FIELD MARGINS - AN AGRICULTURAL PERSPECTIVE

M B HELPS

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SUMMARY

Field boundaries require periodic maintenance which has been and is now generally carried out by the occupiers of the farmland.

Hedges provide shelter for some distance into the field, but on balance these benefits are limited in all but relatively specialised situations.

The greatest area of controversy on field margins is in arable farming landscapes. The problems here are the relative neglect of the hedges and the farmers concern that weeds that develop under the hedge or on the headland can spread into the field.

In mixed or livestock farming districts, fields tend to be smaller, the length of hedges/unit area greater and the hedge itself is seen as more useful as a livestock barrier. However, there are some reservations about the value of hedges in livestock farming systems.

INTRODUCTION

This is very much an agricultural perspective representing, I hope, the reasonably well-informed farmer's view of field margin management. It is recognised that hedges are a valuable ecological resource and the extent of that resource will be emphasised in the later research papers. Field margins, with their associated farm hedges, ditches, headlands and field corners are a characteristic feature of much of lowland England. In our uplands, the place of the hedges can be taken by stone walls in all their varied forms.

In many of our landscapes these field boundaries and field margins are the only semi-natural feature. Even these have to be subjected to some degree of management if the landscape is to survive in its present form. Even so, hedges and associated field margins are subject to constant changes, either improving or deteriorating. The changes are inevitably going to please some interest groups and displease others. Carter (1983) estimated that the 500,000 miles of hedges in the country stood on an area of land that exceeded that of all this country's nature reserves put together. The annual cost of hedge maintenance of these hedges was estimated at £2m. a year (Hall, 1978).

Hedges at ADAS Drayton

ADAS Drayton research centre near Stratford-upon-Avon extends to 200 ha, with soils derived from the Lower Lias, and is typical of a large proportion of the Midland

Clays. The farm is divided into 33 enclosures, ranging from 0.8 to 13 ha and includes approximately 16.6 km of hedges. Average field size is 5.6 ha and we have 89 m hedge/ha.

Recommendations as to an ideal length of hedge/unit area are limited. Records on this are available from surveys of specific areas (e.g. Pollard et al 1974). More recently a range of 60-80 m/ha has been suggested to retain a high density of birds and a broad range of species (Lack, 1992). This means an average field size of between 4 and 7 ha. He comments that with more hedge than this there will be a higher overall density of birds but perhaps fewer species, with those that prefer open areas dropping out. With fewer hedges the overall bird density and the number of species both fall.

Table 1. Length of hedge per hectare for different agricultural situations

		m/ha
Arable area	1969	57.25
Grassland area	1969	89.84
ADAS Drayton	1993	89.10

Land use on Drayton is mixed, with combinable crops (mainly winter wheat), long leys and some permanent grass. The livestock includes both cattle and sheep.

Environmental issues, including some work on farm hedges and field margins, have been a part, but only a part, of the centres experimental programme in recent years, but all our work has been carried out in the context of productive farming systems appropriate to our geographic situation.

Hedges are mechanically trimmed to approximately 1½ m high x 1½ m wide, most of them annually - some in late August/early September and the remainder in December/January. A proportion are left to grow taller with periodic side trimming. Some of the hedges have obviously been laid, at least once, in the distant past, but there is no record of hedgelaying in recent years. Hedgerow trees in the district were decimated by Dutch Elm disease but some Oak (*Quercus* spp) and Ash (*Fraxinus excelsior*) remain and new plantings in field corners and some shelter-belts are developing. Our current species lists include 209 plant species and 63 bird species, 28 of which are breeding on site.

It is my brief to raise topics and issues from an agricultural perspective so I will deal with the subject under the following headings and leave other speakers to deal with issues from the conservationist's point of view.

1. Frequency of hedge trimming and cost
2. Shelter
3. Arable cropping
4. Livestock husbandry

FREQUENCY OF HEDGE TRIMMING AND COST

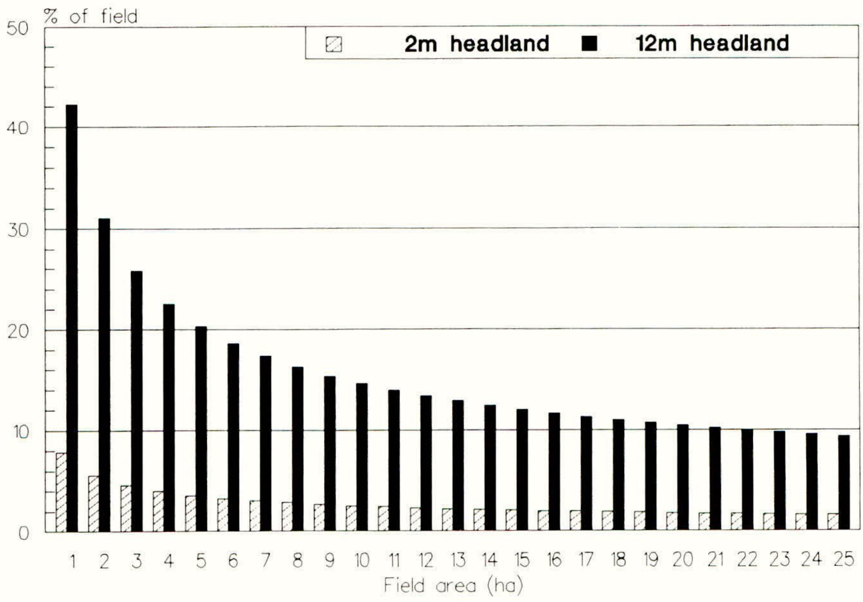
Hedges were originally planted by farmers/landowners for two purposes.

