THE FLORA OF FIELD MARGINS IN RELATION TO LAND USE AND BOUNDARY FEATURES

J.O.MOUNTFORD, T.PARISH, T.H.SPARKS

NERC Institute of Terrestrial Ecology, Monks Wood, Abbots Ripton, Huntingdon, PE17 2LS

ABSTRACT

Within the Swavesey Project, the flora of field margins was recorded in 131 200m long transects in 1986. The exercise was repeated in 1991. For each species, the ground cover was recorded for each component of the field margin. 71 species were recorded in greater detail and the effect of adjacent land-use and type of boundary investigated. The impact of land-use change following drainage is discussed.

INTRODUCTION: THE SWAVESEY PROJECT

In 1985, a flood protection and pump drainage scheme at Cow Fen, Swavesey (Cambridgeshire) led to land-use changes following an altered water table (Harris *et al.*, 1991). 131 field boundary transects (each 200m long) formed the vegetation survey, covering the undrained Mare and Middle Fens, old pumped fen at Overcote, and Cow Fen itself. The survey included areas of low-input grass and intensive arable systems. This paper summarises the surveys and examines the importance of land- use and both the nature and size of the boundary features on a subset of the flora.

METHODS: DATA & ANALYSIS

Each field boundary consisted of one or more components: ditch, ditch bank, hedge, verge and grass track. A vegetation survey of each component for each of the 131 transects was carried out in 1986 and repeated in 1991. The flora was recorded as a list of species and a visual estimate of the ground cover of each. Information from each component was pooled, according to the contribution of that component to the transect, to form a weighted estimate of ground cover for the whole boundary. Transects were classified in three types depending upon the adjacent land-use: **i)** with pasture on both sides of the transect (*GRASS*); **ii)** with arable crops on both sides (*ARABLE*); and **iii)** with pasture on one side and arable on the other (*SEMI*). The present paper focuses on a subset of 71 species, identified either as present in abundance or of particular interest. Between 1986 and 1991 there were modifications to the cropping adjacent to some of the boundary transects. These modifications resulted mainly, but not exclusively, in the redefinition of land-uses from *SEMI* to *ARABLE* as hitherto marginal land was converted to arable.

Preliminary analysis of survey data adopted a rather broad-brush approach. Correlations between boundary features and species ground cover were carried out in order to identify major linear relationships rather than for formal significance testing. Changes in ground cover between 1986 and 1991 were analysed using ANOVA with land-use, fen or modified land-use as factors.

RESULTS AND DISCUSSION

The results are summarised in two tables. Table 1 lists those species that showed a correlation of >|0.2| with one or more measure of boundary size or type. Table 2 shows species whose mean cover changed between 1986 and 1991: I. in particular land-uses or fens; II. where land-use itself changed from *SEMI* to *ARABLE*; and III. where the trend in Cow Fen (site of the 1985 pump drainage scheme) differed in type or degree from other fens.

Species showing correlations with hedge size and tree number

Eight measures of boundary type reflected the extent of hedge habitat (Table 1) and the occurrence of many species was correlated with all or most of these variables. It was not surprising that component shrubs (e.g. *Crataegus monogyna*, *Prunus spinosa* and *Rhamnus cathartica*), invasive shrubs (e.g. *Rubus* spp. and *Sambucus nigra*) and standard trees (e.g. *Fraxinus excelsior* and *Ulmus* spp) were positively correlated with hedge dimensions. Similar trends were shown in forbs typical of partial shade (e.g. *Glechoma hederacea* and *Torilis japonica*). Tall herbs that are eliminated by cultivation or intense grazing survived, protected by the larger hedges (*Conium maculatum* and *Urtica dioica*).

In contrast, species which were negatively correlated with hedge size were generally intolerant of woody shade. This group included aquatics (*Glyceria maxima* and *Phragmites australis*), arable weeds (*Convolvulus arvensis*, *Fallopia convolvulus*, *Papaver rhoeas* and *Sinapis arvensis*) and biennials of disturbed, fallow or neglected areas (*Carduus* spp, *Cirsium* spp, *Dipsacus fullonum* and *Lactuca serriola*).

Species showing correlations with size of drainage channel

Many of the field boundaries included a ditch component, which varied from wide and water-filled to very narrow, shaded and dry for all or most of the year. As expected, macrophytes were positively correlated with ditch dimensions (DD and DW) (*Alisma plantago-aquatica*, *G.maxima* and *P.australis*). There was also a positive correlation between ditch dimensions and both the occurrence of thistles and overall species richness. This result followed the disturbance associated with regrading of drains provided a suitable habitat for invasive biennials. The increased habitat diversity due to the presence of standing water also led to higher species totals. Many of these species showed a positive correlation with the overall width of the boundary (MW).

