AN ECONOMIC ANALYSIS OF FARM HEDGEROW MANAGEMENT.

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ABSTRACT

The paper assesses the effect to farm incomes attributable to changes in hedgerow management associated with environmental enhancement. Hedgerow features and characteristics with potential financial implications for farmers were identified. Data was obtained from standard sources and from farm surveys in various parts of England and Wales. The impact of different hedgerow management practices on cropped areas, yields, farm labour, machinery requirements, and on farm revenues and costs were assessed. Analysis compared the costs and benefits of existing practices to alternative hedgerow systems and fences. The analysis was conducted using three farm models: a 200 ha arable farm; a 75 ha mixed farm; and a 75 ha dairy farm. A review of existing grants for hedgerows was carried out. The need for specific incentives to encourage farmers to adopt preferred hedgerow management practices was considered.

INTRODUCTION

The study of economic impacts of hedgerow management was part of a larger investigation of preferred hedgerow management sponsored by the Directorate of Rural Affairs, Department of the Environment. The study aimed to establish the financial cost which farmers would incur by changing their hedgerow management practices to increase the environmental benefit.

Using information gained from the farm survey carried out by the Institute of Terrestrial Ecology and Cobham Resource Consultants, and other relevant literature, the hedgerow features that would affect farm income and expenditure were identified. The costs of existing hedgerow management practices were identified; covering labour, machinery, supplies and services and including fencing where relevant. The impact of different hedgerow management practices were investigated with regard to the effect on cropped areas, yields, regular farm labour and machinery requirements. Analysis compared the costs and benefits of existing practices to alternative hedgerow systems and fences. The analysis was conducted using three farm models: a 200 ha arable farm; a 75 ha mixed farm; and a 75 ha dairy farm. The data for these models was taken from the aforementioned survey and published sources (Nix, 1990). A review of existing grants for hedgerows was carried out. The additional cost borne by farmers due to environmentally beneficial hedgerow management was identified. Consideration was given to the type and scale of incentives required to encourage farmers to adopt preferred hedgerow management practices.

HEDGEROW FEATURES

The main features of hedgerows relate to the size and the configuration of the hedge itself, and the adjacent verge.

Hedge types

A matrix of hedgerow features was drawn up by the Institute of Terrestrial Ecology (Institute of Terrestrial Ecology, 1992) and four main types of hedge identified. These hedge types may be ranked according to their relative merits in terms of environmental enhancement.

Type 1 is an unmanaged hedge, approximately 5 m high by 4 m wide and is considered to be the best habitat for birds, invertebrates and small mammals, as well as having the greatest landscape, amenity and sport values.

Type 2 is a side trimmed hedge, 4 m high by 2 m wide and has similar merits to type 1. The hedge is cut every second year, preferably cutting half the length of hedgerow on the farm each year.

Type 3 is a fully trimmed hedge 2 m high by 1.5 m wide. It has fewer environmental benefits than those above and is cut every second year.

Type 4 is a fully trimmed hedge 1 m high by 0.75 m wide. It is the most common type of managed hedge that exists on farms, is cut annually and has minimal environmental benefits.

The type 4 hedge is taken as the baseline for the subsequent calculations.

Verges

A verge extending from the outer extremity of the hedgerow for at least 1m has been shown to be highly desirable for wildlife, particularly if it is left uncut. This not only creates an additional area of habitat but also helps reduce any overspill of agricultural field management, for example agrochemicals or mechanical operations, into the hedgerow.

ECONOMIC IMPLICATIONS OF HEDGEROW CHARACTERISTICS

Within the two main hedgerow features, namely hedges and verges, a number of hedgerow characteristics were identified as having potential economic cost and benefit implications for farmers. A change in hedge or verge dimension has implications for land loss, labour and machinery costs and shelter and shade. These characteristics are discussed below, along with fencing, which is the most common field boundary alternative.

Land Loss

The land lost to agricultural production due to a change in hedgerow management is a function of any increase in the width of the hedge or verge. It is affected by the size and shape of the field, and the proportion of the field boundary that is enclosed by a hedgerow. The value of the land loss due to an increase in hedge or verge size was taken as the area lost multiplied by the gross margin of the crop, where the latter comprises the value of the crop output less the direct variable costs such as seed and fertilizer.

Farm labour and machinery costs

Labour and machinery requirements for field operations change in proportion to the area of cropped land. For the purpose of this analysis it has been assumed that any change in crop area due to hedgerow management will not affect the size of the permanent labour force or the machinery inventory. Changes in labour requirements have been valued at the standard hourly wage rate, and average machinery running costs have been estimated at £60/ha and £25/ha for arable and grassland enterprises respectively.

