Marshall Agroecology Limited

GUIDELINES FOR THE SITING, ESTABLISHMENT AND MANAGEMENT OF ARABLE FIELD MARGINS, BEETLE BANKS, CEREAL CONSERVATION HEADLANDS AND WILDLIFE SEED MIXTURES

Defra UK Project BD0412

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1. Introduction

The aim of these guidelines is to provide background information on the objectives of managing field margins with agri-environment scheme support, from wildlife, environmental and agricultural viewpoints, and to indicate sources of further information and advice. This should enable Project Officers and advisers to assist in the implementation of the options, by identifying the different objectives for margins. In addition, the guidelines aim to help advisers to better judge applications for derogations and to identify those areas that will need refining as the support schemes develop.

The guidelines draw on the experience of published scientific work, reviews and research and development experience from a range of organisations. The most important information is presented and is augmented with details of sources of further information and guidance. The guidelines are prepared in bound form, for ease of use. It should be recognised that, in future, there may be changes required to details of the Schemes, now that practical implementation is underway. Additional information will also need to be included. It is expected that updated versions of these guidelines will be available in future.

The guidelines present the aims for each option for field margin, beetle bank, conservation headland and wildlife seed mixture management, with variations where they are possible for achieving different objectives. The guide draws together information on management effects and interactions, so far as is possible. Each approach is discussed separately. Subsequent sections give information on different taxa associated with arable land, particularly bird, mammal and rare plant species identified in the UK Biodiversity Action Plan (BAP).

The guidelines for each option comprise information on the potential benefits to wildlife, the environment and to agricultural practice, the likely problems that may arise and, where possible, the management means to minimise such problems. Where management options are relevant, the requirements of the Codes of Good Agricultural Practice for Water, Air and Soils are referred to.

Where points of contention associated with particular options have been identified, these are noted.

1.1. Threats to the diversity of arable land

Surveys of farmland wildlife have identified serious declines in the populations and ranges of birds and declines in populations of mammals, insects and plants associated with arable land. Changes in arable farming practices have been identified as important factors in these declines.

Declines in farmland birds have been identified for a number of bird species characteristic of arable and mixed farmland (Fuller *et al*., 1995). These birds feed on seeds, invertebrates or both, sometimes at different times of year. Significant declines in the brown hare have also been recorded (Tapper & Barnes, 1986), associated with changes in the availability of high quality food at certain times of year. Declines in the pipistrelle bat are in part likely to have resulted from lower abundance of insect prey in farmland. Information on declines in arthropods in farmland has been published for the Game Conservancy Trust's Sussex Study (Potts, 1991). In the Sussex study area, between 1972 and 1990, arthropods have declined by 4.2% per annum (excluding springtails and mites), with many groups of beneficial insects, such as aphid predators and gamebird food items, declining at faster rates. Bee species are particularly threatened. A range of cornfield weeds, such as corn buttercup and shepherd's-needle, have declined markedly this century, to the extent that some species are now extinct in the UK. These annual flowers are truly dependent on the arable ecosystem, which is characterised by regular soil cultivation.

Changes in farming practices that have been identified as causing declines in biodiversity include 1) concentration on winter crops with a consequent loss of spring crops, 2) increased farm specialisation with a decline in livestock and grass enterprises in arable areas, 3) changes in cultivation dates and 4) loss of semi-natural habitat in farmland, including field margins. The Countryside Survey 1990 (Barr *et al*., 1993) showed that not only have hedgerows declined in length, but the botanical diversity of many field margins has also declined through nutrient enrichment and/or herbicide drift. This study also demonstrated the importance of field margins as refugia for botanical diversity in lowland agricultural landscapes. A series of studies have also demonstrated the importance of field margins as over-wintering sites for a wide range of invertebrates. Whilst the idea of field margins as corridors for animal and plant movement between habitats has only been clearly demonstrated for forest beetles, these landscape elements are used by a wide range of birds, mammals and insects and are important for plants. Pipistrelle bats are almost always found foraging close to hedges and treelines in the Netherlands (Verboom & Huitema, 1997). Studies on weed seed banks in arable fields have demonstrated that the field edge has the most diverse and abundant

seed bank. Thus, the conservation of rare cornfield flowers is likely to be most successful at the field edge.

1.2. The role of field margins

Field margins exist in the landscape as they have, or had in the past, true agricultural functions. In stock farming areas, hedges and walls were maintained to keep stock in or out. In arable land, field margins delineate the field edge and land ownership. In more recent time, a series of subsidiary roles have been identified, reflecting agricultural, environmental, conservation and cultural or historical interests:

Original roles and requirements

1.	To define the field edge
2.	To be stock- or trespasser-proof, to keep animals in or out
3.	To provide shelter for stock
4.	To provide shelter for crops, particularly as windbreaks
5.	To reduce soil erosion by wind or water
6.	Not to compete with the crop for light, moisture or nutrients
7.	Not to harbour weeds, pests and diseases
8.	To harbour beneficial plants and animals
9.	To act as a refuge or corridor for wildlife
10.	To provide a source of fruits and wood

Current and potential functions of field margins

A	Promotion of ecological stability in crops
B	Reducing pesticide use: exploiting pest predators and parasitoids
C	Enhancing crop pollinator populations
D	Reducing weed ingress and herbicide use
E	Buffering pesticide drift
F	Reducing fertiliser and other pollutant movement, especially in run-off
G	Reducing soil erosion
H	Promotion of biodiversity and farm wildlife conservation
I	Maintaining landscape diversity
J	Promotion of game species
K	Encouragement of "countryside" enterprises
L	Maintenance of historical features, heritage and “sense of place”

Table 1: Roles, requirements and potential functions of semi-natural field margins in good agricultural practice (after Marshall 1993).

Studies undertaken by the Institute of Terrestrial Ecology as part of Countryside Survey 1990 have revealed that field margins and other linear features in lowland agricultural landscapes are refugia for most botanical diversity, rather than adjacent fields (Barr *et al*., 1993). Field margins are thus particularly important for the maintenance and enhancement of biodiversity. As linear features, field margins are also thought to act as corridors for the movement of fauna and possibly flora. Evidence for this has been shown for carabid beetles of forest and

woodland in Brittany (Burel, 1989). Further, it is known that bats utilise margins to fly along as part of their feeding behaviour (Verboom & Huitema, 1997). Field margins are also known to be important over-wintering habitat for many insects that move into adjacent arable crops (Sotherton, 1984; Thomas *et al*., 1994; Wratten, 1988). However, it has also been shown that field margins can be barriers to the movement of such species between fields.

Initiatives over recent years have been taken to modify the management of arable field margins for a series of different objectives, often with the aim of enhancing wildlife while providing agronomic benefits, in terms of reduced weed ingress or enhanced populations of beneficial invertebrates. These have been widely investigated, with modifications, across Europe. The diversity of approaches can perhaps be most easily summarised in a Figure:

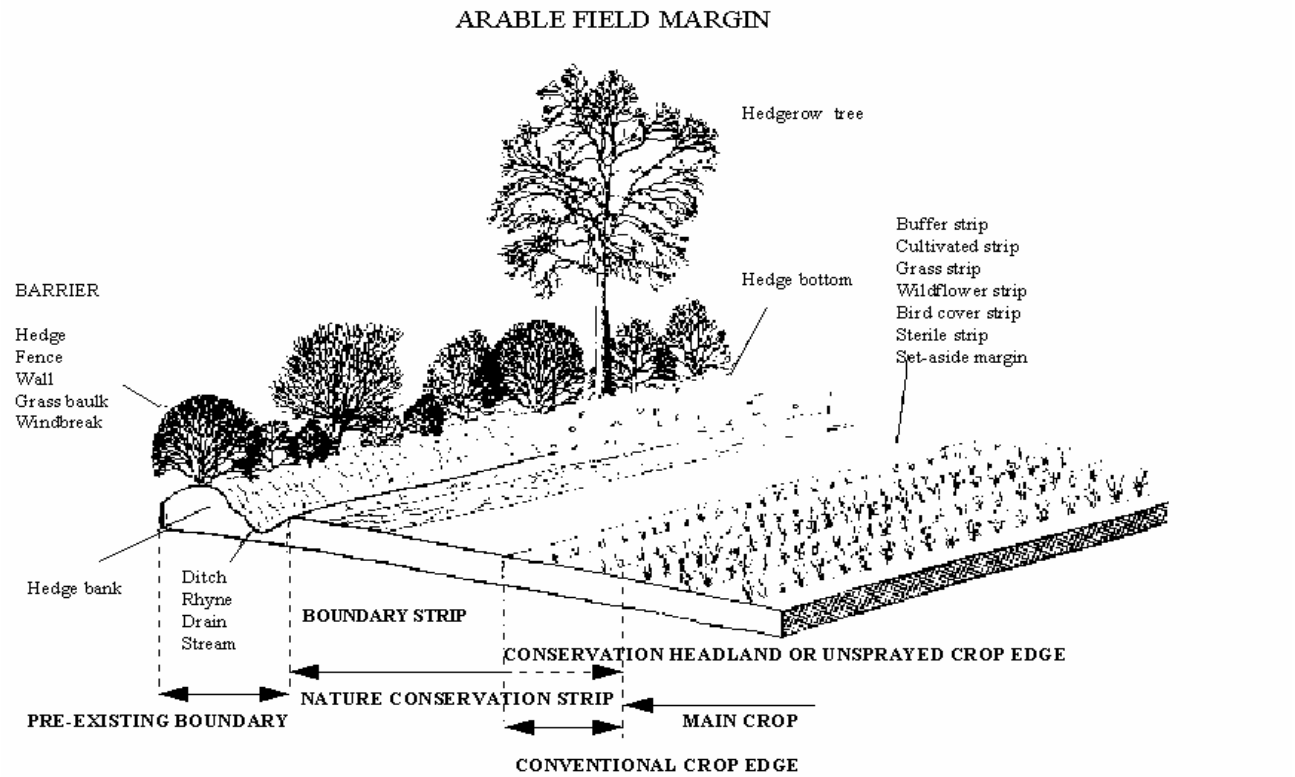


Figure 1. Arable field margin terminology, showing potential margin treatments (after Greaves & Marshall, 1987)

The terminology used here follows that of (Greaves & Marshall, 1987), in which the term field margin includes any pre-existing **boundary** structure, such as a hedge, a **boundary strip** and the **crop edge**, where conservation headlands are located. The diversity of conservation management approaches for field margins can be best summarised as follows:

Boundary Strips:	Grass strip
	Grass and wild flower strip
	Sterile strip
	Uncropped wildlife strip
	Set-aside margin
	Sown wildlife mixtures (strips or blocks)
Crop edge:	Conservation headland
Across fields:	Beetle bank

Within these main approaches, variations are available. For example, within a grass margin, the area nearest the hedge may be managed for tussocky grasses to provide nesting cover for gamebirds and over-wintering habitat for beetles and other invertebrates.

The Arable Stewardship Pilot Scheme, Countryside Stewardship, Tir Cymen in Wales and Environmentally Sensitive Area prescriptions seek to create a wider range of and more diverse arable and field margin habitats, with more broad-leaved weeds and associated invertebrates in the crop and therefore more food for animal species of arable landscapes, in order to arrest the decline in wildlife populations. Specific options related to field margins aim to increase:

- conservation headlands
- field margin strips
- uncropped wildlife strips

and the flora and fauna associated with these areas.

Options available to farmers and land owners for modified management of whole arable fields, for example the encouragement of winter stubbles and undersown spring cereals, is considered in the separate Guidelines for Non-Field Margin Options under Arable Stewardship. Farmers may also propose their own habitat creation and management schemes under the Arable Stewardship and Countryside Stewardship Schemes, aimed at specific conservation objectives. These may include bird seed and insect nectar source crops as blocks within fields or field margin strips.

1.3. Ecological interactions in margins and beetle banks

The diversity of structure that boundaries may have, including walls, hedges and ditches, can promote the diversity of plant communities that may occur there. The addition of conservation management in the form of permanent field margin strips or conservation headlands can further add to this diversity and protect existing habitat from some effects of adjacent farm operations. Boundaries may have a diversity of communities, including woodland, shrub, tall herb, grassland, wetland and arable plant species. However, often the diversity of the margin community is low, reflecting reduced structural diversity and disturbance from fertiliser, herbicide drift and cultivation. The approaches to management supported by several agri-environmental schemes can promote diversity, partly by reducing disturbance and by encouraging an increase in the size of semi-natural habitat on farms.

The perennial plant communities of the boundary may represent important refugia for species of habitats under threat in modern intensively managed landscapes. In the past, the perception that weed species spread from margins into the crop, coloured the management applied by farmers. Broad-spectrum translocated herbicides were widely used, resulting in the elimination of much of the perennial herbaceous flora and promotion of a weedy ruderal flora, often dominated by sterile brome and cleavers, both annuals adapted to germinating in shade under hedges. Under the ESA schemes in Wales, agrochemicals are prohibited in 2 m-wide buffer zones for field boundaries. Sown margin strips also offer protection to the boundary and increase the size of perennial habitat at the field edge. Studies indicate that few perennial plant species spread successfully into adjacent regularly cultivated habitat (Marshall, 1989a).

Other studies have shown that the seedbank of arable fields is often impoverished, but is larger and more diverse at the field edge. Within the crop habitat, there are many annual plant species adapted to regular disturbance that are now rare (See: **Rare plants of arable land** p. 61). Prescriptions for conservation headlands and uncropped wildlife strips have been introduced to enhance the populations of these species. Clearly, permanent field margin strips and prescriptions for rare arable weeds are incompatible, as the disturbance regimes for one preclude the other.

Nevertheless, in many situations it is possible to maintain a perennial margin with modified crop management alongside. The perennial vegetation can support a diverse invertebrate fauna, some associated with individual plant species, while others, like spiders, require vegetation structure. A significant group of invertebrates overwinter in field margins and

migrate into the crop in spring. Some ground beetles do the opposite, aestivating in the margin and emerging in autumn. The perennial herbaceous flora is important as cover for nesting birds, notably the grey partridge, while the adjacent crop habitat is vital for the insect fauna, associated with annual broad-leaved weeds, that forms chick food. The perennial vegetation is also used by small mammals. Thus perennial margin strips, including beetle banks, can be compatible with conservation headlands and uncropped wildlife strips. Under Countryside Stewardship, conservation headlands are promoted alongside margin strips and beetle banks, where soil types are suitable.

Compatibility between management practices will be good in most circumstances, but agreement holders will need to pay attention to weed control in uncropped wildlife strips and conservation headlands, particularly where pernicious weeds are initially present in the margin or crop edge. Good husbandry will keep weed-free sites clean, but weed control may be needed in stubbles to control perennial weeds that colonise the crop edge.

The perennial margin strips have a number of roles, including the reduction of spread of the few annual weeds of hedges, brome and cleavers, into the crop. Grass strips also reduce fertiliser and pesticide drift reaching pre-existing boundary habitats, including watercourses, by moving tractor operations further into the field. Vegetated strips can also reduce surface movement of water into watercourses, buffering fertiliser and silt burdens. However, subsurface flows are not likely to be significantly affected.

Beetle banks across fields will provide new nesting habitat for partridges, overwintering habitat for beetles and suitable vegetation for spiders and small mammals. In combinations with conservation headlands, they may also prove useful for conserving rare cornfield weed populations found within fields.

1.4. Biodiversity Action Plans

As part of the UK response to the Rio Summit, the government published "Biodiversity. The UK Action Plan" in 1994 (Anon, 1994). A commitment to maintaining biological diversity was made and has been further developed by the UK Biodiversity Steering Group (Anon, 1995a; 1995b). Specific Biodiversity Action Plans (BAP) have been developed for individual species under threat and for selected habitats. The Ministry of Agriculture, Fisheries and Food is the lead organisation for two of the earliest Habitat Action Plans for key habitat types, Cereal Field Margins and Species-Rich Hedgerows. The list of species considered is extensive, but divided into priority categories, known as the "Short list" (high priority), the "Middle list" and the "Long list". Biodiversity Action Plans have been formulated for all Short list species and most Middle list species. A number of birds, mammals and plants associated with arable land, and some with field margins, are BAP-listed species and thus particular targets for support under agri-environmental schemes (Table 2). Details of these species, including their habitat requirements are given in subsequent sections: **birds on farmland** (p. 53), **mammals on farmland** (p. 59), **rare plants of arable land** (p. 61).

