# 1.
# Agricultural and Conservation Interests

Chairman: Mr P. A. CHRISTENSEN

# FIELD MARGINS: DEFINITIONS AND STATISTICS

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## INTRODUCTION

Students of hedge history will find an excellent, comprehensive account given by Pollard et al (1974). The following superficial précis is taken unashamedly from that source.

The oldest field enclosures still in use in this country date back to the Bronze Age. Subsequently various groups, including the Romans, enclosed land in different ways. The earliest paper record of these is found in the Laws of Inc, King of Wessex 688 to 694 AD. These provided for the enclosure of crops by fences to protect them from neighbours' stock. From that time to the seventeenth century, the commonest enclosure was formed by the 'dead hedge' of thorns cut from the woods. Subsequently, the use of live thorn hedges, cut and laid at intervals, became more common and set the basis from which much of our hedge landscape has evolved.

The Enclosures Acts promoted a rapid proliferation of hedges during the early nineteenth century. At the same time, rapid development of the Industrial Revolution and the consequent decline in the importance of sheep and increased emphasis on cereals and potatoes, resulted in much subdivision of the then large fields held in common. Generally, the newly created fields were of about 20 acres (8 ha) to suit the dependence of arable husbandry on horse-drawn implements.

This period coincided with greatly increased demand for timber by the Navy and by industry. The latter had a particular demand for elm (Ulmus spp) and much planting of elm hedges occurred. Together with hawthorn (Crataegus spp) hedges, the elm hedge with elm trees became a dominant feature of the landscape.

Increasing sophistication of agricultural machinery during the latter part of the nineteenth century brought vociferous demands for hedgerow removal to increase field size and to promote more efficient use of machinery. The demands of the rotation system that dominated agriculture at this time, however, did not favour field enlargement, and the period was generally one where there was little hedgerow planting or removal.

Essentially, this situation was maintained through to the mid-twentieth century. It was following the Second World War that the major changes in the UK hedged landscape became apparent. These changes reflect the remarkable revolution in crop husbandry during this period in response to insistent demands for increased agricultural production.

While the history of hedges is a fascinating record of political, social and economic change in this country, it serves one particular purpose in this paper. That is to remind the reader that hedges, and thus field margins, are features that are man-made and are continually evolving and developing. Whatever form they take, they have been planted and managed to achieve certain objectives and, generally, have been maintained to achieve those objectives over a long period of time.

The term 'hedge', in the agricultural sense, has different meanings in different parts of the country. These range from stone walls, through turf banks to low thorn hedges with or without mature trees in the hedge-line. The field margin associated with such structures may be similarly varied with the major differences probably occurring between grassland and arable situations. In effect, there can be no one general definition of a hedge, other than perhaps 'a structure which defines the limits of a field'. Equally there can be no one generalized management system. Indeed, the management options are becoming more varied, and more complex, as the increasing public awareness of threats to wildlife persuades farmers to review their policies with regard to hedges and field margins, which are often the interface between agriculture and the natural environment.

For the remainder of this paper we will confine our remarks to the most common hedges, those composed of woody species with associated herbs. It is not our intention, nor does space permit, to give a detailed account of statistics. Rather, we will cover some major aspects superficially with the intention of providing sufficient background to facilitate the discussions that follow in this publication.

## FUNCTIONS OF HEDGEROWS AND FIELD MARGINS

The objectives of retaining hedgerows and field margins are various, reflecting agricultural, environmental, landscape and sporting interests. Probably the most important attributes of the idealised hedgerow are that it should:-

(i) clearly define the field boundary;

(ii) be stock-proof or trespasser-proof as appropriate;

(iii) provide shelter for stock;

(iv) provide shelter for crops by preventing erosion, acting as a windbreak or snow barrier;

(v) not compete with the crop by shading, or by depletion of nutrients, or water;

(vi) not harbour weeds, pests and diseases of crops;

(vii) harbour beneficial insects (e.g. plant pollinators and predators of crop pests) and their host plants.

## CURRENT EXTENT OF HEDGES

During the last three decades, it has been only too clear that hedgerows have been lost from the landscape. Current estimates from the recent Ministry of Agriculture, Fisheries and Food (MAFF) survey (Anon 1985), indicate that, despite new plantings, there is still an annual net loss of hedgerows in England and Wales. Although it is claimed this amounts to less than one per cent of the total stock, there is still strong concern, and as a result MAFF has recently revised its grant support policy in order to encourage replanting.

There are many estimates of the area or length occupied by hedges in the UK. All are subject to varying degrees of error depending on the survey techniques employed and the assumptions made in scaling up the acquired data. However, if we accept recent estimates that hedges occupy about 160,000 ha and have a length of more than 800,000 km, the current loss rate can be seen in a different light. Only one per cent loss each year translates to the weightier figures of 1,600 ha (4,000 acs) or 8,000 km (5,000 miles).

This, of course, is not the complete story by any means. The figures give no indication of the quality of lost hedges, nor of their distribution. It may well be, as claimed on at least one demonstration farm, that judicious hedge removal actually enhances the landscape as well as increasing agricultural efficiency.

## HEDGEROW AND FIELD MARGIN QUALITY

Quite clearly, quality may be defined differently according to the function of the hedge or field margin. The basic qualities for a stock-proof boundary may be widely different from those required in a margin designed with conservation interests in mind, or intended to act as a shelter for crops. However, bearing in mind the present concern over conservation, and the belief that a field margin designed for conservation purposes will include most of the attributes mentioned earlier, it seems appropriate here to consider hedge quality in conservation terms.

Early in 1984, we canvassed several leading scientists in MAFF and the Nature Conservancy Council (NCC) for their views as to the ideal attributes of a field margin. In effect, all the parties contacted concurred with the views expressed by Moore (pers comm) paraphrased below.

In defining the conservation objectives of a field margin, it must be borne in mind that different species of plants and animals have different habitat requirements. These are often exacting and may conflict with each other. Nonetheless, the conservation interests are best served by those field margins which have greatest species diversity of woody and herbaceous plants. This is achieved where a multiplicity of micro-habitats is present and where robust, dominant herbaceous plant species are discouraged. As animals are dependent on plants, many being very specific in their requirements, the diversity of animal species varies with the diversity of plant species.

In practical terms this defines the best field boundary as containing three principal elements:

### Tree and shrub layer

This is particularly important for insects, birds and mammals. Hedge bottoms should be wide (is the A-shaped hedge really the best shape?) and the hedge should contain trees to provide song posts, roosts and nest sites. Age is an important factor here, older hedges containing more shrub species and, hence, more invertebrate and vertebrate species. Management should be timed to ensure that shrubs bear berries and other fruits as winter food for birds.

Tall herb layer

Tall herbs are also important for invertebrates. Plant diversity is important, but umbellifers and composites are especially valuable for insects.

Low herb layer

Low-growing plants are important for animals. Again, plant species diversity is important and should include broad-leaved flowering species as well as grasses. Equally, some bare ground is desirable.

The value of this basic structure will be greatly enhanced if it is adjacent to a ditch, (especially one that permanently contains water), or if it surmounts a bank.

From an agricultural viewpoint, the herb layers should be dominated by perennials, particularly those which suppress the development of aggressive annual 'weeds' such as barren brome (Bromus sterilis) or cleavers (Galium aparine). It goes without saying that the perennials preferably should not be those species which readily invade the adjacent crop.

Although these definitions describe the main characteristics of the field margin to a considerable degree, they omit many of the considerations which have varying importance in differing circumstances. Height and porosity of the hedge will affect its function as a wind and snow barrier, as well as affecting shelter value for animals and insects, or dispersal of insects into the crop. Shape, currently a contentious issue amongst conservationists, may also be important. While much is known about such factors, much more remains to be discovered.

Just as attributes of quality require further elucidation and definition, it is axiomatic also that management options need defining. As was implied earlier, there are as many management options as there are objectives for establishing field margins. The preferred option will depend as much on farmer perception of 'good management' in the past, as on future definitions of what is actually necessary. Thus, future management options may differ between margins treated annually with glyphosate and those maintained free of vegetation by cultivation.

**CURRENT MANAGEMENT OF FIELD MARGINS**

In order to gain information about the practices used by farmers in field margin management, we questioned farmers attending the 1985 Royal Agricultural Show. They provided information on farm size, structure, cropping, location, and on the incidence of different types of field boundary, together with the different management practices employed in their maintenance.