1. To mark boundaries
2. To prevent livestock from straying.

If they are to exist at all any field boundary has to be managed. For any hedge this will mean some form and frequency of cutting, for a ditch some form and frequency of cleaning and for a drystone wall some necessary repairs. Without this management, margin structures will sooner or later become dilapidated. The fact that our landscapes look as they do is because those who have been managing the land in the past have devoted time and money to the maintenance of field boundaries. In general terms I suggest that the farming community must have managed their hedges and field boundaries reasonably over a long period of time, otherwise there would be fewer hedges in the landscape than there now are.

Field size governs the length of hedge per unit area and also the proportion of land covered by hedges and their associated field margins. It can also have an important influence on the work rate of field machinery, through its effect on the amount of turning per unit area and therefore the amount of unproductive time. The proportion of compacted headland will be greater in smaller fields. The relationships between field size and hedge and headland area is illustrated in Fig. 1. From the logistical point of view there is a lot to be said for 20 ha fields!

Figure 1. Area of headland as a percentage of field area



Perhaps, once upon a time, it was possible to trim hedges by hand between haytime and harvest and lay a proportion of hedges each winter. This is now almost impossible. Hedge trimming between late July and early August would nowadays be discouraged because of likely damage to nesting birds.

Over the last 50 years the workforce on farms has roughly halved and farming systems have changed considerably. Not only are fewer staff employed, but farm systems have changed and there is little "spare" time. The usual method of hedge management today is trimming with a flail cutter - often done by a local contractor. Even when this machinery is being used the job competes for a tractor and driver with other essential work. Hedge laying is now very expensive, relative wages of farm staff have increased and this job has not benefited very much from mechanisation. In addition to the problem of cost and availability of labour, hedges to be laid would have to be allowed to grow for some years before the job was done. This would allow climbing plants to develop, encourage gaps in hedges and reduce their value as stock-proof barriers.

The range of costs today is about
£2/m - £3/m for laying and
£0.07/m - £0.17/m for machine trimming

The desirable form or shape of hedge gives rise to much disagreement. Even people who share a strong interest in ornithology can be divided on this point, according to their relative interest in song birds, gamebirds or raptors. From the agricultural point of view, the shape and size of hedge that needs the fewest passes with the hedgecutter has much to recommend it. Subtleties of hedge trimming can be difficult to put into practice if using a contractor. The timing of hedgecutting can also give organisational problems to arable farmers. It is desirable to leave seed and berries on the hedges as late as possible, as a food supply for birds and small mammals. However, if the hedge is only accessible from a ploughed field, the hedge may have to be trimmed before the autumn crop is drilled in mid October, to avoid difficult travelling conditions on the cultivated and drilled headland during the winter.

Frequency of cutting is a subject of potential difficulty. Hedge cutting is undoubtedly easier if it is done annually on all hedges. The softer growth is easier and neater to cut with less visible damage and possibly less risk of die back. However, there are points in favour of longer periods between cutting a proportion of hedges on a farm. Before deciding which hedge could or should be left, it is desirable to consider the species mix and structure of the hedge. Some species will, if left unchecked, cause deterioration of the hedge by their over-vigorous growth, for example Bramble (*Rubus* spp.), Old Man's Beard (*Clematis vitalba*) and Elder (*Sambucus nigra*). A hedge with too many of these may well deteriorate faster if trimmed less frequently than once a year. Alternatively, a hedge with a very high proportion of hawthorn (*Crataegus monogyna*) and few other species may well be able to be trimmed every other year without ill effect.

Most farmers accept the need for variability in shape and form of field boundaries and their management, and the benefits this variability can have for the ecology of the area. On most farms much variability occurs automatically as a result of differences in slope, aspect, accessibility etc., which give variation in hedge height and shape, as well as botanical variation in hedges and field margins.