Table 2. Species that were initially listed as BAP Short or Middle list species in 1995.

Birds	**Mammals**	**Plants**
Skylark	Brown hare	Western Ramping-fumitory
Stone curlew	Pipistrelle bat	Small alison
Grey partridge		Cornflower
Song thrush		Red-tipped cudweed
Linnet		Broad-leaved cudweed
Cirl bunting		Purple Ramping-fumitory
Reed bunting		Red hemp-nettle
Corn bunting		Corn cleavers
Tree sparrow		Shepherd's needle
Turtle dove		Small-flowered catchfly

1.5. Providing advice on field margins

Advisers on farms need to be aware of the motivations and constraints affecting the farmer, farm manager or land owner, as well as the requirements of the schemes in operation. Field margins offer a particular diversity of end-points that can satisfy, surprise or dismay the landowner, depending on their expectations and the constraints of the sites. Engaging and retaining the motivation of the farmer is valuable.

It is therefore important to establish the requirements of the farmer. Additional conservation objectives may then be suggested and added. Harnessing the skills of the agreement holder in management will result in high motivation and greater success in implementing new management practices.

Problems with management operations tend to occur when people other than the agreement holder carry out work, for example, contractors. Maintaining agreement holder interest is the best way to guard against such mistakes.

Questions to consider:
What can field margin management provide?
What target species are present and can be enhanced?
What does the farmer want?
What options are best for the local site?
What problems are likely?
Does the farmer know what is likely to happen?

Is the site the best for the particular option?
Does it affect the landscape?
Does it impact on historical, archaeological or wildlife features?

Diversity of structure and management is likely to deliver greatest diversity of species.

1.6. Objectives for choosing management approaches

There are a series of objectives in managing field margins that can be identified which in turn affect the type of margin management that is best to implement. Table 3 below attempts to provide a series of objectives and associated prescriptions to aid decisions and choices.

Table 3. Management objectives and suitable prescriptions for field margin options.

Objective	**Prescription**	**Comments**
To conserve rare cornfield flowers	1. Conservation headlands, preferably without fertiliser. 2. Uncropped wildlife strips	Check that species are present. If so, grass and flower margins are not suitable
To enhance the plant species diversity of the hedge bottom or field margin	1. Grass and wild flower margins 2. Grass margins; over time, species diversity of the hedge bottom may increase	Rates of species enhancement affected by fertility and opportunity for colonisation
To provide over-wintering habitat for predatory beetles and spiders	1. Grass margins 2. Beetle banks	Tussocky grass is important
To provide pollen and nectar sources for hoverflies, butterflies and pollinators	1. Grass and wild flower margins 2. Conservation headlands, if suitable species are present 3. Sown wildlife mixtures (nectar sources)	
To provide seeds for birds	1. Grass and wild flower margins 2. Conservation headlands 3. Uncropped wildlife strips 4. Sown wildlife mixtures (seed sources)	
To provide insects as chick food for partridges	1. Conservation headlands	Sawfly and other larvae associated with broad-leaved weeds are essential

Objective	Prescription	Comments
To provide cover for ground-nesting birds, including grey partridge	1. Grass margins 2. Beetle banks	Tussocky grass is essential, providing cover and camouflage from predators. Skylark need short vegetation
To provide small mammal feeding habitat	1. Grass and wild flower margins 2. Beetle banks	Encouraging small mammals can enhance predator populations, including owls
To buffer the movement of fertiliser, soil and pesticides to surface water	1. Grass margins	
To reduce the ingress of hedgerow weeds, such as brome and cleavers	1. Grass margins, with or without flowers	

In choosing the appropriate prescription, take account of the specific objectives of the scheme, and assess the relative importance of wildlife, pollution control, access, landscape and archaeological needs for individual sites.

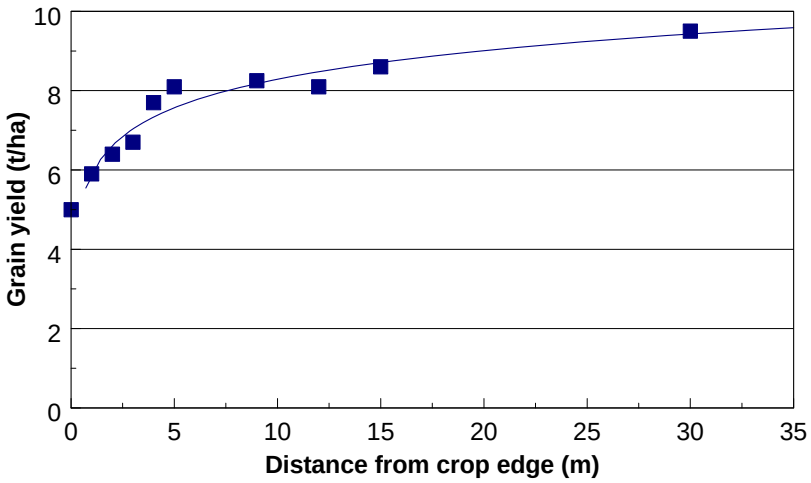
1.7. Cost implications, grant payments and crop yields at field edges

Grant payments under the UK agri-environmental schemes are derived from calculations on the profits foregone by entering each supported management practice. A further calculation may include an element of incentive, to encourage uptake. These calculations are necessarily averaged over the conditions and areas that are relevant. Thus the level of grant is attractive under average conditions, but some farmers will find them more or less attractive, dependent on their individual circumstances.

Studies on the yields of cereals at arable field edges have been made by several organisations, including the Game Conservancy, Harper Adams College and ADAS (Marshall, 1967: Boatman, 1992; Cook & Ingle, 1997; de Snoo, 1997). Typically, yield at the field edge is reduced in comparison to the field centre, as a result of a variety of factors, including shading, soil compaction and weed pressure. There is considerable site-to-site variation, reflecting different soil types and field histories. Some data indicates that headlands yield 18% less than field centres, while conservation headlands yield 8% less than sprayed headlands. An estimate of the yield loss in Dutch cereal conservation headlands was 13% less than the field centre.

Work by ADAS on eight farm sites with no modification to headland husbandry has shown that boundary height and aspect have significant effects on yield of winter wheat at the field edge (Cook & Ingle, 1997). Greatest yield reductions in the headland were given by tall hedges which were North or East-facing (15.6% mean reduction at 2.5 m into the crop, compared with yield at 20 m). Adjacent to North or East-facing low hedges (<2 m high), yields were reduced by an average of 9%, while South or West-facing low hedges had yields reduced by 3.6%. Very recent work by Perry (1998) from a range of fields in Shropshire and Leicestershire has indicated a highly significant relationship between grain yield and distance from the field edge (Fig. 2.).

Figure 2. Relationship between grain yield (tonnes/ha) and distance into the crop, derived from a series of field edges in Shropshire and Leicestershire. Taken from Perry (1998) *The implications of improving the conservation value of field margins on crop production*. PhD Thesis. Harper Adams College.



Yield losses at the field edge can be estimated from these data, to estimate yields foregone and profits foregone against costs for new field margin strips, in the light of grant aid (Table 4). The following figures are illustrative.

Table 4. A comparison of grain yield forgone, costs of sowing grass margins and grant aid available.

Width of strip	Mean grain yield (t/ha)	@ £85/tonne	Seed costs (where used) £/ha (first year)	Grant £/ha per annum
2 m margin	6.0	£510/ha (less growing costs)	£75-380	£750
6 m margin	6.7	£570/ha (less growing costs)	£75-380	£583
2 m beetle bank	9.0	£765/ha (less growing costs)	£75-100	£750

2. Uncropped field margin strips

There are a series of field margin management practices available under the broad title of permanent uncropped field margin strips. These can comprise:

sown grass margin strips
sown grass and wild flower margin strips
naturally regenerated margin strips
sown tussocky grass strips
set-aside margins
uncropped wildlife strips
sterile strips (as additions to margins in the crop edge)

It is possible to create a field margin strip made up of several of these. For example, a sown tussocky grass strip, immediately next to a hedgerow, could have a sown grass and wildflower strip adjacent to it and conceivably an uncropped wildlife strip outside that. The advantage of combining several options is that the diversity of structures will favour diversity of species.

The objectives of margin strips are diverse. Take care to identify the objectives and match these to the most appropriate options. Flexibility with the options and provision of best information to the farmer should give best results.

Current prescriptions include:

Arable Stewardship Option 4. Field margins and strips

Option 4A. Grass field margins 4-12 m wide, averaging 6m, created by natural regeneration or sown grasses

Option 4C. Uncropped wildlife strips 4-12 m wide, averaging 6m wide

ESA prescriptions:

Broads ESA: Grassland margins: establish a grass buffer in arable land adjacent to watercourses at least 6m wide; do not apply fertilisers or pesticides; selected weeds may be spot treated with herbicides; a 1 m sterile strip is allowed.

Avon Valley & Test Valley ESAs: Arable margin buffer strips: Establish a permanent grass sward over a width of 5-30 metres using an appropriate grass seeds mixture; Do not apply any fertilisers or pesticides on this strip.

Breckland ESA: Uncropped wildlife strips: cease arable production on a 6 m or 12 m wide strip; cultivate not more than once a year, not less than once every 2 years; no fertiliser or

pesticides to be applied; selected weeds may be spot treated; do not sow seed; a 1 m sterile strip is allowed.
North Kent Marshes ESA: Buffer strips: establish a grass cover on a strip 6 to 10 m wide; no fertiliser or pesticides to be applied; a 1 m wide sterile strip is allowed
Suffolk River Valleys ESA: Buffer strips: do not apply fertiliser or pesticides to a 6 m wide strip adjacent to hedgerows and watercourses
(Similar prescriptions may be introduced to third and fourth-round ESAs at review in 1998/99)
ESAs in Wales: Strips of land along field boundaries: buffer strips at least 2 m wide adjacent to the boundary may not be treated with agrochemicals, except for the control of bracken, nettles, certain thistle and docks or Japanese knotweed

Countryside Stewardship

Managing arable field margins

- 6 m arable margin
- 2 m grass margins and beetle banks

Set-aside

As 20 m-wide strips, sown or naturally-regenerated vegetation cover can be eligible for set-aside payments.

General comments on field margin strips

Wildlife

Existing field boundary structures, including hedges, walls, grass banks and ditches, comprise a major part of the semi-natural habitat mosaic of farmland. Many of these have been degraded or lost. Under the above prescriptions, a variety of methods of extending and recreating margin habitats are promoted, many of which buffer adjacent habitat from disturbance from farming operations.

Grass margins and beetle banks provide nesting areas for grey partridge in tussocky grass and for skylark in shorter grass. They also provide habitat for insects and small mammals, feeding areas for owls and other birds of prey and over-wintering habitat for many invertebrates. Common flowers can be important sources of pollen and nectar for bees and other insects.

Uncropped wildlife strips at arable field edges provide conditions for rare arable weeds to germinate and set seed. The seeds produced will in turn provide forage for a range of bird species. Fields that been under intensive arable cultivation for many years are likely to have

impoverished seed banks. However, the seed banks are larger and more diverse at the field edge. Thus, wildlife strips at the field edge are more likely to promote rare annuals than in the field centre. Nevertheless, targeting fields known to support rare annual flowers is to be recommended. Fields that have not been in arable production for long are unlikely to support a seedbank of rare annual plants.

Pollution control

Extending grass margins at arable field edges results in farming operations, particularly pesticide and fertiliser applications, taking place further from pre-existing habitat. This in itself provides some protection from drift. Grass margin strips can act as buffer strips when sited next to watercourses. Margin vegetation may act as a physical buffer to drift and to surface movement of water from fields. This may reduce the movement of nitrogen, phosphorous, pesticide and silt into surface waters, fulfilling requirements under the Codes of Good Agricultural Practice. Buffer strips may be of use in Nitrogen Vulnerable Zones or Nitrogen Sensitive Areas, but note that where underdrains are installed, buffer strips are largely ineffective.

Placement of beetle banks strategically across large fields with areas prone to soil erosion can reduce soil losses by reducing overland flows.

Agricultural practice

Wide margin strips may provide easy access for hedge trimming in late winter, after berries have been eaten, without damage to adjacent arable crops. Strips are also one way of satisfying the requirement not to apply an increasing range of pesticides within 6 m of watercourses. Nevertheless, wide strips in small fields may have significant impacts on the working area within fields.

Where annual weeds dominate the field boundary, notably barren brome and cleavers, creation of a perennial grassy margin can form a barrier to weed spread into the adjacent arable crop. Over time, reduced disturbance will also enhance perennials in the boundary, reducing annual weed populations.

Provision of semi-natural habitat for beetles, spiders, bees and hoverflies will enhance their populations. Many of these species are beneficial to adjacent arable crops, either as pollinators or as predators of crop pests. Some hoverfly species, for example, require pollen and nectar to feed on as adults, before seeking out colonies of aphids in which to lay their eggs. The emerging hoverfly larvae are voracious aphid predators.

Set-aside regulations allow margin strips to be included. Such strips may be for rotational set-aside and moved from field to field, or for non-rotational set-aside. In all cases, the width of set-aside margins has to be 20 m wide, under current EU regulations.

Management

Agricultural soils are often highly fertile. High fertility promotes tall, fast-growing plant species at the expense of shorter species, resulting in low species diversity (Marrs, 1993). Where tall, tussocky vegetation is necessary for the nesting of grey partridge, little management may be required. Where a shorter, more diverse perennial plant community is required, particularly with grass margins adjacent to arable crops, management should aim to reduce fertility or the height of perennial vegetation. However, care needs to be taken to avoid disturbance during the breeding season, particularly of ground-nesting birds.

Landscape and archaeology

Landscape is often regarded as subjective and difficult to quantify, yet important for defining regional character and sense of place. In much of lowland England, hedgerows form important visual features in the landscape. Field size and shape are also defining characters, as well as land form and other features, such as woodland. By introducing new field margin features, the character of local landscapes can be affected. Under most management prescriptions, margin strips will be approximately 6 m wide and adjacent to pre-existing boundary structures. To that extent, landscape structure is likely to be affected only modestly. However, beetle banks and blocks of wildlife seed mixtures can have much greater influences. Some care in locating new margin strips should be taken, not forgetting that new features can have either deleterious or beneficial effects. For example, flower-rich margin strips can introduce visual diversity and thus benefit the landscape.

Advisors need to take into account any archaeological features that require protection, when drawing up agreements or advising on management. Where sites must be protected from agricultural operations, permanent margin strips may provide a useful means of buffering sites. However, all grass margin strips require periodic maintenance, usually cutting. Take care that such management is compatible with the requirements of monument protection. Periodically-cultivated uncropped wildlife strips may not be suitable adjacent to some archaeological features.

Conflicts between Options

Under several options, for example Arable Stewardship Option 4A, new grass margins can be created at arable field edges with benefits for wildlife, the environment and for the adjacent arable crop. However, where rare annual cornfield flowers, like prickly poppy, are know to occur in the crop edge, creating a perennial grass strip will prevent their survival. These rare annual plants depend on annual soil disturbance by cultivation for germination and survival. Conservation Headlands and Uncropped Wildlife Strips are more appropriate for their conservation.

Potential conflicts exist where access is allowed. Heavy wear will not favour botanical diversity and disturbance will adversely affect birds and other fauna.

Requirements for the preservation of ancient monuments and archaeological features may conflict with some options, for example, those that depend on regular soil cultivation.