Those plants negatively correlated with ditch size (and overall boundary width) included arable weeds and hedgerow species. Water-filled ditches occurred primarily in grassland where they partially replaced hedges as the stock-proof barrier. Wide arterial drains occurred in all land-uses but were seldom associated with hedgerows since effective drain management demands ready access to the channel.

Species showing correlations with adjacent land-use

Eight species were positively correlated with transects in grassland. These included species tolerant of grazing (*Cirsium* spp, *D.fullonum*, *Potentilla anserina* and *U.dioica*), tall herbs protected from grazing by the stock-proof thorn hedges and a component shrub of the old hedges surviving in the unimproved grass areas of Middle Fen (*R.cathartica*).

Six of the species that were positively correlated with arable were annuals, intolerant of defoliation, but which produce abundant seed and can germinate, flower and fruit rapidly. The perennial *C.arvensis* is favoured by the fragmentation of its rhizome during ploughing. The remaining species may be able to tolerate grazing but are eliminated by the hay-cut that often precedes the introduction of stock (*Bryonia dioica*, *C.maculatum*, *Heracleum sphondylium*, *Lamium album* and *Picris echioides*).

Species changing in abundance between 1986 and 1991

Some species increased or decreased in all fens or all land-uses, but most showed some association with a particular management. The increased area of arable land, particularly following the pump drainage in Cow Fen, favoured eight species, among which *F.convolvulus* and *Galium aparine* were serious weeds in 1986 when much land was converted to arable. *Ranunculus repens* and *Taraxacum* agg. spread where *SEMI* transects were converted to *ARABLE*. Some of the species increasing in grassland may have spread as a result of works associated with regrading of the main drains for drainage or pond creation for conservation (*Cirsium* spp, *L.serriola*, *Rumex* spp and *U.dioica*). More extensive grassland management in all fens and gaps in the sward following drought may have been responsible for the observed increase in total species numbers in pasture transects.

It was thought that lowered water-tables in Cow Fen would affect the vegetation of field margins and a study of ditches supported this view (Mountford *et al.*, in press). However, few species recorded during the present study showed a significant response (Table 2, III). *Phalaris arundinacea* and *R.repens* increased in drained land along newly dug ditches, whilst *B.dioica* and *L.serriola* declined, as a result of hedge trimming and the use of herbicides. Herbicide use increased in Cow Fen, reducing the perennial vegetation of the boundary strip, opening up the boundary for annuals.

Many correlations were as predicted, but changes in Cow Fen were less dramatic than expected, since the drought and lack of flooding in the undrained fens produced changes similar to those in Cow Fen. The contrast between pumped and unpumped fens was much reduced.

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Table 1:   SWAVESEY: Correlations of species ground cover with boundary features in 1986 and 1991 (see notes for key).

Species	TN	TH	HL	HH	CW	BW	VW	DD	DW	MW	HV	BA	Crop
Acer campestre	++	..	..	..	..	..	..	..	..	..	..	..	..
Alisma plantago-aquatica	..	..	..	..	..	..	..	++	.+	..	..	..	..
Anthriscus sylvestris	+.	..	..	++	++	++	.+	..	..	..	++	++	..
Arctium lappa	..	.+	..	.+	.+	..	..	.-	.-	..	.+	..	.G
Bryonia dioica	..	..	..	..	..	..	.-	-.	--	--	..	..	AA
Callitriche spp.	..	..	..	..	..	..	..	+.	..	..	..	..	..
Calystegia sepium	..	..	..	..	..	..	..	+.	++	..	..	..	..
Carduus crispus	..	..	--	..	..	..	++	+.	++	++	..	..	..
Cirsium arvense	..	..	--	..	..	..	+.	..	+.	+.	..	-.	GG
Cirsium vulgare	..	..	-.	..	..	..	++	+.	+.	++	..	..	.G
Conium maculatum	..	..	++	..	..	..	-.	..	..	-.	..	..	A.
Convolvulus arvensis	..	..	..	--	--	--	..	..	--	--	.-	.-	AA
Crataegus monogyna	..	..	++	++	++	++	--	--	--	--	++	++	..
Dipsacus fullonum	..	..	--	..	..	..	++	..	++	++	..	..	.G
Epilobium hirsutum	+.	..	..	..	..	..	..	..	..	..	..	..	..
Fallopia convolvulus	..	..	..	.-	.-	..	..	.-	.-	.-	..	..	.A
Filipendula ulmaria	..	..	..	..	..	+.	..	..	..	.+	+.	..	..
Fraxinus excelsior	++	++	..	++	..	..	..	..	..	..	++	..	..
Galium aparine	..	..	+.	..	..	..	--	-.	--	--	..	..	AA
Geranium dissectum	..	..	..	-.	-.	-.	..	..	..	..	..	..	..
Glechoma hederacea	..	..	..	++	++	..	..	-.	..	..	++	..	..
Glyceria maxima	..	+.	--	..	..	..	..	..	.+	..	..	.-	..
Hedera helix	++	++	..	++	+.	..	..	..	..	..	++	..	..
Heracleum sphondylium	..	..	..	..	..	..	..	..	..	..	..	..	AA
Lactuca serriola	..	..	--	..	..	..	++	..	.+	++	..	..	..
Lamium album	..	..	..	..	..	..	..	..	..	..	..	..	.A
Malva sylvestris	..	..	..	..	..	..	..	..	..	..	.+	..	..
Myosotis arvensis	..	..	..	..	..	..	..	..	..	..	..	..	A.
Papaver rhoeas	..	..	.-	..	..	..	+.	..	++	+.	..	..	..
Phragmites australis	..	..	.-	..	..	..	..	..	++	..	..	..	..
Picris echioides	..	..	..	..	..	..	.+	.+	..	.+	..	..	A.
Potentilla anserina	..	..	..	..	..	..	..	..	..	..	..	..	.G
Prunus spinosa	..	..	..	..	..	.+	..	..	..	..	..	++	..
Quercus robur	++	++	..	..	..	..	..	..	..	..	..	..	..
Ranunculus repens	..	++	+.	..	..	..	.+	..	..	..	..	..	..
Rhamnus cathartica	..	++	..	++	++	++	..	-.	--	..	++	++	.G
Rosa canina	..	..	++	..	..	..	.-	-.	--	--	..	..	..
Rubus fruticosus	..	..	++	++	++	++	..	-.	-.	--	++	++	..
Rumex conglomeratus	..	..	+.	+.	..	..	..	..	..	..	+.	..	..
Rumex crispus	..	..	.+	++	++	.+	..	..	..	..	++	..	.G