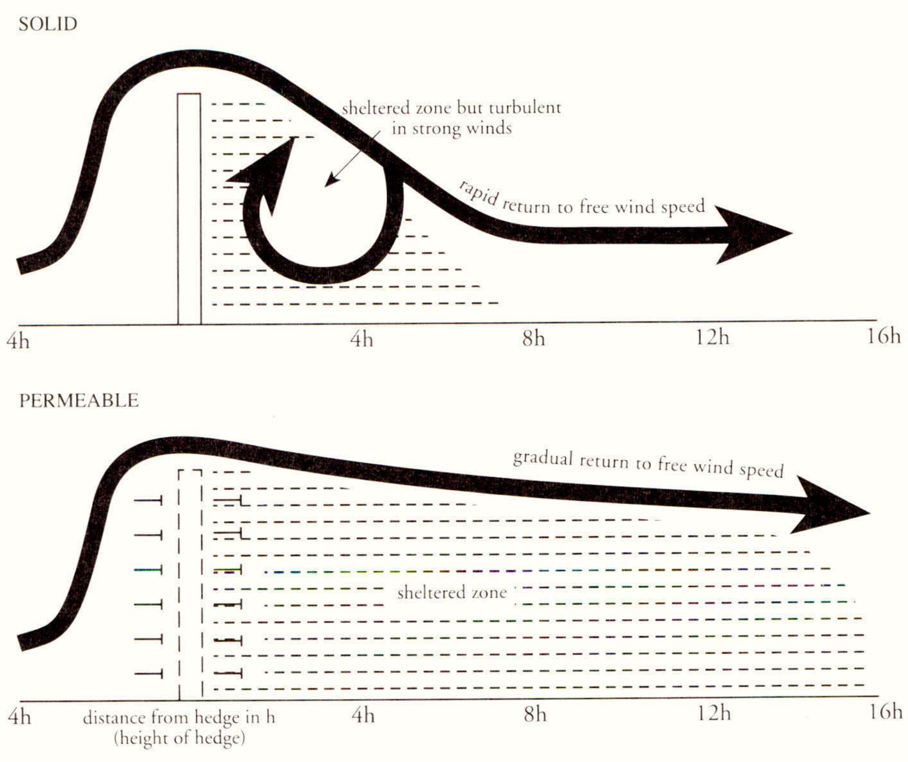
SHELTER

A great deal of work has been done in the past on the influence of an individual hedge on the immediately adjoining field. The primary effect of a hedge is to alter the wind speeds in the area immediately adjoining the hedge. We should also note the quite separate shading effect which is normally less important than wind shelter although perhaps more obvious to the casual observer. It is this shading effect which, combined with the growth of roots from the hedge itself into the field, can be partly responsible for the poor growth of crops often seen in the few rows closest to the hedge.

The shadow cast by a hedge may be very long when the sun is low but significant shading effects are limited to a distance of one or two times the height of the hedge into the field. Many shading/shelter effects are proportional to the height of the hedge.

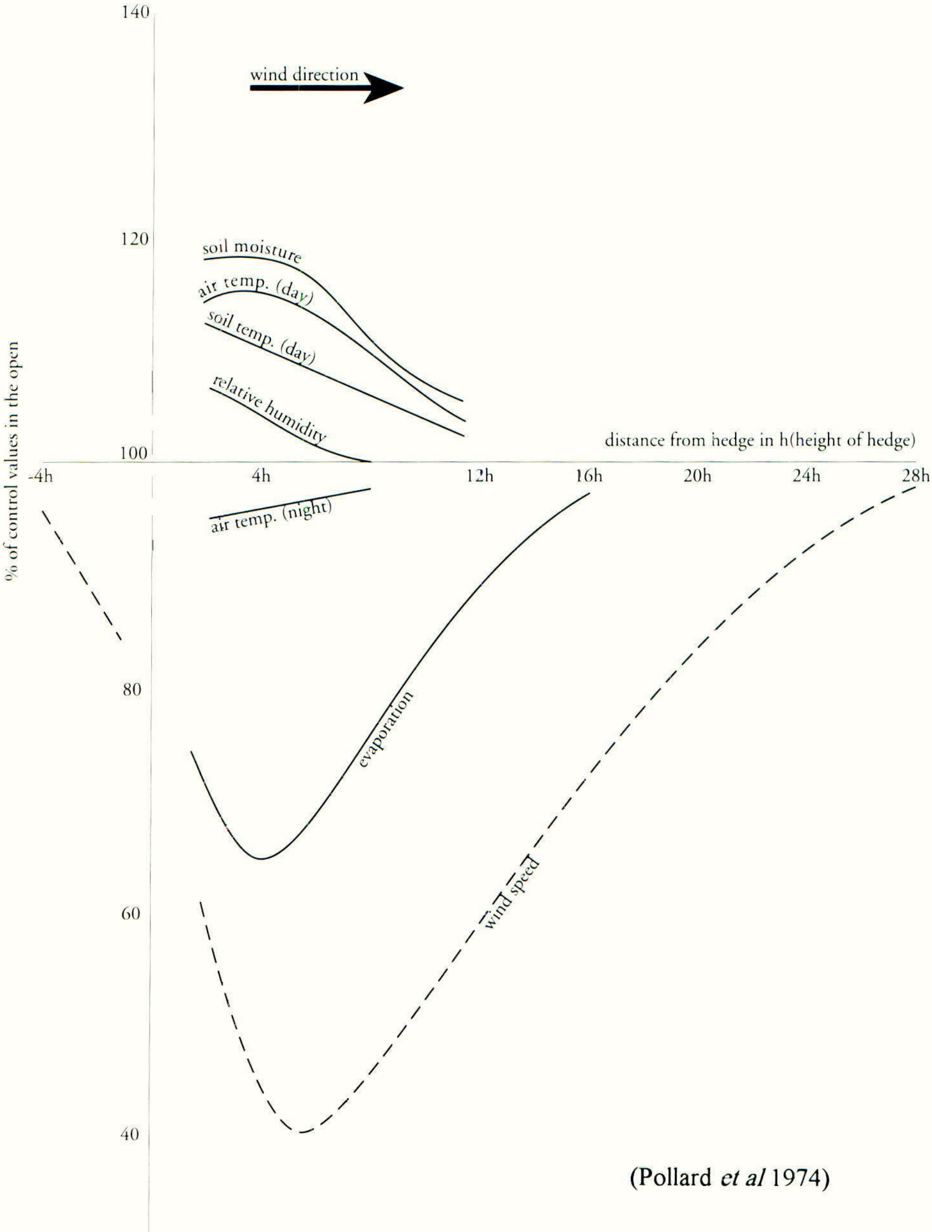
Influence of shelter on wind speed will have marked effects on the micro climate immediately adjoining the hedge (Fig. 2).

Figure 2. Shelter effect of hedges



Farm hedges do in fact provide practically all gradations from an almost solid barrier to an almost completely permeable one. It is perhaps rather surprising that a single permeable hedge provides more shelter in proportion to height than a substantial block of woodland, because the established woodland acts as a solid barrier.

Figure 3. Effect of hedge shelter on climatic factors



(Pollard *et al* 1974)

This summary diagram (Fig. 3.) is a generalisation based on a large number of different experiments with many types of shelter. There are many variables involved but this does provide a basis for discussion of the way in which the physical presence of the hedge can affect soil, plants and animals in the adjoining fields.