Shelter and shade

The main reason for retaining non-stock proof hedges on farms, apart from tradition, is the shelter benefit that the hedge provides to both crops and livestock. The semi-permeable structure of a hedge slows the air flow without adverse turbulence. This reduction in air speed has been shown to have an effect on crop yield (Caborn, 1965). The benefit of additional shelter for stock has also been demonstrated, (Blaxter *et al.*, 1964; Caborn, 1965). However, as the in-wintering of beef and dairy stock is now common agricultural practice in the United Kingdom, the economic benefit of additional shelter is slight.

The shading effect of a hedge depends on its height, orientation and the incidence angle of the sunlight. The shading of field plants adversely affects the growth rate and yields (Caborn, 1965).

It has been assumed that the net effect of shelter and shade on the crop is a 50% reduction in yield or stocking density in the area affected (expressed as the field area equivalent to the hedge height multiplied by the hedge length).

Fencing

On stock and dairy farms, back fencing of hedges is commonplace. If a conservation verge is introduced, a fencing barrier is required to exclude stock from the conservation verge. For cattle a single/double barbed wire or electric fence is sufficient but in the case of sheep a netting fence is necessary. For some field boundaries, a conservation verge involves the relocation of the back-fence rather than an additional fence.

Fencing may be used as an alternative field boundary to a hedge. If so, there are beneficial effects in terms of increasing the area available for cultivation and removal of all shade effects. Fencing costs vary with the type of fence. Costs to supply and erect a wire fence eligible for grant are approximately £3.50/metre. If a fence is erected to protect the verge from livestock, the costs are £3.50/metre for sheep netting and £1.20/metre for a single barbed wire for cattle. In the analysis the costs have been amortised over the life of a fence (which is assumed to be 20 years).

HEDGEROW MANAGEMENT PRACTICES

The most common type of managed hedge on farms is 1 m high by 0.75 m wide with no verge. On livestock farms, back-fencing is commonplace.

The majority of hedges are cut annually, using tractor mounted flail cutters. A small number of farmers use reciprocating cutters or circular saw blades. If a verge is present it is normally cut at the same time as the hedge. Regular management is usually undertaken after harvest on arable farms when labour is available. Where labour and machinery are insufficient, contractors are normally engaged.

Hedgerow management costs vary, depending on whether a farmer uses his own machinery and labour or hires a contractor. The costs increase substantially with the size of the hedge and the number of passes necessary, but these are partly offset by less frequent cutting. The cost of cutting the four hedge types, and verge where present, are shown in Table 1. For unmanaged hedges it is assumed verges are cut once every two years.

TABLE 1. Hedgerow and verge cutting costs (£ per 100 m of hedgerow)

	Hedge type (with verge)			
	Type 1	Type 2	Type 3	Type 4
Number of passes	0 (2)	8 (10)	5 (7)	3 (5)
% cut per annum	0 (50)	50 (50)	50 (50)	100 (100)
Own machinery and labour (£3.01)	0 (3)	2 (15)	8 (11)	9 (15)
Contractor (£2.67)	0 (3)	11 (13)	7 (9)	8 (13)

COST BENEFIT ANALYSIS

Farm models

Three models were used to demonstrate the effect of different hedgerow management practices on different farming systems. A 200 ha arable farm; a 75 ha mixed farm; and a 75 ha dairy farm. The average field size was 10 ha, 7.5 ha and 5.7 ha respectively, with an assumed 66% of field boundary hedged. This resulted in hedgerow lengths of 16138 m, 7207 m, and 8151 m for each farm.

Analysis

For each model, the following points were examined with respect to different types of hedgerow practices, with and without verges, and hedge replacement by fencing:

- the land and field effects on gross margins;
- the impact on labour requirements for existing farm operations, and for hedge and verge maintenance;
- the impact on machinery costs for existing farm operations, and for hedge and verge maintenance; and
- the annual capital costs for establishing fencing.

The total annual costs are shown in Table 2.

TABLE 2. Total annual costs (£ per 100m) of different management practices by farm type with respect to hedge type 4.

Farm type	Hedge type (with verge)				
	Type 1	Type 2	Type 3	Type 4	Fence
Arable	17 (21)	21 (25)	8 (12)	0 (11)	17
Mixed	7 (19)	14 (26)	4 (16)	0 (17)	18
Dairy	22 (40)	23 (41)	9 (27)	0 (25)	16

<u>Summary</u>

(i) With respect to the arable and mixed farms, type 2 is more expensive to farmers in cost per 100 metres and has fewer environmental benefits than type 1.

(ii) Type 3 hedge without a verge offers a relatively cheap way of securing some environmental benefits.

(iii) The inclusion of a verge substantially increases the costs since it involves land loss, verge cutting, and, on livestock farms, conservation fencing.