Species	TN	TH	HL	HH	CW	BW	VW	DD	DW	MW	HV	BA	Crop
Salix spp.	++	++	..	++	++	..	..	..	..	..	..	..	..
Sambucus nigra	..	++	..	++	++	..	..	-.	.-	..	++	..	..
Scrophularia auriculata	..	..	.-	..	..	..	..	+.	..	..	..	..	..
Senecio vulgaris	..	..	..	..	..	..	..	..	..	..	..	..	.A
Sinapis arvensis	..	..	-.	-.	..	..	++	..	..	.+	..	..	A.
Sonchus arvensis	..	..	..	..	..	..	..	.+	..	..	..	..	..
Sparganium erectum	..	..	-.	..	..	..	..	+.	++	..	..	..	..
Torilis japonica	..	..	.+	..	..	..	..	..	--	.-	..	..	..
Tripleurospermum inodorum	..	..	..	..	..	..	..	..	..	..	..	..	.A
Tussilago farfara	..	..	..	..	..	..	..	.+	..	..	..	..	..
Ulmus spp.	++	++	..	..	..	..	..	..	..	..	..	..	..
Urtica dioica	++	.+	..	.+	++	++	.+	..	.+	++	..	..	GG
SPECIES RICHNESS (examined subset)	..	..	..	..	..	..	++	++	++	++	++	..	++ ..

Notes:

i) key to variables

TN number of trees	TH tree height	HL hedge length
HH hedge height	CW crown width	BW basal width
VW verge width	DD ditch depth	DW ditch width
MW margin width	HV hedge volume	BA basal area

ii) Key to Correlations (For each variable and each species two results are presented, for 1986 and 1991 respectively):

+ ($>+0.2$)   - (<-0.2)   . ($-0.2<r<0.2$)
A (positive with arable)   G (positive with grass)

iii) The following species showed no correlations $>|0.2|$ with any recorded boundary feature: *Centaurea nigra*, *Medicago lupulina*, *Phalaris arundinacea*, *Pastinaca sativa*, *Persicaria maculosa*, *Polygonum aviculare*, *Potentilla reptans*, *Rubus caesius*, *Rumex acetosa*, *Rumex obtusifolius*, *Senecio jacobaea*, *Sonchus asper*, *Sonchus oleraceus*, *Taraxacum* agg., *Trifolium pratense*, *Trifolium repens*, *Typha latifolia*, *Veronica chamaedrys* and *Veronica persica*.

iv) Significance testing of correlation coefficients requires assumptions about bivariate normality. Some data will not meet these requirements (particularly crop - a 3 point scale). The results of correlations presented here are intended for guidance only and hence no formal significance testing has been attempted

Table 2: SWAVESEY: Field boundary species changing in abundance between 1986 and 1991 (Significance in brackets).

I.   Increasing in particular land-uses or fens:
      A: Arable; C: Cow Fen; G: Grassland; Gen: Generally; Ma: Mare Fen;
      Mid: Middle Fen; and O: Overcote Fen.

II.   Significantly changing in abundance as *SEMI* transects are converted
      to *ARABLE*: Dec: Decreasing; and Inc: Increasing.