2.1. Perennial field margin strips :
based on grasses, with or without flowers

sown grass margin strips
sown grass and wild flower margin strips
naturally regenerated margin strips
sown tussocky grass strips
set-aside margins

2.1.1. Aims:
to create breeding and feeding areas for ground-nesting birds, small mammals and invertebrates and to create a diverse herbaceous flora at the field boundary. Extended margins will also protect pre-existing semi-natural habitat from drift and reduce pollution of adjacent watercourses.

2.1.2. Size:
Different options require different widths of margin strip. Countryside Stewardship offer 2 m and 6 m-wide margins, while Arable Stewardship offer 4 - 12 m wide strips, to give an average of 6 m. ESA buffer strips are typically 6 m wide. Fertiliser deposition patterns vary according to the machinery used, but recent work shows that spinning disks set with a headland deflector can still reach 4m beyond the target distance (Tsiouris & Marshall, In press). Pesticide drift is dependent on the weather conditions. A buffer strip of 6 m is likely to be sufficient to protect adjacent habitat under average conditions. Greater widths of margin strip are unlikely to provide coincidentally greater benefits for plant species and less mobile fauna. However, for mobile species which depend on grassland resources, such as butterflies, greater widths may be of significant value, particularly in arable landscapes with little grassland present. Under set-aside, margins must be 20 m wide.

2.1.3. Siting:
In arable fields, creation of a 2 m-wide strip of perennial vegetation at the field boundary will reduce populations of annual weeds of hedges, particularly brome and cleavers, reaching the adjacent crop. A reduction of disturbance by agricultural operations, which take place further from the boundary, should allow a more stable and diverse perennial flora to develop over time, particularly if opportunities for colonisation exist. Thus, a 1 m strip should be encouraged in all arable fields; a 2 m option strip provides significantly greater wildlife benefit.

Wider grass margins can be installed in most situations. However, the soil type and the plant species present at the outset can have a major impact on the development of the sward. The location can also have some influence, related to the adjacent habitat. Shading from an adjacent wood, shelterbelt or large hedge may limit the flora to shade-tolerant communities. Little advice on creating margins under such conditions is available. Where adjacent habitats are valuable for the conservation of perennial plant communities and associated species, such as an SSSI limestone grassland, wide grass margins are appropriate. The margin can buffer the valuable habitat, which in turn may provide a source of seeds and rhizomes which can colonise the margin strip.

Wide margin strips may provide easy access for hedge trimming in late winter, after berries have been eaten, without damage to adjacent arable crops. Strips are also one way of satisfying the requirement not to apply an increasing range of pesticides within 6 m of watercourses. Nevertheless, wide strips in small fields may have significant impacts on the working area within fields.

In siting margin strips, take account of historical and archaeological interests. Margins may be used to buffer cultivation damage to ancient monuments (including Saxon hedges). Some account should also be taken of the effect of new features in the landscape. This is particularly the case for new linear features across fields (beetle banks) and for variable-width margins along watercourses. If necessary, take advice from a landscape architect.

Do not site perennial margins where rare arable flowers are known to persist in the seedbank. Examine the field edge, field corners and gateways for evidence of rare annual species (See: **Rare plants of arable land** p. 61).

2.1.4. Choice of grass margin type:

Each location and scheme will have its individual requirements. Advisers need to establish the relative importance of wildlife habitat, the need for access, landscape requirements and historic/archaeological needs. Statutory protection orders must be fulfilled.

Identify the wildlife objectives.
Identify the farming and management objectives.
Identify the likely site, the plant species present at the outset and the soil type.
Identify if access and wear is likely to be significant.
Identify landscape and archaeological impacts.

In general, highly fertile sites on heavy soils will support low plant species diversity. Low fertility light soils tend to have more diverse flora. Weedy sites tend to perpetuate weedy margins, particularly if natural regeneration is used. Some simple rules apply:

- Natural regeneration is useful where the pre-existing and adjacent flora is diverse, typically on light soils.
- Where the field edge and the adjacent flora contains annual, biennial and perennial weeds, sowing grass mixes with or without flowers significantly reduces such problems and regeneration should not be used.
- Where the likelihood of colonisation of flowers is low, then simple grass and flower mixes should be used.
- Where significant wear on the grass strip is likely, with open access to walkers and riders or to vehicular traffic, then a simple hard-wearing grass mix may be used.

2.1.5. Establishment:

2.1.5.1. Natural regeneration

Natural regeneration will provide over-winter stubble habitat during the first winter and encourage a mosaic of bare ground and vegetation patches for at least the first season. This variety will favour several bird species, including skylarks.

Experience with creating grass margins in ESAs (West & Marshall, 1996), indicates that natural regeneration is most successful on lighter soils (not clays) where local seed banks are still diverse and opportunities for colonisation exist. Where weeds are likely to be a problem (i.e. are already a problem in the field or the field boundary), then a grass seed mixture is likely to be the best approach.

2.1.5.2. Sown grass mixes for margins

Timing: Grass-only mixes can be established in autumn or spring, though best establishment is likely to be in September, when soils are warm and moist.

Weed control: where annual and perennial weeds are initially present with high populations, an application of glyphosate or glufosinate before cultivation is recommended. In organic situations, where herbicides may not be used, longer periods of control using cultivation may be required.

Ground preparation: for grass mixes and grass plus flower mixes, a fine seedbed needs to be created. Cultivations as part of the preparation of the rest of the adjacent arable field are often

sufficient (disc, tine and harrow), though rotavation may be required on heavy-land sites. Ploughing is not essential but a fine tilth is needed.
Sowing: seed should be broadcast, rather than drilled.
Roll margin strips to get good seed-soil contact.

Seed mixtures:
Seed should be native and preferably of local provenance.
Sown grass mixtures should follow those in the farmer guidelines or may be tailored to local conditions. Depending on soil type, a range of grasses should be considered, including those given in the following Table 5. For shaded areas, include *Poa nemoralis* and *Brachypodium sylvaticum* with a range of ubiquitous species. For tussocky grass strips, include *Dactylis glomerata*.

Table 5. Grass species suitable for grass margins and the soil types on which they will grow.

		Soil type			
Grass species	**Comment**	**Sand**	**Chalk**	**Loam**	**Clay**
Stewardship species					
Creeping bent (*Agrostis capillaris*)		+		+	
Meadow foxtail (*Alopecurus pratensis*)				+	+
Sweet vernal grass (*Anthoxanthum odoratum*)		+	+	+	+
Meadow brome (*Bromus commutatus*)	Now an arable weed, its origin is in moist grassland			+	+
Crested dogstail (*Cynosurus cristatus*)		+	+	+	+
Cocksfoot (*Dactylis glomerata*)	Tussocky grass	+	+	+	+
Wavy hair grass (*Deschampsia flexuosa*)	Likes acidic soils	+			
Red fescue (*Festuca rubra* ssp. *commutata*)		+	+	+	+
Sheep's fescue (*Festuca ovina*)		+	+	+	
Meadow fescue (*Festuca pratensis*)				+	+
Meadow barley (*Hordeum secalinum*)	Moist soils		+	+	+
Timothy (*Phleum pratense*)	Tussocky	+	+	+	+
Small-leaved timothy (*Phleum pratense* ssp. *bertolonii*)		+	+	+	+
Smooth-stalk meadow grass (*Poa pratensis*)		+	+	+	
Rough-stalk meadow grass (*Poa trivialis*)	Weedy; short-lived; likes damp field edges			+	+
Grass species	**Comment**	**Sand**	**Chalk**	**Loam**	**Clay**

Golden oat-grass (*Trisetum flavescens*)			+	+	
Other grass species					
Wood false-brome (*Brachypodium sylvaticum*)	Shade tolerant		+	+	+
Wood meadow grass (*Poa nemoralis*)	Shade tolerant	+		+	+
False oat-grass (*Arrhenatherum elatius*)	Tussocky species; use non-bulbous form (bulbous= onion couch)		+	+	+
Yorkshire fog (*Holcus lanatus*)	Tussocky; early successional species; do not use in 6 m margins	+	+	+	+
Brown top bent (*Agrostis canina*)		+	+	+	+
Quaking grass (*Briza media*)		+	+		
Ryegrass (Lolium perenne)	Highly bred. Amenity cultivars are useful for hard wearing areas	+	+	+	+

2.1.5.3. Sown grass and wildflower strips

Timing: Grass and wild flower mixes can be established in autumn or spring, though best establishment is given with September sowing, when soils are warm and moist. Some flower species, such as cowslip, need a winter cold treatment before germinating and thus must be sown in the autumn. If September establishment has to be delayed to the following year, either crop and do not fertilise the area, or fallow the strip for the season. Examine the development of the flora; if competitive weeds are likely to dominate the new margin, an application of glyphosate in July only to the area which will be cultivated can be recommended.

Weed control: where annual and perennial weeds are initially present with high populations, an application of glyphosate or glufosinate before cultivation is recommended. In organic situations, cultivations may be used.

Ground preparation: for grass and flower mixes, a fine seedbed **must** to be created. Cultivations as part of the preparation of the rest of the adjacent arable field are often sufficient (disc, tine and harrow), though rotavation may be required on heavy-land sites. Ploughing is not essential but a fine tilth is needed.

Sowing: seed should be broadcast rather than drilled. Seed can be on the surface or up to 2 cm deep.

Roll margin strips to get good seed-soil contact.

Seed mixtures:
Seed should be native and preferably of local provenance.
Sown grasses should follow those in the farmer guidelines or may be tailored to local conditions. Depending on soil type, a range of grasses should be considered (See previous table). If annual grass weeds, such as blackgrass, sterile brome, wild-oats and Italian ryegrass, may threaten the success of sowing, select a mixture with a high proportion of red fescue (*Festuca rubra* ssp. *commutata*). Once the sown grasses have reached 3 tillers, treat with a reduced rate of fluazifop-P-butyl, a graminicide (See: **Herbicides** p. 69) which does not affect red fescue.

Inclusion of common grassland flowers (Table 6) will provide enhanced nectar and pollen resources for insects, including beneficial species of bees and hoverflies. Yellowhammers will utilise sown grass and flower margins, together with several other farmland birds.

A range of commercial seed mixtures are available. Check that they are of native seed stocks. Experience with a comparison of natural regeneration, a grass only mix, an inexpensive commercial mix and three expensive commercial mixes for loam, chalk and sandy soils was made in three ESAs (West & Marshall, 1996). The ESAs were Breckland (sandy), South Wessex Downs (chalky) and the Somerset Levels & Moors (clay). The experiences indicate the following:

- lowest plant species diversity was on the clay soils
- lowest plant species diversity was found on the grass-only mixes
- highest diversity was on the light chalky soils
- higher diversity was given by the more expensive and diverse seed mixes
- a suite of common flowers established successfully from all grass and flower mixes
- greatest cost-benefit was given by simple grass and flower mixes
- results vary from site-to-site depending on soil type, management and plant species present

Some commercial mixes are very expensive, designed for small amenity schemes, rather than farm-scale use. Nevertheless, inexpensive mixes have been designed for farm use by several suppliers.

Sowing rate: 20 kg/ha
Options: 80% grass to 20% flowers or 90% grass to 10% flowers, by weight

The flower component is the expensive part, grasses costing between £75 and £100/ha for native species, while flower mixes cost a minimum of £140/ha.
Note: Many perennial flowers will not flower particularly well during the establishment year, so some farmers like to include a small proportion of annual flowers in the mix, to give colour during the first season. Cornfield species, such as poppy and cornflower, are popular. If the perennial grasses and flowers establish well, these annuals are absent after the first year, unless severe lodging occurs with very high soil fertility, leaving bare ground.

Table 6. Perennial flower species that will establish on most soils.

yarrow (*Achillea millefolium*)	musk mallow (*Malva moschata*)
black knapweed (*Centaurea nigra*)	ribwort plantain (*Plantago lanceolata*)
wild carrot (*Daucus carota*)	meadow buttercup (*Ranunculus acris*)
ladies bedstraw (*Galium verum*)	sorrel (*Rumex acetosa*)
birdsfoot trefoil (*Lotus corniculatus*)	red campion (*Silene dioica*)
ox-eye daisy (*Leucanthemum vulgare*)	

Also consult: *Francis, G. & Dickie, G. (1996)* "Planting Mixes based on the National Vegetation Classification". *H.V. Horticulture Ltd., The Street, Sutton Waldron, Blandford Forum, Dorset DT11 8NZ. 111 pp,* for seed mixes. Local provenance seed is preferred. Contact the co-ordinator of the Flora Locale initiative for guidance (See: **Information Sources** p. 81). A range of commercial wild flower and grass seed mixtures have been used successfully to create margin strips in three Environmentally Sensitive Areas (West & Marshall, 1996), and on commercial farms by Willmot Pertwee Ltd. *Individual site conditions and management* determine the outcome of sowing.

2.1.6. Management:

Restrictions required for Arable Stewardship grass margins are as follows:
Do not use as access tracks
Do not fertilise with organic or inorganic fertiliser, or treat with lime
Do not graze

Without management, grass margins will initially become tall and tussocky, suitable for partridge nesting. If there are sources of shrub and tree seeds close by, or margins are adjacent to shrubs with underground runners, like blackthorn, unmanaged margins will "scrub

over" in time, losing their character. Therefore, a regime of occasional cutting is required to maintain a grassland habitat.

2.1.6.1. Management in the first season:
Note: Before establishing margins, check the site to see if there is evidence of populations of undesirable plants at the outset.

Margins allowed to regenerate naturally will follow a secondary succession, with annual species dominant in the first year and perennials subsequently invading. The exact pattern will depend on the seed bank, local sources of colonisers and management. The successional changes can provide diversity of structure and species. Perennial weeds can be suppressed by sowing a grass mixture. Otherwise, some selective herbicide use to control potentially dominating species occasionally may be needed.

If a sown grass or sown grass and wild flower strip is created, it may be threatened by arable weeds in the first season. Those weeds are most likely to be annual grasses or annual dicotyledonous species, though some biennial and perennial plants may become dominant under some circumstances (See: **Weeds** p. 65).

Annual grass weeds and cereal volunteers in sown strips can be controlled with a selective graminicide, such as fluazifop-P-butyl used at half or quarter rate (See: **Herbicides** p. 69). This herbicide will control most annual grasses, such as sterile brome, blackgrass and wild-oats. It will not affect dicotyledonous species, but may have adverse effects on some perennial grasses, such as crested dogstail, though it will not affect red fescue (include this species in seed mixes which may be threatened by annual grass weeds).

Annual dicotyledonous weeds, unless they reach highly competitive levels, are unlikely to be a problem. If particular species reach high populations on fertile sites and threaten the establishment of sown mixtures by lodging, then cutting in April and May may be required (Marshall & Nowakowski, 1994). Under organic conditions, cutting can be used to reduce the height of annual weeds, thus encouraging the establishment of perennials. Cutting will not control annual grasses and may encourage tillering and seed formation.

Perennial weeds are reduced in competition with sown grasses. Where particular perennial species become dominant or threaten to do so, selective spot treatment can be approved (See: **Herbicides** p. 66).

Management of the grass margin is based on cutting. Where tall, tussocky grass is to be encouraged, cutting is not required in the first year, unless threatened by weeds. For grass and grass plus wild flower strips, the basic management is a single cut in August or September. Avoid cutting between 15 March and 15 July, when ground-nesting birds may be destroyed. The alternative approach, in the first year, is to mow regularly on a monthly basis, starting early in the year. This discourages annual species as well as ground-nesting birds.