While it is still too early in the analysis of the data to draw definitive conclusions, certain salient statistics have emerged. Of the

163 farmers questioned, 75% farmed the headland in the same way as the rest of the field. Of those who did not, some used less herbicide than in the rest of the field (17.5%), some used a specific herbicide on the headland (45%), ploughed prior to burning (15%), used a higher seed rate or higher inputs (12.5%), used less fertilizer (7.5%), cultivated to break up compaction (5%), or grew a different crop (2.5%). The vast majority of those using a different farming method in this area did so to combat weeds, but, significantly, 22.5% claimed to do it for wildlife reasons.

A little more than 30% of the farmers maintained boundary strips around the edges of cereal fields (see later for definition of boundary strip), 88% of these being maintained by rotovation and less than 5% by means of a permanent grass strip. Most of the farmers used boundary strips to prevent weed ingress to the crop (92%), while 40% gave reduction of harvest problems and 14% gave wildlife as additional reasons.

About 39% of those questioned said they used herbicides to control potential crop weeds in the field boundary, more than half of them using glyphosate.

Finally, more than 35% of those questioned claimed to manage field edges on their farms specifically for wildlife. Clearly, this answer in particular cannot be taken in isolation from others given in response to the questionnaire. However, it does indicate encouraging signs of an awareness of conservation in the farming community.

## TERMINOLOGY IN THE DEFINITION OF FIELD MARGINS

Throughout the literature relating to field margins there is a multiplicity of terms, many of which refer to the same part of the margin, resulting in confusion and misunderstanding.

At a recent meeting organised by the Chief Scientist's Group of MAFF, which discussed current research and present and future research needs, it was proposed that three main divisions of the field margin should be recognised. These are represented diagrammatically in Figures 1 and 2, taken from the report of that meeting (Greig-Smith 1986).

### The boundary

The boundary encompasses the barrier such as hedge, fence or wall, the hedge bank if present with its herbaceous vegetation, and any associated water course such as ditch or drain.

### The boundary strip

The boundary strip is effectively the area of ground between the boundary and the crop. It may include farm track, grass strip or a cultivated zone.

### The crop

The term 'headland' may or may not be synonymous with the crop edge indicated in Figure 1. It is suggested that it should be reserved for the strict agricultural meaning of a turning space for machinery. It should not be used loosely to describe the area between hedge and crop. The term 'crop edge' will generally incorporate the headland.

Although these divisions can be used for both arable and grass fields, their components will vary according to the different characteristics of these land uses. The diagrams in Figures 1 and 2 indicate how these differences are accommodated in generic terms.

Clearly, the actual terms used to describe the three divisions could be the basis of much discussion. It may be felt, for example, that Boundary and Boundary Strip may be so similar as to result in erroneous interchangeability. The important, indeed the most important, conclusion is that there must be accepted standard terms to describe the structure of field margins. Only then will existing confusions be eliminated and the basis for easily understood, unambiguous advice be laid.

## REFERENCES

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Greig-Smith, P. W. (1986) The Management of Field Margins. Report of a meeting organized by the Chief Scientists Group, Ministry of Agriculture, Fisheries and Food, London. (Unpublished).

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FIGURE 1 The principal components of an arable field margin (Reprinted from Greig-Smith 1986).

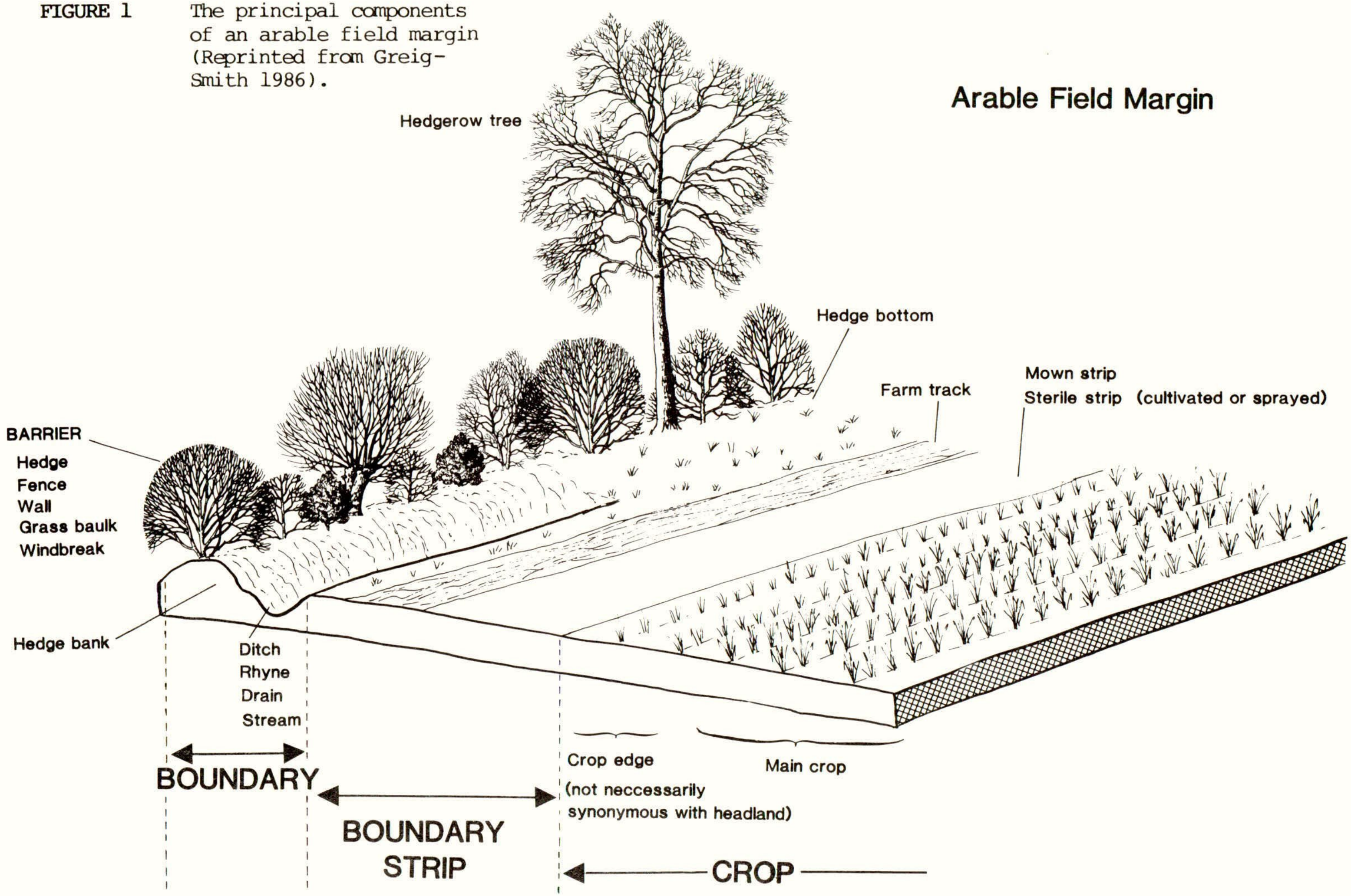
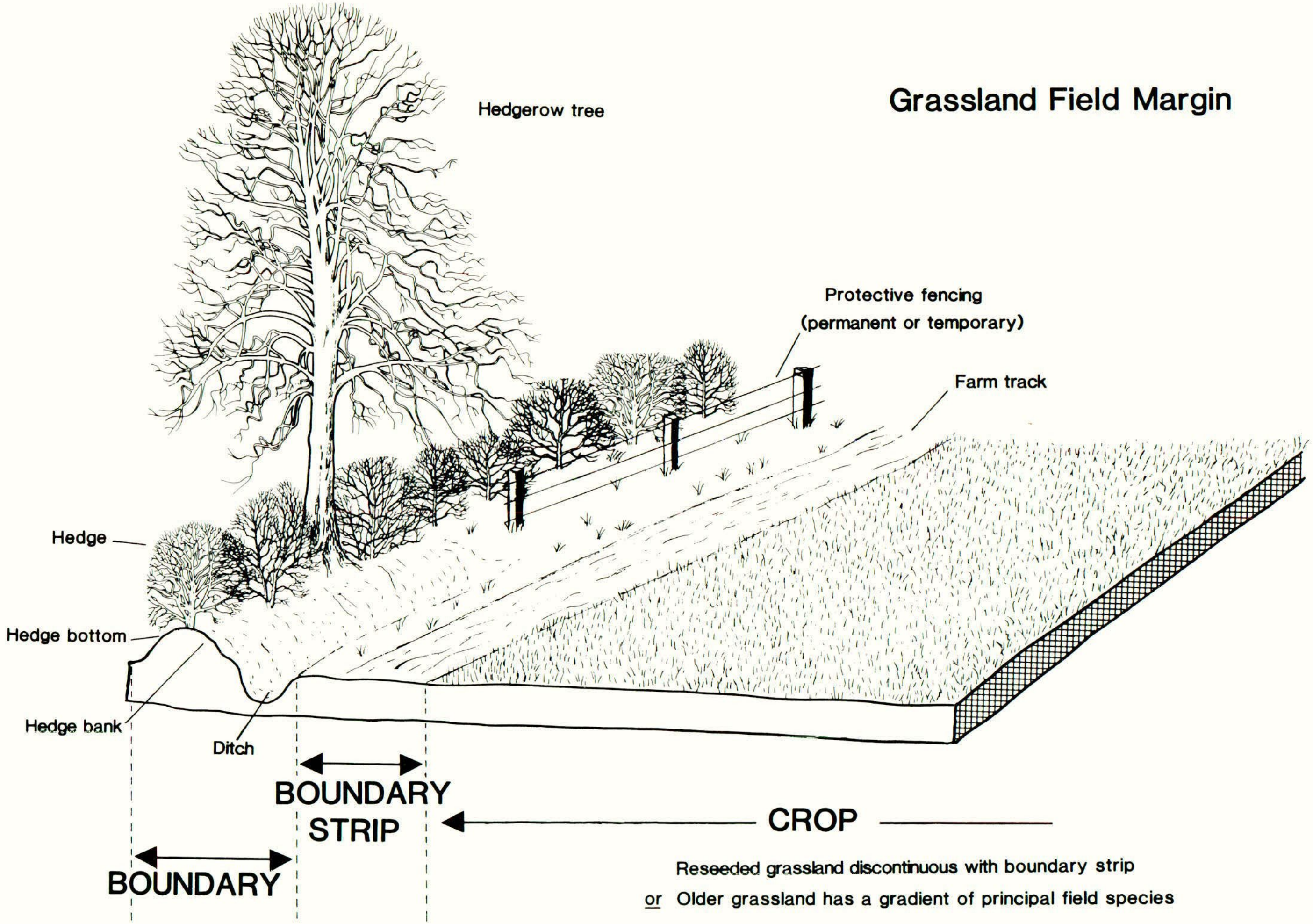