HEDGEROW GRANTS AND INCENTIVES

Grants are available from a number of sources for hedgerows and hedgebanks. However, annual maintenance costs are not usually eligible.

<u>Conclusions</u>

In the context of achieving a transition from existing Type 4 hedgerows without verges to those which enhance environmental qualities, there are two main choices:

- hedge types: Type 3 without a verge is the cheapest option for all farm types but has limited environmental benefits;

- verges: the inclusion of verges adds to environmental quality but can significantly increase costs to farmers, particularly on livestock farms due to the need for conservation fencing.

The preceding analysis has examined the costs to farmers of providing alternative hedgerow characteristics. These costs need to be compared with the environmental benefits provided by the different hedgerow types in order to determine the most cost effective hedgerow management practices.

ACKNOWLEDGEMENTS

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CONSERVATION AND RESTORATION OF SPECIES RICH DITCH BANK VEGETATION ON MODERN DAIRY FARMS

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ABSTRACT

Many ditch banks on modern dairy farms in the western peat district of the Netherlands still contain a species-rich vegetation of international importance. Research was carried out in order to investigate if and how conservation and restoration of this vegetation is compatible with modern dairy farming. The research was started by studying the existing diversity of management in relation to the floristic richness of the ditch bank vegetation. In this way the most important factors determining the species composition were established. Subsequently an experiment was carried out with one of the most important factors: the cleaning frequency of the ditches. The purpose of the experiment was to investigate whether a lower cleaning frequency can be compatible with modern farming and proper water management. That proved to be the case in many situations. In some situations both nature and farmer could even benefit from a lower ditch cleaning frequency.

INTRODUCTION

The plant species diversity of grasslands and ditch banks in the western peat district of the Netherlands is declining because of intensive dairy farming (Provincie Zuid-Holland, 1993). Protecting these nature values by establishing nature reserves is only possible on a limited area because of the high costs. Therefore studies have been carried out to study the possibilities for nature protection within the limits of modern dairy farming (Melman, 1991; Van Strien, 1991; Twisk *et al.*, 1991). The starting-point was that farming and nature conservation don't have to be incompatible, as is commonly assumed (De Boer & Reyrink, 1988). The ditch bank vegetation studies of Van Strien and Twisk will be discussed here.

Study area

The study sites were located in the typical Dutch polder-landscape. The surface soil of these polders consists of peat, intersected by zones of clay and clay-on-peat along the rivers. This landscape was formed by man about a thousand years ago by digging parallel drainage ditches. The result is a landscape with long narrow fields (40-60 m wide and up to 1-2 km deep) separated by ditches (1-7 m wide and 30-60 cm deep). The fields are almost always grasslands with dairy farming as the main form of agricultural land use. The farming intensity is very high with an average N-supply of C. 300 kg N per ha and 1.7 cows per ha.

The polders all lay below the present sea and river level due to drainage and subsequently shrinking of the peat over the last centuries. The water table therefore is man-controlled, in winter 10 to 20 cm lower than in summer. Regional waterboards require the farmers to clean their ditches in order to maintain a proper discharge of water from the polders. Almost all ditches are cleaned mechanically once a year nowadays, often in the autumn. Plants in and near the ditches are removed and dumped on the banks, together with mud from the ditch bottom.

Grassland research

At first the possibilities for nature conservation on the grasslands were investigated (Van Strien, 1991). These possibilities proved to be very limited: grassland vegetation only has some floristic richness when the N-supply is below 100-200 kg N per ha (Figure 1). Such low levels are scarcely attainable in current dairy farming.

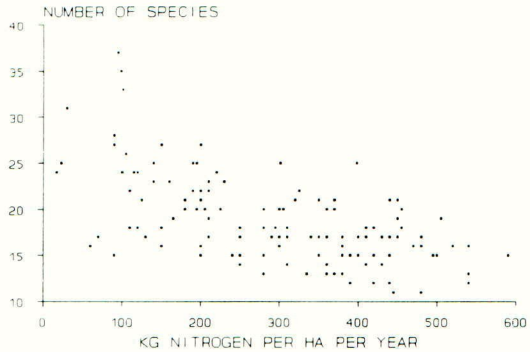

FIGURE 1. The relationship between the number of plant species and the N-supply on grassland (from Van Strien, 1991)

Focus on ditch banks

On the ditch banks along the grasslands however there appeared to be more possibilities to keep and restore species rich vegetation. Firstly, many ditch banks still contain species-rich vegetation, including international quite "rare" species such as *Lychnis flos-cuculi* and *Iris pseudacorus*. Secondly, ditch banks form a marginal part of the farm from a economic point of view. So, management more aimed at nature conservation does not have to result in loss of income. Thirdly, species-rich ditch banks can also be found in situations where the adjacent fields are used intensively, indicating that modern dairy farming can be combined with maintenance of floristic values in the ditch banks. Last but not least, the ditch banks form quite a large potential "nature area", because their lack in width (they are not more than 1 to 2 m wide) is more than compensated by their length (their total length has been estimated at C. 100.000 km for the Dutch peat areas). Therefore, the aim of this research was to consider the possibilities for maintenance or restoration of species-rich ditch banks and its consequences for the farmer.