2.1.6.2. Management in subsequent seasons:
Management of the grass margin is based on cutting.

Diversity of structure can be created by variable cutting regimes (see Figure 3 below, for 6 m margin). For nesting cover for partridges, cutting treatments should aim to create tall, tussocky grass adjacent to the pre-existing field boundary hedge or fenceline. Where tall, tussocky grass is to be encouraged, cut every other year. The area closer to the crop edge may be cut more frequently to reduce vegetation height and encourage species diversity. A single cut in August or September is sufficient on light soils. On more fertile soils, species diversity of sown flower strips may decline with time (Marshall & Nowakowski, 1995). Cutting twice a year, in spring and late summer, can reduce the rate of species loss and is recommended for maintaining plant species diversity.

Cutting must not be done during the breeding season, so an early spring cut (before 15 March, if possible) and a cut after crop harvest are the optimum times. Where possible, cuttings should be removed, in order to reduce soil fertility. This is often not practical, but if methods can be devised on farm they should be encouraged. Using a forage harvester has been found to be particularly effective.

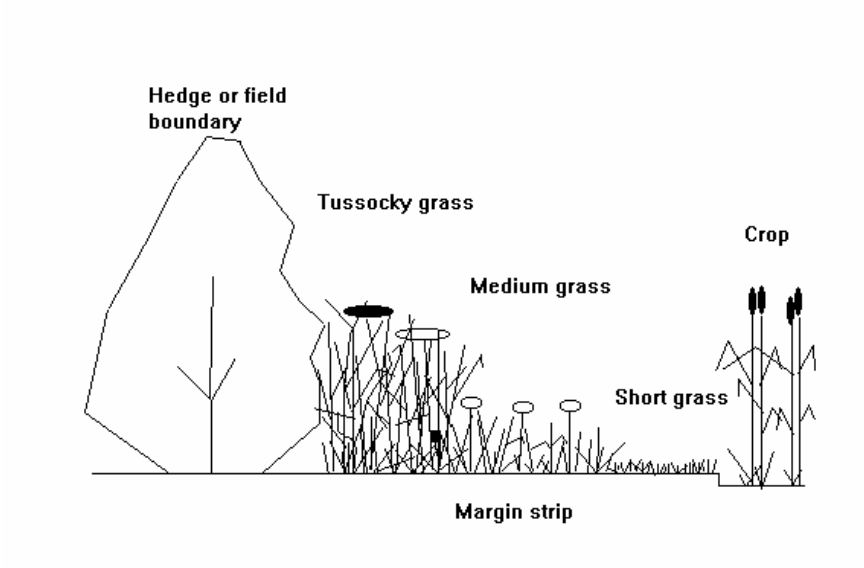


Figure 3. Options for managing grass strips at arable field edges to provide structural diversity. Tussocky grass may be cut every other year, to provide nesting cover for partridges. Medium height grass can be cut in spring and late summer to encourage botanical diversity, while short grass next to the crop may be mown more frequently.

2.1.6.3. Cutting equipment:

Reciprocating blade and circular blade cutters can be used, but if the cut biomass left behind is large, it can collect as swaths of cut vegetation that kills plants underneath. Avoid this, or devise methods to collect and remove the cuttings. Flail cutters will give a better result, if cut material cannot be removed. Studies at ADAS Boxworth have shown that a straw chopper used on set-aside vegetation prevents the build-up of swaths of cut vegetation, which may kill smothered plants.

Cutting heights should be a minimum of 5 cm.

Take care <u>not</u> to cut too low and create bare ground, which will be colonised by annual weeds.

Where possible, cuttings should be removed, in order to reduce soil fertility. This is often not practical, but if methods can be devised on farm, they should be encouraged. A forage harvester has proved to be a simple method of removing cuttings, either into a trailer or the adjacent hedge or crop. But <u>do not</u> spread cut material into the crop, if it contains seeds of annual weeds, such as sterile brome and cleavers.

2.1.7. Cost implications: (see p. 12)
Arable Stewardship payment rates for grass margins are supported at £583/ha . These translate to £23 per 100 m of a 4 m-wide strip and £70 per 100m of a 12 m-wide strip. Beetle banks attract a rate of £15 per 100 m, equivalent to £750/ha.
Under Countryside Stewardship, payment rates are £35/100m/year for 6 m arable margins and £15/100m/year for 2 m grass margins and beetle banks.

Seed costs (one-off cost):
Native grasses only: £100/ha
Grass and flowers: £240 - £380/ha

2.1.8. Problems:
The most likely problems to be faced are posed by weeds. If a sown grass or sown grass and wild flower strip is created, it may be threatened by arable weeds in the first season. Those weeds are most likely to be annual grasses or annual dicotyledonous species, though some biennial and perennial plants may become dominant under some circumstances (See: **Weeds** p. 65). When using sown mixtures, take care to ensure good establishment. Where necessary, selective herbicides can be helpful (See: Management above and **Herbicides** p. 69) or cutting.

Once established, some perennial weeds can become dominant, particularly on fertile and heavier soils. Where species such as creeping thistle threaten the margin, then spot treatment with selective herbicides can be recommended. However, management to reduce available soil nitrogen can also reduce populations of nitrophilous species, like broad-leaved dock, over time.

2.1.9. Feedback:
Are specific herbicides needed to control particular weeds in newly-created grass margins?

Further information:
Leaflet: *"Field Margins - making them work and pay"*. Willmot Pertwee Ltd, 14 New Hythe Lane, Larkfield, Aylesford, Kent ME20 6PN, 18 pp. (See: **Information Sources** p. 81)

2.2. Uncropped wildlife strips

2.2.1. Aims:

to encourage rare annual and biennial arable plants and provide foraging for seed-eating birds

2.2.2. Size:

The width of uncropped wildlife strips at the field edge should be 4m to 12 m wide, averaging 6 m wide.

2.2.3. Siting:

Uncropped strips must be in arable fields at the field edge and are best sited where rare annual cornfield flowers are known to be present in the seed bank. These strips were developed in the Breckland ESA to conserve the rare, specialist flora of the sandy soils, notably Breckland speedwell, fingered speedwell and the spring speedwell. Examination of the field edge, field corners and gateways may reveal if rare annuals are present.

Not all sites will have rare arable flowers present in the seed bank. Where these species are know to be present in the field, uncropped wildlife strips can be a useful way of encouraging their conservation. Even if rare species are not present, the technique can provide valuable seed sources for birds. Nevertheless, competitive annual weeds may become a problem in some sites. Before establishing these strips, take note of existing weed problems and any indications of soil fertility. Highly fertile sites are unlikely to support rare annuals and are more likely to have serious annual weed problems. Uncropped strips are best sited on light soils, particularly sandy and chalky sites.

2.2.4. Establishment:

Strips are created by cultivating in either spring or autumn only. The timing of cultivation has a marked influence on the species that establish from seed. Autumn cultivation will encourage autumn-geminating species and spring cultivation will encourage spring-germinators (See: **Rare plants of arable land** p. 61 and **Weeds** p. 65). No crop should be sown and the flora is allowed to develop naturally. Under Arable Stewardship, autumn cultivation may be to a depth of 150 mm (6”), while spring cultivation should only be made with tined implements to 100 mm (4”).

2.2.5. **Management**:

Strips must not be used as access tracks, nor be irrigated or receive organic or inorganic fertiliser or lime. Strips should not be grazed and should not be affected by adjacent field operations.

Do not fertilise uncropped strips, as this will encourage nitrophilous competitive species. Cultivation should only be made once a year as a maximum, but not less than once every two years. A low frequency of cultivation will allow perennial and biennial species to increase in abundance at the expense of the annual flora, which the strips are designed for.

Annual grass weeds such as sterile brome and blackgrass can become serious problems, if they are initially present in high densities. These can be successfully controlled with graminicides (See: **Herbicides** p. 69). The abundance of less desirable annuals can also be reduced by cutting. Dicotyledonous annuals can be checked by two cuts, in April and May, though annual grasses may still tiller and flower vigorously after cutting.

A 1 m sterile strip at the outside edge of the uncropped strip is allowed, to create a barrier to weed ingress and as an area for chicks to dry out after wet weather. **Extreme care** should be taken in application of herbicides in this sensitive area, as drift into the uncropped strip can occur, adversely affecting the desirable flora, reducing boundary diversity. Weeds such as brome shed seed over 1 m from the parent plant; a 1 m strip is unlikely to be an efficient weed barrier.

2.2.6. **Cost implications**: (see p. 12)

Arable Stewardship payment rates for uncropped strips are £583/ha. These translate to £23 per 100 m of a 4 m-wide strip and £70 per 100m of a 12 m-wide strip.

2.2.7. **Problems**:

Under some circumstances, the flora of uncropped strips may become dominated by aggressive species. For example, sterile brome and blackgrass can become serious problems, if they are initially present in high densities. Where annual grass weeds are or become a

problem, spring cultivation will control plants that germinate in the autumn, notably barren brome. Nevertheless, some weeds can become troublesome, particularly on heavier soils. Annual grass weeds can be successfully controlled with graminicides (See: **Herbicides** p. 69). The abundance of less desirable annuals can also be reduced by cutting. Dicotyledonous annuals are significantly checked by two cuts in April and May, though annual grasses may still tiller and flower vigorously after cutting.

Under infrequent cultivation, perennial weeds can invade these strips. More frequent cultivation is to be recommended under those circumstances, though an application of a total herbicides, such as glyphosate, shortly before cultivation can be effective. Herbicide application at this time would not affect seed return from the previous season. Herbicidal control is only permitted for the perennial weeds, spear thistle, creeping thistle, curled dock, broad-leaved dock and ragwort, using a weed wiper or spot treatment (See: **Herbicides** p. 74

2.2.8. Feedback:

Under what circumstances do particular weed problems occur?

Is there a need to develop new selective weed control techniques?

3. Beetle banks

Creating a permanent 2 m-wide grassy strip across a field can provide new habitat for birds, small mammals and invertebrates. The beetle bank may connect to existing field edges or have gaps up to 25 m wide at either end to allow machinery access. Combination with conservation headlands either side of a beetle bank is likely to enhance wildlife benefits.

Currently supported prescriptions are:

Arable Stewardship Option 4. Field margins and strips

Option 4B. Beetle banks 2-3 m wide

Countryside Stewardship

Managing arable field margins

- 2 m grass margins and beetle banks

General comments on beetle banks

Wildlife

Existing field boundary structures, including hedges, walls, grass banks and ditches, comprise a major part of the semi-natural habitat mosaic of farmland. Many of these have been degraded or lost. Beetle banks provide a method of recreating a linear margin habitat across fields.

Beetle banks provide nesting areas for grey partridge in tussocky grass and possibly for skylark in shorter grass. They also provide habitat for insects and small mammals, feeding areas for owls and other birds of prey and over-wintering habitat for many invertebrates. Common flowers can be important sources of pollen and nectar for bees and other insects, if these develop.

In combination with conservation headlands either side of a beetle bank, wildlife benefits are likely to be enhanced.

Pollution control

Placement of beetle banks strategically across large fields with areas prone to soil erosion can reduce soil losses by reducing overland flows. This may reduce the movement of nitrogen,

phosphorous, pesticide and silt into surface waters, fulfilling requirements under the Codes of Good Agricultural Practice.

Agricultural practice

Provision of semi-natural habitat for beetles, spiders, bees and hoverflies will enhance their populations. Many of these species are beneficial to adjacent arable crops, either as pollinators or as predators of crop pests. Some hoverfly species, for example, require pollen and nectar to feed on as adults, before seeking out colonies of aphids in which to lay their eggs. The emerging hoverfly larvae are voracious aphid predators.

By dividing up a field, a beetle bank may change machinery working patterns.

The small size of beetle banks makes them vulnerable to the effects of fertiliser and pesticide drift within the field. Fertiliser drift is of little consequence where only tussocky grass is grown, but insecticide drift may cause non-target effects on beneficial invertebrates. Conservation headlands in combination with beetle banks may be appropriate.

Management

Agricultural soils are often highly fertile. High fertility promotes tall, fast-growing plant species at the expense of shorter species, resulting in low species diversity (Marrs, 1993). Where tall, tussocky vegetation is necessary for the nesting of grey partridge, or for small mammals, little management may be required. Beetle banks are usually sown to tussocky grasses and managed irregularly. Thus, they are often not suitable for skylark and tend not to develop a diverse perennial plant community.

Landscape and archaeology

Landscape is often regarded as subjective and difficult to quantify, yet important for defining regional character and sense of place. In much of lowland England, hedgerows form important visual features in the landscape. Field size and shape are also defining characters, as well as land form and other features, such as woodland. By introducing new field margin features, the character of local landscapes can be affected. Some care in locating beetle banks should be taken, not forgetting that new features can have either deleterious or beneficial effects.

Advisors need to take into account any archaeological features that require protection, when drawing up agreements or advising on management. Where sites must be protected from agricultural operations, permanent margin strips such as beetle banks may provide a useful

means of buffering sites. However, all grass margin strips require periodic maintenance, usually cutting. Take care that such management is compatible with the requirements of monument protection.

Conflicts

The effect of introducing a beetle banks across a field, may be to change the machinery working patterns within the field. This may have practical consequences for the farmer, in terms of direction of work, timing and efficiency.

Beetle banks

3.1. Aims:
to provide tussocky nesting habitat for grey partridge, breeding and feeding areas for small mammals and over-wintering habitat for beetles and spiders. Creating raised grass banks across fields provides new over-wintering habitat for beneficial insects (Thomas *et al*., 1991; 1992). Small mammal populations will provide food for owls and other raptors.

3.2. Size:
The width of the beetle bank should be 2 to 3 m wide and about 0.4 m high ideally. A 3 m strip may be created in the first year and reduced to 2 m subsequently. The technique is used to create semi-natural habitat within large fields, dividing large blocks into smaller areas with a new field margin. This can have agricultural benefits in enhancing beneficial insect populations, as well as wildlife benefits in providing new feeding and breeding habitat.

3.3. Siting:
By careful location across slopes, beetle banks can reduce within-field erosion. Although originally designed as temporary features within fields, beetle banks can provide better habitat structure, if connected to and connecting other semi-natural habitats. Connections between woods or hedges should be encouraged. Arable Stewardship allows gaps of 25m for working machinery, at each end of beetle banks.

Where the soil types are light, then a combination of beetle bank with adjacent conservation headland can encourage a diverse flora and fauna. If rare arable weeds are present in the field, this combination may be particularly appropriate.

Beetle banks as new margins across fields can have a visual impact in the landscape. If necessary, consult a landscape architect.

3.4. Establishment:

Timing: Tussocky grass mixes can be established in autumn or spring, though best establishment is likely to be in September, when soils are warm and moist.

Weed control: where annual and perennial weeds are initially present with high populations, an application of glyphosate or glufosinate before cultivation is recommended.

Ground preparation: A reasonable seed bed is required. Cultivate as part of normal field preparation, but consider creating a raised bank by ploughing furrows towards each other from either side. Wildlife objectives are likely to be better achieved by creating a bank, but it is not essential for encouraging over-wintering invertebrate populations.

Sowing: seed should be broadcast, rather than drilled. Machinery sowing on a bank is very difficult, so hand-sowing is likely to be the most practical option on banks.

Seed mixtures:

Seed should be native and preferably of local provenance.

Sown grass mixtures should follow those in the farmer guidelines or may be tailored to local conditions. Depending on soil type, a range of grasses should be considered, including those given in the following Table 7.

Table 7. Grass species suitable for creating tussocky grass.

		Soil type			
Grass species	Comment	Sand	Chalk	Loam	Clay
Meadow foxtail (*Alopecurus pratensis*)				+	+
Cocksfoot (*Dactylis glomerata*)	Tussocky grass	+	+	+	+
Red fescue (*Festuca rubra* ssp. *commutata*)		+	+	+	+
Meadow fescue (*Festuca pratensis*)				+	+
Timothy (*Phleum pratense*)	Tussocky	+	+	+	+
Smooth-stalk meadow grass (*Poa pratensis*)		+	+	+	
False oat-grass (*Arrhenatherum elatius*)	Tussocky species; use non-bulbous form (bulbous = onion couch)		+	+	+
Yorkshire fog (*Holcus lanatus*)	Tussocky; early successional species; do not use in 6 m margins	+	+	+	+

If annual grass weeds, such as blackgrass, sterile brome, wild-oats and Italian ryegrass, may threaten the success of sowing, select a mixture with a high proportion of red fescue (*Festuca rubra* ssp. *commutata*). Once the sown grasses have reached 3 tillers, treat with a reduced rate of fluazifop-P-butyl, a graminicide (See: **Herbicides** p. 69) which does not affect red fescue.

