopodium album	L.	Fat-hen
Chenopodium polyspermum	L.	Many-seeded Goosefoot
Chenopodium rubrum	L.	Red Goosefoot
Cirsium arvense	(L.)Scop.	Creeping Thistle
Cirsium vulgare	(L.)Scop.	Spear Thistle
Clinopodium vulgare	L.	Wild Basil
Convolvulus arvensis	L.	Field Bindweed
Coronopus squamatus	(Forskal)Acherson	Swine-cress

Crataegus monogyna	Jacq.	Hawthorn
Crepis capillaris	(L.)Wallr	Smooth Hawk's-beard
Cynosurus cristatus	(L.)Wallr.	Crested Dog's-tail
Dactylis glomerata	L.	Cock's-foot
Dipsacus fullonum	L.	Teazel
Elymus repens	(L.)Gould	Common Couch
Epilobium hirsutum	L.	Great Willowherb
Equisetum arvense	L.	Field Horsetail
Erophila verna	(L.)Chevall	Whitlow-grass
Eupatorium cannabinum	L.	Hemp-agrimony
Euphorbia exigua	L.	Dwarf Spurge
Euphorbia helioscopa	L.	Sun Spurge
Fallopia convolvulus	(L.)A Love	Black Bindweed
Festuca rubra	L.	Red Fescue
Fraxinus excelsior	L.	Ash
Fumaria officinale	L.	Common Fumitory
Galium aparine	L.	Cleavers
Galium verum	L.	Lady's Bedstraw
Geranium dissectum	L.	Cut-leaved Crane's-bill
Geranium robertianum	L.	Herb-Robert
Glechoma hederacea	L.	Ground-ivy
Glyceria plicata	Fries	Plicate Sweet-grass
Gnaphalium uliginosum	L.	Marsh Cudweed
Hedera helix	L.	Ivy
Heracleum sphondyllium	L.	Hogweed
Holcus lanatus	L.	Yorkshire-fog
Holcus mollis	L.	Creeping Soft-grass
Hordeum distichon	L.	Two-rowed Barley
Hordeum murinum	L.	Wall Barley
Hordeum secalinum	Schreb.	Meadow Barley
Hordeum vulgare	L.	Barley
Hypericum perforatum	L.	Perforate St.John's-wort
Juncus bufonius	L.	Toad Rush
Kickxia spuria	(L.)Dumort	Round-leaved Fluellen
Knautia arvensis	(L.)Coulter	Field Scabious
Lactuca serriola	L.	Prickly Lettuce
Lamium album	L.	White Dead-nettle
Lamium amplexicaule	L.	Henbit Dead-nettle
Lamium purpureum	L.	Red Dead-nettle
Lapsana communis	L.	Nipplewort
Legousia hybrida	(L.)Delarbre	Venus's-looking-glass
Leucanthemum vulgare	Lam.	Oxeye Daisy
Lithospermum arvense	L.	Field Gromwell
Lolium perenne ssp. *perenne*	L.	Perennial Rye-grass
Matricaria matricariodes	(Less.)Porter	Pineappleweed
Malva sylvestris	L.	Common Mallow
Medicago lupulina	L.	Black Medick

Mentha arvensis	L.	Field Mint
Myosotis arvensis	(L.)Hill	Field Forget-me-not
Odontites verna	(Bellardi)Dumort	Red Bartsia
Papaver rhoeas	L.	Common Poppy
Phalaris arundinacea	L.	Reed Canary-grass
Phleum pratense	L. ssp. *bertolonii* (Bornm.)DC.	Small Timothy
Phleum pratense	L.	Timothy
Phragmites australis	(Cav.)Trin ex Steudel	Common Reed
Picris echioides	L.	Bristly Oxtongue
Plantago lanceolata	L.	Ribwort Plantain
Plantago major	L.	Greater Plantain
Poa annua	L.	Annual Meadow-grass
Poa pratensis	L.	Smooth Meadow-grass
Poa trivialis	L.	Rough Meadow-grass
Polygonum amphibium	L.	Amphibious Bistort
Polygonum aviculare agg.	L.	Knotgrass
Polygonum lapathifolium	L.	Pale Persicaria
Polygonum persicaria	L.	Redshank
Potentilla reptans	L.	Creeping Cinquefoil
Prunus spinosa	L.	Blackthorn
Quercus robur agg.	L.	Pendunculate Oak
Ranunculus bulbosus	L.	Bulbous Buttercup
Ranunculus repens	L.	Creeping Buttercup
Rosa canina	L.	Dog-rose
Rubus fruticosus	L.	Bramble
Rumex acetosa	L.	Common Sorrel
Rumex crispus	L.	Curled Dock
Rumex obtusifolius	L.	Broad-leaved Dock
Rumex sanguineus	L.	Blood-veined Dock
Sambucus nigra	L.	Elder
Scrophularia auriculata	L.	Water Figwort
Senecio erucifolius	L.	Hoary Ragwort
Senecio jacobea	L.	Common Ragwort
Senecio vulgaris	L.	Groundsel
Sherardia arvensis	L.	Field Madder
Silene latifolia	Poiret ssp. *alba* (Miller)Greut.& Burd.	White Campion
Sinapis arvensis	L.	Charlock
Sison amomum	L.	Stone Parsley
Sisymbrium officinale	(L.)Scop	Hedge Mustard
Solanum nigrum	L.	Black Nightshade
Solanum tuberosum	L.	Potato
Sonchus arvensis	L.	Perennial Sow-thistle
Sonchus asper	(L.)Hill	Prickly Sow-thistle
Sonchus oleraceus	L.	Smooth Sow-thistle
Stachys sylvatica	L.	Hedge Woundwort
Stellaria media	(L.)Vill.	Common Chickweed
Tamus communis	L.	Black Bryony

Taraxacum officinale agg.	Wigg.	Common Dandelion
Thlaspi arvense	L.	Field Penny-cress
Torilis japonica	(Houtt.)DC.	Upright Hedge-parsley
Trifolium repens	L.	White Clover
Tripleurospermum inodorum	Schultz Bip.	Scentless Mayweed
Trisetum flavescens	(L.)Beauv.	Yellow Oat-grass
Triticum aestivum	L.	Wheat
Tragopogon pratensis	L.	Goat's-beard
Tussilago farfara	L.	Colt's-foot
Urtica dioica	L.	Common Nettle
Urtica urens	L.	Small Nettle
Veronica anagallis-aquatica	L.	Blue Water-speedwell
Veronica arvensis	L.	Wall Speedwell
Veronica hederifolia	L.	Ivy-leaved Speedwell
Veronica persica	Poiret	Common Field Speedwell
Veronica polita	Fr.	Blue Field Speedwell
Vicia faba	L.	Field Bean
Vicia sativa (ssp. *nigra*)	L.	Common Vetch
Viola arvensis	Murray	Field Pansy

A1.5 SPECIES RECORDED IN THE SEED BANK

(i) The two metre margins

Aethusa cynapium	L.	Fool's Parsley
Alliaria petiolata	L.	Garlic Mustard
Alopecurus myosuroides	Hudson	Black-grass
Anagallis arvensis	L.	Scarlet Pimpernel
Anthriscus sylvestris	(L.)Hoffm.	Cow Parsley
Aphanes arvensis	L.	Parsley Piert
Apium nodosum	(L.)Lag.	Fool's Water-cress
Arenaria serpyllifolium	L.	Thyme-leaved Sandwort
Atriplex patula	L.	Common Orache
Avena fatua	L.	Wild Oat
Bromus sterilis	L.	Barren Brome
Capsella bursa-pastoris	Medic	Shepherd's Purse
Cardamine hirsuta	L.	Hairy Bittercress
Chenopodium album	L.	Fat-hen
Chenopodium polyspermum	L.	Many-seeded Goosefoot
Chenopodium rubrum	L.	Red Goosefoot
Cherophyllum temulentum	L.	Rough Chervil
Cirsium arvense	(L.)Scop.	Creeping Thistle
Cirsium vulgare	(L.)Scop.	Spear Thistle
Clematis vitalba	L.	Traveller's-joy
Coronopus squamatus	(Forskal)Acherson	Swine-cress
Crepis capillaris	(L.)Wallr	Smooth Hawk's-beard
Crepis vesicaria ssp. *haenseleri*	L.	Beaked Hawk's-beard
Cytisus scoparius	L. Link	Broom
Dactylis glomerata	L.	Cock's-foot
Dipsacus fullonum	L.	Teazel
Epilobium ciliatum	Rafin.	American Willowherb
Epilobium hirsutum	L.	Great Willowherb
Euphorbia exigua	L.	Dwarf Spurge
Euphorbia helioscopa	L.	Sun Spurge
Euphorbia peplus	L.	Petty Spurge
Fallopia convolvulus	(L.)A Love	Black Bindweed
Galium aparine	L.	Cleavers
Geranium dissectum	L.	Cut-leaved Crane's-bill
Glechoma hederacea	L.	Ground-ivy
Glyceria plicata	Fries	Plicate Sweet-grass
Gnapthalium uliginosum	L.	Marsh Cudweed
Holcus lanatus	L.	Yorkshire-fog
Hordeum vulgare	L.	Barley
Hypericum hirsutum	L.	Hairy St.John's-wort
Hypericum tetrapterum	Fr.	Square-stalked St.John's-wort

Juncus bufonius	L.	Toad Rush
Juncus effusus	L.	Soft-rush
Juncus inflexus	L.	Hard Rush
Lactuca serriola	L.	Prickly Lettuce
Lamium album	L.	White Dead-nettle
Lamium purpureum	L.	Red Dead-nettle
Lapsana communis	L.	Nipplewort
Legusia hybrida	(L.)Delarbre	Venus's-looking-glass
Lolium perenne	L.	Perennial Rye-grass
Matricaria matricariodes	(Less.)Porter	Pineappleweed
Myosotis arvensis	(L.)Hill	Field Forget-me-not
Papaver rhoeas	L.	Common Poppy
Plantago major	L.	Greater Plantain
Poa annua	L.	Annual Meadow-grass
Poa pratensis	L.	Smooth Meadow-grass
Poa trivialis	L.	Rough Meadow-grass
Polygonum aviculare	L.	Knotgrass
Polygonum lapathifolium	L.	Pale Persicaria
Polygonum persicaria	L.	Redshank
Potentilla reptans	L.	Creeping Cinquefoil
Quercus robur	L.	Pendunculate Oak
Rorippa nasturtium-aquaticum	(L.) Hayek	Water-cress
Rumex crispus	L.	Curled Dock
Rumex obtusifolius	L.	Broad-leaved Dock
Rumex sanguineus	L.	Blood-veined Dock
Sambucus nigra	L.	Elder
Scrophularia auriculata	L.	Water Figwort
Senecio vulgaris	L.	Groundsel
Sinapis arvensis	L.	Charlock
Sonchus asper	(L.)Hill	Prickly Sow-thistle
Sonchus oleraceus	L.	Smooth Sow-thistle
Stachys sylvatica	L.	Hedge Woundwort
Stellaria media	(L.)Vill.	Common Chickweed
Taraxacum officinale	Wigg.	Common Dandelion
Trifolium repens	L.	White Clover
Tripleurospermum inodorum	Schultz Bip.	Scentless Mayweed
Triticum aestivum	L.	Wheat
Urtica dioica	L.	Common Nettle
Veronica anagallis-aquatica	L.	Blue Water-speedwell
Veronica arvensis	L.	Wall Speedwell
Veronica beccabunga	L.	Brooklime
Veronica persica	Poiret	Common Field-speedwell
Viola arvensis	Murray	Field Pansy