FIGURE 2 The principal components of a grassland field margin (Reprinted from Greig-Smith 1986).



# AGRICULTURAL PROBLEMS OF WEEDS ON THE CROP HEADLAND.

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## INTRODUCTION

Grass weeds are the dominant problem on the headlands of arable fields. They are adapted to a wide range of soil types and have been encouraged by the recent swing to winter cereal cropping and early autumn sowing. The important problem species are annuals, or rarely biennials after late spring germination. Their success is associated with a very high level of seed production, whereas perennials propagating by means of rhizomes or stolons are much less of a problem in UK agriculture as a result of the introduction of the herbicide glyphosate.

A few species of grass weeds are better adapted to heavier soils which are less prone to drought, but most are cosmopolitan in the arable areas of the UK. Only a very few of the annuals are able to survive and reproduce in the community of perennial grasses typical of a stable undisturbed hedgerow flora. The majority are serious competitors with arable crops on the headland, and are well adapted to colonising the strip of disturbed ground between the crop and hedge where their seed production is unrestricted.

Various biological factors have to be considered when the agronomist is planning chemical and cultural control methods because these will depend on the behaviour of the species involved. Such factors include: i) the timing and periodicity of seedling emergence, ii) their competitive ability, iii) time of ripening and shedding of seed and, iv) seed dormancy factors and longevity.

## THE ORIGINS OF SOME PROBLEM WEEDS OF ARABLE FIELDS

### Grasses

| Uncultivated areas<br>Hedgerow, ditch and path sides, field margins | Cultivated areas<br>Field margin, headlands and whole fields |
|---|---|
| *Elymus repens* (Common Couch) | *Alopecurus myosuroides* (Black-grass) |
| *Agrostis stolonifera* (Creeping Bent) | *Bromus commutatus* (Meadow Brome) |
| *Agrostis gigantea* (Black Bent) | *Phalaris paradoxa* (Awned Canary-grass) |
| *Arrhenatherum elatius* (False Oat-grass) | *Phalaris spp* (Canary-grass) |
| *Bromus sterilis* (Barren Brome) | *Apera spica-venti* (Loose Silky-bent) |
| *Bromus hordeaceus (mollis)* (Soft-brome) | |
| *Avena fatua* (Wild-oat) | |
| *Avena ludoviciana* (Winter Wild-oat) | |
| *Poa trivialis* (Rough Meadow-grass) | |
| *Hordeum murinum* (Wall Barley) | |

Hordeum murinum is not a problem of arable crops but can be serious in grass leys and herbage seed crops as a headland weed and sometimes in longer-term leys. The hedgerow grasses are characterised by their pendulous inflorescences which hang over the field edge or crop and shed their seed, or are caught up by the combine harvester and cultivation tackle and dispersed into the field.

Dicotyledons

The majority of species are specific to the hedgerow flora and are not found in the cultivated area of the field where the majority of dicotyledons are hemicryptophytes. The important exception is cleavers (Galium aparine). Very rarely mugwort (Artemisia vulgaris), hogweed (Heracleum sphondylium) and cow parsley (Anthriscus sylvestris) are found growing on the crop headland but do not constitute a threat because they are not able to survive intensive cultivations.

Survey results

A recent survey by the Weed Research Organisation (WRO) (Chancellor and Froud-Williams 1983) of weeds in cereal fields was carried out in an area of central southern England bounded by Lincolnshire, Essex, Gloucestershire and Hampshire, in the years 1981 and 1982; results for 1981 are given in Table 1.

Avena spp, E.repens, Poa trivialis and A.myosuroides occurred in more than 20% of winter cereals. 9% of winter cereals were infested with B.sterilis but a further 7% had B.sterilis growing in the hedge or field margin. Most of the infested fields only had brome on the headlands. Poa trivialis was more common in the west and E.repens in the east of the survey area.

In both years Avena spp and E.repens were the most frequently recorded species but they were not at such severe levels as A.myosuroides or P.trivialis. Most species increased in frequency in 1982, except P.trivialis. Only two weeds (Avena fatua and E.repens) were important in spring barley crops.

Of the dicotyledonous weeds found in the survey, field pansy (Viola arvensis) (11%) and Galium aparine (10%) were the most frequent in occurrence but at mostly light levels of infestation. Other broad-leaved weeds occurred in 6% or less of fields, well below the level of grass weeds. Galium aparine had a higher frequency in the east, whilst Viola arvensis, common chickweed (Stellaria media) and knotgrass (Polygonum aviculare) had a more western distribution.

**THE BIOLOGY AND CONTROL OF HEADLAND WEEDS**

Annual Grass Weeds

These tend to dominate the weed infested areas in arable crops. Alopecurus myosuroides, Avena spp, and Bromus spp are particularly widely

**TABLE 1**

The occurrence in 1981 of the nine most frequent grasses and their levels of infestation in cereals. For each crop the columns for light and heavy infestations are shown as percentages of the first column (% fields infested).

| | Winter Wheat | | | Winter barley | | | Spring barley | | |
|---|---|---|---|---|---|---|---|---|---|
| | % fields infested | % light | % heavy | % fields infested | % light | % heavy | % fields infested | % light | % heavy |
| _Avena spp_ | 32 | 76 | 24 | 31 | 71 | 29 | 52 | 62 | 38 |
| _Poa spp_ | 29 | 52 | 48 | 6 | 57 | 43 | 0 | 0 | 0 |
| _Elymus repens_ | 26 | 75 | 25 | 20 | 81 | 19 | 53 | 67 | 33 |
| _Alopecurus myosuroides_ | 23 | 50 | 50 | 9 | 71 | 29 | 11 | 72 | 28 |
| _Bromus sterilis_ | 12 | 68 | 32 | 4 | 64 | 36 | 0 | 0 | 0 |
| _Lolium multiflorum_ | 10 | 74 | 26 | 6 | 76 | 24 | 5 | 67 | 33 |
| _Agrostis spp_ | 9 | 75 | 25 | 5 | 75 | 25 | 4 | 82 | 18 |
| _Phleum pratense_ | 6 | 78 | 22 | 2 | 77 | 23 | 4 | 94 | 6 |
| _Arrhenatherum elatius_ var _bulbosum_ | 4 | 72 | 28 | 1 | 90 | 10 | 2 | 56 | 44 |

(From Chancellor and Froud-Williams 1983) distributed, but Apera spica-venti and canary grasses (Phalaris spp) tend to be more local in distribution.