STUDY DESIGN

A multifactor, transverse study design was used to assess the individual effects of the agricultural factors (Van Strien, 1991). This approach implied the spatial comparison of a great number of plots on ditch banks (>300 spread over >100 dairy farms) differing in management regime. Data on grassland exploitation, ditch management and properties of the banks were obtained from the farmers and from field observations. Only steady-state situations were selected, i.e. situations with a more or less constant management for at least the previous 5 years. The study plots were carefully selected, to yield a data set with an almost independent variation of the factors studied. All factors involved are mentioned in Table 1.

TABLE 1. The influence of some factors on number of plant species in the ditch bank vegetation as well as the expected compatibility of measures with farming practice (based on Van Strien, 1991).

Factor *(+ range)*	Number of species	Expected compatibility
Nitrogen supply on grassland *(0 - 550 kg N ha^{-1} $year^{-1}$)*	--	++[3]
Type of use *(meadow - pasture)*	ns	-
Level of ditch water *(15 - 80 cm below surface)*	--	--
Slope aspect *(South - West - East - North)*	-[1]	irrelevant
Slope angle *(0 - 35 degrees)*	++[1]	-
Soil type *(mesotrophic peat - eutrophic peat - mes. clay-on-peat - eutr. clay-on-peat)*	ns	irrelevant
pH of topsoil *(pH-H_2O 4.0 - 7.2)*	++	+
P and K of topsoil	ns	+
Ditch cleaning frequency *(once every year - less than once every 3 years)*	++[2]	+?
Ditch cleaning method *(hand - mowing-basket - ditch-scoop - auger)*	ns	++
Peat mud dressing *(less - more than 5 years ago)*	ns	++

1) Effects depend on slope angle and slope aspect respectively.
2) Optimum relationship.
3) Meant is keeping only the banks free from nitrogen supply.

EFFECTS ON VEGETATION

In this paper we will focus on the (distinct) effects on species richness (for effects on other characteristics of floristic richness see Van Strien, 1991). The number of species decreases with increasing nitrogen supply on the parcel (Table 1). The number of species decreases with higher ditch water level (i.e. lower water table). The floristic richness was greater for south-facing banks than north-facing banks, and steep south-facing banks than gentle south-facing banks. The number of species was also larger at a high pH of the bank soil. There appeared to be an optimum relationship between cleaning frequency and number of species (Table 1 and Figure 2). The remaining factors could not be proven to be of importance (but see Melman, 1991 and Melman & Van Strien, 1993 for more detailed information on the effects of type of land use, ditch cleaning method and peat mud dressing).

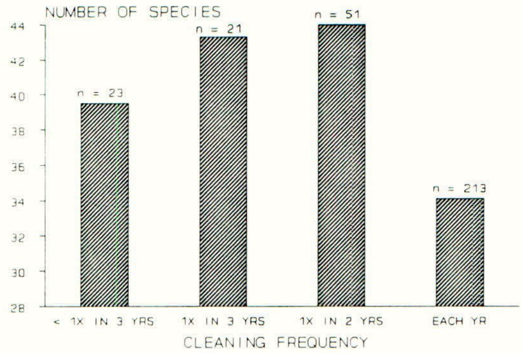

FIGURE 2. Mean number of species on ditch banks in relation to cleaning frequency of ditches (based on Van Strien, 1991)

The relationships above found (with special emphasis on ditch cleaning frequency) will be discussed in relation to aspects that determine the application of measures, i.e. compatibility with farming practice, risk of spreading of noxious weeds and social and political aspects.

COMPATIBILITY WITH FARMING PRACTICE

On the basis of the observed relations, measures can be formulated that may maintain or restore floristic values on the ditch banks. The technical and financial compatibility with farming practice will determine to what extent farmers are able and willing to adopt these measures. This compatibility has been estimated on the basis of knowledge of the farming practice (Table 1). For one of the most promising measures, reducing the cleaning frequency of the ditches, an experiment was performed to study the compatibility more closely (see Melman & van der Linden, 1988 for a similar experiment keeping the banks free from fertilizer).