(ii) Additional species recorded in fields adjacent to the two metre margins experiment

Achillea millefolium	L.	Yarrow
Agrostis stolonifera	L.	Creeping Bent
Carex flacca	Schreber	Glaucous Sedge
Chamaenerion angustifolium	(L.)Scop.	Rosebay Willowherb
Dryopteris felix-mas	(L.)Schott	Male Fern
Kickxia elatine	(L.)Dumort	Sharp-leaved Fluellen
Lamium album	L.	White Dead-nettle
Malva sylvestris	L.	Common Mallow
Picris echiodes	L.	Bristly Oxtongue
Polygonum amphibium	L.	Amphibious Bistort
Ranunculus repens	L.	Creeping Buttercup
Sisymbrium officinale	(L.)Scop	Hedge Mustard
Solanum nigrum	L.	Black Nightshade
Thlaspi arvense	L.	Field Penny-cress
Veronica hederifolia	L.	Ivy-leaved Speedwell
Veronica polita	Fr.	Blue Field Speedwell
Verbascum thapsus	L.	Great Mullein

APPENDIX 2 THE NUMBERS OF INVERTEBRATES CAUGHT ON THE EXPERIMENTAL FIELD MARGINS

The mean numbers per treatment of total invertebrates (see Chapter 8.2.2) and of spiders, Auchenorrhynca, Heteroptera and Aphids, caught in each $0.5m^2$ sample collected from both the old and new zones of the field margins, are tabulated by date and treatment in tables A2.1 to A2.16.

Table A2.1 Mean number of invertebrates per sample unit (0.5 m^2) on the old margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	147.2	308.3	722.8	253.3	168.7	256.5	196.7	292.7	299.2	242.0	478.8
U/NC	120.4	272.8	319.7	203.3	159.3	225.0	220.5	331.8	289.2	292.2	484.5
S/SpSu	332.6	252.0	125.2	79.5	109.3	129.7	84.3	198.5	177.0	129.8	408.5
U/SpSu	203.4	231.5	98.7	71.2	132.5	127.3	100.8	134.2	174.2	121.2	367.0
U/SpSu/L	159.0	188.2	127.2	110.8	100.8	175.7	110.0	191.0	234.7	200.8	419.7
S/Su	151.0	246.5	-	-	95.8	196.3	115.2	109.5	241.8	120.3	291.2
U/Su	159.6	200.2	-	-	74.5	174.6	95.5	149.3	160.8	88.7	353.8
S/SpAu	179.4	235.2	-	-	139.7	111.8	149.3	196.5	162.3	231.5	394.7
U/SpAu	343.2	201.5	-	-	126.0	139.5	161.8	287.7	170.0	196.8	523.3
U/Spray	161.2	241.0	-	-	161.8	224.0	194.0	137.7	185.3	194.5	310.7

Table A2.2 Mean number of invertebrates per sample unit ($0.5m^2$) on the new margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	-	246.0	420.8	251.5	210.3	251.0	289.7	348.5	259.0	321.8	430.3
U/NC	-	153.3	124.5	184.7	125.8	194.2	190.3	222.3	199.7	244.8	329.7
S/SpSu	-	152.3	111.5	82.5	65.8	143.7	101.5	180.8	137.7	142.3	318.2
U/SpSu	-	201.5	94.7	74.3	75.2	107.7	109.7	221.8	109.5	144.7	361.7
U/SpSu/L	-	128.0	130.0	54.8	64.7	152.0	117.8	190.0	204.3	169.3	307.8
S/Su	-	249.3	-	-	78.2	169.0	129.3	194.5	214.8	150.5	351.7
U/Su	-	208.7	-	-	74.0	120.7	69.8	179.5	162.5	127.2	356.8
S/SpAu	-	199.0	-	-	135.2	125.2	197.8	209.0	136.2	234.7	427.0
U/SpAu	-	179.5	-	-	70.3	110.0	162.2	209.5	124.5	207.5	345.7
U/Spray	-	249.5	-	-	103.8	199.6	140.8	144.5	214.3	212.0	292.7

Table A2.3 Mean number of spiders per sample unit ($0.5m^2$) on the old margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	70.8	100.2	106.5	75.7	80.5	40.7	36.5	77.5	51.2	19.3	185.8
U/NC	31.4	74.7	67.0	68.5	71.7	36.5	41.7	95.7	53.7	22.5	192.0
S/SpSu	114.4	69.7	30.3	24.2	48.2	19.7	12.2	23.8	19.0	8.3	76.2
U/SpSu	87.8	48.3	20.0	21.7	56.7	20.5	12.7	22.5	23.3	6.5	99.2
U/SpSu/L	64.8	56.2	18.0	26.7	48.7	28.2	19.6	24.5	28.7	9.8	138.7
S/Su	51.8	44.3	-	-	34.8	23.7	14.8	18.2	35.5	10.2	96.2
U/Su	50.2	42.7	-	-	30.7	24.4	13.0	26.7	28.7	7.0	98.2
S/SpAu	59.2	67.0	-	-	73.5	10.2	28.5	55.5	20.2	26.3	157.0
U/SpAu	107.6	47.8	-	-	75.3	18.8	27.0	61.7	25.2	13.2	187.0
U/Spray	73.4	70.8	-	-	104.5	57.0	30.2	30.5	34.0	15.2	141.2

Table A2.4 Mean number of species of spider per sample unit ($0.5m^2$) on the old margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	6.6	9.5	7.7	7.8	7.7	6.8	7.3	10.2	9.7	6.3	12.3
U/NC	4.4	8.5	9.6	7.5	6.0	6.8	8.7	9.7	9.0	7.8	12.2
S/SpSu	7.2	9.8	5.2	6.5	5.0	4.8	4.7	5.7	5.2	3.8	10.0
U/SpSu	6.0	7.3	4.2	5.8	7.5	4.7	5.0	6.0	4.3	2.8	9.7
U/SpSu/L	7.0	8.7	3.5	6.5	6.7	5.0	6.0	7.3	5.2	4.0	10.5
S/Su	6.6	6.5	-	-	4.8	3.5	5.6	6.2	6.2	3.5	9.3
U/Su	5.6	7.5	-	-	5.7	5.6	4.2	4.8	4.2	2.7	10.2
S/SpAu	7.4	9.0	-	-	7.2	2.0	6.5	7.3	4.7	5.7	12.2
U/SpAu	9.8	5.5	-	-	8.0	4.2	6.6	8.5	4.8	4.0	11.8
U/Spray	6.0	8.0	-	-	7.2	6.4	6.8	7.0	5.3	6.3	10.5

Table A2.5 Mean number of spiders per sample unit (0.5m^2) on the new margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	-	70.2	49.7	111.0	103.3	43.8	69.2	85.2	47.2	35.8	175.3
U/NC	-	45.0	22.0	66.7	59.7	29.8	41.7	64.7	37.3	20.0	143.8
S/SpSu	-	41.5	9.2	21.8	21.3	13.7	8.5	24.7	8.3	8.3	99.7
U/SpSu	-	40.2	6.3	17.7	24.5	8.7	12.2	15.0	6.8	7.7	112.3
U/SpSu/L	-	23.5	7.2	18.0	24.2	11.8	21.5	23.0	11.8	12.2	106.2
S/Su	-	48.8	-	-	19.2	25.3	11.8	36.5	21.8	14.3	104.5
U/Su	-	45.3	-	-	27.7	15.3	6.7	32.3	17.3	5.7	98.2
S/SpAu	-	42.0	-	-	69.3	13.2	51.8	42.5	10.5	30.7	173.2
U/SpAu	-	41.8	-	-	40.0	5.3	32.2	38.5	9.5	15.3	141.0
U/Spray	-	42.0	-	-	51.7	21.6	31.7	46.2	26.5	14.5	133.5

Table A2.6 Mean number of species of spider per sample unit ($0.5m^2$) on the new margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	-	9.0	6.7	10.2	8.5	5.5	10.2	10.4	7.0	6.7	12.2
U/NC	-	7.5	4.8	9.3	6.8	5.3	7.3	7.5	5.7	6.8	10.7
S/SpSu	-	6.3	3.2	5.0	5.0	3.2	3.8	5.0	3.5	3.3	8.2
U/SpSu	-	6.5	2.0	4.7	4.7	2.8	4.8	3.8	2.8	3.0	7.7
U/SpSu/L	-	4.5	2.6	4.0	4.7	3.5	5.0	6.2	4.3	4.0	9.3
S/Su	-	7.2	-	-	3.7	5.0	3.8	5.0	5.2	3.8	8.3
U/Su	-	7.8	-	-	4.7	4.2	3.2	5.5	4.0	2.3	9.7
S/SpAu	-	6.3	-	-	6.8	3.7	7.3	7.0	3.7	6.5	12.2
U/SpAu	-	6.5	-	-	6.8	2.0	6.6	6.0	3.7	4.7	9.7
U/Spray	-	8.3	-	-	5.3	3.8	7.5	6.2	6.6	5.0	8.8

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Table A2.7 Mean number of Auchenorrhyncha per sample unit (0.5m^2) on the old margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	22.8	31.2	47.5	48.2	18.3	90.0	54.5	63.7	26.5	60.8	102.2
U/NC	48.2	23.5	23.0	36.3	16.8	37.2	54.5	77.5	22.0	56.8	93.8
S/SpSu	134.2	16.3	16.5	16.7	9.3	18.7	23.8	77.3	13.3	41.0	129.0
U/SpSu	55.6	19.2	6.7	14.8	13.3	20.5	34.8	29.8	12.8	33.8	73.0
U/SpSu/L	21.5	21.2	10.0	21.2	6.8	26.2	24.6	52.8	14.5	33.3	82.2
S/Su	42.4	14.0	-	-	14.2	26.3	32.3	34.0	21.7	21.7	75.0
U/Su	51.4	18.5	-	-	4.3	22.0	24.2	45.7	12.0	19.8	101.8
S/SpAu	65.8	28.2	-	-	12.8	30.4	31.0	64.7	15.7	48.8	73.2
U/SpAu	68.4	7.8	-	-	10.5	25.3	35.5	89.2	17.5	47.2	66.7
U/Spray	29.8	18.4	-	-	8.2	48.8	46.3	40.2	25.8	27.5	51.3