III. Significantly changing in abundance in Cow Fen compared to other
      fens: DA: Decreasing in arable; DG: Decreasing in grassland;
      IA: Increasing in arable; and IG: Increasing in grassland.

Species	I	II	III
Bryonia dioica	A (***)	Inc (*)	DA (+)
Calystegia sepium	C (*)	.	.
Cirsium arvense	Mid (**)	.	.
Cirsium vulgare	Gen	.	.
Convolvulus arvensis	A (*)	.	IG (+)
Dipsacus fullonum	Gen	.	.
Epilobium hirsutum	.	.	DG (+)
Fallopia convolvulus	A (***)	.	.
Galium aparine	A (**)	Inc (**)	.
Geranium dissectum	Gen	.	DG (+)
Glechoma hederacea	G (+)	.	.
Heracleum sphondylium	Gen	.	.
Lactuca serriola	G (*)	Dec (+)	DA (*)
Lamium album	A	Inc (**)	.
Papaver rhoeas	.	Inc (+)	DA (+)
Pastinaca sativa	.	Dec (*)	.
Phalaris arundinacea	Gen	.	IG (+)
Phragmites australis	O (***)	.	.
Potentilla reptans	Gen	.	IA (+)
Prunus spinosa	.	.	IG (*)
Ranunculus repens	G (**)	Inc (*)	IA (+)
Rumex crispus	Ma (*)	.	.
Rumex obtusifolius	Ma (**)	.	.
Senecio vulgaris	A (*)	.	.
Sonchus asper	O (**)	Inc (*)	.
Sparganium erectum	Gen	.	.
Taraxacum agg.	Gen	Inc (*)	.
Torilis japonica	Gen	.	.
Urtica dioica	Ma (***)	.	.
SPECIES RICHNESS	Ma (***)	.	.

Note: Significance: + = <10%; * = <5%; ** = <1%; *** = <0.1%.

THE EFFECTS OF FIELD MARGINS ON BUTTERFLY MOVEMENT

G. L. A. FRY

Norwegian Institute of Nature Research, PO Box 5064, N-1432 Ås-NLH, Norway.

W. J. ROBSON

Department of Biology, The University, Southampton, SO9 5NH, England.

ABSTRACT

This study examines the effects of hedgerows on the inter-field movement of butterflies, using observation of behaviour both at field margin sites and at an artificial hedge. It was found that the number of butterflies leaving a meadow varied considerably depending on the structure of boundary vegetation. The percentage of butterflies crossing boundaries increased with the percentage of the boundary length where vegetation was less than 1.5m tall. When tested experimentally, it was found that even a 1m high hedge, without gaps, can significantly reduce the number of butterflies crossing a field boundary. Implications for the management of field margins are discussed.

INTRODUCTION

Over the last few decades, the European landscape has changed considerably. Modern intensive farming techniques have resulted in vast crop monocultures, whilst native vegetation has become increasingly fragmented, persisting as small patches against a backcloth of pasture and arable fields (Fry, 1991). On marginal land, the trend has been towards abandonment of farming with the result that many traditionally lightly cultivated or grazed meadows have succumbed to succession and reverted to forest (Erhardt, 1985). Again this results in increased isolation of habitat patches since remaining meadows are separated by forest and continuity of habitat type is lost.

Butterflies are just one of many groups which have suffered as a result of these changes in land use. In intensively farmed areas, pesticides affect butterflies directly (Davis *et al.*, 1991), and herbicides and fertilisers induce vegetation changes resulting in losses of important nectar sources and larval food plants. Recently, there have been attempts to enhance the wildlife value of farmland, and field margins have become a focus of attention. Whilst butterflies have benefitted from the change to selective spraying regimes and from increasing the area of low herbaceous vegetation in field margins (Rands & Sotherton, 1986; Dover, 1989; Dover *et al.*, 1990; Lagerlof *et al.*, 1992), the role of hedges and shelterbelts is less clear-cut.

Hedgerows provide shelter, larval food plants, protection from agrochemicals and good growth conditions for nectar resources for butterflies. Both woodland and grassland species are able to use the ecotone habitat provided by hedges. For example, the rare black hairstreak (*Strymonidia pruni*), a woodland species, finds its food plant, sloe (*Prunus spinosa*), in hedgerows, whilst the meadow brown (*Maniola jurtina*), a species of open grassland, makes use of the grasses growing

in the undisturbed land at the hedge bottom (Dowdeswell, 1987). It has been suggested that when hedgerows link habitat patches, they act as movement corridors, allowing butterflies to disperse through alien habitats and colonise new patches (Dover, 1990).

This study considers the possibility that hedges may also have negative impacts on butterflies by acting as barriers to their movement. If hedgerows reduce movement across landscapes, the probability of dispersing individuals reaching new habitat patches will be reduced, resulting in isolation of populations and increasing the risks that local extinction rates will be higher than recolonisation rates.