The most beneficial effect on species richness when lowering the cleaning frequency is the change from once a year to once every two years (Figure 2). The effects of this change on the dairy farming practice were studied in an experiment (Twisk *et al.*, 1991). The effects on the water board tasks (e.g. controlling the water table) were also studied, but will not be discussed here. Eighteen farmers volunteered to skip one regular ditch cleaning in one ditch. The changes in ditch width, depth and filling grade with plants were measured twice a year. In a few ditches the changes in water table (due to rainfall and water discharge) was measured constantly. In addition the time needed to clean the ditch was determined in order to investigate the effects of restricting the ditch cleaning frequency on the amount of labour or costs.

Measurements in combination with model computations showed that water discharge was always sufficient if the ditch was wide enough (>3 m) and deep enough (>30 cm). Most ditches in the peat district exceed this size and are in fact oversized for their functon as drainage channels. One of the reasons for this is that the ditches in former days were used for transportation of e.g. cattle by boat. In some cases the next ditch cleaning took more time, undoing the advantage of only having to clean the ditches once every two years instead of every year. In most cases however, the next ditch cleaning took no more time than usual, giving the farmer the benefit of only having to clean the ditches at half the previous frequency. Considering that an average farm has at least 5 km of ditches, this can mean quite a reduction of labour. So, both farmer and nature could benefit from a lower ditch cleaning frequency.

NOXIOUS WEEDS

The most noxious weeds such as *Cirsium arvense* and *Rumex obtusifolius* rarely occur on the banks, but instead prefer the high-lying parts. Nevertheless the risks of weeds spreading from the banks to the adjacent fields was studied because farmers fear such an effect (Van Strien, 1991). Comparing the amount of weeds on the ditch banks with the floristic richness of the ditch banks (Figure 3) showed that management of the vegetation on the low-lying parts of the banks aimed at species diversity should not increase weed problems, but instead should reduce them.

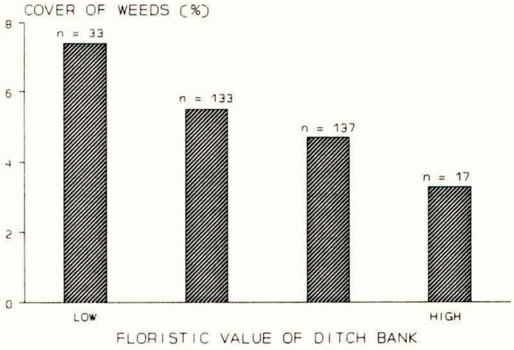

FIGURE 3. The relationship between the summed cover of 12 weed species on the ditch bank and the floristic richness of the bank vegetation (from Van Strien, 1991)

SOCIAL & POLITICAL ASPECTS

The prospects of the ditch bank vegetation do not depend solely on the compatibility of the measures with the technical and economical aspects of farming. There are also psychological and socio-cultural obstacles to vegetation management.

Many Dutch farmers associate vegetation management with poorly productive grasslands, with neglect and with an increase of noxious weeds (Van Strien & Ter Keurs, 1988). However, these opinions mainly arise because farmers are unfamiliar with ditch management. As shown above, for ditch banks none of these associations are correct. Increased information on vegetation management in recent years and practical demonstration of results appear to have had impact, because more and more farmers incorporate this management into their farming practice.

Ditch bank management for conservation purposes could be further promoted if grants are given for the purchase of machines that are necessary for that kind of management and if farmers are rewarded financially for the "production" of species-rich banks on their farms ("nature production payment"). Experiments with this kind of financial stimulation are currently under investigation (see papers from Melman and Kruk *et al.* elsewhere in this issue).

CONCLUSIONS

The results of the above discussed studies prove that farming and nature conservation (in the form of field margin management) can indeed be compatible, as was our assumed starting point. The studies also show that in some cases farming and nature conservation can even benefit from each other.

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VEGETATION PATTERNS AND CHANGES IN FIELD BOUNDARIES AND CONSERVATION HEADLANDS IN SCOTTISH ARABLE FIELDS

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ABSTRACT

A survey of 50 field margins in Game Conservancy guidelines conservation headland managed fields in eastern Scotland is described. A total of 101 plant species were recorded; of which 87 were in the boundary, 58 within 1m, 36 at 2.5m and 34 at 5m from the boundary. There were fewer species noted in the boundary than in earlier southern England surveys, but the vegetation was generally regarded as being diverse, with tussock and creeping grasses and a range of broad-leaf species. The boundary strip/crop margin had a wide range of annual species. There was some indication of ingress of creeping species from the boundary, in fields that had been managed in this way for more than 1 year; most noticeably *Cirsium arvense.* Spread of another serious weed of arable crops *Elymus repens* was not evident, but it was present, together with the invasive species *Bromus sterilis* and *Galium aparine,* and care should be taken in managing fields to prevent their spread.