Table A2.8 Mean number of species of Auchenorrhyncha per sample unit (0.5m^2) on the old margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	4.4	4.3	2.0	5.3	4.0	4.3	6.5	6.7	3.2	4.5	7.0
U/NC	3.8	5.8	2.0	4.3	3.3	3.7	6.3	5.8	3.0	5.3	8.0
S/SpSu	3.4	5.4	1.7	4.2	2.0	3.2	4.2	5.2	2.5	5.2	6.5
U/SpSu	3.0	4.7	1.5	4.8	3.2	2.2	5.2	4.5	2.2	3.7	8.3
U/SpSu/L	3.3	5.0	1.5	5.0	2.5	3.5	3.8	5.7	1.7	4.0	8.2
S/Su	3.6	3.8	-	-	2.2	3.3	5.5	5.0	3.5	4.5	6.7
U/Su	2.6	5.5	-	-	2.2	4.8	5.0	5.0	2.8	3.5	6.7
S/SpAu	3.2	4.5	-	-	3.0	2.8	4.5	5.0	3.0	5.3	7.0
U/SpAu	3.2	3.0	-	-	2.3	2.8	6.3	4.0	2.3	4.3	8.2
U/Spray	2.2	4.0	-	-	2.5	3.5	6.3	4.8	2.3	4.3	7.0

Table A2.9 Mean number of Auchenorrhyncha per sample unit ($0.5m^2$) on the new margin

	Sample Round									
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	-	8.7	55.2	34.5	21.3	74.8	86.0	101.5	45.5	65.2	91.5
U/NC	-	5.2	11.3	37.3	18.7	34.2	43.7	56.3	22.2	38.2	65.5
S/SpSu	-	12.3	12.7	15.5	16.5	29.0	32.3	84.7	11.8	38.5	85.0
U/SpSu	-	11.8	3.7	18.0	9.3	17.7	25.3	102.7	10.3	32.8	77.5
U/SpSu/L	-	8.8	4.6	10.3	10.8	21.7	25.5	76.2	10.5	32.2	67.7
S/Su	-	9.8	-	-	19.5	36.3	43.8	92.5	18.7	24.3	101.3
U/Su	-	14.7	-	-	10.3	21.5	15.3	67.8	12.7	27.7	96.7
S/SpAu	-	6.2	-	-	14.8	22.3	43.7	84.8	24.8	41.8	81.3
U/SpAu	-	5.5	-	-	5.3	21.2	24.4	74.3	10.0	41.7	69.0
U/Spray	-	10.3	-	-	18.2	37.8	34.0	20.5	27.7	19.8	48.0

Table A2.10 Mean number of species of Auchenorrhyncha per sample unit ($0.5m^2$) on the new margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	-	4.7	2.0	5.5	4.3	5.0	7.4	6.2	4.2	5.7	6.8
U/NC	-	3.0	1.5	4.0	4.2	4.3	5.7	5.8	3.2	4.5	8.0
S/SpSu	-	3.7	1.7	3.2	2.2	3.3	5.0	4.5	2.0	4.0	6.2
U/SpSu	-	3.3	1.3	3.7	3.8	3.0	4.2	4.8	1.7	5.2	8.8
U/SpSu/L	-	3.0	1.4	2.7	2.5	3.3	5.3	5.7	1.5	5.0	8.0
S/Su	-	4.0	-	-	2.8	3.3	4.8	4.2	2.8	3.8	5.5
U/Su	-	3.2	-	-	2.8	3.7	3.8	4.5	2.3	5.2	8.0
S/SpAu	-	3.0	-	-	3.7	3.0	5.3	4.8	2.0	5.3	6.8
U/SpAu	-	2.7	-	-	3.2	3.8	5.2	5.3	1.7	4.5	6.7
U/Spray	-	2.8	-	-	3.0	4.0	5.2	4.2	3.7	4.5	5.8

Table A2.11 Mean number of Heteroptera per sample unit ($0.5m^2$) on the old margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	1.8	7.8	8.2	10.2	3.5	24.5	20.3	6.5	13.7	20.2	11.7
U/NC	2.0	9.0	12.0	11.2	2.7	30.8	23.7	11.7	11.8	46.8	7.8
S/SpSu	1.0	6.3	1.0	2.2	3.2	7.3	3.5	1.0	3.7	4.7	20.2
U/SpSu	1.0	7.0	0.7	2.8	3.8	11.3	7.7	3.3	9.0	5.0	8.2
U/SpSu/L	1.0	6.3	1.2	3.3	1.7	10.0	7.2	4.2	7.8	11.4	8.2
S/Su	1.2	6.3	-	-	1.3	34.3	7.5	1.5	2.8	5.2	12.3
U/Su	1.4	8.3	-	-	1.7	17.0	5.0	6.2	3.8	3.8	13.7
S/SpAu	2.6	8.8	-	-	1.8	25.6	13.8	4.0	8.5	24.0	7.5
U/SpAu	2.8	4.8	-	-	2.0	22.5	9.2	5.5	9.0	12.5	9.8
U/Spray	0.8	4.6	-	-	1.7	25.2	27.5	1.7	7.5	32.0	9.0

Table A2.12 Mean number of species of Heteroptera per sample unit (0.5m^2) on the old margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	1.2	2.8	1.5	4.0	2.0	3.7	6.0	3.0	3.5	3.7	4.8
U/NC	0.6	4.5	1.8	4.0	2.3	4.2	4.0	4.5	3.7	6.0	4.0
S/SpSu	1.2	2.8	0.8	1.8	1.7	3.2	1.0	0.8	2.2	1.3	3.8
U/SpSu	0.6	3.3	0.7	1.8	2.3	2.8	2.7	1.5	3.3	1.3	3.8
U/SpSu/L	0.8	2.5	0.8	2.3	1.5	3.2	2.4	2.2	2.8	2.8	3.2
S/Su	1.0	2.5	-	-	1.0	2.5	2.2	1.0	1.8	1.8	3.8
U/Su	1.0	3.3	-	-	1.2	3.2	2.0	3.0	2.0	1.7	3.5
S/SpAu	1.4	2.7	-	-	1.3	2.6	4.8	2.4	3.7	5.8	3.7
U/SpAu	1.4	2.4	-	-	1.7	3.2	3.8	2.2	2.0	4.5	4.2
U/Spray	0.6	2.6	-	-	1.2	4.2	6.5	1.0	3.2	3.5	4.5

Table A2.13 Mean number of Heteroptera per sample unit ($0.5m^2$) on the new margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	-	12.5	9.2	16.0	3.0	43.7	16.7	4.7	13.3	23.5	10.3
U/NC	-	9.2	4.8	8.7	2.0	44.7	19.8	6.0	13.5	36.3	9.7
S/SpSu	-	5.8	1.0	1.7	0.3	11.7	1.5	2.8	3.7	4.8	9.7
U/SpSu	-	6.5	0.8	2.8	2.7	14.7	5.5	3.3	3.7	5.2	17.0
U/SpSu/L	-	7.0	1.2	2.3	0.5	15.0	4.7	3.0	5.7	5.3	17.5
S/Su	-	11.5	-	-	2.3	16.2	5.2	1.3	5.0	8.7	11.5
U/Su	-	8.5	-	-	1.8	10.8	2.8	4.0	3.5	5.3	13.0
S/SpAu	-	8.7	-	-	3.2	37.0	10.7	4.3	15.7	15.8	7.5
U/SpAu	-	6.2	-	-	1.5	25.0	13.8	4.2	7.3	22.3	7.8
U/Spray	-	14.3	-	-	2.2	50.0	10.8	3.3	11.3	37.0	10.5

Table A2.14 Mean number of species of Heteroptera per sample unit ($0.5m^2$) on the new margin

	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	-	3.0	2.0	5.0	2.2	3.5	4.0	2.2	2.8	4.8	5.2
U/NC	-	3.2	2.0	3.3	1.2	4.8	5.5	3.3	2.3	4.8	4.5
S/SpSu	-	1.8	1.0	1.3	0.3	3.2	1.2	1.8	1.7	1.2	3.2
U/SpSu	-	2.7	0.7	1.7	1.5	2.2	2.7	2.0	1.7	1.8	5.8
U/SpSu/L	-	3.0	1.0	1.8	0.3	3.2	2.0	2.0	2.5	2.2	4.8
S/Su	-	2.3	-	-	1.3	2.5	1.3	1.0	2.3	2.3	3.5
U/Su	-	3.3	-	-	1.2	3.2	1.3	1.5	2.0	1.8	5.8
S/SpAu	-	2.5	-	-	1.5	3.8	3.3	2.3	2.0	5.2	4.7
U/SpAu	-	2.7	-	-	1.3	2.8	4.6	2.0	2.8	4.5	3.2
U/Spray	-	3.7	-	-	1.3	4.2	2.7	1.5	3.3	3.8	3.3

Table A2.15 Mean number of aphids per sample unit ($0.5m^2$) on the old margin

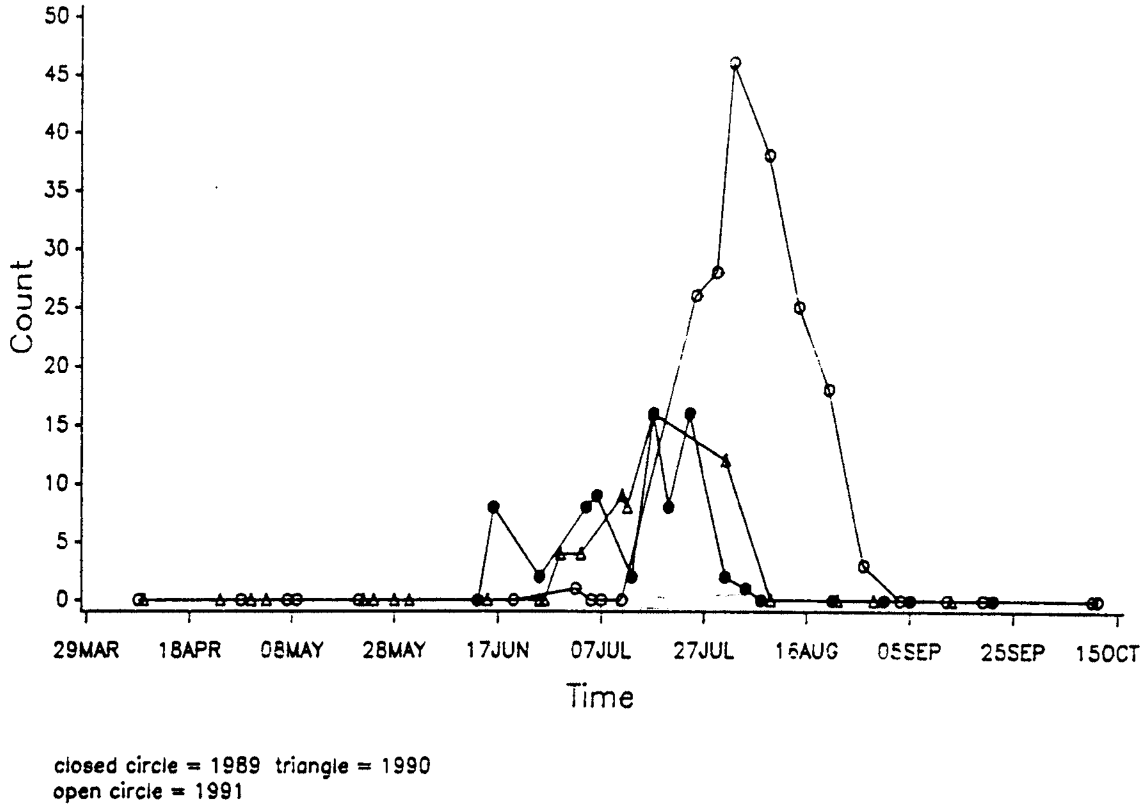
	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	0	0.3	387.5	0	0	1.2	0.8	0	0.2	1.8	0
U/NC	3.8	0	63.2	0	0	2.5	1.2	0	0.5	2.7	0
S/SpSu	27.2	0	12.3	0.8	0	3.2	0	2.2	0.3	1.5	1.0
U/SpSu	6.2	0	21.3	1.3	0.2	0.5	1.0	0.7	0	2.0	0.7
U/SpSu/L	1.5	0.7	21.7	0	0	2.3	0.6	1.7	0.2	0.8	1.7
S/Su	4.4	0	-	-	0	0.8	0.7	0	0	0	0
U/Su	12.2	0	-	-	0	2.6	0.7	0.7	0	0.7	0.2
S/SpAu	3.4	0.2	-	-	0	1.4	0.3	0	0	2.8	0
U/SpAu	91.6	0	-	-	0	0.7	1.8	0	0	2.5	0.2
U/Spray	0.8	1.8	-	-	0	2.8	2.0	0	0	6.7	0.7