It can be said that most of the physical parameters recorded show very little variation beyond the normal headland adjoining a well trimmed, typical lowland hedge, 1.5 metres high. Shelter from wind would appear more important in certain crops (e.g. fruit) and on certain soils than on others, e.g. root crops on light soil subject to wind erosion. Similarly, shelter would be more important for certain classes of livestock, e.g. newborn lambs or young calves at turnout. Shelter can in fact be harmful if the field boundary creates snowdrifts or frost pockets. It follows that shelter is much more important at some times of the year than at others. Modern farm systems have to some extent reduced the general importance of hedges as a source of shelter, but increased the importance of specialised forms of shelter in horticultural or arable cropping. For example, specialised husbandry techniques to reduce the risk of soil blowing, or high hedges to protect orchards.

ARABLE CROPPING

Much controversy on farm hedges is based on perceptions of hedges in the context of today's specialised and well-mechanised arable cropping systems. In these, hedges are generally tolerated, but the intensity of hedge management has decreased and many hedges have deteriorated - some to the point of being difficult to classify as hedges any longer (Barr *et al.,* 1991).

In the context of intensive cereal production hedges can be perceived as of little practical benefit. To a farmer restricted growth and later ripening of crops close to a tall dense hedge can be all too obvious. This may be due to the rabbits living in the hedge, or the Couch grass, Cleavers and Sterile Brome invading the adjoining field from the hedge bottom, or to the hedge itself. Either way, the neglected hedge becomes a candidate for removal.

Management decisions about the hedge-bottom, the crop headland and any gap between these are less clear. The farmers concerns about this area are generally concentrated on weeds and the risk of spreading them from the field margin into the field. In practice these risks need not be very great. The problem weeds have to be there in the first place. The best defence is likely to be a strong close natural vegetation in the hedge bank and the farmer should minimise the risks of damaging the natural vegetation close to the hedge for this reason.

The bromes (particularly *Bromus sterilis* and *Bromus commutatus*) are a particular hedgerow problem, as potentially is Couch (*Elymus repens*). Cleavers (*Galium aparine*) is probably the only dicotyledonous weed species which appears as a widespread problem in field margins. It has, however, been suggested that hedgerow populations do not pose a major threat to arable crops (Froud-Williams 1984). Despite this, *G. aparine* is widespread in many field margins and fields.

Neither fertiliser or herbicides should be applied into the hedge. They can both directly or indirectly favour weed species at the expense of the natural flora of the hedgebottom so the practise is both wasteful and environmentally damaging. Successful hedge and field margin maintenance and weed control depends very much on the details of workmanship involved. Weed species are encouraged by any bare soil left in the field margin. When ploughing the field margins the furrow is best turned towards the centre of the field to give a sharp cut off to the cultivated area. This will also reduce the low spots a few metres in from the field margin where waterlogging frequently occurs. Normal cultivation will tend to fill the furrow but should work to this clearly marked edge. If the line of cultivation of a field margin is allowed to vary from year to year closer to or further from the hedge, this may hasten the spread of weeds or weed seeds into the field. Similarly, undrilled or uncultivated bare soil between the crop and the hedge-bottom will encourage growth of weeds.

Ditches are part of the farm drainage system and, like the rest of the field margin, need maintenance. Grass banks need regular trimming and silt and sludge must be removed and deposited on the adjoining headland rather than on the ditch-bank itself where it will smother the existing vegetation, encourage weed problems and more rapidly slip back into the ditch.

There are several advantages in having a narrow managed gap between the hedgebottom and the crop headland.

1. Physical spread of weeds from hedgebottom can be controlled by rotary cultivation, spraying or mowing repeated as necessary during the growing season.

2. A clear gap reduces the risk of applying fertiliser or agro-chemicals into the hedge-bottom.

3. This gap provides a clear track for the divider of the combine.

The crop headland can be an important proportion of the field - in a square 10 ha field a 12 m headland is about 14% of the area.

Turning on the headlands in difficult soil conditions can result in surface compaction and a poor seedbed. Conditions on the headlands may require different cultivations from the rest of the field. Differential sowing dates between headland and the remainder of the crop are not a practical proposition because of wheeling problems, but some farmers do say they use heavier seedrates. Herbicide performance can be reduced if there is a poor quality seedbed and headlands with poorer crops offer less competition to weeds. Wild Oats and Blackgrass are particularly difficult to eradicate from headlands. If fields are large enough to accommodate them, set aside headlands may be a suitable proposition.

Soil borne pest problems are not known to be more common in field margins than elsewhere in the crop. In fact a compacted headland could inhibit the free movement of slugs and reduce their feeding. Other pests known to be more serious on headlands tend to be those of non-cereal crops.

Defenders of hedges and field margins can make impressive lists of predators and parasites of pests, and of pollinating insects which can also move between hedges and field margins and the crops. It is not easy to strike a balance between the beneficial and negative aspects of field margin flora and fauna. It is unlikely that there is any benefit to agricultural crop production beyond a certain distance from the hedge. Similarly, hedges do not usually cause pest problems in cereal crops.

GRASS AND LIVESTOCK

Hedges are frequently claimed to provide a stock-proof barrier to grazing livestock. Indeed many were originally established for this purpose. This is reflected in the greater importance of hedges in mixed farming and livestock areas. Unfortunately stock management has changed since the hedge lines were planted. As a result of intensification, the size of individual livestock units and animal group size has increased, as has grass production/unit area. Grazing systems have been developed which result in high grazing pressures. These have risen to as much as 17-21 ewes/ha, possibly with twin lambs, set stocked until weaning, or 5 dairy cows/ha on a rotational grazing system in early summer. These levels are not unusual on productive grassland.