METHODS

The study site was an abandoned hay meadow system in Telemark county, Southern Norway. The main meadow complex lies at about 450m a.s.l., is 1.5-2ha in area and is surrounded by several different land-use types, including bog, deciduous forest, conifer plantation, clear-felled area and other meadows.

Observation of butterfly behaviour at field boundaries

Eight boundaries, of various lengths, were recognised according to their type, structure and adjacent land use. Each boundary was divided up into sections 5m long and extending 3m into the meadow from the boundary line. The flight path of every butterfly entering a recording section, within a one minute period, was recorded. Map location was recorded to the nearest metre.

Three categories of flight path were recognised: entering the meadow; leaving the meadow; and "rebounds". The latter included cases where a butterfly approached the boundary but turned back into the meadow rather than crossing, or entered the recording section and moved parallel to the boundary.

Butterfly flight behaviour was recorded, following the same protocol, along a line transect through the open meadow to act as a control. Records were collected throughout the day on 18 suitable days, between late June and early August 1991. Recordings were not made when the mean air temperature was less than 17 °C, during strong wind or during precipitation. Species were identified according to Chinery (1989). Arcsin transformed percentage data were analysed by linear regression.

Experiment using an artificial hedge

To investigate the barrier effect of hedges, an artificial hedge was constructed, comprising 12 x 5m long sections, with three replicates of each treatment. The treatments were: A = 0m high, B = 1m high, C = 2m high and D = 3m high.

Wooden stakes were set into the ground at 5m intervals from each other and green tarpaulins stretched between the stakes. The tarpaulin of each section could be fixed at 1m, 2m or 3m high, independently of the height of the rest of the hedge, by means of hooks screwed into the stakes. This design meant that the hedge could be quickly dismantled during unsuitable weather conditions and at the end of each day. The hedge was orientated in an east-west direction in order to minimise

the effects of shadow.

Butterfly movements were monitored by four observers, each recording butterfly activity over one 5m section for 30 minutes. This allowed simultaneous recording of each of the height treatments, thus standardising recording for each run. The experiment used a randomised block design in which the sequence of treatments was changed for each recording of all height replicates.

RESULTS

Simple observation indicated that butterfly responses to field boundaries were highly dependent on boundary structure (see Fig. 1).
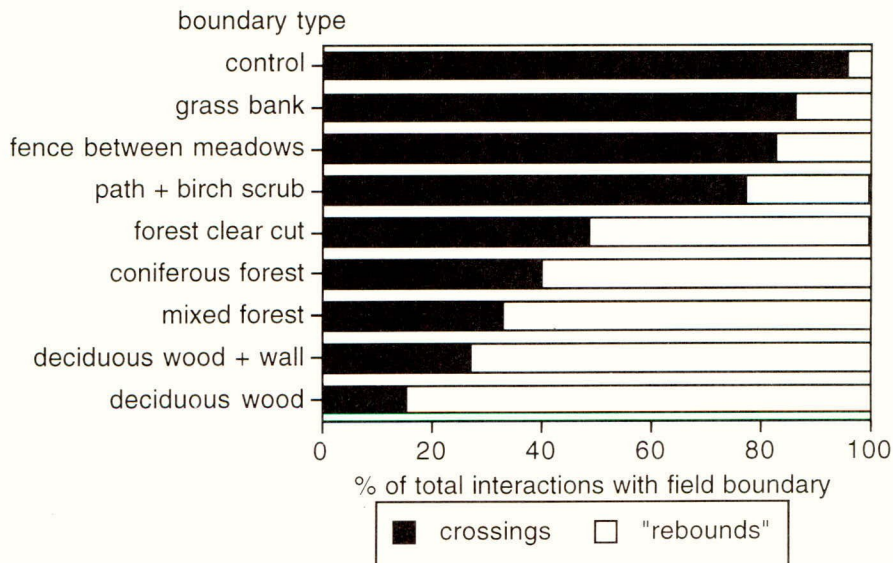
Fig. 1: The percentage of butterflies crossing the different field margins of the Sverveli meadow system.

Of all crossings observed over natural boundaries, 91% occurred through gaps in the boundary vegetation (total sample size, including all species = 1047 butterflies).

The number of butterflies crossing each natural boundary, as a proportion of the total number of approaches to the boundary, was positively correlated with the percentage of the boundary length were vegetation was less than 1.5m tall ($r^2=0.9$; $p<0.001$ for all species combined).There appeared to be an optimum degree of openness, about 30-40%, beyond which further increases in openness had little effect on movement rates across the boundary. This threshold was lower for Arran browns (*Erebia ligea*) than scarce coppers (*Heodes virgaureae*) (See Fig. 2).

There was no consistent relationship and no significant correlation between the number of butterflies crossing through individual gaps in the boundary vegetation

and gap size ($r^2=0.005$; $p>0.10$).