Inclusion of common grassland flowers (Table 8) will provide enhanced nectar and pollen resources for insects, including beneficial species of bees and hoverflies. **However, without an annual mowing regime, the dominance of tall grasses will eliminate most flower species over a period of 5 years.** In beetle banks, preferably select those species which persist well.

A range of commercial seed mixtures are available. Check that they are of native seed stocks. Experience with a comparison of natural regeneration, a grass only mix, an inexpensive commercial mix and three expensive commercial mixes for loam, chalk and sandy soils was made in three ESAs (West & Marshall, 1996). The ESAs were Breckland (sandy), South Wessex Downs (chalky) and the Somerset Levels & Moors (clay). The experiences indicate the following:

- lowest plant species diversity was on the clay soils
- lowest plant species diversity was found on the grass-only mixes
- highest diversity was on the light chalky soils
- highest diversity was given by the more expensive and diverse seed mixes
- a suite of common flowers established successfully from all grass and flower mixes
- greatest cost-benefit was given by simple grass and flower mixes
- results vary from site-to-site depending on soil type, management and plant species present

Some commercial mixes are very expensive, designed for small amenity schemes, rather than farm-scale use. Nevertheless, inexpensive mixes have been designed for farm use by several suppliers.

Sowing rate: 20 kg/ha
Options: 80% grass to 20% flowers or 90% grass to 10% flowers, by weight
The flower component is the expensive part, grasses costing between £75 and £100/ha for native species, while flower mixes cost a minimum of £140/ha.

Table 8. Perennial flower species which will establish under most conditions. (* = species that persist well)

yarrow (*Achillea millefolium*) *	musk mallow (*Malva moschata*)
black knapweed (*Centaurea nigra*) *	ribwort plantain (*Plantago lanceolata*) *
wild carrot (*Daucus carota*)	meadow buttercup (*Ranunculus acris*)
ladies bedstraw (*Galium verum*)	sorrel (*Rumex acetosa*)
birdsfoot trefoil (*Lotus corniculatus*)	red campion (*Silene dioica*) *
ox-eye daisy (*Leucanthemum vulgare*)	

Also consult: *Francis, G. & Dickie, G. (1996)* "Planting Mixes based on the National Vegetation Classification". *H.V. Horticulture Ltd., The Street, Sutton Waldron, Blandford Forum, Dorset DT11 8NZ. 111 pp,* for seed mixes. Local provenance seed is preferred. Contact the co-ordinator of the Flora Locale initiative for guidance (See: **Information Sources** p. 81).

3.5. Management:

Management is based on cutting. In the first year, the bank may be cut in March to check annual weeds that may be present and subsequently in late summer. Avoid cutting during the nesting season after 15 March. Thereafter, cut only every second or third year to allow a tussocky grass structure to develop, and after 15 July. Do not apply organic or inorganic fertilisers, lime or agrochemicals, except where essential for annual grass weed control. Beetle banks must not be used as access tracks or allowed to be damaged by machinery.

3.6. Cost implications: (see p. 12)

Beetle banks attract a rate of £15 per 100 m, equivalent to £750/ha, under Arable Stewardship and Countryside Stewardship.

Seed costs (one-off cost):

Native grasses : £75-100/ha

3.7. Problems:

Under some conditions, annual weeds may threaten the establishment of sown species. Cutting may check the weeds and encourage the sown perennial grasses to establish. Under some circumstances a graminicide may be used, but see **Herbicides** (p. 69).

3.8. Feedback:

Which grass mixtures establish best and on which soils?

Do partridges nest in beetle banks? Is there any preference for banks that are connected or unconnected to hedgerows?

Do any annual weeds threaten the establishment of beetle banks?

4. Cereal crop conservation headlands

A variety of prescriptions exist for conservation headlands, but all are based on manipulation of insecticide and herbicide inputs to allow broad leaved weeds and associated insects to survive in the cereal crop edge, to benefit grey partridge and rare cornfield flowers in particular. In this country, the Game Conservancy Trust has developed the technique particularly for gamebirds (See: Game Conservancy Trust leaflet: "Managing field margins"). The technique was first developed in Germany to conserve rare cornfield flowers and is still grant-supported in several of the federal states there. In the UK, the technique is applied to cereal crops only and may be rotated round the farm from field to field.

Current prescriptions include:

Arable Stewardship Option 3. Crop margins 10-12 m wide with no insecticide applied after 15th March

Option 3A. No insecticide after 15th March; limited herbicides allowed

Option 3B. No insecticide after 15th March; limited herbicides allowed; no fertiliser applications

ESA prescriptions:

South Downs ESA: No insecticide after 1 January; herbicides allowed are tri-allate, diclofop-methyl, difenzoquat, flamprop-m-isopropyl or fenoxaprop-ethyl; glyphosate is allowed as a spot-treatment pre-harvest for couch, black bent or onion couch; fluroxypyr spot treatment for cleavers; a 1 m sterile strip allowed next to the field boundary.

Breckland ESA: No insecticide after 15 March; spot treatment of cleavers allowed; grass weed herbicides must be agreed in writing with the Project Officer.

Clun ESA: No insecticide after 15 March; herbicides allowed are tri-allate, diclofop-methyl, difenzoquat, flamprop-m-isopropyl, fenoxaprop-ethyl, tralkoxydim or clodinfop-propargyl; glyphosate may be used pre- or post-harvest; fluroxypyr may be used only for cleavers as a spot treatment; other herbicides require approval.

South Wessex Downs ESA: at least 6m wide; No insecticide after 31 December; herbicides allowed are tri-allate, diclofop-methyl, difenzoquat, flamprop-M-isopropyl, fenoxaprop-ethyl, fenoxaprop-P-ethyl, tralkoxydim, fenoxaprop-P-ethyl + diclofop methyl or clodinafop-propargyl; glyphosate may be used pre-harvest as a spot treatment for couch, black bent or onion couch; amidosulfuron spot treatment for cleavers only; fluroxypyr may be used only with the approval of the Project Officer; 1 m sterile strip allowed; do not use surface cultivation methods for weed control.

ESAs in Wales (except the Cambrian Mountains ESA): Conservation headlands: In addition to the 2 m boundary strip, a headland at least 4 m wide may be establsihed in arable land. No fungicides or insecticides after 1 January. Herbicides only to the 1m nearest the crop or with the approval of the Project Officer.

Countryside Stewardship

> Where soil type and condition are suitable, cereal crops that abut 6 m or 2 m field margin strips should be managed following Game Conservancy Conservation Headland Guidelines

Details of the two Arable Stewardship conservation headlands Options, the basic exclusion of insecticides and only selected use of herbicides (Option 3A) and the extension to exclude fertiliser as well (Option 3B) are described in following sections 4.1. to 4.9. (pp. 43-46).

General comments on conservation headlands

Wildlife

Reduced pesticide use in an arable crop edge will allow broad-leaved weeds, including some rare cornfield flowers, (See: **Rare plants of arable land** p. 61) to grow and set seed. This will in turn provide resources for a range of invertebrate species and thus encourage foraging by grey partridge and corn bunting.

Note: The seed bank of arable fields is typically larger and more diverse in the field margin. So, rarer plant species are more likely to persist at the crop edge and more likely to survive where no herbicide is applied.
Note: The land owner may know of the existence of rare weeds; if he does not, a quick field survey of field edges, gateways and field corners may reveal the best locations for conservation headlands. Do not site perennial grass strips where rare cornfield annuals are known to exist in the seed bank.

Pollution control

Reduced use of agrochemicals including fertiliser immediately adjacent to non-crop habitat (hedges, ditches and field margins), will result in protection of such habitats from chemical disturbance, reducing the risk of drift events.

Agricultural practice

This option encourages the increase in populations of beneficial insects, particularly predators of crop pests, both in the crop edge and the pre-existing margins. Beetles and spiders, some of which provide food for birds, eat aphid and other dipteran pests in cereals. Some of these beneficial species migrate into the adjacent crop during the summer from the field edge.

The development of a weedy crop edge has important implications for crop harvesting and yield. Studies indicate that conservation headlands yield on average 8% less than conventionally managed headlands. Nevertheless, grain samples may be contaminated and arrangements may need to be made to harvest and store grain separately from the main field. Large estates with a game shooting interest successfully grow cereal seed crops with conservation headlands, saving headland grain for gamebird feed.

Management

Reduced crop yields are usually recorded in arable field edges under full pesticide and fertiliser programmes. Reduced use of pesticides and fertiliser will further reduce crop yield. Grain samples may be poor, requiring separate harvesting of the headland. Unfertilised crops will be yellow in comparison to the adjacent fertilised arable crops. Grass weeds and some competitive broad-leaved weeds can become a problem in some sites. Knowledge of the likely weed pressure is useful.

Conservation headlands are most appropriate for cereal crops. The technique has been tried in other crops, including potato, with little environmental benefit and increased weed problems. The location of conservation headlands is best in cereals. Where weed problems develop, particularly with grass weeds, move conservation headlands. A broad-leaved break crop, such as oilseed rape, will allow the use of suitable herbicides to control problem grasses.

Sterile strips 1 m-wide created by herbicides or cultivation are allowed under some prescriptions to create a barrier to weed ingress and as an area for chicks to dry out after wet weather. **Extreme care** should be taken in application of herbicides in this sensitive area, as drift events into the pre-existing boundary can exacerbate annual weed problems of sterile brome and cleavers, reducing boundary diversity. Weeds such as brome shed seed over 1 m from the parent plant; a 1 m strip is unlikely to be an efficient weed barrier.

Landscape

As conservation headlands are part of a cereal crop, their landscape impact is likely to be small, unless a flush of poppies or mayweeds produce a strip of flowers at the field edge.

Further information:

Fact Sheet 2: *"Guidelines for the management of field margins"*. The Game Conservancy Trust, Fordingbridge, Hants SP6 1EF. (See: **Information Sources** p. 81)

Conservation Headlands

4.1. Aims:

to encourage a range of broad-leaved weeds and their associated invertebrate species to survive in the arable crop edge, providing chick food for grey partridge and other species. Reduced pesticide use in the crop edge will limit non-target effects of pesticides into the field boundary and adjacent habitat.

Conservation headlands have significant positive impacts on populations of grey partridge (Rands, 1985), operating via increased chick survival on increased insect populations, notably sawfly larvae, associated with broad-leaved weeds. Several other groups are also be enhanced by conservation headlands (Sotherton *et al*., 1985). Studies have shown that the use of fertiliser in the crop edge results in a closer canopy with less light penetration and greater natural control of weeds. If the crop is more competitive, then the weed flora will be less abundant and so will be the associated invertebrates. Rare weeds are more likely to grow and set seed in headlands that are not fertilised (Kleijn & Van der Voort, 1997). The technique is used in Germany to conserve rare cornfield flowers (Schumacher, 1987; Jörg, 1994).

4.2. Size:

Conservation headlands should be at least 6 m wide, which corresponds with half the working width of much farm machinery. Under Arable Stewardship the widths are 10 m to 12 m of crop margin.

4.3. Siting:

Conservation headlands should be sited at the edges of cereal fields. Under Arable Stewardship the headlands may move each year with normal crop rotations. Some care should be taken in siting these headlands, selecting areas where rare arable species may be present in the seed bank and not where competitive arable weeds are likely to dominate the headland under relaxed herbicide use. Nevertheless, a range of herbicide treatments can cope with most annual grass weeds and cleavers can also be treated.

As conservation headlands are also aimed at encouraging seed-feeding birds and other groups, consideration should be given to siting them adjacent to diverse, well-established boundaries, preferably connected to other semi-natural habitat on the farm. In such situations, conservation headlands can provide food and cover adjacent to nesting and source areas.

As conservation headlands are part of a cereal crop, their landscape impact is likely to be small, unless a flush of poppies produces a strip of red flowers at the field edge.

4.4. Choice of headland option:

If rare weed species are found germinating in conservation headlands, farmers should be encouraged not to apply fertiliser (Option 3B - Arable Stewardship), as well as following the requirements for no insecticides. The lack of added fertiliser will reduce the vigour of the crop and other species, reducing competition on the rarer species.

4.5. Establishment:

The crop should be established in the same manner as the rest of the field.

Action point: If rare weed species are found germinating in conservation headlands, farmers should be encouraged not to apply fertiliser.

4.6. Management:

No insecticides may be applied after 15th March (31 December in South Downs and South Wessex Downs ESAs). In winter crops, autumn insecticides to control aphids which may be carrying viruses such as Barley Yellow Dwarf Virus should be applied according to the predicted need, rather than on a prophylactic basis.

Serious grass weed infestations may be controlled with a limited set of graminicides and tri-allate (See below and: **Herbicides** p. 77). An important aim of conservation headlands is to encourage a reasonable cover of broad-leaved weeds. Control of broad-leaved weeds is therefore limited to the use of amidosulfuron, or possibly fluroxypyr, up to 31st March, aimed at controlling cleavers, a competitive weed that can spread into the crop from the field margin. After 31st March, exceptional circumstances may require herbicide intervention.

Advisers should make decisions on derogations on the basis of the likely crop loss from weed pressure, selecting a herbicide that will give the best selective control of the problem species.

Under Arable Stewardship Option 3B, no inorganic or organic fertiliser may be applied to the conservation headland from the harvest of the previous crop. Applications to adjacent land should not encroach onto the conservation headland.

4.7. Cost implications: (see p. 13)

Under Arable Stewardship payment levels are £100/ha for ordinary conservation headlands and £150/ha for headlands where fertiliser is also excluded.

Further reductions in crop yield over those normally found at the field edge can be expected with conservation headlands. However, input costs are likely to lower than usual, though attention will need to be given to planning special operations only applied to the headlands.

4.8. Problems:

The presence of increased weed populations in the crop headland can alarm farmers who are used to vigorous and largely weed-free crops.

Note: Application of fertiliser can increase the growth of nitrogen-responsive weeds such as cleavers. Avoiding fertiliser can reduce competitive weed pressure, as well as opening up the cereal canopy.
The lack of fertiliser will cause the cereal crop to yellow. This can also alarm farmers.

If the headland is taken to harvest, separate harvesting is likely to be required, to prevent seed contamination of grain samples. Where no fertiliser is used in the headland, cereal grain sizes as well as yield may be reduced, giving poor grain samples.

Undesirable weed populations can be a problem in some sites. Weed communities vary from field to field and between soil types (See: **Weeds**. p. 65). On heavy soils, annual grass weeds such as blackgrass can dominate. Other annual grass weeds that are likely to be a problem in some sites are wild-oat, sterile brome and Italian ryegrass. The graminicides listed below

(Table 9) have been selected to control such species. Where perennial grass weeds, such as couch, onion couch or black bent, are a problem, pre- or post-harvest application of glyphosate, a translocated herbicide, is recommended. Spot treatments only are allowed under most prescriptions.

Table 9. Herbicides for use in conservation headlands.

Annual grass weed control	Cleaver control	Perennial grass control
tri-allate	amidosulfuron	glyphosate
diclofop-methyl	fluroxypyr	
diclofop-methyl + fenoxaprop-P-ethyl (barley only)		
difenzoquat		
flamprop-m-isopropyl		
fenoxaprop-ethyl (wheat only)		
fenoxaprop-P-ethyl (wheat only)		
tralkoxydim		
clodinfop-propargyl (not barley)		

4.9. Feedback:

Which weed species create problems in conservation headlands?

Are new selective herbicide treatments needed?