Table A2.16 Mean number of aphids per sample unit ($0.5m^2$) on the new margin

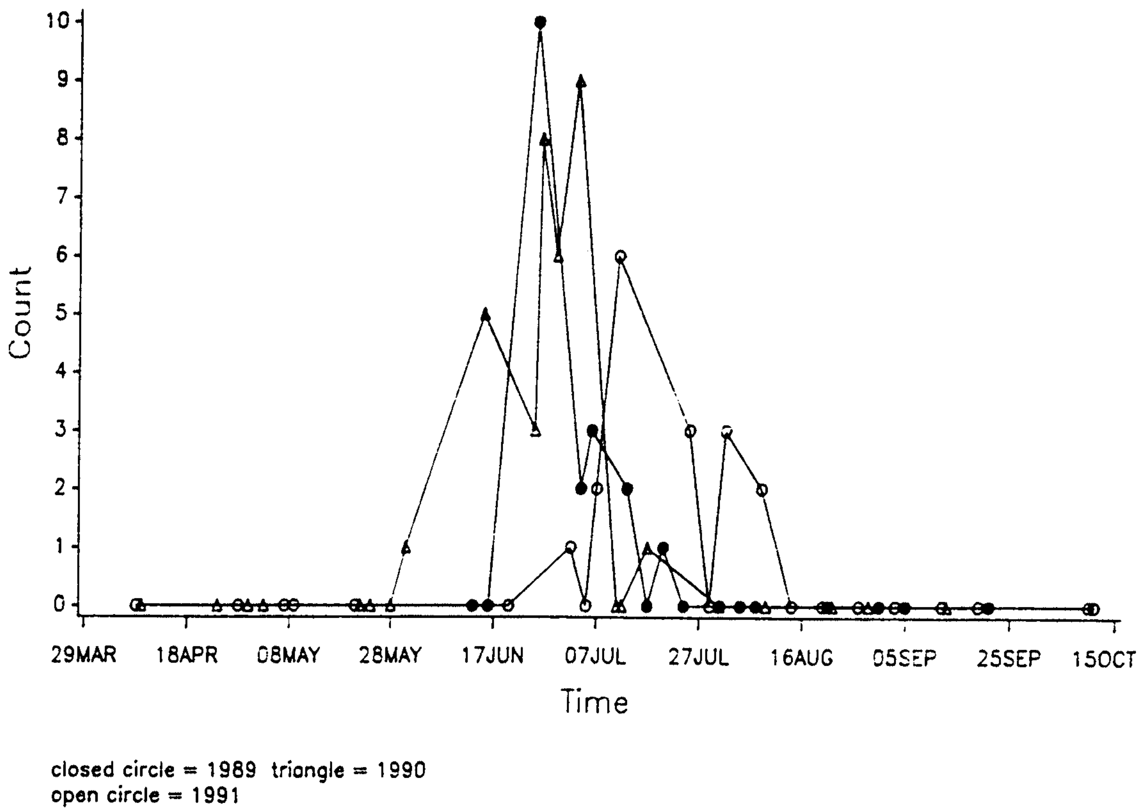
	Sample Round										
	Sep 1987	Sep 1988	May 1989	Jul 1989	Sep 1989	May 1990	Jul 1990	Sep 1990	May 1991	Jul 1991	Sep 1991
S/NC	-	0	230.0	0	0	2.0	0.3	0.7	0.2	2.5	0.3
U/NC	-	1.3	42.3	0	0	0.8	0.5	0	0	3.2	0.3
S/SpSu	-	1.8	23.0	0.5	0	5.5	0	0.2	0	2.2	0.8
U/SpSu	-	19.3	34.0	0.8	0.3	2.2	0.2	0.5	0.2	2.2	2.0
U/SpSu/L	-	1.0	55.2	0.2	0	2.7	0.2	0.3	0.2	0.5	1.2
S/Su	-	1.5	-	-	0.3	3.2	0.5	0.8	2.2	0.7	1.2
U/Su	-	1.2	-	-	0.2	1.5	0.3	0	0.7	0.7	0.8
S/SpAu	-	0	-	-	0	3.0	0.7	0	0.2	0.8	1.3
U/SpAu	-	0	-	-	0	1.0	0.8	0.3	1.8	5.5	0.2
U/Spray	-	0	-	-	0	0.4	0.3	0.3	0.2	2.8	1.8

APPENDIX 3 THE ABUNDANCES OF BUTTERFLY SPECIES ON THE TWO METRE MARGINS, 1989-1991

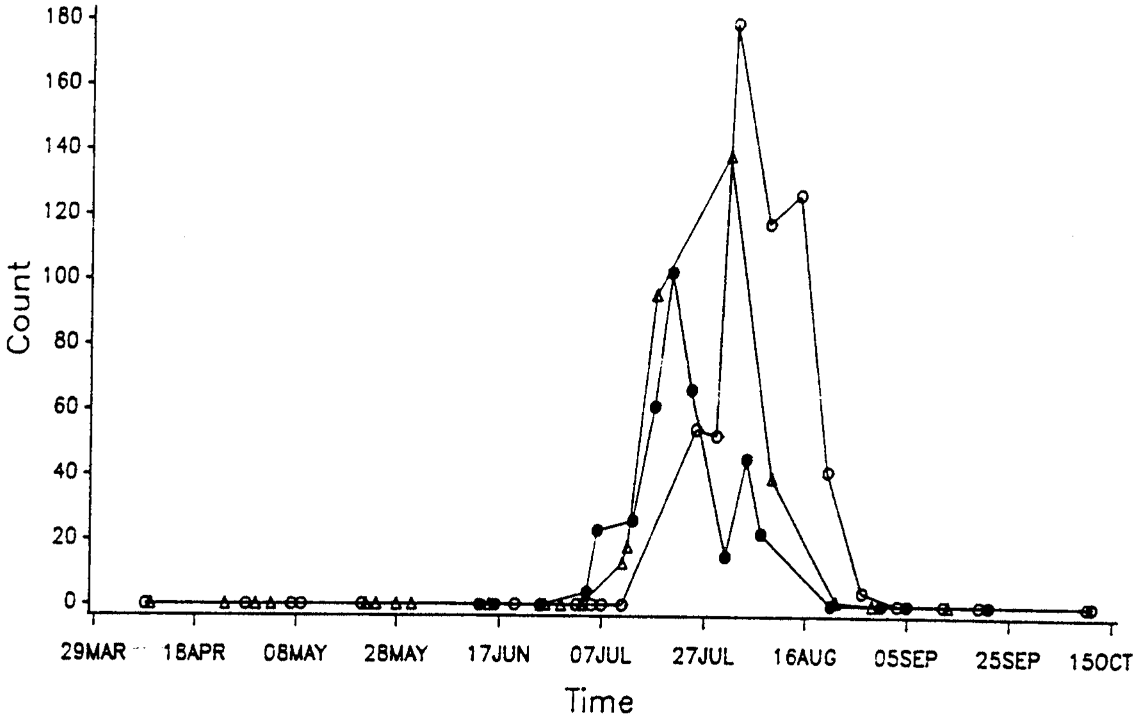
The figures in this appendix show the total numbers of individuals of each butterfly species recorded on each transect date on the two metre margins in 1989, 1990 and 1991.