% of boundary length where vegetation was <1.5m

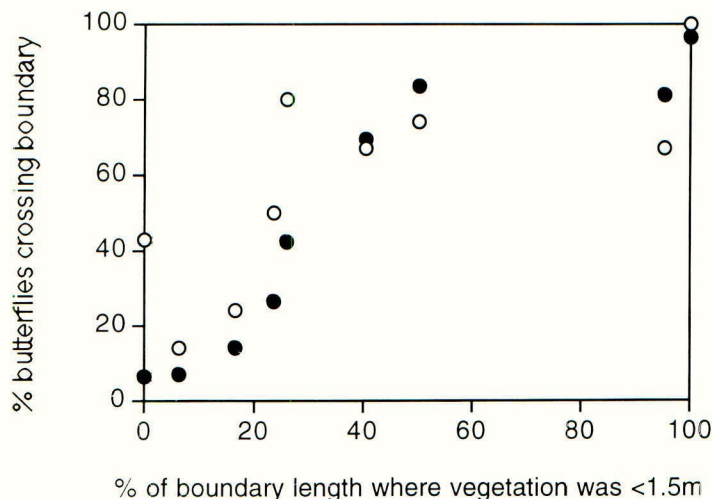Fig. 2: The relationship between the percentage of butterflies crossing a field boundary and the percentage of boundary length where vegetation was ≤ 1.5m tall. ● scarce copper (*Heodes virgaureae*) n = 739; o arran brown (*Erebia ligea*) n = 224.

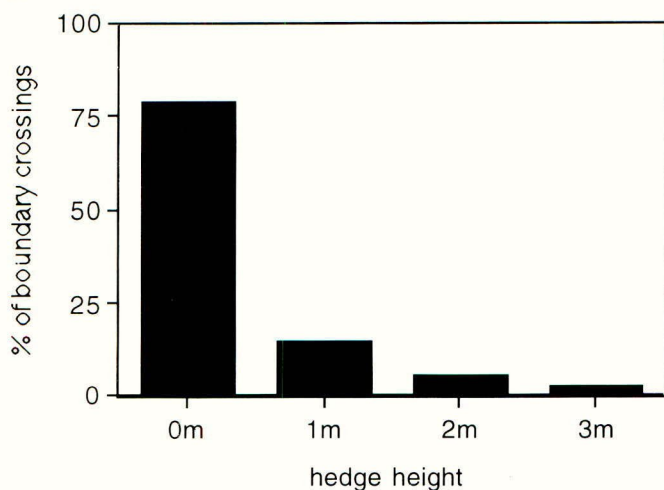The experimental approach confirmed the barrier effect of tall vegetation (see Fig. 3).

hedge height

Fig. 3: The percentage of butterflies (all species) crossing the different experimental height treatments (n=1808).

Even a 1m high hedge significantly reduced landscape permeability to butterflies. Pairwise replicated G-tests comparing the number of butterflies (all species included) crossing different height treatments (45 replicates of each treatment) showed that each of the treatments differed significantly from all others (p<0.001 in all cases).

DISCUSSION

These results indicated that field margins can have a previously unrecognised negative role in butterfly dispersal at the landscape level; margins of tall vegetation form barriers to the movement of butterflies. The degree of barrier effect can vary for different species, for example, *E. ligea* , a species of open woodlands, accepts a lower threshold of openness than *H. virgaureae*, a meadow species. This type of threshold, where permeability shows no further increase after a certain percentage openness, was proposed theoretically by Stamps *et al.* (1987) who examined edge permeability using computer models. They found that a small increase in permeability of a 'hard' (relatively impermeable) edge, resulted in a dramatic increase in emigration, whilst for moderately permeable edges further increases in permeability had little effect on emigration rates.

Observations of butterflies, both at natural boundaries and at the artificial hedge, revealed that they often fly parallel to tall boundary structures and cross when they reach a gap. A few individuals, from a wide range of species, did cross tall structures suggesting that, while most of the species studied were capable of crossing tall hedges, they were inhibited by behavioural mechanisms. Whether the barrier effect is physical or behavioural, the result is the same: dispersal is reduced. This increases the isolation of fragmented populations, diminishing 'rescue effects', i.e. the chance that populations close to extinction will be revived by the arrival of immigrants, and reducing gene flow between populations (Descimon & Napolitano, 1993).

Hodgson (1993), in his life-strategy approach to factors influencing the abundance of British butterflies, states that butterflies of 'open' or migratory population structures tend to be commonest. We suggest that the permeability of field boundaries plays an important role in this mobility and thus in the abundance of butterflies. Further, we believe that more information is required on factors determining boundary permeability to improve modelling of population dynamics at a landscape scale.