Are the weed problems originating from the field boundary or are they prevalent in the field?

Further information:
Fact Sheet 2: *"Guidelines for the management of field margins"*. The Game Conservancy Trust, Fordingbridge, Hants SP6 1EF. (See: **Information Sources** p. 81)

5. Wildlife Seed Mixtures

Aims:

to provide nectar, seeds and cover for insects, birds and mammals typical of farmland, when created as field margin strips or blocks within fields.

Wildlife

Wildlife seed mixtures, created as margin strips or blocks of game cover in fields, can provide habitat for a range of insects and forage and nesting areas for birds. Finches, in particular, can use the seed resources provided by a range or mixtures of cover crops carried through the winter. These areas can also be used for cover by brown hares. Seed mixtures of grasses and wild flowers can provide pollen and nectar sources for a range of insects and habitat for insects, mammals and birds.

Environment

As margin strips, these mixtures can act as buffers between farming and adjacent semi-natural habitat, including water courses, reducing overland flow of dissolved fertiliser, pesticide and entrained silt.

Game

A number of proposals will result in benefits to game shoots. There should also be explicit benefits for other wildlife, such as songbirds.

Landscape

Either as blocks or strips, wildlife seed mixtures can have significant impacts on the landscape. Consider the impact of proposals on the landscape. Consult a landscape architect if there may be changes visible over large distances or in sensitive situations near towns and villages.

Three main types of proposal are likely to come forward: specific wildbird seed mixtures, mixtures to encourage pollinating insects and game cover crops.

5.1. Wild bird seed mixtures

Seed mixtures for wild birds have been the subject of research by the British Trust for Ornithology and the Royal Society for the Protection of Birds (See: **Information Sources**: p. 81). Mixtures can include species that produce seeds favoured by seed-eating birds, such as teasel and burdock. A variety of mixtures can be established, requiring a variety of management approaches. Where annual or biennial species are to be encouraged, then a degree of disturbance to allow germination is necessary. If the mixture is perennial, then occasional mowing, outside the nesting season form 15 March to mid-July, can be allowed.

5.2. Seed mixtures for pollinators and other insects

A variety of seed mixtures can be proposed for insects. Pollinating insects favour legumes, like white clover, and labiates, such as white deadnettle (Corbet, 1995; Saville *et al*., 1997) and a limited number of annual plant species. Different flowers provide different nectar resources for the long- and short-tongued pollinators. The perennial flowers might be established as components of a grass sward. Alternatives include the "Tübinger Mischung" or Tübingen Mixture of plants designed to provide forage for relatively short-tongued wild bees, or nectar-rich species such as phacelia (*Phaecelia tanacetifolia)* or borage (*Borago officinalis*). Recent work suggests that the Tübingen mix and the Ascot Linde SN mixture from the Netherlands are not suitable for encouraging insect diversity under UK conditions. This reflects the dominance of phacelia in the commercial mixes (Carreck & Williams, 1997), as shown below in Table 10.

Table 10. Components of bee forage mixes, as % seed weight

Plant	***Latin name***	**Nectar (N) or Pollen (P)**	**Tübingen**	**Ascot Linde SN**
Dill	*Anethum graveolens*	P	2	
Borage	*Borago officinalis*	N	1	
Black mustard	*Brassica nigra*	N + P		20
Marigold	*Calendula officinalis*	P	5	
Cornflower	*Centaurea cyanus*	P	3	
Coriander	*Coriandrum sativum*	P	6	
Buckwheat	*Fagopyrum esculentum*	N	20	20
Sunflower	*Helianthus annua*	N + P	5	
Lupin	*Lupinus albus*	P		15
Mallow	*Malva sylvestris*	P	3	
Caraway	*Nigella spp.*	P	5	
Phacelia	*Phacelia tanacetifolia*	N + P	40	25
Radish	*Raphanus sativus*	N + P	3	20
White mustard	*Sinapis alba*	N + P	7	

A modified Tübingen mixture has been used on the continent, comprising: Black medick, white mustard, hogweed, corncockle, borage, common knapweed, wild carrot, wild parsnip, chicory, viper's-bugloss, white campion, evening primrose, poppy, yarrow, scented mayweed, ox-eye daisy and tansy (after Nentwig, 1993).

To provide pollen and nectar sources through the year, the flora needs to contain a mixture of species that flower at different times, giving a flower succession. A proposed alternative, as in the case of *Phaecelia*, is to use a species that flowers for an extended period, though in practice this has not proved effective in enhancing the diversity of beneficial insects. Strips of *Phaecelia* are grown at the edges of arable fields by some UK farmers, particularly in fields of field beans which need pollinating insects. There is some evidence that such flower strips enhance populations of aphid predators, notably hoverflies.

5.3. Seed and game cover crops

A number of cover crops developed by the Game Conservancy Trust can provide cover for birds and food supplies of seeds. The use of cover crops for gamebirds is well-described in the Game Conservancy book *Game and Shooting Crops*. A wide variety of species can be grown, providing cover alone or cover and food. The duration of cover and availability of seeds varies with the crops grown. Some species last through the winter, while others have dissipated by early autumn. Sunflower, for example, provides much seed but this will have disappeared by Christmas. Collaborative research currently underway by the Game Conservancy and the British Trust for Ornithology is examining a variety of cover crops for wild bird use.

Cover crops can be planted as single species plots or as mixtures, including alternate strips. Mixtures provide structural variety and the possibilities for providing seed through the winter. The range of cover crops, with brief comments is given in Table 11 below. Interim results of work by the Game Conservancy and BTO on the use of different cover crops by birds is also given, taken from the Game Conservancy magazine *Gamewise*, Spring/Summer 1998.
To establish good crops of the cover species, they may need to be grown with attention to nutrition and weed control. Whilst there may be opportunities to encourage a range of weed species within cover crops, the provision of good seed supplies may require good agriculture. Experience indicates that second-year kale that has flowered and produced seed may give the best seed supplies for seed-feeding birds over winter. These spring-sown cover crops need to be established early in April, rather than May, to achieve good winter cover.

Table 11. Effects of different cover crops on the occurrence of birds in winter.

Cover crop	**Comments**	**Birds in winter**
Maize	Food and cover. Poor cover in late winter. Can be troubled by rooks and rats.	?
Cereals, including rye and triticale	Food and cover.	greenfinch, yellowhammer, corn bunting, chaffinch
White Millet	Food and cover. Best used in mixtures. Good seed production.	yellowhammer, corn bunting, reed bunting, chaffinch
Quinoa	Good seed provision, but more open in winter. Mixes with kale are useful.	yellowhammer, chaffinch
Sunflower	Good seed production, but supplies are gone by Christmas	greenfinch
Linseed	Late provision of seeds.	?
Parsnip	Allowed to seed, can be useful	?
Chicory		?
Rape		greenfinch, reed bunting, chaffinch, linnet
Kale	Kept to the 2nd year provides excellent cover and seed supplies	greenfinch, reed bunting, chaffinch, linnet

A mixture of species will encourage a succession of seeds to be available through the autumn. winter and spring. Where possible, the natural broad-leaved weed flora should also be allowed to establish and set seed, though a balance between the sown crop and the weeds will need to be struck.

6. Birds on farmland

A range of bird species are found in farmland, using resources within grassland and arable fields and within adjacent semi-natural habitats, including hedgerows, woodland, scrub and wetland (Lack, 1992).

Declines in farmland birds

Significant declines in farmland birds have been recorded in the British Trust for Ornithology's Common Bird Census (CBC) returns between 1969 and 1994 (Fuller *et al*., 1995). Some percentage declines are given in Table 12.

Table 12. Percentage declines in the CBC farmland index, 1969-1994

Species	% decline, 1969-1994
Tree sparrow	89
Grey partridge	82
Corn bunting	80
Turtle dove	77
Lapwing	62
Skylark	58
Linnet	52

A number of birds associated with farmland are on the short, medium and long lists of the UK Biodiversity Action Plan (Anon, 1995). Action Plans have been published for species on the short list and are under consideration for those on the middle and long lists. Birds on the BAP lists are given below in Table 13.

Table 13. Bird species associated with farmland on the Biodiversity Action Plan lists.

Species	
BAP short list	BAP long list
skylark	yellowhammer
stone curlew	reed bunting
grey partridge	dunnock
song thrush	bullfinch
	blackcap
BAP middle list	redwing
linnet	fieldfare
cirl bunting	barn owl
corn bunting	lapwing
tree sparrow	
turtle dove	

Identification

A range of good identification books are available, including the *Collins Pocket Guide to Birds of Britain and Europe*, by H. Heinzel, R. Fitter & J. Parslow (5th. Edn., 1995) 384 pp. For a fuller description, try *The Birdwatcher's Handbook. A field guide to the natural history of the birds of Britain and Europe*, by P.R. Ehlich, D.S. Dobkin, S.L.Pimm & D. Wheye (1994), Oxford University Press, 700 pp.

Target species habitat requirements

Skylark:
Nests are found in short vegetation on the ground, particularly grassland, though they will use spring cereals. Chicks feed only on insects during their first week of life. Adults eat a mixture of insects, seeds and leaves, and will eat grass seeds if nothing else is available. Skylarks avoid hedgerows and trees, preferring shorter vegetation up to 0.5 m tall that is sparse or open. In winter, skylarks prefer cereal stubbles over all other field types, but will use set-aside, grass leys, cereals and root crops.

Stone curlew:
Nests in scrapes in sparsely vegetated ground. Short heaths and dry grassland with 2 cm high cover are favoured, but will nest in spring sown crops with short vegetation. Chicks are fed on invertebrates. Adults are nocturnal (will forage in the day with chicks). The diet includes earthworms, woodlice, spiders, millipedes, beetles and snails from open ground.
Associated with free-draining stony soils, dry heaths with short open vegetation, dry grassland and arable fields.

Grey partridge:
Tall, tussocky vegetation in hedgerows is their preferred nesting habitat, particularly on banks, where dead grass is the most important factor providing cover and protection from predators. Partridges prefer shorter hedges (2m) to tall hedges with trees and require areas in which chicks can dry out in wet weather.
Chicks require an insect diet for the first 2 weeks of life. Thereafter, they switch to a mixed diet with adults feeding largely on broad-leaved weeds and seeds. Partridges are a steppe or prairie species and are well adapted to cereal fields where sufficient insects and plants are available for feeding and suitable nesting areas are present.

Song thrush:
Nests in trees, shrubs, climbing vegetation and occasionally on the ground. Chicks are fed on insects and some fruit. Adults eat a wide range of invertebrates and, in autumn, fruits. Elder, yew, sloes and ivy are important (Snow & Snow, 1988).
Considered a bird of woodland; in farmland it is associated with increasing hedge height, with maximum incidence with 7 m high hedges and two trees per 30 m. Hedgerow trees are important, as are foraging areas of grassland, leaf litter or moist ground. In winter, local populations are joined by others from Scandinavia. Favours permanent grassland in winter, but will use broad-leaved crops. Avoids winter cereal fields.

Linnet:
Linnets nest in dense vegetation, scrub and trees, including hedges, up to a height of 2 m.
Chicks are fed entirely on small seeds, the same diet as adults.
Birds avoid tall trees and are associated with scrub, preferring short hedges (1.2 m) with no trees. Occur in stubbles and fallow where weed seeds are abundant and in field boundaries next to pasture and arable. They avoid improved grass and cereals in winter.

Cirl bunting:
Largely restricted to South Devon. Shows a marked preference to nest in bushy hedgerows or (to a lesser degree) thorny scrub, with gorse, blackthorn and bramble favoured, and on banks.
Chicks are fed a wide range of invertebrate food items, but with Orthoptera comprising a dominant part of their diet in August. Rarely, grass seeds may be included.
During winter Cirl Buntings forage almost exclusively in stubble fields, in mixed flocks, feeding on the seeds of cereals and annual weeds, and remaining close to hedgerows.
Conservation headlands may provide suitable winter habitat.

Corn bunting:
Nests mainly on the ground in arable fields, notably barley, but also in grassland and

occasionally at the base of hedges or at 1.5 m in bushes. Stubbles undersown with clover are particularly favoured for nesting. Chicks mainly eat insects; after fledging more plant material, notably leaves and buds, is eaten.
Corn buntings are typical of open arable fields, rather than grassland, where they tend to nest along hedges and fencelines. In winter, they prefer cereal stubbles over all other fields and avoid winter cereals and improved grassland.

Tree Sparrow:
Nests in holes in trees, notably pollard willows and earth banks. Where no holes are available, will use dense vegetation and hawthorn hedges. Chicks are fed on invertebrates for the first week of life. Adult diet is largely seeds of grasses, cereals and annual herbs, collected while foraging on the ground. Invertebrates are taken during the breeding season. Preferred habitat is open country with trees, tall hedges and small woodlands. Greatest incidence is in farmland with tall (7 m) hedges with 1 or 2 trees per 30 m. In winter, they form large flocks with finches and house sparrows.

Turtle dove:
Summer visitor to Britain, nesting low down in bushes, thickets and orchards and foraging mainly in woodland, scrub and orchards in the South East. Feeds on seeds on the ground. Prefers wooded landscapes with tall hedges and woodland.

Lapwing:
Nests in open farmland from mid-March in short vegetation less than 15 cm high. Rough grassland is the favoured nesting habitat, but also uses spring crops and improved grassland. Chicks are raised in grassland on invertebrates. Adult diet includes earthworms, beetles, ants, spiders and Lepidopteran larvae.
Lapwing are associated with tussocky grassland, particularly wet areas and avoid hedges, trees and tall vegetation. Spring-sown crops are also favoured, especially when next to grassland. In winter, short grassland is favoured, with cultivated land used for roosting flocks.

<u>Feeding preferences of birds</u>

Further details of bird feeding requirements have been recently reviewed by Vickery (1998).

The following two tables list the known feeding habits of target BAP bird species.