T. sylvestris abundance (all treatments) in 1989, 1990 and 1991.

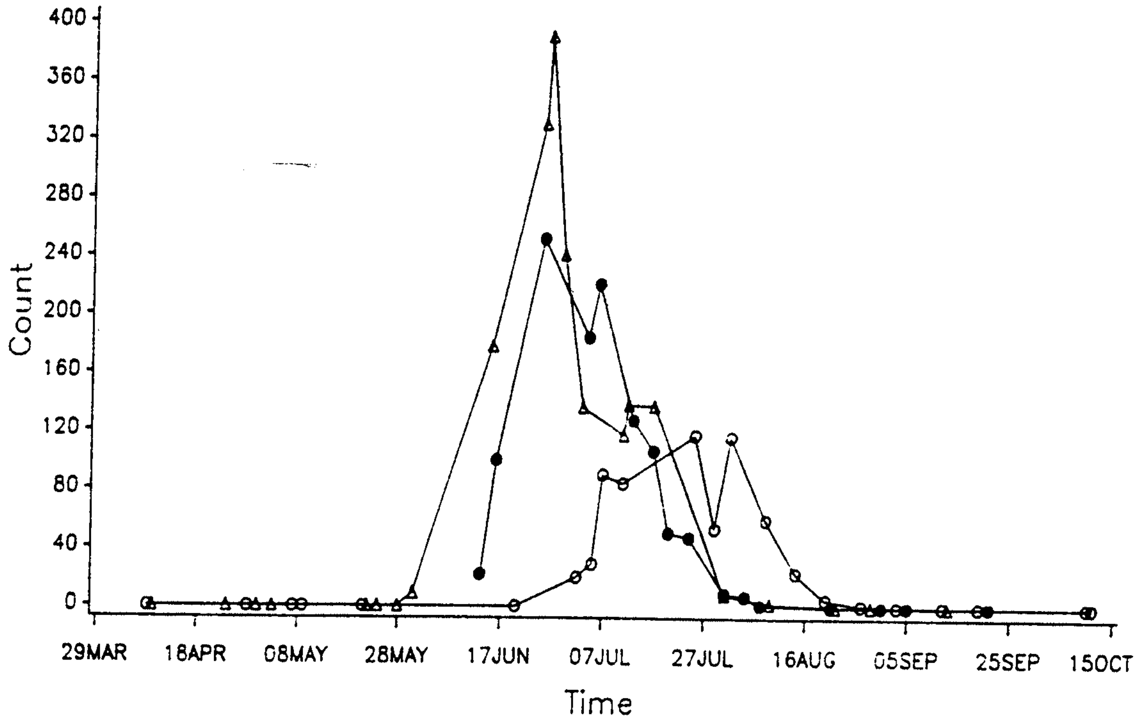


O. venata abundance (all treatments) in 1989, 1990 and 1991.



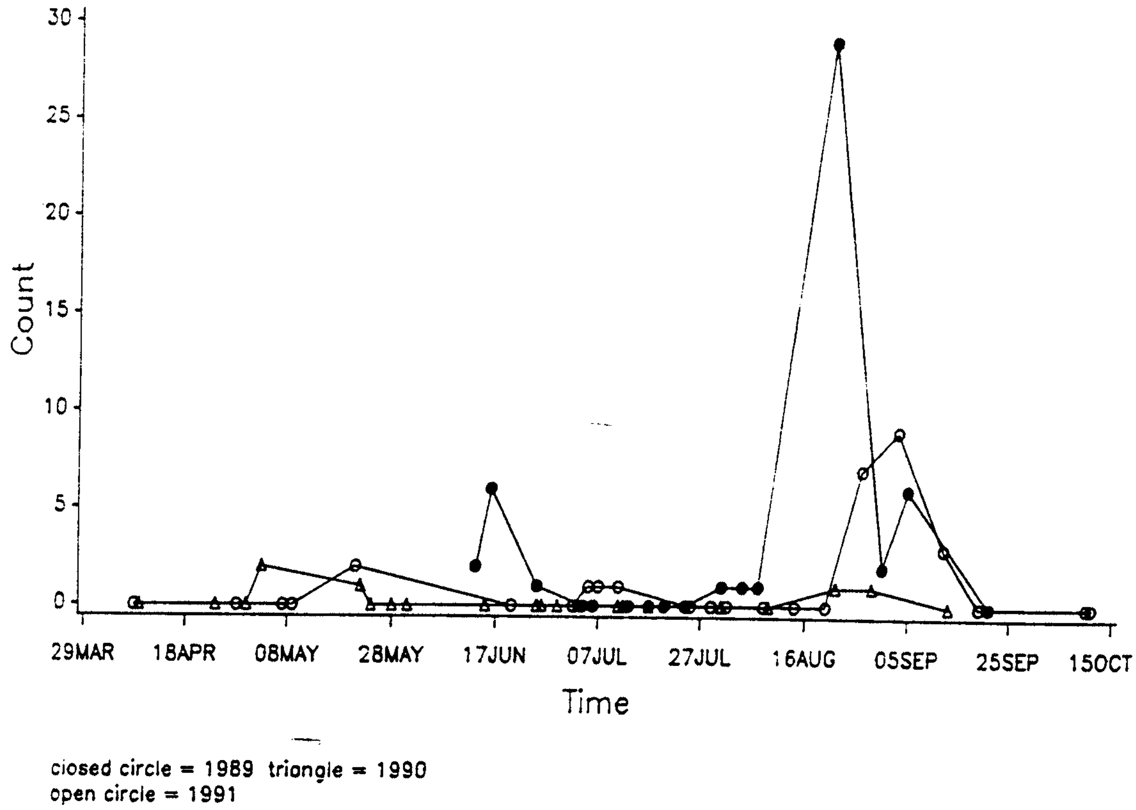
closed circle = 1989 triangle = 1990
open circle = 1991

P. tithonus abundance (all treatments) in 1989, 1990 and 1991.

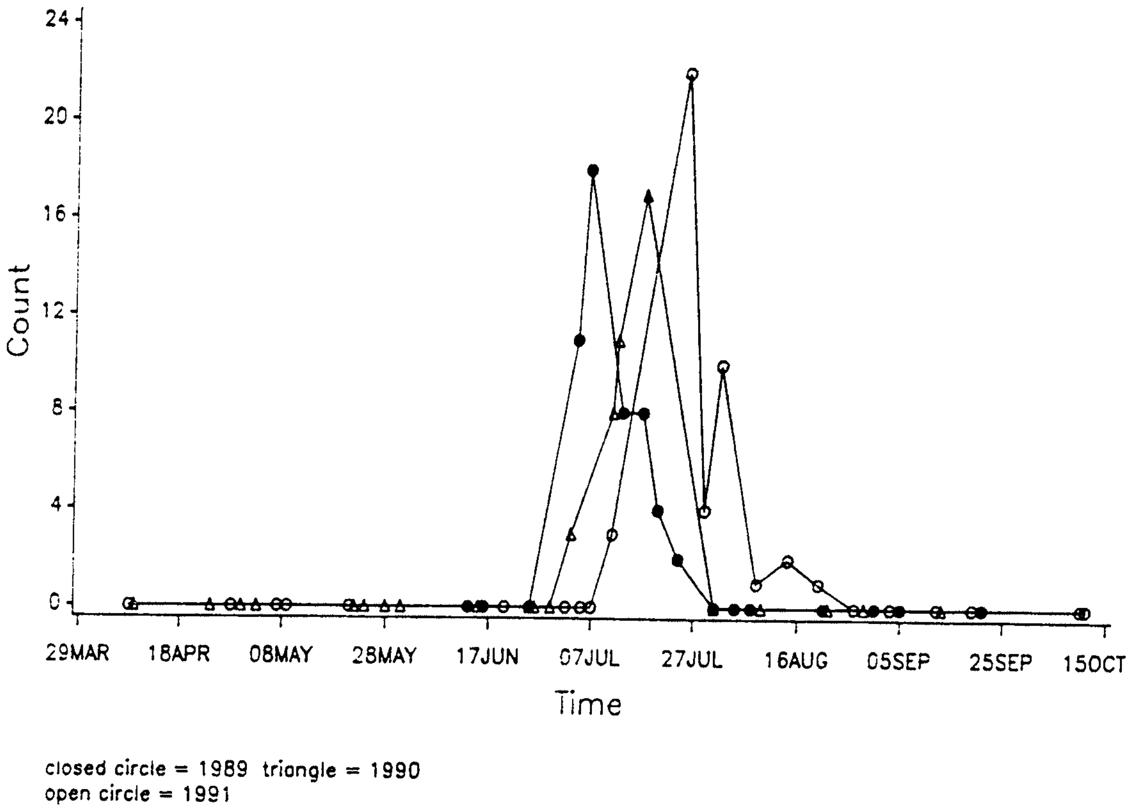


closed circle = 1989 triangle = 1990
open circle = 1991

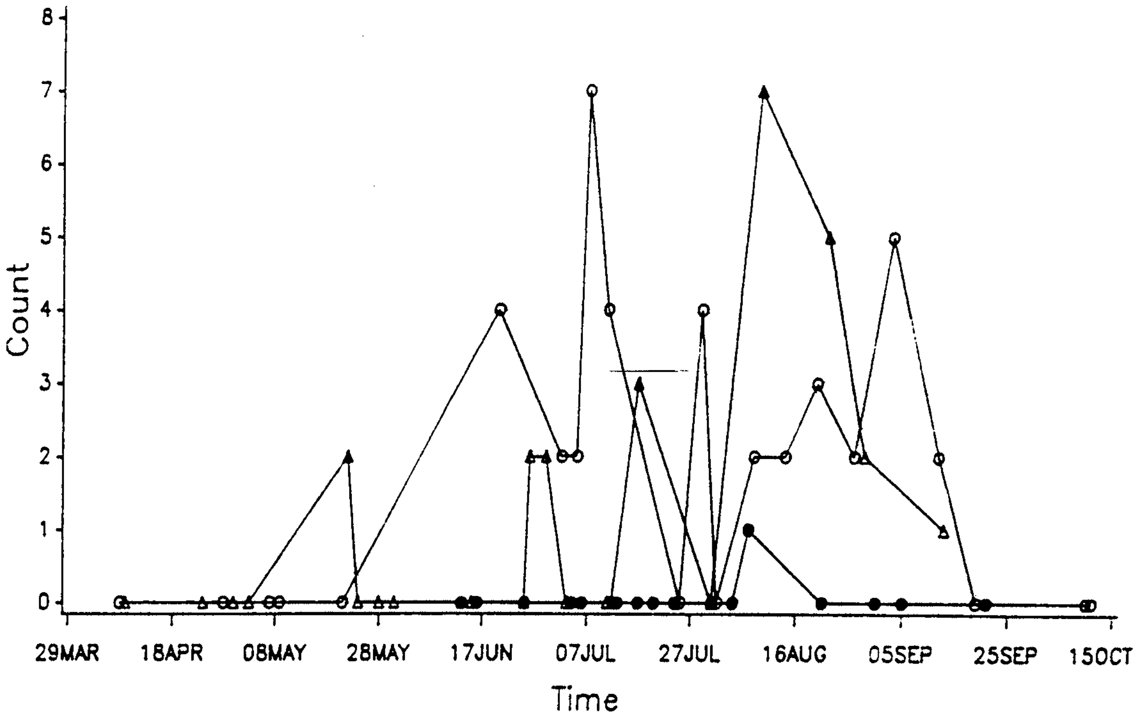
M. jurtina abundance (all treatments) in 1989, 1990 and 1991.