Whilst the extension of field margins benefits butterflies by increasing nectar resources and food plants, the structure of constituent hedges should be taken into account so that inter-field movement is not restricted. Management of farm hedges for wildlife conservation requires planning, both in terms of the characteristics of the hedge and its position in relation to other hedges, woodlots, uncultivated land etc. The key characteristic of any hedge is variation; for butterflies this means, in particular, variation in height. Tall hedges provide sheltered habitat conditions, basking and perching sites (Rosenberg, 1984; Scott, 1974) whilst gaps in the hedge increase inter-field movement. If hedges link habitat patches they can act as corridors, facilitating dispersal of individuals. Therefore a combination of extended field margins and tall hedges could be used to direct butterfly movements over agricultural land, for example between patches of uncultivated meadow - perhaps

as part of a future set-aside scheme. However, where tall hedges surround fields or have no links with other habitat fragments, they can act as barriers to butterfly movement across landscapes and isolate populations, increasing their vulnerability.

ACKNOWLEDGEMENTS

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THE INFLUENCE OF FIELD BOUNDARY STRUCTURE ON HETEROPTERAN DENSITIES WITHIN ADJACENT CEREAL FIELDS

S.J. MOREBY

The Farmland Ecology Unit, The Game Conservancy Trust, Burgate Manor, Fordingbridge, Hants, SP6 1EF

ABSTRACT
Densities of the true bugs (Hemiptera: Heteroptera) within cereal field headlands were studied with respect to head-land aspect and structure of the adjacent boundary. The influence of these features on the dominant heteropteran species *Calocoris norvegicus* and two pooled Heteropteran groups, grass feeders and predatory species were studied. Boundary type affected the distribution of all groups with most individuals being found in headlands adjacent to hedgerows. The effect of aspect was less obvious, *Calocoris norvegicus* was most numerous in west-facing headlands, while the groups of predatory and grass-feeding species were more numerous in north-facing ones.

INTRODUCTION
Within the last five decades many previously common species of flora and fauna of the arable landscape have declined in numbers, with many once common species now becoming the subject of concern among conservationists, while others are now classified as endangered and are to be found in the British Red Data Book (Batten *et al.*, 1990). One such species, the grey partridge (*Perdix perdix* L.), a once common sight in Britain's cereal fields, has declined dramatically. The major reason for this decline on arable land was found to be the indirect effects of pesticides acting to disrupt food chains (Potts, 1986). These products, especially herbicides and insecticides, caused a reduction in the densities of arthropod species that were essential food items in the diet of young partridge chicks. While the Heteroptera are one of the important groups of these so-called chick-food arthropods, little is known about their distribution and abundance within field headlands, the main brood-rearing area for partridges (Green, 1984), or about the effect of adjacent field boundaries. This study examined the heteropteran fauna of cereal field headlands adjacent to three common types of field boundary, post and wire fences, hedgerows and woodland edges, and examined the influence of boundary structure and aspect upon this important, non-pest insect group.

MATERIALS AND METHODS

Hetroptera were studied on a large Hampshire estate near Basingstoke during early July in 1988. Samples were collected using a Thornhill vacuum suction sampler (Thornhill, 1978) and five samples of five, 0.1m² sub-samples were collected at each headland site. To reduce possible variation between sites all sampling was carried out over a six-hour period (10 a.m.-4 p.m.) within spring barley crops, 3m from the field edge. Only selectively sprayed Conservation Headlands (Sotherton, 1991) were sampled to overcome the effects of pesticides. Within these

headlands large distinct monoculture areas of arable weeds were avoided.
Twenty sites per boundary type (hedgerow, woodland edge or post and wire
fence), were sampled over nine fields. All field boundaries were sited
on a slight bank at the field edge (about 50cm high) and covered with
grass and dicotyledonous species. Post and wire fence boundaries were
simply barbed-wire fences separating two fields, the hedgerow boundaries
varied between 2-3 m in height and consisted of shrub and tree species
cut every two-five years, while the wooded boundaries contained shrubs
and trees 3-15m high, separating fields from wide shelter belts, small
woods or copses. For every boundary type, five samples were taken for
each aspect, north, south, east or west-facing. In the following
sections post and wire fence boundaries will be referred to as grass.

All Heteroptera were identified to species level and were then
either grouped for analysis or, in the case of the dominant species,
Calocoris norvegicus (Gmelin), analysed with respect to stage of
development (nymph or adult). Three groupings were used, Total
Heteroptera, grass-feeders (Stenodemini) and predatory species (Nabidae
and *Anthocoris* spp.). A mean of the five samples from each site were
calculated and these data were analysed using a two-way ANOVA to measure
the effects of boundary structure and aspect.