Table 14. Animal foods of bird species listed in Birds of Conservation Concern and thought to use field margins. Invertebrates listed are dietary components of adults and nestlings unless otherwise indicated. Where season (s; summer, w; winter) is not indicated the seasonal information is not available. [Taken from Vickery (1998) *Use of cereal fields by birds: A review in relation to field margin managements*]

Bird Species	Lepidoptera	Diptera	Colleoptera	Hymenoptera	Arachnida	Others
Grey Partridge (summer)	larvae	Tipulidae	larvae Carabidae Curculionidae Staphylinidae Chrysomelidae	Formicidae (p) Symphyta Ichneumonidae Braconidae		Acrodidae Delphicidae Cicadellidae Orthoptera Hemiptera
Turtle Dove						Mollusca
Song Thrush (summer)	larvae (Noctuidae)	larvae	larvae (Elateridae)	larvae	Araneae	Annelida Mollusca
Tree Sparrow[1] (winter)	larvae	larvae	Curculionidae		Araneae	Orthoptera Hemiptera
Linnet (summer)	larvae	Muscidae	Curculionidae Coccinellidae Elateridae Chrysomelidae		Araneae	Hemiptera
Bullfinch	larvae		adults		Araneae	Mollusca
Reed Bunting	larvae larvae	Tipulidae Tipulidae Chironomidae Tabanidae	Curculionidae	Symphyta (larvae)	Araneae	Collembola Odonata Ephemeroptera Orthoptera
Corn Bunting	larvae	Tipulidae	Scarabidae		Araneae	Orthoptera Dermaptera
Cirl Bunting (Mainly N) (summer)	larvae	Tipulidae	Curculionidae Staphylinidae	Symphyta		Orthoptera

Table 15. Main plant foods of bird species listed in Birds of Conservation Concern but shown to use field margins in section 3. Items listed are dietary components of adults and nestlings unless otherwise indicated (A; adult diet, N; nestling diet). Fr; fruit, sd; seeds, w; winter, s; summer. [1]species showing a preference for field margins in winter in only one of two years (Organic Farm study), [2] species showing a preference for field margins in winter (Organic farm study) and avoidance in summer (Set-aside study)
[Taken from Vickery (1998) *Use of cereal fields by birds: A review in relation to field margin managements*]

Bird Species	Cereal (seeds)	Grass (seeds)	Annual weed (seeds)	Biennial seeds	Perennial herb seeds	Others
G. Partridge (mainly A, w & s)	unspecified		Polygonaceae Caryophyllaceae Borginacea		Polygonaceae Leguminosae Borginacea	Labiatae (fr) unspecified green plant material
Turtle Dove (A & N, w & s)		Festuca Setaria	Fumariaceae Chenopodiaceae Cruciferae Polygonaceae Compositae	Cruciferae	Compositae Polygonaceae Leguminosae	unspecified green plant material
S. Thrush (mainly A, w & s)						Oleaceae (fr) Rosaceae (fr) Taxaceae (fr) Aquifoliaceae (fr) Araliaceae (fr) Loranthaceae (fr)
T. Sparrow[1] (A & N, w & s)		Poa Echinochloa Digitaria Lolium Setaria	Polygonaceae Chenopodiaceae Amaranthaceae Caryophyllaceae Borginacea		Polygonaceae Borginaceae Caryophyllaceae	
Linnet (A & N, w & s)	unspecified	Poa	Polygonaceae Caryophyllaceae Chenopodiaceae Cruciferae Compositae	Cruciferae	Polygonaceae Compositae Caryophyllaceae Cruciferae	
Bullfinch (A & N, w)	unspecified	Poa	Polygonaceae Caryophyllaceae Cruciferae Chenopodiaceae Compositae Cruciferae	Cruciferae	Polygonaceae Ranunculaceae Compositae Cruciferae Caryophyllaceae	Rosaceae (sd) Ulmaceae (sd) Aceraceae (sd) Urticaceae (sd) Euphorbiaceae (sd) Violaceae (sd) Ericaceae (sd) Caprifoliaceae (sd) Salicaceae (fl) Fagaceae (fl) Ranunculaceae (sd)
Reed Buntings (A & N, w & s)	unspecified	Poa Lolium Festuca Elymus	Chenopodiaceae Amaranthaceae Caryophyllaceae Cruciferae	Cruciferae	Leguminosae Cruciferae Caryophyllaceae	Rosaceae (fr)
Corn Bunting (mainly A, w)	unspecified		Polygonacea		Polygonacea	
Cirl Bunting (mainly A, w & s)		Poa Lolium Festuca Elymus	Compositae Polygonaceae Caryophyllaceae		Polygonaceae Caryophyllaceae Compositae	

Items are listed only if they are present in the diet and have been quantified or described as an important dietary component (see Wilson *et al*. 1996). Further data may show other taxa to be important.

7. Mammals on farmland

Two species, the brown hare and the pipistrelle bat, are particularly associated with farmland and have shown significant population declines over recent years. A long-term decline in brown hare numbers has been associated with changes to arable farming practices which have reduced the availability of high-quality food (Tapper & Barnes, 1986). The changes in agriculture include loss of traditional crop rotations, decreased cropping diversity and increased field size. Mammal species associated with farmland and listed in the UK Biodiversity Action Plans are given in Table 16.

Table 16. Farmland mammal species listed in the short, middle and long lists of the UK Biodiversity Action Plan.

Species	
BAP short list	BAP long list
brown hare	hedgehog
pipistrelle	badger
	common shrew
	pygmy shrew

Identification

The Pocket Guide to Mammals of Britain and Europe, by A.M. Hutson (1995) Collins & Brown, 184 pp. is useful. A full treaty is given by David MacDonald (1993) in his *Field Guide to the Mammals of Britain and Europe*, Harper Collins, 448 pp.

Target species habitat requirements

Brown hare:
Nest sites are usually hidden in tall vegetation.
Hares require feeding and resting areas. They will feed in grassland and arable fields, utilising short new growth, i.e. winter cereals in winter, then spring cereals and grass, which is their preferred habitat. Their home range is extended in areas of large field size. During the day, they will utilise woodland and hedges for shelter. Mixed farms have greatest abundance of hares.

Pipistrelle bat:
Females form nursery colonies in spring to give birth to young. Males stay in the same roost, typically roofs, churches and old trees, all year. Bats commute between roosting and feeding areas. They feed on flying insects, particularly caddisflies and midges; the young are weaned at about 7 weeks, when they are able to hunt as well as adults.
Feeding areas are on regular beats, with rivers and ponds and woodland edges particularly selected. Bats avoid open fields but use hedges and treelines. Foraging areas are selected on insect abundance.
Adults hibernate over winter and start feeding in spring. However, starvation in spring is a common cause of death.

8. Plants in arable land

The flora of arable fields is, of course, dominated by the sown crop. However, a variety of plant species are adapted to the regularly disturbed (cultivated) regime, notably cornfield annuals and some competitive perennial and biennial weeds. An increasing number of annual plant species adapted to cornfields are becoming rare and in need of protection or enhancement. At the edges of arable fields, the field margins may support a diverse flora, representing adjacent habitat, such as woodland, heathland or grassland. Often field margins are refugia for many plant species in otherwise intensively managed agricultural land. Management practices which enhance the size of semi-natural habitat can encourage the diversity of such areas and may buffer the effects of adjacent agricultural operations.

8.1. Rare plants of arable land

Many formerly common flowering cornfield weeds, such as corn buttercup and shepherd's needle, have become rare (Wilson, 1994). Some species, such as thorow-wax (*Bupleurum rotundifolium*), are probably extinct in Britain. Surveys of rare weed occurrence have been made within the Botanical Society of the British Isles Scarce Plant Project for 18 species listed in Table 17 below. Modifications to field margin management, particularly uncropped wildlife strips and conservation headlands, can allow these species to survive. Set-aside management may also provide an opportunity to encourage these annual plants (Firbank & Wilson, 1995).

The timing of cultivation, either in autumn for winter crops or in spring for spring crops, has a marked influence on the weed communities that develop (Chancellor, 1985). Autumn-germinating species are favoured by winter cereal crops, while spring cultivation largely eliminates these and favours spring-germinating species, such as the Polygonaceae (knotgrasses).

Table 17. Rare arable flowers on Biodiversity Action Plan Lists, or noted under the Cereal Field Margin Habitat Biodiversity Action Plan, or surveyed under the BSBI Scarce Plant Project. * = species on BAP middle list; # = BAP long list; A = autumn-germinating; S = spring-germinating. G = dormancy known in the genus.

Species	**Germination (A = autumn; S = spring)**	**Seedbank longevity (m=months; y=years)**	**Soil type**	**Seed Dormancy**
pheasant's eye (*Adonis annua*) #	S/A		chalk/brash	G
ground pine (*Ajuga chamaepitys*)#				
small alison (*Alyssum alyssoides*)#				G
dense silky-bent (*Apera interrupta*)	A?			G
loose silky-bent (*Apera spica-venti*)	A	1-5 y	sand	Yes
cornflower (*Centaurea cyanus*)*	A/S			Yes
broad-leaved spurge (*Euphorbia platyphyllos*)#	A/S		chalk/clay	G
red-tipped cudweed (*Filago lutescens*)*				
broad-leaved cudweed (*Filago pyramidata*)*			chalk/sand	
Western ramping-fumitory (*Fumaria occidentalis*)			sand/loam	G
purple ramping-fumitory (*Fumaria purpurea*)*				G
tall ramping-fumitory (*Fumaria bastardii*)	A/S			G
dense-flowered fumitory (*Fumaria densiflora*)	S		chalk	G
few-flowered fumitory (*Fumaria vaillantii*)	A/S		chalk	G
red hemp-nettle (*Galeopsis angustifolia*)*	S			G
false cleavers (*Galium spurium*)				G
corn cleavers (*Galium tricornutum*)*				G
field gromwell (*Lithospermum arvense*)#	A-S		chalk/clay	
field cow-wheat (*Melampyrum arvense*)#	S			
prickly poppy (*Papaver argemone*)	A/S	>20 y		Yes
rough poppy (*Papaver hybridum*)	A/S	> 20 y	chalk	G
corn parsley (*Petroselinum segetum*)#	A		chalk/clay	G
purple-stem cat's-tail (*Phleum phleoides*)#				G
cornfield knotgrass (*Polygonum rurivagum*)	S			G
corn buttercup (*Ranunculus arvensis*)#	A		clay	G
shepherd's-needle (*Scandix pecten-veneris*)*	A/S	3-12 m	clay	
small-flowered catchfly (*Silene gallica*)*	S		sand/gravel	
night-flowering catchfly (*Silene noctiflora*)	S	5-20 y	all soils	Yes
spreading hedge-parsley (*Torilis arvensis*)#	A		clay/loam	G
narrow-fruited cornsalad (*Valerianella dentata*)#	S			
broad-fruited cornsalad (*Valerianella rimosa*)*			clay/chalk	
Breckland speedwell (*Veronica praecox*)	Winter			G
fingered speedwell (*Veronica triphyllos*)#				G
slender tare (*Vicia parviflora*)			clay/brash	G

Studies of weed seed banks in arable fields show that more seed and more species are represented at the field edge. Therefore, field margin Options which allow annual cultivation but reduce the effects of herbicides and competition from vigorous plants, should encourage these species. Uncropped wildlife strips and conservation headlands, particularly unfertilised, are most appropriate for encouraging rare weeds. Where species are know to occur in the crop edge, oversowing a perennial grass margin will not allow these annual plants to persist. Sown perennial grass margins are not recommended in such situations.

Identification

Accurate identification of these uncommon species is needed. The *"Field Guide to Rare Arable Flowers"* by Philip Wilson and Nick Sotherton (1994), published by the Game Conservancy, is a very useful guide to 16 of these species. A new guide by Philip Wilson is currently in preparation. The *New British Flora of the British Isles* by Stace, C.E. (1991; 2nd edn 1997), Cambridge University Press is an excellent advanced botanical text, which can be augmented by good illustrated Field Guides, such as *The Wild Flowers of Britain and Europe* by Fitter, R., Fitter, A. & Blamey, M. (1974), Collins.

Checking the identification of plants

The Botanical Society of the British Isles has referees to all the plant genera of the British Isles and for plants from certain habitats. The referees will check identifications of plant material, if you send it with an *sae*. The referee for arable weeds is:

Dr E J P Marshall,
IACR - Long Ashton Research Station,
Department of Agricultural Sciences
University of Bristol
Long Ashton
Bristol BS41 9AF

He will confirm the identification of material sent to him and return it if requested. Plants should be mounted dry on paper, preferably with flowers and seeds, and should have a description of where found, including National Grid Reference, habitat and associated species.

Target species habitat requirements

All arable flowers require cultivated soil. Some species are associated with light soils, some with sandy soils and some with chalky soils. Some are spring germinators, others germinate in autumn (see above). Many species are not particularly associated with soil type (See: **Weeds** p. 65).

Note: The land owner may know of the existence of rare weeds; if he does not, a quick field survey of field edges, gateways and field corners may reveal the best locations for conservation headlands.

Note: Local Biological Records centres, usually run by the county Naturalist Trust, should be able to provide data on local records, which will help target suitable sites. Otherwise, contact the national Biological Records Centre at ITE Monks Wood Research Station, Abbots Ripton, Huntingdon, PE17 2LS (Tel: 01487 773381; Fax: 01487 773467)

Action point: If rare weed species are found germinating in conservation headlands, farmers should be encouraged not to apply fertiliser.

8.2. Weeds

Weeds can be most simply defined as plants that grow where they are unwanted. In arable land, most plants growing in the crop are regarded as weeds that either compete with the crop affecting yield or reduce quality, or have both effects. In semi-natural habitats, weeds may be those that dominate the flora at the expense of other species, or which threaten to spread into adjacent crop land. A variety of growth forms, life history strategies and dispersal methods are shown by weeds. For example, some weeds are annuals spreading by seeds, while others are biennials or perennials spreading via seeds, stolons and rhizomes.

Classic studies by Brenchley (Brenchley, 1911; 1912; 1913) in the early part of the century attempted to identify the associations of weeds in arable land with soil types and crops. The strict association of weeds with soil types was limited, with many species of weeds being of general occurrence. Some species are nevertheless most often found on some soils (see on).

Common weeds

The occurrence of weeds in arable land has been surveyed from time to time in a variety of ways and in different areas. One of the most recent surveys was conducted by technical staff of Schering Agriculture (now AgrEvo) in 1988 (Whitehead & Wright, 1989). Weeds in fields of winter wheat and winter barley were recorded, representing a 4% sample of UK fields. The commonest broad leaved and grass weeds are given in Table 18 below.

Table 18. The main broad-leaved and grass weeds in winter cereals (% fields infested) in Great Britain (total) and from three main regions. From Whitehead (1989).

Species	**Total**	**Anglia**	**Southern**	**Western**
Chickweed (*Stellaria media*)	94	92	90	96
Common speedwell *(Veronica persica*)	72	76	69	59
Mayweeds (*Matricaria* spp.)	67	68	63	63
Cleavers (*Galium aparine*)	58	60	55	58

Species	Total	Anglia	Southern	Western
Red deadnettle (*Lamium purpureum*)	47	36	47	39
Field pansy (*Viola arvensis*)	45	45	49	54
Charlock (*Sinapis arvensis*)	36	41	38	42
Ivy-leaved speedwell *(Veronica hederifolia*)	30	33	33	26
Shepherd's *purse (Capsella bursa-pastoris*)	23	21	20	24
Volunteer rape	23	22	10	16
Common poppy (*Papaver rhoeas*)	18	27	20	11
Fumitory (*Fumaria officinalis*)	17	7	17	20
Fathen (*Chenopodium album*)	13	11	10	13
Parsley piert (*Aphanes arvensis*)	12	13	17	14
Cranesbills (*Geranium* spp.)	11	11	11	14
Grass weeds				
Annual meadow grass (*Poa annua*)	79	66	78	88
Wild-oats (*Avena* spp.)	42	51	45	40
Blackgrass (*Alopecurus myosuroides*)	38	70	35	26
Couch grass (*Elymus repens*)	21	21	19	20
Ryegrass (*Lolium* spp.)	14	7	15	19
Sterile brome (*Bromus sterilis*)	13	12	12	10
Rough-stalk meadow grass (*Poa trivialis*)	7	3	12	2
Volunteer cereals	7	7	9	5

Certain species are more prevalent in the East, notably blackgrass, while others, notably fumitory, are commoner in the West.

The major factors affecting weed communities within arable crops are field history, soil type, crop type, timing of cultivation and herbicide use (Chancellor *et al*., 1984). There are often marked field-to-field differences in weeds on the same farm. The timing of cultivation, either in autumn for winter crops or in spring for spring crops, has a marked influence on the

weed communities that develop (Chancellor, 1985). Autumn-germinating species are favoured by winter cereal crops, while spring cultivation largely eliminates these and favours spring-germinating species, such as the Polygonaceae (knotgrasses).

Data collated from Brenchley for weeds of general occurrence, or commonly found on either sandy, chalk, loam or clay soils are listed in Table 19 below.

Table 19. Weed species found generally distributed or associated with sand, chalk, loam or clay soils (in alphabetical order of latin names). Derived from Brenchley(1911-13).