P. aegeria abundance (all treatments) in 1989, 1990 and 1991.

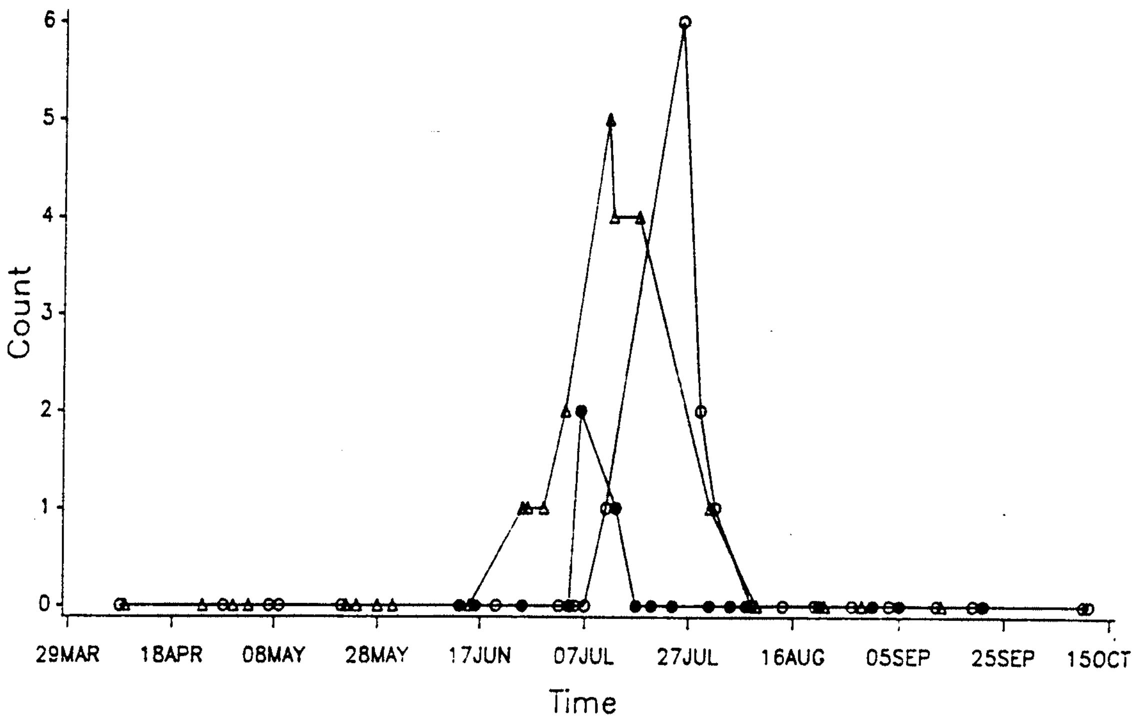


A. hyperantus abundance (all treatments) in 1989, 1990 and 1991.



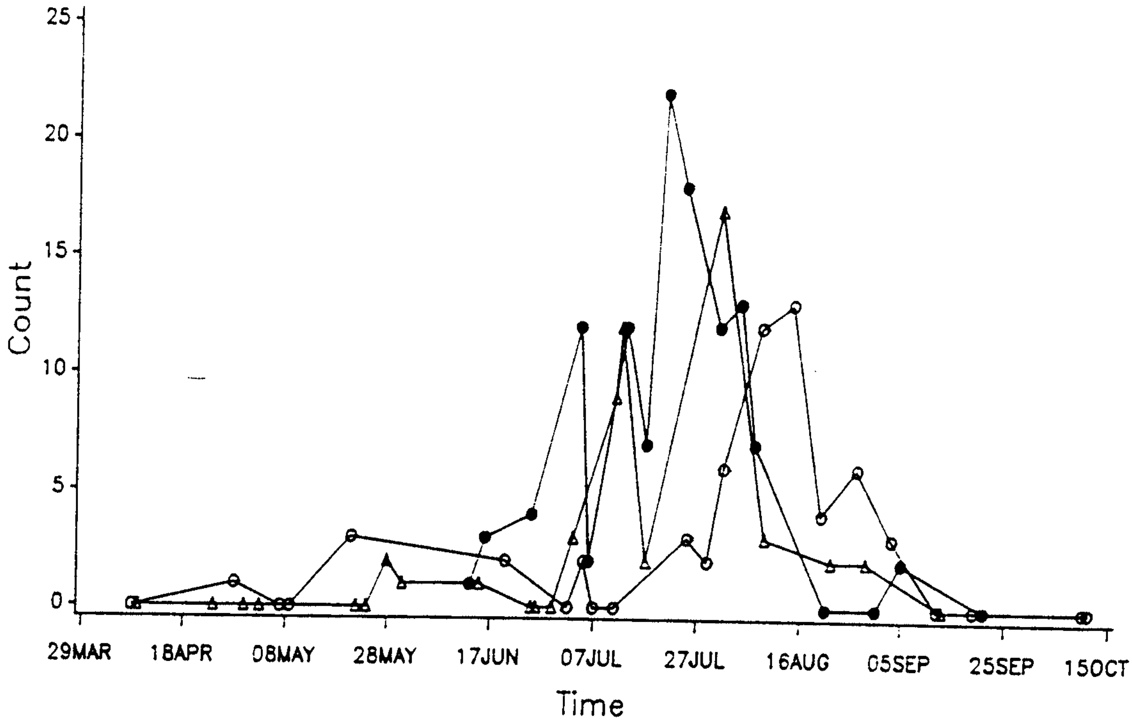
closed circle = 1989 triangle = 1990
open circle = 1991

C. pamphilus abundance (all treatments) in 1989, 1990 and 1991.



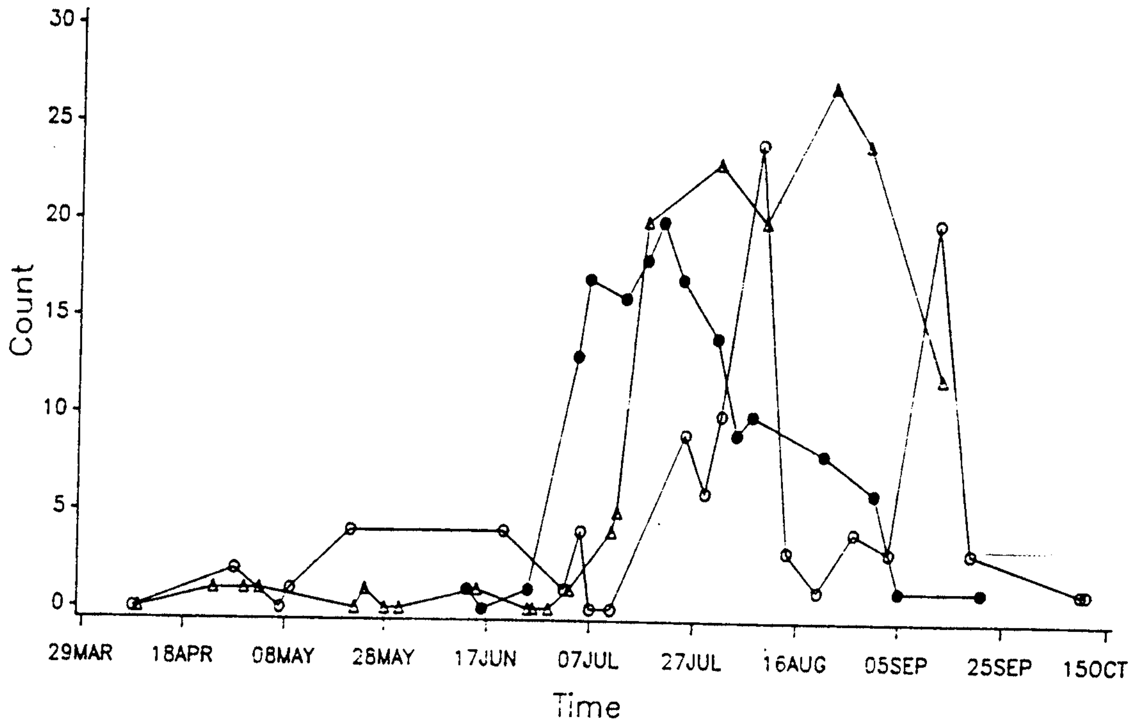
closed circle = 1989 triangle = 1990
open circle = 1991

M. galathea abundance (all treatments) in 1989, 1990 and 1991.



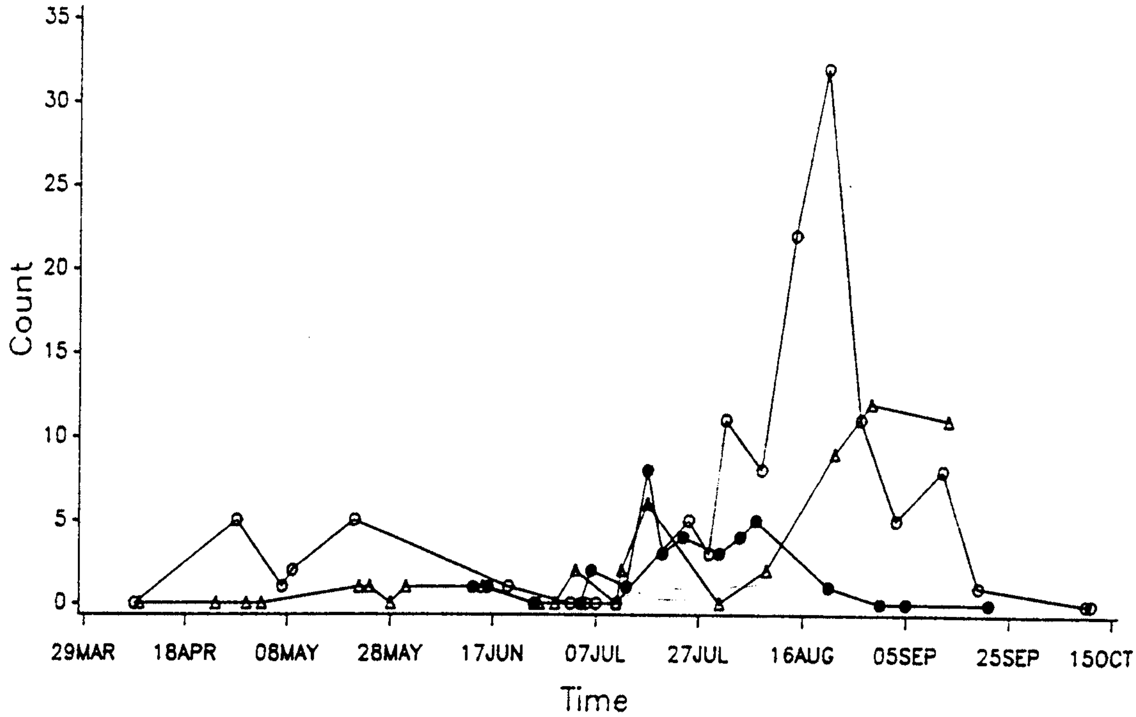
closed circle = 1989 triangle = 1990
open circle = 1991