At these high grazing pressures, the livestock will browse hedges to which they have access. When this happens alongside long-term leys or permanent swards the damaged hedge does not remain a reliable stock-proof barrier. Any accessible ground flora beneath the hedges is eaten or damaged by the stock and after several years the hedge takes on a typical tufted appearance. The hedge thus deteriorates. This problem suggests a need to double fence hedges in these situations. It is of course also necessary to fence stock out of ditches at the field margin of fields used for grazing, to avoid stock treading in the bank.

Late trimming of hedges is considered the environmentally friendly option. This carries with it the risk that small pieces of debris will still be hard and sharp in the spring and there is a risk that they can cause lameness in young lambs. This risk is increased if the lambs can get in underneath a hedge, as they like to do in play and to get shelter. Shade and shelter are attractive to all types of grazing livestock.

The hedges and/or the livestock sheltering there are attractive to flies, some of which can be carriers of infection, e.g. summer mastitis in dairy heifers and dry cows, or New Forest Eye disease in cattle. In sheep, particularly in lambs on lowland farms, the risk of blow fly strike has been a reason for the use of a persistent summer dip. Again, blow flies prefer living close to hedges rather than in the middle of a field.

CONCLUSIONS

The overall perception of farmers would be

1. There are landscape and amenity benefits to be derived from the diversity and variability of the British landscape. Hedge and field boundaries give character to this diversity.

2. There are possible, but at this stage unquantified, macro-climate benefits from a hedged landscape, as opposed to a prairie.

3. There are ecological benefits to be derived from having a proportion of semi-natural vegetation within any landscape.

4. All field boundaries need periodic maintenance and this costs both time and money, both of which are becoming harder to find.

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THE ROLE OF FIELD MARGINS IN THE LANDSCAPE

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ABSTRACT

I examine the various roles of field margins at the landscape level. Emphasis is on how the pattern of field boundaries in the landscape affects their functions as wildlife habitat, movement corridors, a recreation resource, and their interactions with agricultural systems. The success of field margins in fulfilling these roles is dependent on a combination of their local site quality, length per unit area of farmland and spatial arrangement in the landscape. Of particular importance is their degree of connectedness, alignment to slope and aspect. I conclude that an approach based on the principles of landscape ecology is essential for developing a theoretical foundation for understanding field margin function.

INTRODUCTION

The appreciation of the role of landscape level processes in determining field margin function is a major change since the last BCPC conference in 1986 (Way & Greig-Smith, 1987). In this collection of papers only one explicitly examines the evidence for larger scale effects (Morris & Webb, 1987). Other papers provide evidence for the increase in species and numbers of individuals with length of hedgerow in a landscape. These papers do not, however, make reference to the network pattern formed by hedges and other margins. Since then, research has focused on whether the spatial arrangement of margins in the landscape determines their value. This focus from site to landscape scale is partly due to the rapid growth of landscape ecology as a branch of ecology (Forman & Godron, 1986; Turner & Gardner, 1991). Landscape ecology has forced us to consider new dimensions and larger scales. For field margins, the studies of Baudry in France (Baudry, 1988; Baudry, 1989; Burel & Baudry, 1990) and Merriam in Canada (Fahrig & Merriam, 1984; Merriam, 1988; Middleton & Merriam, 1983; Wegner & Merriam, 1990) have been very influential in demonstrating the need to consider their spatial pattern in the landscape. My aim in this paper is to examine the importance of a landscape ecological approach to field boundary management. I do not examine the importance of the structure, vegetation and local management of field margins for wildlife, as other chapters address these issues.

SOME LANDSCAPE CONCEPTS

As a basis for my argument, I use some definitions of primary landscape characteristics (Forman & Godron, 1986) and apply them to field margins.

Landscape structure

At the landscape level, structure refers to the relationship between the various components of a landscape; their size, shape, diversity, density, and spatial pattern. Although we tend to concentrate on the biological components of field margins, structure also includes other components such as energy, nutrients, and their physical architecture. Field margins vary in type, width, length, habitat diversity, and their connectedness in the landscape. Their structure may be very simple (fence line) or very complex (old hedgerow). Some field margins are very uniform along their length while others are very variable.

Landscape function

Landscape functions relate to the interactions between components of a landscape. For field margins, these will be determined by the flows of materials, energy and species along them, and between them and agricultural fields or other habitats such as woods, streams, roads, etc.

Landscape change

Landscapes change through time, and so do their structure and function. Field margins originated mainly because they were of direct advantage to farming systems; keeping stock from crops, marking ownership boundaries, as shelter belts, etc. Over time, they undergo successional changes in biota, and management will respond to technology and the needs of farming. If margins fall out of use, they are removed or become neglected and degraded. This evolution affects the structure of the field margin network and all its functions. Restoration schemes need to address specific functions of field margins. This will influence the selection of appropriate management techniques. No single margin can fulfil all potential functions.

FIELD MARGINS AS WILDLIFE HABITAT

Most of the wildlife living on farmland is dependent on fragments of once extensive semi-natural habitat. These fragments maintain populations of plants and animals on farmland that would not otherwise survive there. If we define fragmentation as the disruption of habitat continuity (Lord & Norton, 1990), then clearly most semi-natural habitats on farmland are very fragmented. Even larger habitat units such as woodlands are isolated patches in a matrix of agricultural fields in many European countries. The ecology of fragmented habitats and the species that inhabit them is a major component of modern conservation biology (Hansson, 1992; Saunders *et al.*, 1991). This also provides the most important theoretical argument for understanding the role of field boundaries in conserving biodiversity on farmland. Here I concentrate on the role of the landscape network of field margins in maintaining wildlife populations.