Black-grass (Alopecurus myosuroides)

A.myosuroides is confined to cultivated soils and is rarely found in hedgerows. With Avena spp it is the most widespread annual grass weed of winter sown crops (cereals, oilseed rape, beans) of southern, midland and eastern counties. A.myosuroides prefers heavier soils of high moisture content but has spread onto lighter soils, including the chalks, as a result of intensive winter cropping. It is also spreading into northern counties and the south-west.

A.myosuroides is a severe problem in winter wheat with significant effects on yield from as low as 10 plants per $m^2$ and with 100 plants per $m^2$ reducing yield by 1.0 tonne/ha or more depending on crop vigour. Winter barley is less sensitive to competition because of its dense autumn habit, despite early sowing which encourages high numbers in the crop.

A.myosuroides is capable of producing many seeds, from 10 to 500 per plant depending on density. There is a long period of flowering from May to August and much seed is shed in winter wheat but grain contamination mainly occurs in winter barley. 90% of seed germinates from the top 2.5 mm of soil, dormancy occurs in seed buried below 50 mm and seed can survive 3 years but the annual mortality rate of buried seed is very high. A.myosuroides seeds germinate readily after shedding as there is no innate dormancy apart from that induced by waterlogging or deep burial. On heavy soils most seedlings emerge by the end of the year and spring germination is minor in midland and southern counties but tends to be more of a problem in eastern counties.

The problem areas for A.myosuroides are in early winter sowings, minimal soil cultivation systems and where there is poor weed control resulting from the build up of the herbicide adsorptive factor after straw burning. A.myosuroides plants surviving from the stubble of the previous crop are so well rooted as to be resistant to herbicides. Studies at the WRO (Moss 1985) have shown that cultivation of stubble ground under damp conditions allows many plants to survive into the newly sown crop if they are not sprayed with a desiccant or well ploughed. These plants can produce four times as many fertile tillers per plant compared to those arising from seed. Control measures to prevent the carry-over of these plants from the previous stubble reduce the numbers, and greatly assist the control of A.myosuroides emerging from seed in the next crop.

The level of control of A.myosuroides needs to be over 95% annually in order to contain it or offer some chance of reducing numbers. Herbicides need to be applied in the early autumn in winter cereals for maximum effect. Burning cereal straw can kill 40 - 80% of new seed (Moss 1980a), and increase germination (allowing seedlings to be killed) before sowing the next crop. The introduction of spring crops or a change in cultivation system from direct drilling or minimal cultivation systems to ploughing greatly assists herbicide efficiency. Herbicide efficiency also tends to be higher in winter break crops such as oilseed rape and field beans.

Wild-oat (Avena fatua), Winter Wild-oat (A. ludoviciana)

Avena spp, unlike Alopecurus myosuroides, are able to grow and set seed in the hedgerow vegetation and verges and so act as a reservoir of contamination, however, their density in such situations is generally low. The ability of Avena spp to germinate after many years of burial is a well known factor in their efficiency as problem weeds.

Straw burning is an aid to control measures but in comparison the mortality of shed seed on the soil surface is much higher if cultivation is delayed until December. The seed of A. fatua either dies or germinates within 2 - 3 years of shedding, on the other hand the first large seed in the spikelet of A. ludoviciana has a much shorter dormancy than the second. A. ludoviciana has a peak of germination in November and December whereas the autumn germination of A. fatua is smaller but with a peak in the spring. With both species there is less seed dormancy in a drought year and therefore more autumn germinators are likely to appear.

Ploughing-in seed does not offer a good control of Avena spp because of their long dormancy but assists in reducing numbers initially in winter sown crops when compared to minimal cultivation or direct-drilling systems. However rotational ploughing every 4 years, alternating with tine cultivation, helps to increase seed mortality (WRO 1983). Herbicides are much more important than cultural techniques as control measures on arable farms. Breaks in the cycle of continuous winter cereals, especially spring sown crops, will help to reduce populations of A. ludoviciana.

Avena spp have declined in importance relative to Alopecurus myosuroides over the last decade as a result of intense herbicide use by farmers and national campaigns organised by MAFF, WRO and commerce. However the recent WRO survey (Table 1) demonstrated that Avena spp were still the most frequently recorded species in winter cereals, and the frequency of fields infested increased from 32% (1981) to 39% (1982). In winter wheat (although the authors suggest that weather conditions preventing effective spray application may have been responsible) A. ludoviciana accounted for 17% of the total infestations, a proportion that has changed little since the 1950s (Thurston 1954).

A long term study by the WRO and ADAS on a heavy soil cereal farm near Wantage (Berkshire) demonstrated the downward trend in Avena spp that has occurred in practice (Wilson and Scott 1982). However the annual herbicide bill was very high (£47 - £65/ha), and in some years sequential sprays were applied as well as hand roguing when densities were sufficiently low. It was evident in this 8 year study that there was no equivalent decline in Alopecurus myosuroides numbers in the ley/ arable or continuous cereal fields.

Loose Silky-bent (Apera spica-venti)

This weed is not a regular inhabitant of the hedgerow flora as it cannot compete with perennial grasses. A. spica-venti is restricted to light sandy soils in eastern, south-eastern and southern counties. It produces many light seeds which are shed before harvest and is mainly a pest of winter sown cereals.

It can be competitive at high density and a reduction in the yield of grain of 30% has been recorded with a panicle density of 140 per $m^2$ in ADAS trials in the south-east region with winter barley. In some years more seed seems to germinate in the spring than the autumn, even in winter barley which tends to be sown early, but the author has no information on the behaviour of dormancy in A. spica-venti.

A. spica-venti is easily controlled by herbicides suitable for Alopecurus myosuroides control and spring application in winter cereals can be very effective.

Barren Brome (Bromus sterilis), Meadow Brome (B. commutatus), Soft Brome (B. hordeaceus)

B. sterilis is frequently found in hedgerows and verges where it behaves as an annual and biennial, and seed germinates in the shade and establishes plants. The pendulous panicles hang over the field margin and shed seed into the crop or are caught up and distributed by the combine and cultivation equipment. B. sterilis showed a dramatic rise after the dry autumn of 1977 when a large germination occurred in the spring, and proved resistant to herbicides. It rapidly colonises hedgerows, verges and ditch sides that have been damaged by fire or herbicide.

B. sterilis is a widespread problem on crop headlands in midland and western, eastern, south-eastern and south-western regions on a wide range of soils. The weed is encouraged by early sowing, especially in winter barley. B. sterilis is less of a problem on mixed farms and on infested cereal farms is mainly confined to headlands and field margins; only 10% of fields in the recent WRO survey (Table 1) had the weed beyond the headland.

B. sterilis produces many tillers, up to 10 per plant even in dense situations, each spikelet has 6 - 8 seeds with 10 - 12 spikelets per panicle. Shedding of seeds starts in July and August, which is later than A. myosuroides so there is much contamination of harvested winter barley grain. The panicles lodge as ripening proceeds and shed seeds may even germinate in the standing crop if the soil is moist. The basal seeds tend to persist on the panicle and are then liable to be dispersed in baled straw.

Seed dormancy of B. sterilis is induced by light, drought, low temperature or deep burial but seed is only viable for one year. There is a slight vernalisation requirement and spring germinating plants produce less seed. B. sterilis germinates rapidly and has more rapid root growth than A. myosuroides or Avena spp, so it becomes more resistant to herbicides at earlier stages of development. The leaves are also tough and hairy which prevents uptake of sprays. The coleoptile can grow to 13 cm but seedlings will not emerge below this depth in the soil.

Work at the WRO (Moss 1980b) and Boxworth Experimental Husbandry Farm (EHF) (Rule 1984, 1985) showed that straw burning destroyed over 95% of shed seed of B. sterilis and B. commutatus and reduced seedling emergence numbers by 94%. Seed on the soil surface declined by 85% between July and late August in the absence of burning - 44% germinated and 41% suffered post-germination mortality; ploughing to 20 cm eradicated the weed (WRO 1983).

B. sterilis and B. commutatus are headland problems because of the lack of straw burning. Heavily contaminated straw from headlands must be baled and removed and burnt to avoid spread into clean areas. Stale seedbed techniques on the headlands are not successful in dry times and good ploughing is essential for control. Survivors on the crop headland are best controlled by herbicide sequences such as triallate in the seedbed followed by isoproturon or metoxuron with the majority of weeds at not more than the three leaf stage (Orson 1981).

The cultivated gap between the hedgerow and crop is rapidly colonised by brome species because of their rapid germination and growth. The bromes are also spread in cereal seed, especially home saved.