P. brassicae abundance (all treatments) in 1989, 1990 and 1991.



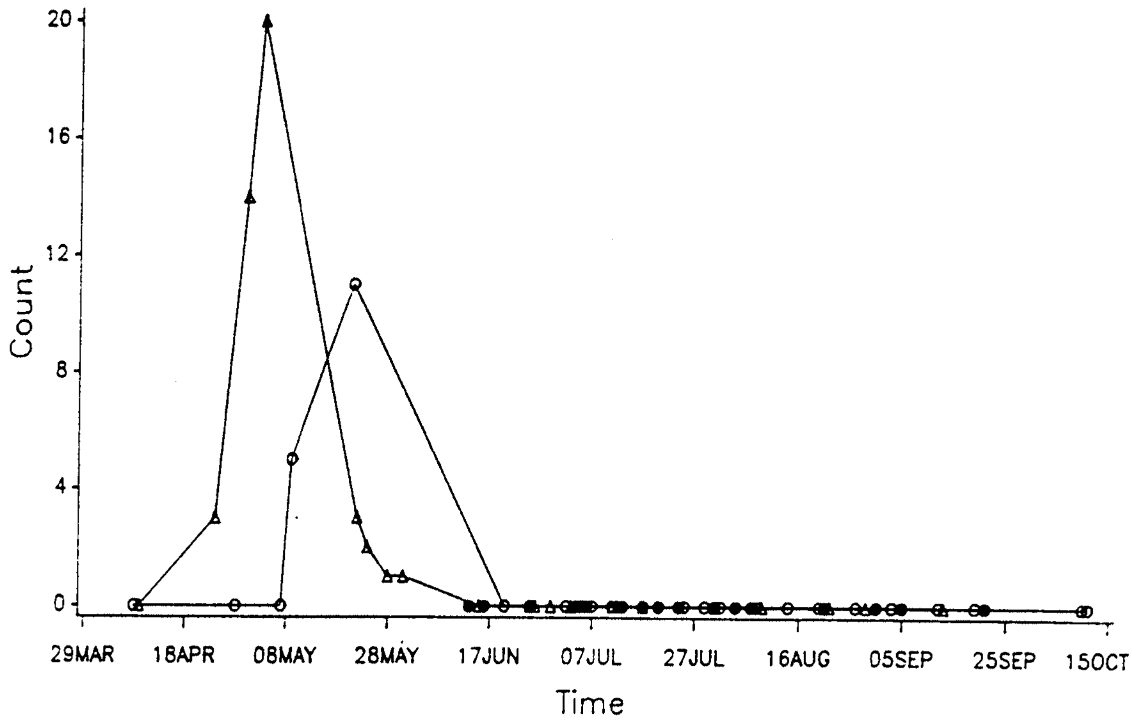
closed circle = 1989 triangle = 1990
open circle = 1991

P. rapae abundance (all treatments) in 1989, 1990 and 1991.



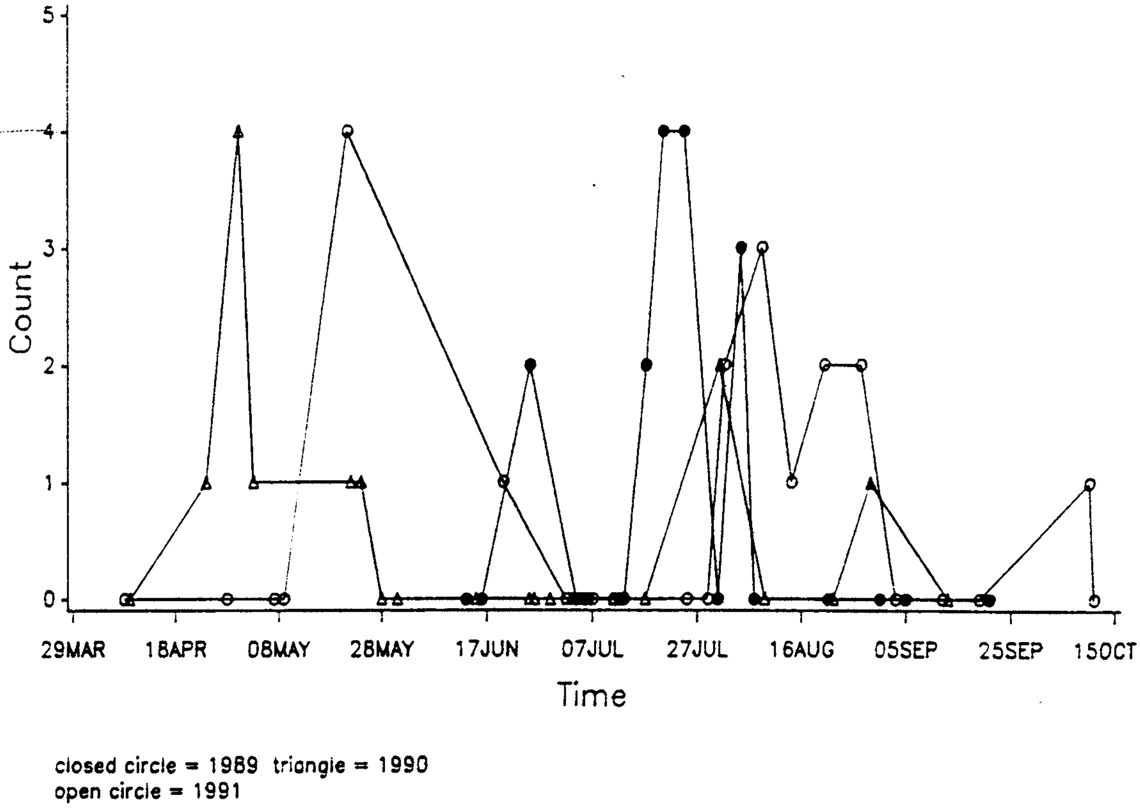
closed circle = 1989 triangle = 1990
open circle = 1991

P. napi abundance (all treatments) in 1989, 1990 and 1991.

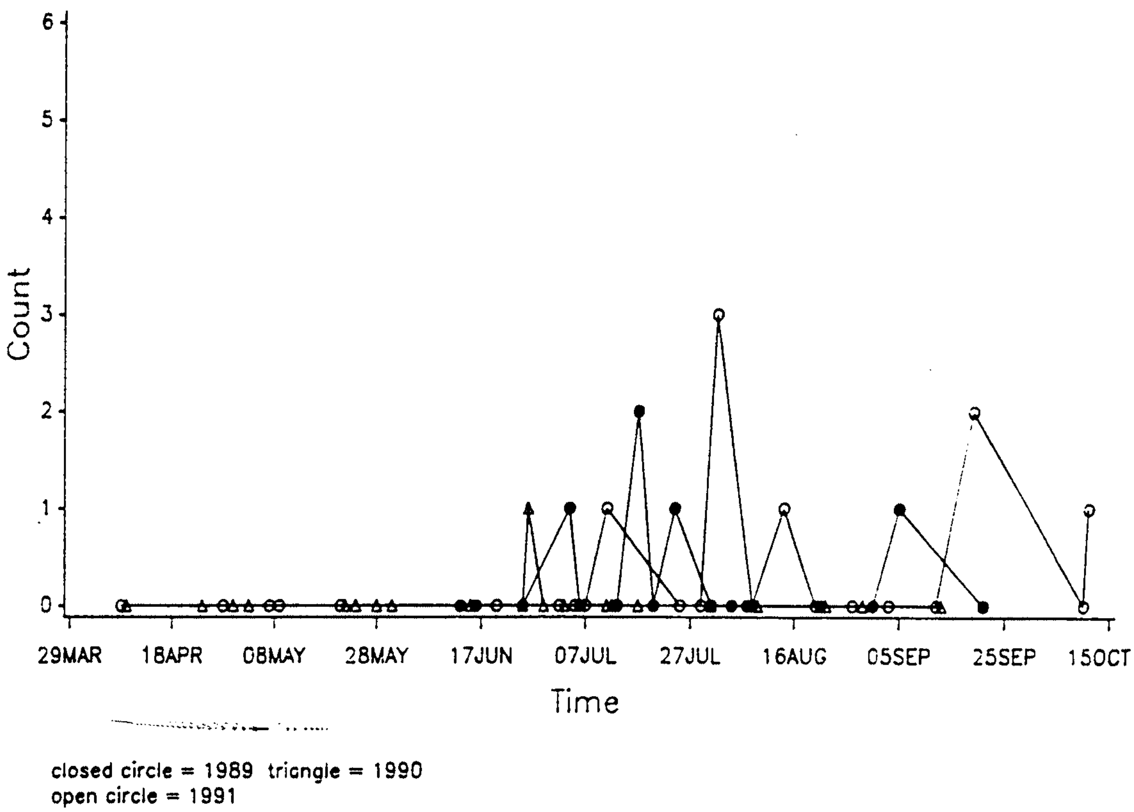


closed circle = 1989 triangle = 1990
open circle = 1991

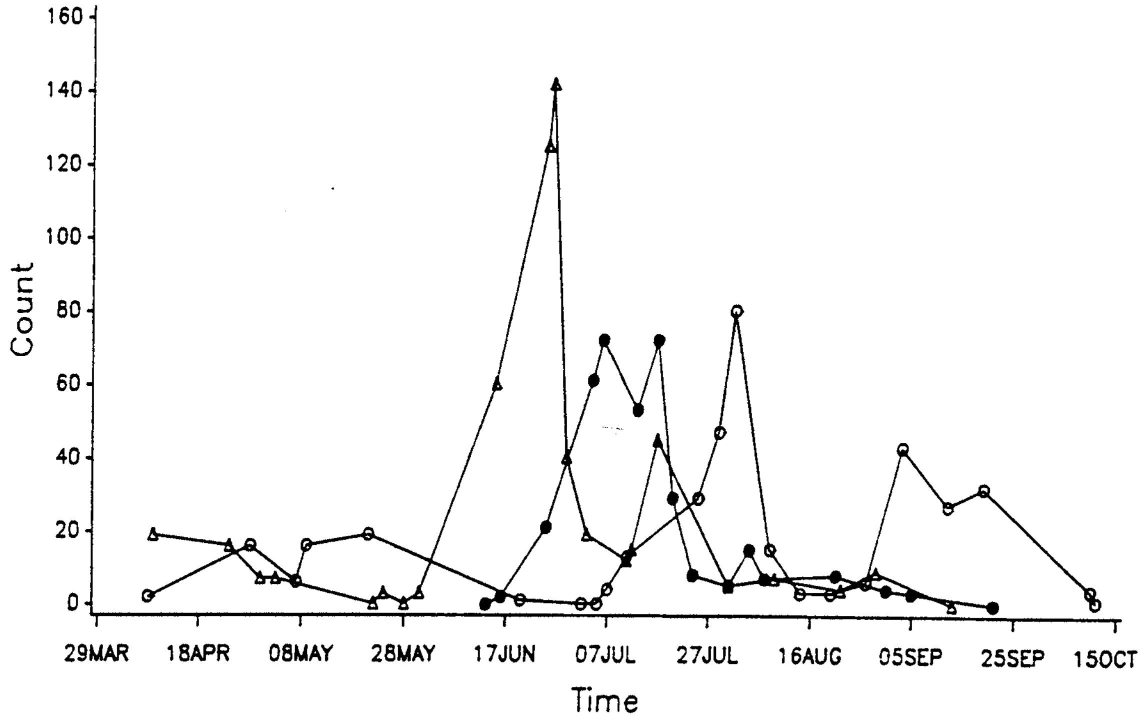
A. cardamines abundance (all treatments) in 1989, 1990 and 1991.