Metapopulation dynamics

The theory of metapopulation dynamics (Gilpin & Hanski, 1991) provides a general model for describing systems of local populations. Hanski (1989) discusses the development of metapopulation theory and its relevance to nature conservation. Many species living on farmland exist as small local populations surviving on fragmented habitat patches. They only manage to persist because their rate of extinction within patches is less than their rate of recolonisation. The important factors in the survival of metapopulations are the size and dynamics of each sub-population, and the rate of dispersal between patches (Wu *et al.*, 1993). Specific metapopulation models have been developed for plants, birds, mammals and frogs; see the reviews by Gilpin & Hanski (1991), Hansson (1992), and Opdam (1991). Field margins are patches of habitat (e.g., grassland or woodland) supporting sub-populations of species which operate as a metapopulation. These species would otherwise be rare or absent on farmland. We need to identify which species have this type of population structure and how we can improve the links between sub-populations.

Source-sink dynamics

In mosaic landscapes where species reproduce in more than one habitat, considerable variation in reproduction rates may occur. Populations in good habitats where reproduction exceeds mortality rates (sources) may contribute to other sub-populations where the reproduction rate is lower than mortality rates (sinks) (Howe *et al.*, 1991; Pulliam, 1988). Field margins are surely the source habitats for many species surviving on farmland. These species persist only if there are sufficient lengths of good quality field margin habitat in a matrix of crop fields. The pattern of field margins in the landscape affects inter-patch movement and is an important component of "source-sink" dynamics. Through source-sink processes, field margins may be supporting populations of declining species on farmland, even though surveys would find most individuals in other, non-sustaining habitats.

Movement corridors

Perhaps the most controversial claim for field margins is their function as movement corridors. There are several reviews of the value of wildlife corridors e.g., (Bennett, 1990; Hobbs, 1992; Saunders & Hobbs, 1991; Simberloff *et al.*, 1992) but there remains little evidence that field margins act as corridors linking habitat patches, enhancing the dispersal of individuals and stabilizing populations. Several studies (Baudry, 1988; Baudry, 1989; Burel, 1989; Burel & Baudry, 1990; Middleton & Merriam, 1983; Samways, 1993; Sustek, 1992; Wegner & Merriam, 1990) clearly demonstrate the extension of woodland species of plants and animals into farmland through field margins. Saunders & Hobbs (1991) also include examples of species dispersal such as birds moving along bush corridors on migration. However there is little empirical evidence of movement corridors being essential for the persistence of populations. In his review, Hobbs (1992) concludes that although we lack experimental data on the beneficial role of movement corridors, observational evidence accumulates. He recommends collecting hard data on corridor function but points to the dilemma of conservation planners who have to make decisions now.

When examining the wildlife corridor concept, we must distinguish between connectedness - an expression of the physical linkages in a landscape, and connectivity - the landscape function describing the degree of inter-connection between the sub-populations of a demographic unit. Even when field margins are linked, they may fail to connect habitat patches because some lengths are unsuitable as movement corridors (Burel, 1989). Obtaining evidence for the corridor function of field margins will take careful planning and design, as described in (Inglis & Underwood, 1992).

Field margins are important habitats for a wide range of animal and plant species found on farmland. Although there are few species found exclusively in field margin habitats, many would have restricted ranges or be absent from intensively farmed land without margins. For each species there are a set of habitat conditions most favourable for growth, and reproduction. In addition, the position of field margins in the landscape will be a major determinant of their role in maintaining species diversity. This will apply to species diversity both within hedgerow networks and on farmland generally.

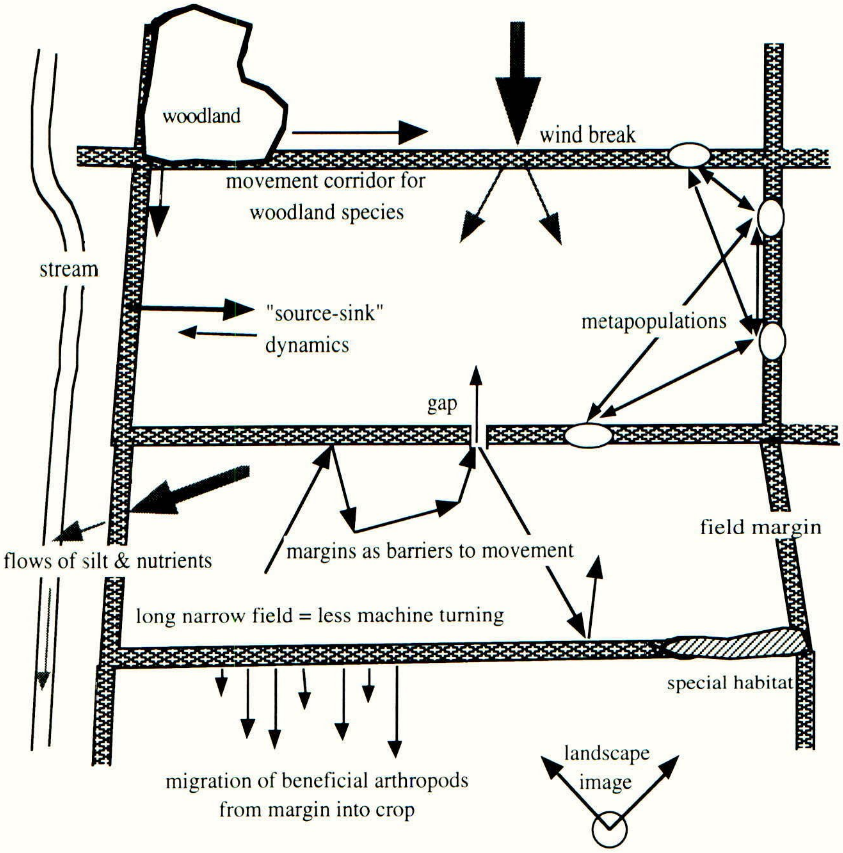


Fig. 1 Schematic view of some functions of field margins which require study at the site, field, and landscape levels.