B. commutatus is not a feature of the hedgerow flora but is a headland problem probably associated more with heavier soils than B. sterilis. B. hordeaceus is more local as a problem particularly in grassland and can populate verges. B. commutatus has taller panicles than B. sterilis and sheds seed later and so tends to cause more contamination of harvested grain. The seedlings are more prostrate with finer leaves and there is some evidence of seed dormancy. It requires the same control measures as B. sterilis but is less susceptible to isoproturon and more susceptible to metoxuron herbicides. B. hordeaceus sheds its seed earlier than B. sterilis, germinates more rapidly and is probably easier to control.

### Awned Canary-grass (Phalaris paradoxa), Bulbous Canary-grass (P. aquatica), Lesser Canary-grass (P. minor)

The Phalaris spp are not found in hedgerow habitats, and P. paradoxa is a headland problem typically in winter wheat on heavier soils. Although it is widely distributed it is only locally common but there are indications that it is spreading. Phalaris canariensis, P. aquatica and P. minor are found in arable soils at low infestations. P. aquatica is grown for game cover and is a perennial with short woody rhizomes and tuberous stem bases and can persist on verges. P. minor is also used for game cover but is spreading in arable soils from shed seed.

P. paradoxa can be introduced by contaminated cereal seed or via game cover mixtures. Potential seed production is very high and populations have been found with 1,200 panicles per $m^2$ and 100 seeds per panicle. The seed is shed in spikelet clusters but only the central spikelet is fertile. The seed starts to shed in July and August and about half can germinate immediately under suitable conditions. The rest germinate in the autumn and spring between temperatures of $5^{o}$ to $20^{o}$ C but not above $25^{o}$ C. A variety of dormancy mechanisms are involved (WRO 1983). Seedlings can emerge from 10 cm depth in the soil.

P. paradoxa is encouraged by winter cereal cropping and minimal cultivation systems but it can also be a nuisance in spring sown crops.

Ploughing is not so effective as a method of control as it is for B. sterilis because buried seed can survive for more than one year. P. paradoxa was found to be resistant to some grass weed herbicides (eg chlortoluron and isoproturon) but fortunately it is well controlled by pre-emergence applications of terbutryne, pendimethalin,or chlorsulfuron + methabenzthiazuron. These herbicides may also be used sequentially with triallate.

Diclofop-methyl post-emergence has also proved effective in controlling P. paradoxa provided the weed has not more than 3 to 4 leaves at spraying (Martindale and Livingston 1982).

## Perennial Grass Weeds

The perennial grass weeds spread by rhizomes, stolons and bulbils but seed production is also important in Agrostis spp, Poa spp and Arrhenatherum. They are important constituents of the stable hedgerow flora, and if damaged by fire or herbicide are rapidly replaced by annual weeds such as B. sterilis and Galium aparine which consitute a greater hazard to arable crops.

### Couch-grass (Elymus repens), Black Bent (Agrostis gigantea), Creeping Bent (Agrostis stolonifera)

These grasses are frequent inhabitants of the hedgerow, ditch-side and verges, the Agrostis spp preferring lighter soils. Agrostis stolonifera is also common in old pasture and its seed remains viable for some years when buried. The rhizomes of E. repens invade the field area from the hedgerow and are spread by cultivations - shed seed is less important as a means of spread. Seed production is much higher in Agrostis spp and the light seed is readily dispersed.

Although control measures have greatly improved in recent years, the 1981 WRO Survey (Table 1) indicated that E. repens was still one of the most widespread weeds in cereals, particularly in spring barley. However the infestation levels were less severe than P. trivialis or A. myosuroides.The percentage of fields infested with Agrostis spp was much lower than with E. repens.

Repeated cultivations between crops help to control the rhizomes and stolons of E. repens and Agrostis spp, or various herbicides can be applied to the weed regrowth in stubbles, whilst selective graminicides will suppress growth in broad-leaved crops. However, the most effective current control measure is the pre-harvest application of glyphosate in cereals. E. repens and Agrostis spp are most susceptible to glyphosate at the emergence of the inflorescence when there is plenty of leaf to intercept the spray. Glyphosate uptake is greatly enhanced by adequate soil moisture and high relative humidity so that spraying late at night or when there is dew on the leaf is advocated. However, light is necessary for the translocation of glyphosate to the rhizomes. Great care is needed when applying pre-harvest glyphosate to avoid damage from drift to the hedgerow vegetation.

### Rough Meadow-grass (Poa trivialis)

P. trivialis is frequent on ditch sides, verges and pastures. It is not as common as E. repens in hedgerows, so the field margin is not an important source of spread. The 1981 WRO Survey (Table 1) showed that P. trivialis was one of the most widespread weeds in extent and severity of infestation in winter cereals. It was not found in spring barley because of its vernalisation requirement. In the survey fewer fields of winter barley were found to be infested compared to winter wheat, particularly in the east of the survey area, but in the south-west it is a severe problem in winter barley probably because of its tolerance to shading and preference for moist soil conditions.

It spreads by means of a high seed production rather than vegetatively although it is perennial. Buried seed remains viable for some years and has a vernalisation requirement. A recent study at the WRO (WRO 1983) showed differences in the behaviour of P. trivialis seed collected from long term arable or grassland habitats. Seeds from arable populations had longer dormancy and there were indications that differences in dormancy and response to light quality and depth of burial were genetically controlled (WRO 1983).

ADAS trials have shown that P. trivialis can reduce the yield of cereal grain but that it is readily controlled by herbicides, and as lower rates of herbicide are effective for controlling P. trivialis it is cheaper to control than A. myosuroides. In spite of its high seed production and dormancy and longevity of buried seed, it does not seem to constitute such an economic problem as A. myosuroides which has larger effects on cereal yield.

False Oat-grass (Arrhenatherum elatius), Onion Couch (Arrhenatherum elatius var bulbosum)

A. elatius is one of the most frequent species inhabiting hedgerows and verges and is not distinguishable from var. bulbosum. Seed from a single plant produces a whole range of types from those with no bulbils to those with several. Each bulbil is capable of producing a plant.

var. bulbosum is a difficult weed on deeper and more fertile brash soils and chalks of the south. However its frequency of occurrence and severity of infestation were found to be low in the 1981 WRO Survey (Table 1). In the field it tends to form small dense patches from which the rate of spread tends to be slow although the bulbils multiply at a high rate.

var. bulbosum propagates from a large seed production which sheds before harvest in winter wheat and by the mechanical dispersal of bulbils by cultivations. The seedlings of var. bulbosum are very easy to control by herbicides but control of the bulbils by chemicals or cultivations is very difficult.

In ADAS trials the treatment of infested crops with L flamprop-isopropyl at Zadoks crop growth stage 32 significantly reduced panicle numbers by over 60% and the seeds in the surviving panicles were only 20% viable. Repeat treatments over three years gave 86% control by weight of bulbils (Temple pers comm). Bulbils increase at a very high rate in the absence of cultivations; in a WRO study (Ayres 1981) they multiplied by a factor of 34 over two years but by only 1.3 after late ploughing in December. Minimal cultivation or direct drilling systems for cereals allowed a large increase in bulbils. Stubble treatment with glyphosate has given very variable results due to the lack of new shoot growth and low numbers of shoots per bulbil. Pre-harvest applications of glyphosate were also variable in control because of the early senescence of the foliage of var. bulbosum in winter wheat. Spring applications of specific graminicides in broad-leaf crops such as peas, beans and oilseed rape may give better control of var. bulbosum than post-harvest treatments in the autumn but further work is needed on this aspect.

## Broad-leaved weeds

The majority of dicotyledons found in the hedgerow community are woodland shade-loving species and are not a significant source of arable weeds, with the important exception of cleavers (Galium aparine).

### Cleavers (Galium aparine)

G. aparine is common in hedgerows and verges and spreads onto headlands. It is one of the most widely distributed broad-leaved weeds and of great economic importance in winter sown crops. G. aparine is found on a wide range of soil types but growth is better on clay loams because of its susceptibility to drought on light soils.

G. aparine has a very high potential for seed production and is encouraged by early sowing of winter cereals under minimal cultivation systems, but work at the WRO (Froud-Williams 1984) does not seem to suggest that ploughing alters the population dynamics of the weed. The seed in the soil loses dormancy in the autumn but regains it in the spring until it becomes totally dormant from May to August. High temperature in the summer breaks dormancy but seeds do not germinate until the temperature drops in the autumn (Froud-Williams 1984).