INTRODUCTION

Field margins can be an important wildlife habitat on arable farmland. Regular applications of herbicides to arable crops have reduced the population of many arable weeds, and have adversely affected the numbers of associated insect species, many of which are important food sources for game birds and other birds (Sotherton, *et al.* 1991). There is evidence that herbicides could affect the composition of boundary flora (Marshall & Birnie, 1985); with similar consequences. Observations from SAC farm advisory work indicate that many farmers have used non-selective herbicides to eradicate perennial creeping weeds such as *Elymus repens*, so changing the boundary flora leaving a species poor habitat. The Game Conservancy has developed management guidelines for arable field margins, known as conservation headlands, to reduce the impact of crop management on birds by reducing or preventing herbicide and insecticide use in the field margin (Sotherton, 1990). A boundary strip, free of crop is recommended, and the crop margin up to the headland tramline receives no broad-leaf weed herbicide or insecticide during spring or summer.. The work upon which these recommendations were based was undertaken in southern England. The aim of the investigation described here is to examine the development of the conservation headland field margin flora under northern arable conditions, and to advise farmers of weed problems that may arise from such an approach. The data is also perceived to be of assistance in developing potential set-aside policies.

MATERIALS AND METHODS

Fifty arable fields (29 spring barley, 19 winter wheat, 1 winter barley, 1 triticale) from Eastern Scotland, managed to some extent as conservation headlands, were selected for the survey in summer 1993. A representative headland was selected in each field from which a 100 m strip was chosen avoiding field entrances. At 10m intervals, a total of 11 short transects were run from the field boundary into the crop edge. A 0.25m² quadrat was placed in the boundary vegetation at the start of the transect and at 1m, 2.5m and 5m into the crop. A total of 44 quadrats were therefore assessed in each strip. The percent ground cover of each species of higher plant occurring in each quadrat was recorded.

RESULTS

Table 1 lists the species occurring in the survey, comparing occurrence at each sampling point on the transect. The table also includes lists of species seen in the 1992 survey (Carnegie and Davies, 1993), but not found in 1993 to give a complete flora from the series. There were 101 species in 1993, of which 87 were found in the boundary (38 exclusive), 58 at 1m (3 exclusive), 36 at 2.5 m and 34 at 5 m (crop areas), none of which were exclusive to these sampling points. The species with the greatest frequency and overall ground cover are listed in Table 2. The grasses, *E. repens, Dactylis glomerata* and *Holcus mollis* tended to dominate the boundary of the fields, with *Cirsium arvense, Galium aparine, Heracleum sphondylium* and *Urtica dioica* the most frequent broad-leaf species. Other common species were *Poa pratensis, Arrhenatherum elatius, Agrostis stolonifera, Festuca rubra* and *Poa trivialis* plus the annuals *Poa annua* and *Stellaria media.* The field boundary strip tended to have *S. media, Tripleurospermum/Matricaria* spp., *Polygonum aviculare* and *P. annua* present plus a range of both boundary and crop margin species. The boundary species with a spreading habit were present in many boundary strips at moderate levels, notably *C. arvense* and *G. aparine*. *E. repens* was observed at low density in the crop in this survey. Occasional plants of *H. sphondylium, H. mollis, U. dioica, P. pratensis, P. trivialis* and *R. obtusifolius* were recorded in the crop margin. Comparison was made between fields which had had greater than one year conservation headland management out of three seasons, and those which had only been under such management in 1993 (Table 3). There was little difference between the frequency and ground cover of the listed species, except for a general increase in *R. obtusifolius,* an increase in ground cover, although not incidence, of *C. arvense,* and possibly of *T./Matricaria* spp.

DISCUSSION

A similar number of species were seen in this survey to the 1992 survey of fewer fields (Carnegie and Davies, 1993). There were a few differences noted in the minor species

TABLE 1. Species lists for 1993 field margin survey, and additional species seen in 1992 survey [ ]