THE ROLE OF FIELD MARGINS IN INTEGRATED FARMING

It is generally accepted that we need to move agriculture away from over-reliance on external sources of energy and chemicals and towards greater dependence on ecological services. Field margins are often recommended as landscape features worthy of protection for their value to nature and visual quality. We also have a duty to examine their role in crop production and the longer term sustainability of farming systems.

Enhancement of integrated pest management

There is wide acceptance of the importance of field margins as reservoirs of the natural enemies of crop pests (Wratten, 1988). Data is also available on the movement of beneficial arthropods from margins into crops (Coombes & Sotherton, 1986; Dennis, 1991). Many polyphagous predators have significantly higher densities close to margins (15-30m) in the spring. Thomas *et al.* (1991) found similar effects for specially designed margins (beetle banks) planted to enhance predator densities. The potential of these findings for pest control has been of great interest to integrated farming schemes. Until recently, however, few cases of pest control have been planned at the landscape level. The ever increasing power of desktop computers, the widespread availability of geostatistical software, and data on species dispersal have increased the ease of analysis and modelling of pest control at the field, farm and landscape levels (Liebhold *et al.*, 1993). The distances that natural enemies penetrate the crop (at the pest growth stage where they can reduce economic losses) could become the basis for optimizing the spacing of field margins in the landscape. To improve pest control models we need more information on the factors affecting natural enemy migration out into crops, its rate and timing. The spatial pattern of margins in the landscape clearly affects the within-field dispersal of beneficials, and, therefore, the costs and benefits of margins to agriculture.

Reducing the apparancy of crops

Crops grown in large monocultures suffer greater pest damage than when grown as polycultures or in rotation (Paoletti *et al.*, 1992). Part of the reason is that pests have to find their host plants (in space and time) and monocultures make this easy for them. Field margins can have an impact on the host searching behaviour of many pests, especially those with poor dispersal ability. The same argument supports the use of inter-cropping, but margins are more permanent strips of non-crop vegetation which may be managed to enhance natural enemies and to fragment the crop into patches, reducing its apparancy.

Shelter and wind breaks

The benefits of field margins as wind breaks and shelter are one of the few reasons why they remain as an integral part of some farming systems (Russel & Grace, 1979). The correct positioning of shelter belts in a landscape is based on simple physical attributes of the landscape such as wind direction, slope, and aspect. In hilly and mountainous areas, wooded field margins across slopes also hinder the downward flow of heavy cold air into the productive valleys.

Reducing environmental problems and landscape restoration

The ecological basis for landscape restoration, especially of degraded agricultural land, is a very active field of research (Saunders *et al.*, 1993). Both the structure of individual margins and their landscape pattern are integral components of restoration schemes to combat soil erosion, salination (Saunders *et al.*, 1993), and nutrient run-off (Haycock *et al.*, 1993). Since field margins influence the flows of materials in landscapes, they play an important role in any restoration strategy.

Reducing the impact of pesticides on non-target organisms also requires us to examine the properties of individual field margins and their spatial relationships, as well as pesticide application regimes (Sherratt & Jepson, 1993). If species move freely from field to field they may be vulnerable to correlated extinctions. In contrast, if margins have low permeability, they may prevent species escaping from pesticide application or cultivation. In ameliorating environmental problems, the arrangement of field margins in the landscape, as well as their quantity and quality, will necessitate careful planning to achieve success.

FIELD MARGINS, LANDSCAPE IMAGES, AND RECREATION

Recreation is an increasingly important product of agricultural land. Urban populations have increasing access to the countryside for a wider range of recreational activities. Field margins are important visual elements determining aesthetic appreciation of the countryside. They are associated with most footpaths, bridal paths and other access routes providing shelter and natural history experience. The work of the Game Conservancy has demonstrated that margins can enhance the game value of farms (e.g., for partridge) while improving their visual quality through wild flower and butterfly diversity. The chocolate box or calendar images, portraying traditional patch-work field structures divided by woody hedges, are highly dependent on the spatial pattern of landscapes. Appreciation of the countryside is linked to previous experience and other social factors. This causes problems when people are asked to accept change. We can expect a storm of protest if new types of margin do not resemble this visual ideal, even when rich in wildlife and aiding agricultural sustainability. We therefore need a better understanding of how the pattern of field margins interacts with people's enjoyment of the countryside.

The type and pattern of field boundaries are also important factors in selling landscape restoration schemes to farmers. In the USA, farmers resisted take-up of soil conservation plans even when offered financial incentives. Landscape architects discovered, through interview and landscape perception experiments, that the visual impression of conservation measures conveyed an image of poor stewardship. Areas of semi-natural vegetation including buffer strips and margins were given low ratings by farmers. However, if pictures of the same farms were 'landscaped' by image processing to look more tidy and cared for, e.g., addition of white board fences, objections turned to praise (Nassauer, 1992). In countryside planning we must be continuously aware of the powerful emotional feelings evoked by landscape and that field margins are very important visual components of farms.