Work at the WRO (Froud-Williams 1984) has also suggested behavioural differences between long-term arable and hedgerow populations of G. aparine. Hedgerow G. aparine has a lower growth rate and the seed exhibits less dormancy, germination also occurs over a wider range of temperatures with optima between $10^{o}$ to $14^{o}$C compared to $9^{o}$ - $12^{o}$C for 'arable' G. aparine. Light promotes the germination of G. aparine but seeds on the soil surface are very susceptible to straw burning and to high post-germination mortality. Seedlings are able to emerge from 10 cm depth in the soil but optimum emergence is from 5 cm. Froud-Williams concluded that hedgerow populations of G. aparine are unlikely to present a major weed problem in arable crops.

G. aparine is of economic importance because it interferes with cereal harvesting and contaminates the grain sample. Direct competitive effects are severe and per capita probably more important than the the effects of annual grass weeds on yield. G. aparine is twice as competitive as Stellaria media and similar low growing broad-leaved weeds. Competition occurs from emergence and continues after ear emergence of the cereal, so much so that fertile tillers, grains per ear and grain size are all reduced (Peters 1984). Low numbers of G. aparine (5 - 10 per $m^2$) can have significant effects on the yield of cereals if soil moisture is adequate.

Herbicides are efficient in controlling G. aparine but sequential autumn and spring spray applications may be necessary in winter cereals to prevent seed return. The level of control is generally poor in winter sown oilseed rape and this increases the burden of seed on the other crops in the rotation.

## SPECIFIC WEED PROBLEMS ASSOCIATED WITH HEADLAND CONDITIONS

In cereals the headland area is associated with problems of soil conditions which are not ideal for optimum crop growth, or the activity of soil applied herbicides. Levels of weed control on the headland need to be of a very high order to cope with the extra large numbers of weeds associated with this area and so prevent spread to the rest of the field. This is particularly so in those fields where disturbed hedge and field margins are severely infested with economically important weeds which have high rates of seed production.

The soil of the headland may be badly compacted due to the turning of cultivation implements and after harvest dry conditions and compaction reduce the efficiency of the plough in terms of penetration and inversion, so that trash and weed seeds are not effectively buried to a suitable depth.

Soil compaction problems and the formation of clods reduce the activity of residual herbicides which are the main tool in the fight against grass weeds. In addition shallow sowing resulting from compaction or the breakdown of clods during weathering can lead to herbicide damage and less competitive crops. There is also more physical damage to the growing crop because of implements turning on the headland, whilst overlapping during spraying increases the chances of chemical phytotoxicity.

## THE HEADLAND AS A FIREBREAK AREA

As a result of the new regulations governing the burning of cereal straw, 15 or 25 metres of straw need to be cleared from the headland and 5 metres of it ploughed or cultivated. The headland straw is frequently full of seeds and needs to be baled and carted or otherwise moved to an area where it can be thoroughly burnt, so that it does not contaminate the rest of the field.

A most important factor is that the firebreak area does not now benefit from straw and stubble burning. High levels of control of shed weed seeds by straw burning have been demonstrated by the WRO (Moss 1980b) with over 80% mortality of Avena spp, Bromus spp and A. myosuroides seeds. Over 90% control of Bromus sterilis and B. commutatus was found at Boxworth EHF after the straw was burnt (Rule 1984, 1985).

Because the headland constitutes an area of potential weed build-up on arable fields, many farmers consider it cost effective to apply sequential herbicide treatments to the headland area (eg triallate granules followed by isoproturon).

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# FIELD MARGIN FLORA AND FAUNA; INTERACTION WITH AGRICULTURE

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## ABSTRACT

Field margins are viewed as sources of weeds, pests and diseases by arable farmers. Work at Long Ashton is examining the validity of that perception. Weed distributions relative to the field boundary are described. Some weed species originate from the hedgerow, but most do not. Both beneficial and pest invertebrates occur in field margins. Interactions are illustrated between cereals, grasses, aphids and barley yellow dwarf virus.

## INTRODUCTION

Field margins are a traditional part of the lowland landscape in Britain. Their original function of containing stock has largely disappeared under arable cropping in the eastern counties of England. Thus hedges have been viewed with a jaundiced eye by many arable farmers. Nevertheless field margins constitute the commonest element of non-cropped land on the farm and present a potential haven for wildlife. Whilst a wide variety of plant and animal species is probably desirable from a conservation view point, some restrictions on both fauna and flora may be necessary if agricultural interests are considered. The perception that field margins are a source of weeds, pests and disease is widespread but needs critical examination. To make judgements about which species should be encouraged and which discouraged requires an understanding of the way in which crops may suffer or benefit from hedgerows, and how agricultural practices can affect hedgerow plants and animals. An understanding of the ecology involved can be used to develop and put into practice suitable management to satisfy the requirements of farmers, and of wildlife conservation in non-cropped areas. At present we have very inadequate knowledge about the processes involved. The extent to which species are useful or detrimental to agriculture depends largely on the cropping pattern; for one crop, natural enemies of aphids may be required, for another crop an increase in insect pollinators. The same hedgerow-supported species may be pests in one crop but not in another, and rotational farming will inevitably bring rapid changes in the pest status of some species.

In this paper we discuss the status of the ground flora of the hedgebottom and the role of its insect fauna in relation to arable fields. Particular attention is given to cereal fields, though the importance of the field margin in grass farming may be as great as in arable.

## SURVEY OF FARMING PRACTICE

An interview survey of farmers was carried out in the Arable Section at the 1985 Royal Agricultural Show at Stoneleigh, Warwickshire. Details of headland, field edge and hedgerow management were sought from farmers growing cereals. One hundred and sixty three respondents, each growing at least some cereals, were questioned about their cereal field edges, including the flora. Approximately a quarter of farmers either drilled at double rate, sprayed extra pesticides or carried out other activities on the crop edge. The remainder farmed the crop edge similarly to the rest of the field. In answer to a further question, 30% of the farmers reported that they created a barrier strip between the crop and the hedgebottom. Where herbicides were used to create a barrier, glyphosate and paraquat were the most common. Most farmers cultivated up to the hedge base. Surprisingly, 60% of farmers said they used herbicides in the hedgebottom. In this high proportion there was no differentiation between regular hedgebottom spraying and occasional nettle (Urtica dioica) or thistle (Cirsium spp) patch spraying. Nevertheless, the practice of hedgebottom spraying appears to be more common than previously supposed. The overriding motivation for management at the cereal field edge was for weed control, indicating a perception that field edges harbour weeds which spread into the field. The main threats were thought to be barren brome (Bromus sterilis) and cleavers (Galium aparine), both of which have, until recently, been poorly controlled by herbicides in the field.

## THE FLORA OF FIELD MARGINS

The hedgerow has been described as a form of woodland edge habitat, which typically maintains a high diversity of plants and animals. Studies have shown that approximately a third of the British flora has been recorded from hedges (Pollard et al 1974). None can be called a true hedgerow species, in that none is found exclusively in that habitat. However Hooper (1970) stated that hedge removal may seriously affect uncommon species, particularly those rare species which have a high proportion of their populations in hedges.

The hedgerow has also been thought to act as a "corridor" for wildlife on farmland. This may be true for some groups, though woodland plants appear unable to spread easily along hedges (Helliwell 1975). A review by Way (1972), using data from the Warwickshire County Flora, included an analysis of the comparative occurrence of crop weed species in cropped and non-cropped areas, including hedges.

## PLANT SURVEYS

A series of plant surveys has been carried out by one of us (EJPM) on three farms, one in each of three counties, Cambridgeshire (Boxworth Experimental Husbandry Farm - EHF), Essex (Bovingdon Hall) and Hampshire (The Manydown Estate), with the purpose of examining the influence of the field margin on crop weed floras. Plant species in the hedgebottom and in the crop were recorded and numbers are shown in Table 1.

Only about 25% of the hedgebottom species also occurred in the field at 5 m or further from the hedge, and it is concluded that only a limited number of hedgebottom plant species is likely to appear as field weeds in cereals. Although, over the whole study many species occurred in both hedgebottom and crop, only a few were consistently recorded (Table 2).