G. rhamni abundance (all treatments) in 1989, 1990 and 1991.

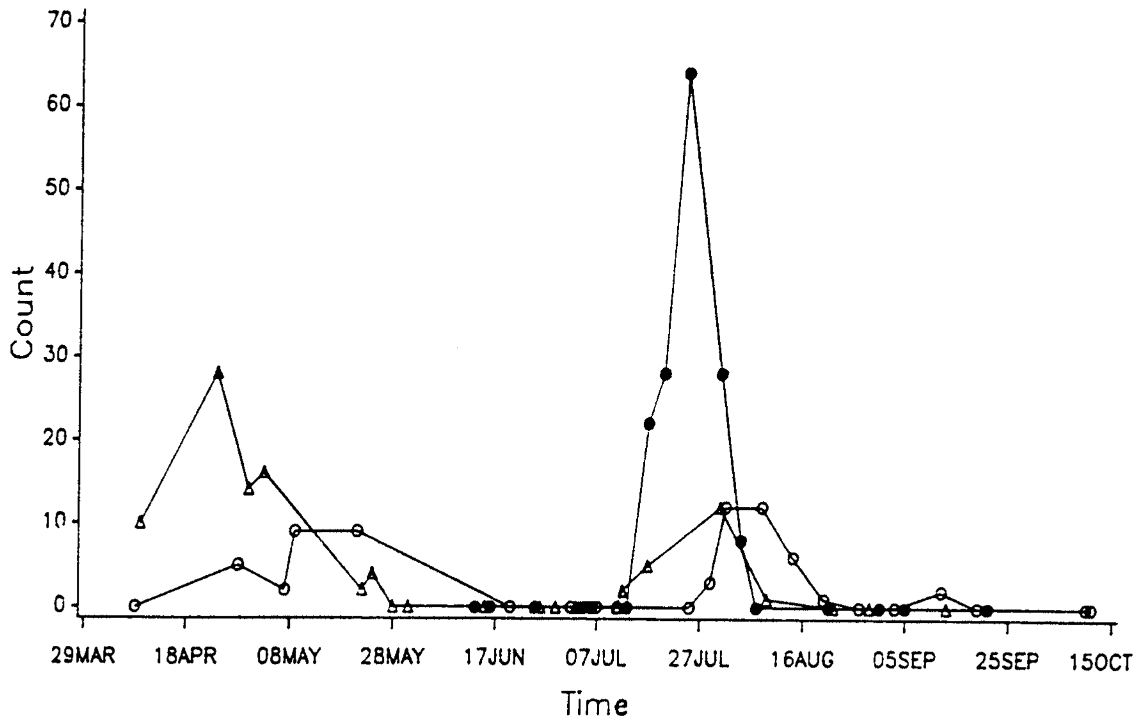


P. c-album abundance (all treatments) in 1989, 1990 and 1991.



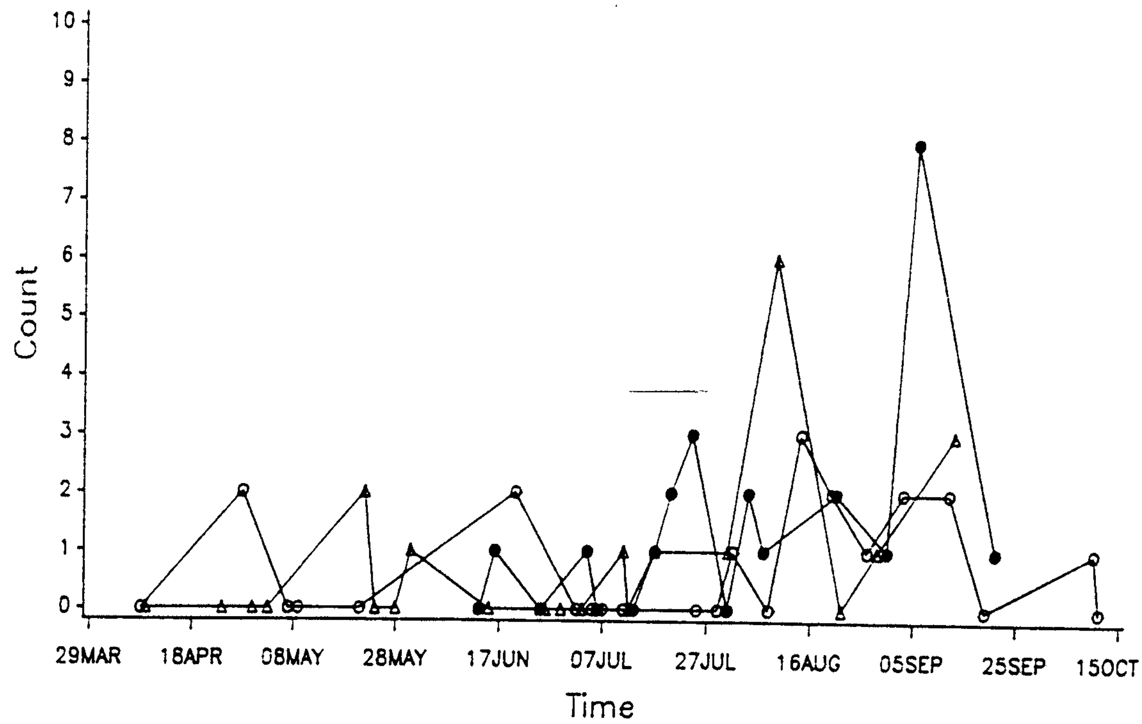
closed circle = 1989 triangle = 1990
open circle = 1991

A. urticae abundance (all treatments) in 1989, 1990 and 1991.



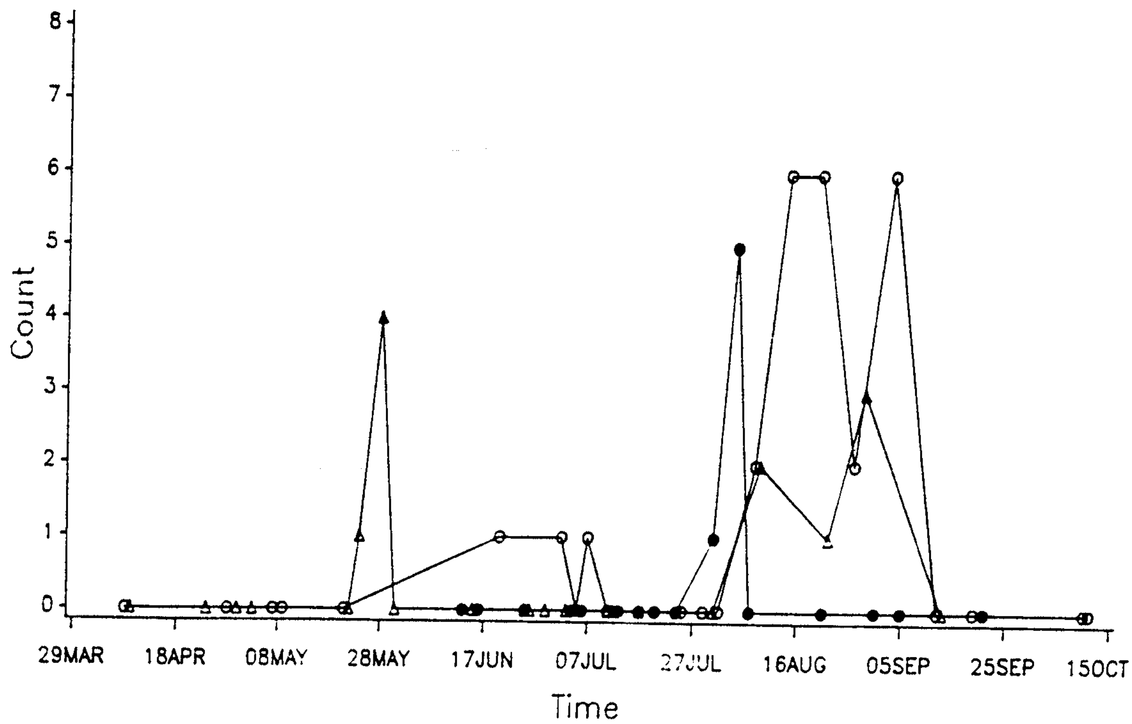
closed circle = 1989 triangle = 1990
open circle = 1991

I. io abundance (all treatments) in 1989, 1990 and 1991.



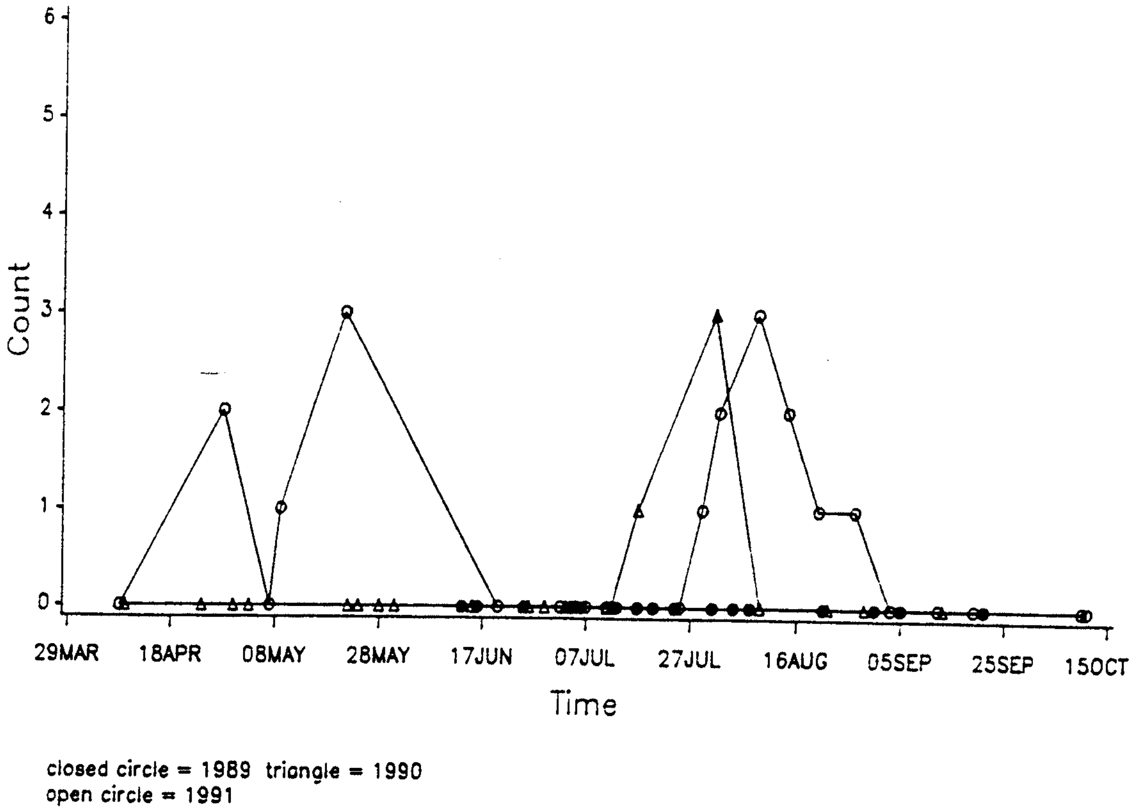
closed circle = 1989 triangle = 1990
open circle = 1991

L. phlaeas abundance (all treatments) in 1989, 1990 and 1991.



closed circle = 1989 triangle = 1990
open circle = 1991

P. icarus abundance (all treatments) in 1989, 1990 and 1991.



C. argiolus abundance (all treatments) in 1989, 1990 and 1991.