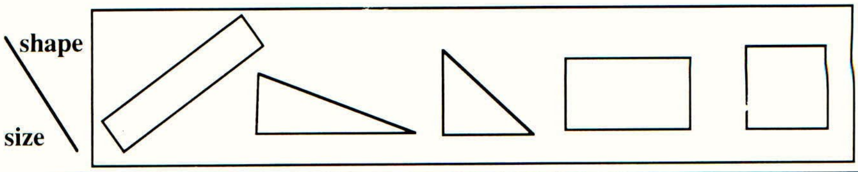
SOME DIFFICULT MANAGEMENT QUESTIONS

Field margins as barriers

For good or bad, field margins are also semi-permeable barriers in the landscape. This is a benefit in reducing pesticide drift, hindering the flow of nutrients and silt in run-off, reducing the spread of pests and disease, and for providing shelter from wind. However, the consequences of barrier effects on species conservation is poorly understood (see also corridors above). Field margins may significantly reduce the dispersal of carabid beetles between fields (Mauremootoo & Wratten, 1993) and increase isolation between populations of meadow butterflies (Fry & Main, 1993). It may therefore be necessary to create functional gaps in hedgerow networks to allow for inter-field movement of weak dispersers. Since such gaps may be insurmountable barriers for the movement of other species along woody hedgerows, a clear conflict of interests arises. It may be possible to resolve this through better understanding of the needs of different ecological groups of species (Bink, 1989; Duelli *et al.*, 1990; Hodgson, 1993). It is, however, likely to remain a difficult management choice.

What about costs ?

The economy of scale has been a major argument for the destruction of thousands of kilometres of field margins. Increased mechanisation and the scale of farm machinery are often quoted as the rationale for the loss of hedges, walls and other margins. Recent research in Norway and Finland (Sky, 1992) has questioned the validity of this argument. Agricultural engineers found the major costs involved in cereal production are related to the time it takes for machinery to work a crop. All operations from preparation through to harvest take their toll in wear on expensive equipment, fuel consumption and manpower costs. Modelling and field trials showed that field shape plays a key role in determining the magnitude of these costs. These studies found the economy of scale argument applied only to very small field systems (at least for mechanisation), with only marginal benefits gained from fields over 5 ha (see Fig 2).



0.5 ha	1.80	1.85	1.93	1.93	2.17
1 ha	1.48	1.53	1.53	1.58	1.73
2 ha	1.25	1.32	1.33	1.35	1.45
4 ha	1.13	1.17	1.18	1.20	1.28
8 ha	**1.00**	1.10	1.08	1.10	1.18

FIG. 2 An example of time costs associated with field shape and size for cereal production (from Sky, 1992). Comparisons are shown against the time cost for the most efficient shape, shown in **bold** type (1.0 = c.10 h/ha).

Large fields are associated with the most serious environmental problems in Norway and probably elsewhere. If the costs caused by these problems were taken into account, it would reduce even further the benefits of scale. It would seem that it is more important to have an optimal shape of field (long and narrow) to reduce turning large tractors and harvesters than to increase the size of field with the consequent loss of margin habitat.

Land ownership and landscape management

Although there is a strong emotional bond between a farmer and the boundaries of his holding, landscape management will call for greater co-operation between farms. This may require a new look at the responsibilities of land ownership. Otherwise, the introduction of environmental measures on farmland will be unfair. Costs will be unevenly distributed, leaving some farmers economically disadvantaged while neighbouring farms benefit from those actions. This is not new thinking; farmers have shared resources, such as access to water or isolated pastures for many thousands of years.

Various schemes of official land consolidation have evolved to redistribute land to increase farming efficiency, especially where holdings are fragmented and difficult to manage as a unit. Around 20% of farmland in Europe have been reorganized in this way in recent times - often with no consideration of the environmental consequences and resulting in major losses of hedgerows (Baudry & Burel, 1984). The scope of official land consolidation is being broadened to explore the potential for adjusting farm boundaries to meet environmental objectives. Similar processes also occur in most countries without formal organization. Farmers work together to tackle the threats posed by flooding, avalanches, soil erosion or pollution. For example, in the wheatbelt of Western Australia, Land Care groups have introduced catchment management plans to combat salination and soil erosion. These co-operative projects across ownership boundaries aim to even out the costs and benefits to participating farmers (Saunders *et al.,* 1993). Voluntary approaches, where whole catchments or valleys work as a single management unit, benefit the environment and farming efficiency. To manage field margin networks, co-operation between farmers and planning at a larger scale than the individual farm will be essential.

CONCLUSION

I believe the available evidence strongly supports the need to consider the spatial arrangement of field margins in the landscape as well as their site quality. All the functions that margins perform are affected by their pattern. It is also clear that although margins may be able to achieve multiple objectives on farmland, no one type of margin can fulfil all possible functions. Margins are not uniform strips, they are very heterogeneous along their length. We should therefore be careful in generalizing, and in scaling up findings from site studies to landscapes.

In several countries monitoring schemes for field margins are underway. In the cases I have examined, the results obtained will be used to develop some form of index of environmental quality. Few schemes include a range of field margin types (emphasis being on hedges); some, but not all, include an assessment of quality; and very few make any attempt to assess the landscape pattern of margins. Classification into type, assessment of quality (against clearly defined criteria) and the patterns of margin networks are all needed for a comprehensive assessment and to make comparisons between areas.

We are only beginning to understand the effects of different spatial patterns of field margins on their function. The available data suggests that long narrow fields, following the contours of the land would give the best return for investment. Rectangular fields are the most efficient for machinery, for the dispersal of beneficial insects and for reducing silt and nutrient run-off. If we combine this knowledge with data on the merits of different types of margin, we should be able to optimize the value of margins to both agriculture and nature conservation.

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