**TABLE 1**

Numbers of plant species in the hedge, the field and in both locations on three farms

| Site | Number of fields | Mean numbers of species | | |
|---|---|---|---|---|
| | | In hedge | In field | Common to hedge and field |
| Cambridgeshire | | | | |
| Boxworth 1984 | 5 | 24.6 | 14.2 | 5.2 |
| Boxworth 1985 | 5 | 23.2 | 15.6 | 7.0 |
| Hampshire | | | | |
| Manydown 1984 | 12 | 25.5 | 16.7 | 6.0 |
| Manydown 1985 | 9 | 19.8 | 10.7 | 2.1 |
| Essex | | | | |
| Bovingdon Hall | 24 | 23.5 | 7.0 | 3.5 |

**TABLE 2**

Plant species found consistently on three farms both in the hedgebottom and in the field beyond 5 m. Data are the number of sampled fields where the species was common to hedge and field.

| | Boxworth | | Manydown | | Bovingdon Hall |
|---|---|---|---|---|---|
| | 1984 | 1985 | 1984 | 1985 | 1985 |
| Number of study fields: | 5 | 5 | 12 | 9 | 24 |
| <u>Elymus repens</u> (Common Couch) | 4 | 4 | 5 | 1 | 8 |
| <u>Alopecurus myosuroides</u> (Black-grass) | 3 | 1 | 7 | 2 | 15 |
| <u>Poa trivialis</u> (Rough Meadow-grass) | 0 | 2 | 11 | 5 | 0 |
| <u>Bromus sterilis</u> (Barren Brome) | 4 | 5 | 4 | 0 | 3 |
| <u>Galium aparine</u> (Cleavers) | 5 | 4 | 7 | 3 | 11 |
| <u>Convolvulus arvensis</u> (Field Bindweed) | 2 | 2 | 1 | 0 | 8 |
| <u>Fallopia convolvulus</u> (Black-bindweed) | 1 | 0 | 4 | 1 | 3 |
| <u>Cirsium arvense</u> (Creeping Thistle) | 1 | 0 | 3 | 1 | 2 |
| <u>Veronica persica</u> (Common Field-speedwell) | 0 | 2 | 5 | 1 | 6 |

The occurrences of known field weeds (cf Froud-Williams and Chancellor 1982; Chancellor and Froud-Williams 1984) only in the hedgebottom flora are also shown in Table 3 .

**TABLE 3**

The number of sampled fields (out of 55) where common weeds were recorded, and numbers of fields where species were found only in the hedge or only in the crop. Species in decreasing order of incidence (after Chancellor and Froud-Williams 1984).

| Species | No of fields recorded | No of fields in hedge only | No of fields in crop only |
|---|---|---|---|
| Elymus repens (Common Couch) | 52 | 26 | 4 |
| Avena fatua (Wild-oat) | 22 | 7 | 4 |
| Alopecurus myosuroides (Black-grass) | 45 | 4 | 15 |
| Poa trivialis (Rough Meadow-grass) | 51 | 33 | 0 |
| Bromus sterilis (Barren Brome) | 44 | 26 | 2 |
| Galium aparine (Cleavers) | 51 | 18 | 3 |
| Viola arvensis (Field Pansy) | 26 | 2 | 23 |
| Convolvulus arvensis (Field Bindweed) | 42 | 23 | 6 |
| Myosotis arvensis (Field Foreget-me-not) | 29 | 12 | 10 |
| Stellaria media (Common Chickweed) | 29 | 4 | 19 |
| Polygonum aviculare (Knotgrass) | 36 | 5 | 25 |
| Fallopia convolvulus (Black-bindweed) | 34 | 1 | 24 |
| Rumex obtusifolius (Broad-leaved Dock) | 17 | 14 | 2 |
| Cirsium arvense (Creeping thistle) | 37 | 28 | 2 |

Bromus sterilis is a hedgerow species that has become a field weed, particularly under minimum-cultivation techniques (Froud-Williams et al 1980). The data show that in about 60% of fields where B. sterilis was found it was absent from the crop. It may therefore be reasonable to propose that hedgerow species are those with a 60% or greater occurrence only in hedgebottoms. These data may therefore indicate that the grasses P. trivialis and A. fatua are hedgerow species. Among the dicotyledonous species, R. obtusifolius and C. arvense are probably also hedgerow species that spread into the crop. While F. convolvulus was commonly found in both crop and hedge (Table 2), it appears not to be a hedgerow species. G. aparine, thought to be a hedgerow species, occurred in hedges alone on only 18 fields (35%) out of 51 in which it was recorded. This would perhaps support the hypothesis that there are differences between field and hedgerow populations of the species (Froud-Williams 1985). However, these data may not portray the entire picture, in that species capable of highly efficient dispersal would not be expected to be recorded in the hedge alone.

The distributions of plants relative to the hedge have been mapped in detail at Boxworth and Manydown. Data collected at Manydown Estate indicate four distribution patterns relative to the hedge (Marshall 1985a):

(I) limited to the hedgebottom
(II) limited to the field
(III) present in the hedge and at decreasing density into the field
(IV) other patterns

Field distributions (Type II) were found for the typical annual broad-leaved weeds of cereals, such as P. aviculare. Type III distributions were recorded for species such as C. arvense, G. aparine, P. trivialis, E. repens and B. sterilis.

Examination of plant distributions in 5 m transects traversing the hedgebottom out into the crop have been made at Boxworth, counting plants in 10 cm by 10 cm areas within a $0.25m^2$ quadrat. Species in the hedge which shed seed or spread by rhizomes can establish in the field area next to the hedge. The majority, however, have poor dispersal and survive only close to the hedge.

Dispersal of plants from the hedgerow occurs by a variety of means. Vegetative spread can occur, eg by rhizome growth of E. repens. Seeds can drop from tall plants into the field edge. Wind disperses some species into the field and the activity of insects, birds and mammals (man included) may move some seed into the field (eg Fenner 1985). Once the plant or propagule has reached the crop, there are opportunities for further movement into the field by mechanical means. The combine harvester will move seed considerable distances. Soil cultivations may also move seed (Fogelfors 1985). However, important questions remain. How significant are edge populations in maintaining field populations of weeds? What conditions favour spread and can soundly based management limit economically significant spread?

**INSECTS OF FIELD MARGINS**

The distribution of insects within and adjacent to hedges depends on the flora and many other factors. It varies with species and whilst some stay close to the hedge others move well into adjacent crops. The walkers spread less than the fliers but this is a subject on which much more information is needed. We also need to know more about insect/plant relationships. However, from existing knowledge of the geographical distribution of species, of their preferences for certain soil types and habitats, and of their biology, it is possible to make some predictions about which plant and insect species are likely to be found in and around certain types of hedgerow. There are opportunities to test such predictions in the studies now being done at Boxworth and Manydown.

Hedgerows may provide some fauna with essentials such as shelter and food on a temporary basis, but for others an association with hedgerow plants may be vital for the survival of the species in that area. For example, some aphid species overwinter as eggs on perennial plants found in hedges; Metopolophium dirhodum on wild rose (Rosa spp.), Sitobion fragariae on bramble (Rubus spp), and Rhopalosiphum padi on bird-cherry (Prunus padus). These aphids also live on grasses and can transmit Barley Yellow Dwarf virus (BYDV) from them to cereals. In predicting the risks to cereals it is valuable to know the origins of such aphids because BYDV does not persist through the egg stage. Aphids are also important because they are links in food chains which enable their natural enemies, and those of other pests, to survive.

In addition to supporting populations of predators and pests, hedgerows provide habitats for other types of beneficial fauna such as pollinators. There is much scope for manipulating the flora to provide nectar and pollen sources for wild bees and other pollinating species, especially adjacent to crops where hive bees have to be introduced to pollinate the crop.

## EFFECTS OF DISTURBANCE ON PLANTS

The hedgebottom is prone to periodic disturbance which takes several forms, including cultivation, burning and agrochemical application or contamination. Fertilizer drift is held to be a major factor in vegetation change. High soil fertility will allow dominance of only one or two aggressive ground flora species at the expense of low-growing species and thus lead to low diversity (Green 1972). The effects of fertilizer and patterns of deposition in the hedgebottom have yet to be studied, as have those of burning. The influence of herbicide application and drift on the hedgebottom flora is a subject of study at Long Ashton.

## HERBICIDES AND HEDGEROW FLORA

It is now accepted that the application of broad-spectrum translocated herbicides to hedgebottoms is counter-productive. Most of the troublesome field weeds are annual species relying on seed return for survival. When the mainly perennial hedgerow species are eliminated, bare ground conditions favour seed germination of annuals, such as G.aparine. The increased incidence of Bromus sterilis, a typical component of hedgerows at low populations, is due to the creation of bare ground suitable for germination. It seems sensible, therefore, to encourage a good vegetation ground cover of mostly perennial species.

To assess the effects of general applications of herbicides on field edge floras, two approaches are being used at Long Ashton. In the first, pot-grown hedgerow plants are being sprayed with cereal herbicides and plant growth-regulators (work sponsored by the Perry Foundation). In the second, field and field-edge floras are being monitored under conditions of contrasting herbicide use. Within the Ministry of Agriculture, Fisheries and Food (MAFF) Boxworth Project (Stanley and Hardy 1984), the floras of fields are being monitored on areas receiving either Prophylactic spraying, Supervised treatments (applied only when thresholds are exceeded), or Integrated treatments (where cultural operations are used to further reduce pesticide input).