RESULTS

All groups of Heteroptera were more numerous in crops adjacent to
hedgerows compared to those adjacent to grass boundaries. These
differences were significant for *Calocoris norvegicus* nymphs, total
numbers of *C. norvegicus* and, because of the dominance of this species
in the samples, for the total numbers of Heteroptera (Table 1). The
presence of a hedgerow was also associated with more Heteroptera in the
crop compared to wooded boundaries for all groups except the pooled
group of predatory species. However none of these differences were
significant. Only *C. norvegicus* nymphs were significantly more numerous
adjacent to wooded boundaries compared to grass. One group, the grass-
feeders, exhibited a significant boundary/aspect interaction, however
none of the individual boundary or aspect comparisons were significant.

When comparing *C. norvegicus* numbers in relation to boundary aspect,
lowest numbers of *C. norvegicus* occurred in north-facing headlands, with
highest numbers of both nymphs and adults occurring in west-facing ones.
None of the differences between south-, east- or west-facing headlands
were significant but significantly more adults occurred in south- and
west-facing headlands compared to north-facing ones (Table 2). While no
significant differences were found between the headlands in respect to
numbers of predatory and grass-feeding heteropteran species, highest
densities of both groups occurred in north-facing headlands.

DISCUSSION

The dominant heteropteran species collected during this study was
Calocoris norvegicus, a species which made up 60-80% of all Heteroptera
found in headlands regardless of boundary or aspect type. While woody
species are preferred for oviposition (Southwood & Leston, 1959),
cereals appeared to be the major food plant for *C. norvegicus* within the

field. The influence of the boundary structure on this species, which was found in significantly higher numbers in headlands adjacent to hedges or woods rather than grass, was more likely to be due to the suitability of the field boundary vegetation as oviposition and overwintering sites for eggs. While headland aspect seemed to influence adult feeding sites, (twice the number of individuals occurred in the warmer east-, west- and south-facing headlands), the effect of aspect may have been indirect, with possibly a greater diversity of flowering plant species occurring in these areas. If aspect had a similar effect on adults in the previous year, no noticeable effect on oviposition was observed, as the numbers of nymphs collected were similar in all headlands.

Predatory Heteroptera may have been directly influenced by the crop microclimate or indirectly affected by the abundance of suitable prey items, such as Hemiptera and other soft bodied prey groups. These prey may have themselves been more numerous in the microclimatic conditions offered by headland crops shaded by hedgerows and trees. The distribution of the grass-feeding species, (twice the number of individuals occurring in headlands adjacent to hedges compared to grass), was perhaps unexpected. However, while this group may be found in grass-weed free crops, their abundance and distribution is primarily effected by the presence of tall grass weed species in the field such as black-grass (*Alopecurus myosuroides* Huds.).and rough meadow-grass (*Poa trivialis* L.)

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TABLE 1. Mean number of Heteroptera per 0.5m² (± S.E.) occurring in three boundary types

| | Boundary Structure | | | |
	Hedge	Wood	Grass / wire fence	
Total Heteroptera	18.02 ± 1.63	11.82 ± 1.27	10.32 ± 1.63	H-G **
Calocoris norvegicus - Total	14.87 ± 1.79	7.20 ± 1.12	7.31 ± 1.56	H-G **
Calocoris norvegicus - Adults	4.91 ± 0.89	1.10 ± 0.23	2.76 ± 0.71	ns.
Calocoris norvegicus - Nymphs	9.95 ± 1.33	6.09 ± 1.00	4.55 ± 1.07	H-G ***
				W-G *
Predators	1.76 ± 0.58	3.80 ± 0.56	1.44 ± 0.44	ns.
Grass-feeders	0.96 ± 0.22	0.45 ± 0.11	0.47 ± 0.14	ns.

$*P < 0.05$ $**P < 0.01$ $***P < 0.001$

Boundary - Hedgerows = H
          - Wood = W
          - Grass/fence = G

TABLE 2. Effect of headland aspect on mean number of Heteroptera per $0.5m^2$ (± S.E.)

	Aspect				
	North	South	East	West	
Total Heteroptera	11.47 ± 1.49	12.40 ± 2.06	13.65 ± 1.86	15.22 ± 2.29	ns.
Calocoris norvegicus - Total	7.23 ± 1.37	9.81 ± 2.20	9.72 ± 1.77	12.29 ± 2.29	N-W*
Calocoris norvegicus - Adults	1.17 ± 0.21	3.67 ± 1.07	3.34 ± 0.96	3.39 ± 0.80	N-S* N-W**
Calocoris norvegicus - Nymphs	6.06 ± 1.36	6.13 ± 1.38	6.37 ± 1.16	8.87 ± 1.79	ns.
Predators	3.20 ± 0.89	1.51 ± 0.65	2.89 ± 0.64	1.65 ± 0.29	ns.
Grass-feeders	0.83 ± 0.19	0.39 ± 0.11	0.46 ± 0.10	0.43 ± 0.12	ns.

Aspect - North = N
        - South = S
        - East = E
        - West = W

$*$ $P < 0.05$ $**$ $P < 0.01$ $***$ $P < 0.001$