Species only in field boundary		*Agrostis stolonifera*	***Species in crop + boundary strip only***	*Holcus mollis*
*Acer pseudoplatanus**	*Stellaria holostea*	*Arrhenatherum elatius*	*Capsella bursa-pastoris*	*Lamium amplexicaule*
*Achillea millefolium**	*Trifolium dubium**	*Cerastium vulgatum*	*Chenopodium album*	*Lamium purpureum*
Alopecurus pratensis	*Trifolium pratense*	*Chamerion angustifolium*	*Euphorbia helioscopia*	*Lapsana communis*
Amsinckia micrantha	*Ulex europaeus*	*Dactylis glomerata*	*Fallopia convolvulus*	*Myosotis arvensis*
Anthriscus sylvestris	*Veronica chamaedrys*	*Equisetum arvense*	*Filaginella uliginosa**	*Papaver rhoeas*
Atriplex patula	*Vicia cracca*	*Festuca pratensis**	*Lycopsis arvensis**	*Phleum pratense*
*Bromus hordeaceus**	*Vicia sativa**	*Holcus lanatus*	*Raphanus raphanistia**	*Poa annua*
*Centaurea nigra**	*Vicia sepium*	*Lolium perenne*	*Solanum tuberosum*	*Poa pratensis*
*Cerastium tomentosum**	*[Agrostis gigantea*	*Mentha arvensis*	*Spergula arvensis*	*Poa trivilis*
Crepis spp.	*Asperula arvensis*	*Senecio jacobaea**	*Viola arvensis*	*Polygonum aviculare*
*Deschampsia cespitosa**	*Carduus personata*	*Stellaria graminae*	*[Volunteer cereals*	*Polygonum persicaria*
Digitalis purpurea	*Festuca ovina*	*Torilis japonica**	*Aphanes arvensis*	*Ranunculus repens*
Festuca rubra	*Filipendula ulmaria*	*Urtica dioica*	*Avena fatua*	*Rumex obtusifolius*
Galium cruciata	*Impatiens sp.*	*Veronica hederifolia*	*Borago officinalis*	*Sinapis arvensis*
Galium verum	*Knautia arvensis*	*[Cardamine hirsuta*	*Polygonum persicaria*	*Stellaria media*
*Geranium dissectum**	*Moenchia erecta*	*Galium saxatile]*	*Sonchus arvensis*	*Taraxacum officinalis*
*Geranium sp.**	*Sarothamnus scoparius*		*Veronica serpyllifolium]*	*Trifolium repens*
*Hydrocotyle vulgaris**	*Senecio vulgaris*	***Species only in boundary strip***	***Species found at all transect positions***	*Tripleurospermum/Matricaria spp.*
Lathyrus pratensis	*Silene latifolia*	*Sonchus oleraceus*	*Aira praecox**	*Veronica persica*
*Lotus corniculatus**	*Symphytum sp.*	*Veronica agrestis**	*Brassica napus olifera*	
Plantago lanceolata	*Taraxacum officinale*	*Urtica urens*	*Bromus sterilis*	
Rosa canina	*Trifolium campestre]*	*[Anchusa arvensis*	*Chamomilla suaveolens**	
Rubus fruticosus		*Glechoma hederacea*	*Cirsium arvense*	
Rubus idaeus	***Species in field boundary + boundary strip (1m)***	*Sisymbrium officinalis]*	*Cirsium vulgare*	
Rumex acetosa	*Aegopodium podagraria*		*Elymus repens*	
Rumex crispus	*Aethusa cynapium*		*Fumaria officinalis*	
*Sambucus nigra**	*Agrostis capillaris*		*Galeopsis speciosa*	
*Silene dioica**			*Galium aparine*	
Sonchus arvensis			*Heracleum sphondylium*	

***** *Seen only in 1993 survey***

TABLE 2. Ranking of major species based on % frequency (F) by sites, and % overall ground cover (C), where F= >19% of sites, and/or C = >0.99%, at one or more survey points from the field margin (0, 1, 2.5 or 5m)

	F					C			
Species	0m	1m	2.5m	5m		0m	1m	2.5m	5m
E. repens	90	48	4	2		13.2	2.9	0.1	T
D. glomerata	84	6	-	-		15.0	0.7	-	-
H. mollis	80	28	4	-		19.9	2.3	0.6	-
C. arvense	74	62	14	2		3.7	2.7	0.6	T
G. aparine	72	28	20	10		4.4	1.7	0.6	0.4
H. sphondylium	70	12	-	2		5.9	0.2	-	T
U. dioica	66	4	-	2		3.7	0.2	-	T
P. pratensis	60	8	-	2		3.5	0.4	-	T
A. elatius	56	-	-	-		7.5	-	-	-
P. annua	54	50	90	90		5.5	6.8	6.1	8.5
A. stolonifera	46	10	-	-		4.0	0.3	-	-
F. rubra	42	-	-	-		3.7	-	-	-
S. media	40	88	80	62		1.7	14.2	11.4	4.3
P. trivialis	38	22	6	4		2.4	1.3	0.2	0.1
A. sylvestris	28	-	-	-		1.5	-	-	-
R. obtusifolius	26	18	2	-		1.5	1.1	0.1	-
P. pratense	22	2	-	2		1.1	0.2	-	T
C. angustifolium	16	8	-	-		1.8	0.4	-	-
B. sterilis	8	6	2	2		1.1	0.2	0.1	0.2
V. cracca	26	-	-	-		0.4	-	-	-
C. vulgatum	22	8	-	-		0.4	0.2	-	-
H. lanatus	20	6	-	-		0.9	0.2	-	-
R. repens	20	18	4	2		0.6	0.5	0.1	0.1
Tripl./Matricaria	12	62	58	40		0.3	4.7	3.8	1.8
P. aviculare	2	48	38	38		0.2	2.3	1.7	1.3
G. speciosa	4	34	24	14		0.1	0.8	0.3	0.2
V. arvensis	-	34	28	20		-	0.6	0.6	0.5
M. arvensis	12	28	24	2		0.7	0.6	0.3	T
S. arvensis	-	26	20	18	-	-	0.5	0.5	0.3
C. bursa-pastoris	-	24	26	16	-	-	0.5	0.9	0.6
L. purpureum	6	22	16	8		0.3	0.5	0.9	0.1