Pot experiments testing the effects of herbicides applied at recommended field rates are showing which species may be affected by inadvertent applications to field margins. Preliminary results have been reported by Birnie (1984, 1985) and Marshall and Birnie (1985). So far mecoprop has been shown to affect the greatest number of the species under test. Other broad-leaved herbicides were more limited in their effect and present less of a potential threat to the field margin.

In the Boxworth Project, treatments have been imposed for two full seasons and data are available for a season prior to that. Differences have been recorded in the field flora (Marshall 1985b). Changes in the flora of field edges are equivocal, with perhaps a trend on one Integrated field (see above) towards increased diversity in the hedgebottom following the imposition of treatments.

The data so far confirm that field applications of herbicides can potentially affect field margin floras. Direct applications, even if accidental, will certainly affect the ground flora at the hedge base. In general, disturbance of the hedge by physical or other means appears to be counter-productive both for arable cropping and for wildlife conservation.

## INFLUENCE OF CROP AND FIELD MARGIN MANAGEMENT ON INSECTS

Cereal aphids are widely distributed and important crop pests and provide a good example of how management of hedgerow and of crop interact, and affect the fauna. Those aphids which are pests of cereals have a wide range of host plants in the Gramineae, including many species of grass which are found either as weeds in the crop, or in hedgerows, or in both situations. These grasses are not all equally good aphid hosts and the risk to adjacent crop plants may vary according to species, its abundance, and its distribution (Smith et al 1984). However, a greater threat to crops comes from BYDV, the most important virus transmitted by aphids from grasses to cereals. Strains of this virus are not equally well transmitted by all the cereal/grass aphids; the most damaging strain is carried by *Rhopalosiphum padi*. When the reproductive rate of the two most important cereal aphids is compared on different grasses (Table 4) it can be seen that there is considerable variation between both aphids and plants (Wright et al 1984).

**TABLE 4**

Number of 4th and 5th instar aphids produced by 10 aphids in 10 days from the onset of reproduction

| Host grass | *Rhopalosiphum padi* | *Sitobion avenae* |
|---|---|---|
| *Bromus sterilis* (Barren Brome) | 11.47 | 6.76 |
| *Avena fatua* (Wild-oat) | 9.64 | 8.56 |
| *Poa trivialis* (Rough Meadow-grass) | 9.25 | 7.46 |
| *Arrhenatherum elatius* (False Oat-grass) | 6.76 | 5.56 |
| *Agrostis gigantea* (Black Bent) | 6.53 | 4.95 |
| *Elymus repens* (Common Couch) | 5.40 | 4.27 |

LSD (p = 0.05) : ± 0.71

B. sterilis is a good aphid host and a good host for BYDV. Work in progress aims to determine how closely aphid susceptibility relates to virus susceptibility in a range of grasses; early results show that Poa spp are also good virus hosts. We have yet to detect virus in Elymus repens and Agrostis gigantea. Thus, improvements in prediction of BYDV risk to cereals from grasses will require knowledge of both aphid and host plant distribution, and of aphid/host-plant/virus relationships. Such knowledge will help to identify those plants which can or cannot be tolerated in field margins from the cereal farmers point of view. The need to improve such predictions has become urgent as a result of two major changes in farm practice. Firstly, the BYDV problem has increased because of emphasis on early drilling of winter cereals, which results in crops being at a susceptible stage when autumn aphid migrations occur. Secondly, incorporating straw rather than burning it, with the requirement to cultivate headland strips, will benefit a range of insect species, but it will also result in more volunteer cereals and other weeds. Such "green bridges" between crops may necessitate more herbicide treatments. We have shown that treating grassy stubbles with paraquat or glyphosate at least one week before ploughing can significantly reduce BYDV in the following cereal crop. Paraquat is more effective in this respect than glyphosate, and this may be explained by another recent Long Ashton finding, that paraquat, unlike glyphosate, is directly toxic to aphids. Thus, direct as well as indirect effects on fauna can occur through the use of herbicides. The effects of these and other herbicides on a range of invertebrate species are now being investigated.

If grasses, in or adjacent to hedgerows, are to be managed rather than killed, and this is to be done with plant growth-regulators, then choice of chemical could be influenced by its effect on fauna. For instance, our laboratory tests show that mefluidide treatment can allow aphids to double their reproductive rate on some grasses. If chemical treatments lead to increases in species like aphids, there may be benefits for their predators, but if, as pests, they are encouraged, particularly at early crop growth stages, there may also be undesirable agricultural consequences. Effects of chemicals are likely to have greater overall impact on fauna if deliberately sprayed into hedge bottoms than as a result of spray drift, but more quantitative data are needed.

Hedgerows can also affect the distribution and abundance of insects because they act as windbreaks (Lewis and Stephenson 1966). Insects and weed seeds will be deposited in the sheltered zones behind hedges as if they were inert particles, thus extending the influence of the hedge. Knowledge of the height and porosity of a hedge and the windspeed enables the sheltered zones to be identified. It may be possible to use such information when winds are blowing in particular directions, to predict where migrant airborne invertebrates and weed seeds will be concentrated, at least initially. Studies have certainly shown differences in the fauna of hedges of different structure (Sotherton et al 1981). The physical effects of hedges may need to be considered together with biological factors in field margin management.

**FIELD MARGIN MANAGEMENT**

Before setting out management options, the reasons for having a hedge need to be defined. An ecological perspective can then be useful in selecting suitable regimes. The requirements of a hedgerow can be divided into agricultural, landscape and wildlife considerations. In simple terms the farmer requires a boundary which does not adversely affect the crop, the environmentalist requires optimum wildlife diversity, and the landscape architect is looking for visual diversity. These objectives should be compatible.

The ecological perspective on the botanical side gives us the following generalisations:

- ground vegetation needs to be managed to interrupt succession to shrub and tree cover

- diverse habitats tend not to exhibit dominance by one or two species at the expense of others (cf brome-dominated hedges)

- optimum growth conditions (ie few limiting factors and high fertility) favour dominance and low diversity

- bare ground is typically colonised by prolific seeding annuals

Therefore we should accept that some form of regular maintenance is necessary to keep shrubs in check. Fertilizers should not be allowed to contaminate the hedge. Bare ground will encourage annuals.

An annual or biennial trim of the hedge is usually extended to the hedge base. The ground flora can be cut post-harvest but should not be scalped so that bare ground results. The hedge base should not be sprayed or fertilized. Present experience indicates that once the hedge base is sprayed out, a farmer will be obliged to carry out routine spraying because annual weeds are encouraged.

Management of weed break between crop and hedge

There is interest in the creation of weed breaks between crop and field margins. This break can be bare ground created chemically in spring or early summer, or by rotavating a strip periodically through the season. In a situation where potential weeds in the hedge are at low levels it is questionable whether a weed break is necessary, especially if it introduces the risk of spray contamination of the hedge base. Bare ground is difficult to maintain. More information is needed to decide whether faunal movement is restricted or increased on bare ground and the significance of this to the adjacent crop. In situations where the hedge base is a mass of field weeds, the sterile strip may offer positive benefits by creating a weed break, by facilitating harvest, and by allowing operations to establish a stable hedgebottom flora. Current ADAS trials work may provide the required information here. Preliminary results from Long Ashton on controlling the flowering of B. sterilis by cutting and the use of growth-retardants has been disappointing. Chemical control, followed by cutting to encourage perennials, and possibly seed introduction, may prove the way forward. Experience on rehabilitating hedges infested with G. aparine is lacking.

The insertion of a grass strip between the crop and the field edge may be a good way of rehabilitating the degraded flora of hedgebottoms. If a suitable seed mixture was established and then managed by a late season cut, perennials should be encouraged and the annuals decline. Such a strip might be managed to encourage beneficial fauna. Some farmers have had grass strips for centuries, but we have no information on how they were established.

## CONCLUSION

In conclusion, if the hedgerow is not farmed (no soil disturbance, fertilizer, herbicide) and inputs kept to a minimum, but some physical maintenance carried out, then a reasonable flora should be maintained. Some weed species will occur naturally in the hedge bottom. However, the incidence of such weeds should be at low populations, and normal farming operations in the field proper should adequately control those plants which are dispersed out into the field. The balance between beneficial and pest invertebrates and their interactions with plants in the field edge and with crop plants requires much further study.


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