T: <0.05% ground cover

lists between the surveys, but the major species were common, and tended to show a similar pattern of distribution. The species lists contain many similarities with those of Chancellor & Froud-Williams (1984) and Marshall (1985a; 1985b), who carried our surveys of field margins in southern England, the major difference being the lack of *Alopecurus myosuroides* and *Fallopia convolvulus* in this survey. Marshall (1985a/b) indicates that few species are capable of spreading from the boundary to the crop, but the list of species from this boundary survey includes a number which are known to spread, including *E. repens, C. arvense* and *G. aparine*. These were found in the boundary and crop of a number of fields, and there was some indication from fields that had had more than one year of field margin management with no herbicide use of an increase in ground cover of *C. arvense*. There was less evidence of a general increase in the other species.

TABLE 3. Frequency (F) (% all quadrats) and mean % ground cover (C) of major plant species in 9 field margins having been managed >1 y of 3 y as conservation headlands, compared with 1 y only managed headlands

	>1 y sites		1 y only	
	%F	**%C**	**%F**	**%C**
C. arvense	38.9	14.4	37.8	4.4
E. repens	41.7	9.9	34.8	11.5
G. aparine	27.8	4.9	33.5	5.6
H. mollis	36.1	16.6	26.2	21.1
P. annua	86.1	6.9	82.9	8.3
P. aviculare	36.1	2.3	30.5	4.8
R. obtusifolius	30.6	9.5	12.8	1.6
S. media	72.2	13.7	66.5	11.2
Tripl./Matricaria	41.7	11.1	43.3	5.5

In part the lack of major problem of weed spread from boundaries in this survey must be related to a selective choice of boundaries by farmers, and it was evident on some fields that *C. arvense* in headlands had been treated with a clopyralid based herbicide treatment during the early summer to reduce spread. The boundary vegetation in the survey was dominated by tussock grasses such as *D. glomerata, A. elatius* and *Phleum pratense*, mixed with creeping grasses such as *E. repens* and *H. mollis*. There was also a range of perennial broad-leaf species, in particular *C. arvense, H. sphondylium* and *U. dioica*, with *G. aparine*. This canopy limited the development of a wide range of other plant species, and the average number recorded per field boundary was 15.2. This compares with an average of 24.6 from 17 fields surveyed at two farms in southern England by Marshall (1985a). However, the dense vegetation was considered to provide good quality wildlife habitat.

A range of weed species have been identified by Sotherton et. al. (1985) as to be important hosts to insect fauna which are a food source, along with the weeds themselves, for gamebirds and songbirds. The data is mostly in association form, with the removal of weeds leading to reductions in fauna rather than linking specific species with specific fauna. Nevertheless, there are indications that *P. aviculare* and related species, and *Tripleurospermum/Matricaria* spp. are important examples. These are common species in this survey, present throughout the transects. The boundary strip points contained 58 species in total, with no one species dominating, although *S. media* and *P. annua* were very common, indicating the availability of a large food resource.

In the absence of weeds such as *B. sterilis* and *G. aparine*, the effect of weed cover on crop yield from the headland has been shown to be small (Fisher, et al., 1988), Nevertheless, Davies and Whiting (1990) have shown that *P. aviculare* and *S. media* can affect harvesting and *Lolium perenne* can contaminate grain. Carnegie and Davies (1993) listed some of these species that have shown similar effects in the literature, and others that they considered have an equal effect from advisory experience. A number of these species are also difficult to control in other parts of the rotation; notably *C. arvense*.

It is concluded that these conservation headlands show a wide diversity of plant species, which although not as diverse as some southern field margins, could still be a major wildlife habitat resource. The sites were selected to avoid severe *B. sterilis, E. repens* and

G. aparine problems, but where these species are present, care should be taken to avoid spread into crops. The fields where conservation headlands had been repeated did not show large increases in these species, but rotation of the headlands should be encouraged to reduce the risk. There is some evidence, however, that *C. arvense* may increase, and herbicide options may eventually be required to maintain control.

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