Generalists	**Sand**	**Chalk**	**Loam**	**Clay**
Creepiong bent	Bugloss	Mugwort	Corncockle	Blackgrass
Shepherd's purse	Soft brome	Chicory	Stinking mayweed	Common orache
Common mouse-ear	Corn marigold	Smooth hawksbeard	Daisy	Dwarf spurge
Fat-hen	Viper's-bugloss	Sun spurge	Ox-eye daisy	Cleavers
Creeping thistle	Common whitlowgrass	Common toadflax	Purple spurge	Cut-leaved cranesbill
Field bindweed	Early forget-me-not	(+ loam) Fool's parsley	Ryegrass	Hogweed
Swine-cress	Sorrel	Common knapweed	Prickly poppy	Sharp-leaved fluellen
Wild carrot	Annual knawel	(+ sand) Basil thyme	Rough-stalk meadowgrass	Creeping cinquefoil
Couch grass	Corn spurrey	Corn chamomile	Silverweed	Corn buttercup
Field horsetail	(+loam) Common stork's-bill	Thyme-leaved sandwort	Selfheal	Marsh woundwort
Cleavers	Small toadflax	Common orache		
Red deadnettle	Marsh cudweed	Musk thistle	Red campion	
Mayweed spp.	Yorkshire fog	Common cudweed	White mustard	
Corn mint	Common poppy	Dove's-foot cranesbill		
Field forget-me-not	Long-headed poppy	Small-flowered cranesbill		
Greater plantain	Knotted pearlwort	Wild mignonette		

Timothy	Small-flowered catchfly	Night-flowereing catchfly		
Knotgrass				
Creeping buttercup				
Wild radish				
Curled dock				
Broad-leaved dock				
Shepherd's-needle				
Groundsel				
Field madder				
White campion				
Charlock				
Perennial sowthistle				
Chickweed				
Knotted hedge-parsley				
Green field-speedwell				
Common field-speedwell				

The lists above are not comprehensive and are derived from surveys when agricultural practice was very different to today. Nevertheless, the dominance of generalist species is obvious. It is clear that it is not easy to predict the size and content of likely weed communities, given the generalist occurrence of so many species and the variation that is a natural feature of weed assemblages. The species listed in Table 18 are more likely to give a better picture of the weed communities now likely to be found.

9. Herbicides

General comments

Advice on herbicide use should only be made by BASIS-qualified staff.

Read the product label before use.

Note that products may only be used on approved crops or in approved situations.

Products approved for use on grassland are legal for use on grass field margins.

Products approved for use on the appropriate cereal crop are legal for use on conservation headlands.

Follow the Green Code: the Code of Practice for the Safe Use of Pesticides on Farms and Holdings (1998)

Information on compounds and products is given in the MAFF & HSE book *"Pesticides 1998"*, published by the Stationery Office and *"The UK Pesticides Guide 1998"* published by CAB International and BCPC (see Reading List).

The definitions of vegetation covers which will increasingly be used for pesticide approvals have been modified recently. These include:

Green cover on land temporarily removed from production: fields covered by natural regeneration or by planted green cover crop which will not be consumed by humans or livestock, but which will be growing harvested crops in other years (e.g. green cover on set-aside)

Amenity grassland: areas of semi-natural or planted grassland with minimal management (e.g. railway and motorway embankments, airfields)

Older pesticide use definitions from *The UK Pesticide Guide* include non-crop areas and turf/amenity grass.

Non-crop areas: a number of products have approval for use on non-crop areas, defined as land not used for crop production. Sown grass field margin strips, beetle banks and uncropped wildlife strips might be classified as non-crop areas, but conservation headlands *are crop land, not non-crop* areas. Grass margins and beetle banks in agricultural land are

more likely to be classified as agricultural grassland, while uncropped margin strips are less easy to classify.

Turf/amenity grass: a number of products have approval for use on turf and amenity grass. It is unclear if such approvals are applicable to sown grass margins and beetle banks. Consult the label, the product manufacturer and the Pesticides Safety Directorate. Details of such herbicides are not included in subsequent sections.

For the control of broad-leaved weeds in stubbles, field margins and headlands, selective application through a weed wiper or patch spraying through a knapsack sprayer is recommended. Check that the product has approval for use in a weedwiper or applied with a knapsack

The following sections cover herbicides for use in field margins and non-crop areas and specific uses in field margin strips, beetle banks and conservation headlands.

9.1. Off-label approvals and compounds approved for use in field margins, land temporarily removed from production and non-crop areas

Herbicides are cleared for use as listed on their product labels. However, extra uses can be made, if "off-label" approvals have been granted. Fluazifop-p-butyl, for example has an off-label approval for use in field margins (shortly to be on the label). Compounds that have approval for use in field margins, set-aside and land temporarily out of production (LTRFP), headlands and hedges are listed in Table 20. A range of herbicides carry label approvals for non-crop land, which is defined as land not intended for the production of crops. Details of the herbicides and mixtures of them which are approved for use in non-crop areas are listed in Table 21.

Table 20. Herbicides with specific approval for use in field margins, hedges and land temporarily out of production (LTRFP), including set-aside.

Herbicide	**Location**	**Use**
Cycloxydim	LTRFP	annual & perennial grasses
Metsulfuron-methyl	LTRFP	annual dicotyledons
Fluazifop-P-butyl	Field margins, LTRFP	annual grasses, brome, volunteer cereals, wild oats
Propyzamide	Cereal field margins	annual dicotyledons, grasses and perennial grasses
Thifensulfuron-methyl	LTRFP	docks
Dalapon + dichlobenil	Hedges	annual weeds, perennial grasses, bracken and rushes
MCPA	Land not intended for cropping	
Clopyralid + triclopyr + fluroxypyr	Non-rotational set-aside, gardens	Docks, nettles and thistles
Clopyralid (Off-label)	Established grassland	Weed wiper control of thistles

Asulam (Off-label)	Road verges	docks and bracken
Total vegetation control Diquat + paraquat	Field margins, LTRFP	Total
Glufosinate-ammonium	LTRFP and headlands	Total
Glyphosate	LTRFP, headlands, hedges (as directed spray)	Total
Paraquat	Field margins, LTRFP	Total

LTRFP = land temporarily removed from production

Table 21. Herbicides with specific approval for use in non-crop areas. Note: check the labels for specific uses and herbicide selectivities.

Herbicide	**Use**
Glyphosate	Annual and perennial weeds, bracken, total vegetation control
2,4-D + dicamba + mecoprop	Annual dicotyledons, brambles, perennial dicotyledons, stinging nettle, woody weeds
MCPA	Annual dicotyledons, creeping thistle, daisies, docks, perennial dicotyledons
Chlorpropham + tar acids + fenuron	Annual dicotyledons, annual grasses, chickweed
Dicamba + mecoprop + triclopyr	Annual dicotyledons, brambles, broom, docks, gorse, perennial dicotyledons, stinging nettle, woody weeds
Diquat + paraquat	Annual dicotyledons, annual grasses, perennial grasses, total vegetation control, volunteer cereals
Diuron	Annual dicotyledons, annual grasses, annual meadow grass, perennial weeds
Herbicide	**Use**

Diuron + glyphosate	Annual dicotyledons, annual grasses, perennial dicotyledons, perennial grasses
Glufosinate-ammonium	Annual weeds, perennial weeds
Paraquat	Annual dicotyledons, annual grasses, creeping bent, perennial ryegrass, rough meadow grass
Picloram	Annual dicotyledons, bracken, Japanese knotweed, perennial dicotyledons, woody weeds
Asulam	Bracken, docks
Dicamba	Bracken
Imazapyr	Bracken, total vegetation control
Triclopyr	Brambles, broom, docks, gorse, perennial dicotyledons, rushes, stinging nettle, woody weeds
Amitrole	Couch grass, creeping bent, creeping thistle, docks, perennial grasses, total vegetation control
Amitrole + 2,4-D + diuron	Total vegetation control
Amitrole + bromacil + diuron	Total vegetation control
Bromacil	Total vegetation control
Bromacil + diuron	Total vegetation control
Bromacil + picloram	Total vegetation control
Dalapon + dichlobenil	Total vegetation control
Dichlobenil	Total vegetation control, volunteer potatoes
Fosamine-ammonium	Woody weeds

9.2. Control of perennial broad-leaved weeds in field margin grass strips and beetle banks

Products approved for use on grassland are legal for use on grass field margins.

(Some products approved for use in non-crop areas may be legal for use on grass field margins – consult the label)

Patches of perennial and biennial broad-leaved weeds may be controlled using selective spot application techniques, preferably through a weed wiper. If a sown grass margin is established well, it will significantly reduce populations of perennial weeds. The following herbicides are useful (also see herbicides listed on p. 71-3).

glyphosate :	translocated herbicide, effective on almost all growing species, except established thistle.
clopyralid :	good on members of the daisy family (Compositae/Asteraceae), though best only on young thistles. Does not affect grasses.
triclopyr and mixtures :	good for thistles, nettles and docks. Does not affect grasses.
glufosinate-ammonium :	contact-acting herbicide with activity against a wide range of species; cleared for use in set-aside.

9.3. Control of annual weeds in grass margins and beetle banks

Products approved for use on grassland are legal for use on grass field margins.

(Some products approved for use in non-crop areas may be legal for use on grass field margins – consult the label)

Annual grass weeds, such as blackgrass, barren brome, Italian ryegrass, volunteer cereals and wild-oats may occur in such abundance in a sown grass margin that the success of the sowing is threatened (Marshall & Nowakowski, 1991). This may require the use of a grass-selective herbicide (graminicide). Studies indicate that those graminicides, such as fluazifop-p-butyl, cleared for use in field margins and set-aside, have varying selectivity between sown perennial grasses. However, red fescue (*Festuca rubra*) is unaffected by these compounds.

Experience with fluazifop-p-butyl indicates that reduced rates (half or quarter field rate, dependent on the size of the grass weeds) of the compound should be used, and should only be applied after the sown perennial grasses have reached a growth stage of at least 3 tillers. Good control of sterile brome, blackgrass and other annual grasses can be achieved.

Control of annual broad-leaved weeds in grass margins is difficult to achieve without reducing populations of desirable, less-competitive weeds. Problem species are cleavers (*Galium aparine*) and chickweed (*Stellaria media*), which may be controlled with amidosulfuron and benazolin respectively. However, selectivity is likely to be too broad for use under field margin Options and neither is cleared for use in these situations. Cutting offers the best means of checking dominant annual weeds, while allowing sown species to establish.

Note: where grass margins are created using natural regeneration, successional processes will reduce populations of annual weeds in the second and subsequent seasons, if sufficient perennial species establish. The use of herbicides is not usually necessary under these

circumstances. An exception may occur with perennial weeds, for example thistles, when they are prevalent before the margin is created. Sowing a grass or grass and wild flower seed mixture will significantly suppress such perennial weeds (West *et al*., 1997) over the first two to three years.

9.4. Grass weed control in conservation headlands

Products approved for use on the appropriate cereal crop are legal for conservation headlands.

In order to allow a range of broad-leaved weeds to establish in conservation headlands, weed control is limited to serious grass weeds and cleavers. A limited range of herbicides are allowed in conservation headlands for grass weed control. The grass weeds that are likely to occur are: annual meadow grass, wild-oats, blackgrass, couch grass, ryegrass, sterile brome and rough-stalk meadowgrass. These weeds will occur on all soil types, though blackgrass is more prevalent on clay soils.

The herbicides allowed and listed below (Table 22) are mostly compounds from the family of "fops" and "dims", which show good selectivity against grass weeds and while not generally affecting crops (**Note**: some products are only safe to certain cereals. See below). Nevertheless, some compounds show some effects on broad-leaved weeds, which are to be encouraged under the Arable Stewardship Options.

Table 22. Grass weed herbicides for use in conservation headlands.

Herbicide	**Comments**
tri-allate	soil-incorporated - affects some broad-leaved weeds if used pre-emergence. Tri-allate can reduce production of cuticular wax in some species, sensitising them to later herbicide application
diclofop-methyl	Grass control only
difenzoquat	Grass control only
flamprop-m-isopropyl	Use in spring on conservation headlands
fenoxaprop-ethyl	Grass control only
fenoxaprop-P-ethyl	**Wheat only**. Grass control only
fenoxaprop-P-ethyl + diclofop-methyl	**Barley only.** Grass control only
tralkoxydim	Grass control only
clodinafop-propargyl	**Not on barley.** Grass control only

Note: Some blackgrass (*Alopecurus myosuroides*) populations have developed resistance to a range of "fop" and "dim" herbicides (Moss & Cussans, 1991). Resistance has also been found in wild-oats (*Avena* spp.) and Italian ryegrass (*Lolium multiflorum*). Repeated (annual) use of the same herbicide is not recommended. If resistance is a threat, move conservation headlands and control grass weeds in break crops or stubbles with different herbicides. Consult the recommendations of the Weed Resistance Action Group (WRAG) (See: **Reading list** p. 83) and your local crop consultancy staff for details of any local records of resistance.

The susceptibility of the major grass weeds to the listed herbicides is given in Table 23.

Table 23. Grass weeds controlled in cereal conservation headlands. ++ = susceptible; + = suppression; - = no control

Herbicide	**Annual meadow-grass**	**Wild-oats**	**Blackgrass**	**Couch**	**Ryegrass**	**Sterile brome**	**Rough-stalk meadow-grass**
tri-allate	++	++	++	-		+	++
diclofop-methyl	-	++	++	-	++	-	++
difenzoquat	-	++	-	-	-	-	-
flamprop-m-isopropyl	-	++	+	-	-	-	+
fenoxaprop-ethyl	-	++	++	-	-	-	++
fenoxaprop-P-ethyl	-	++	++	-	-	-	++
fenoxaprop-P-ethyl + diclofop-methyl	-	++	++	-	++	-	+
tralkoxydim	-	++	++	-	++	-	-/+
clodinafop-propargyl	-	++	++	-	+	-	++

9.5. Annual broad-leaved weed control in conservation headlands

Products approved for use on the cereal crop are legal for use on conservation headlands.

Note: The objective of conservation headlands is to allow broad-leaved weeds and their associated invertebrate fauna to develop.

The only herbicide for broad-leaved weed control which may be used without derogation in Arable Stewardship conservation headlands up to 31 March is amidosulfuron (Eagle). This herbicide has a limited spectrum of weeds that are controlled, but is particularly effective against cleavers (*Galium aparine*) (West, 1994; LARS Technical Report No. 110). At field rates of 30 g a.i./ha (40 g/ha Eagle), cleavers, charlock, wild radish, scentless mayweed, corn marigold, knotgrass, pale persicaria, corn spurrey, cut-leaved cranesbill, broad-leaved dock and field bindweed are controlled, **as well as the rare weeds corn buttercup and shepherd's-needle**.

Other herbicides that might be used for control of cleavers include fluroxypyr, though this will control a wider range of plant species and can have adverse effects on woody species of hedges (Marshall, 1989b). There is at least one further compound under development that shows excellent selective control of cleavers, quinmerac (Boatman & Bain, 1992). However, this is not available commercially at present and would be illegal to use.

If chickweed (*Stellaria media*) is a dominant or patchy weed, the herbicide benazolin may be suggested, though some desirable rare weeds may be eliminated by its use and it is not approved for use on cereals alone.

Poppy (*Papaver rhoeas*) is a common weed with dormant seed. It is susceptible to many broad-leaved weed herbicides at early growth stages. It is also one of the few species suppressed by quinmerac.

9.6. Using pesticides near water

Many pesticides, including herbicides, are damaging to the aquatic environment. An increasing number of products are now not allowed to be applied within 6 m of water by tractor-mounted spraying equipment or within 2 m of water when applied through a knapsack sprayer. More than 400 products now carry this requirement as part of their label approval. The wording on product labels is, typically:

> *Since there is a risk to aquatic life from use, direct spray from ground-based vehicle-mounted/drawn sprayers must not be allowed to fall within 6 m of surface water or ditches; direct spray from hand-held sprayers must not be allowed to fall within 2 m of surface waters or ditches; spray must be directed away from water*

The list of products that carry this requirement is published in The Pesticide Register which is published by The Stationery Office for the Pesticides Safety Directorate and the Health and Safety Executive. A list was published in Issue No. 8, August 1997, with subsequent additions in following issues. An up-to-date list is also published on the WorldWideWeb at:

http://www.maff.gov.uk/aboutmaf/agency/psd/forms/buffer_zone/buffzone.htm

The following herbicides listed in previous sections carry the above requirements: *metsulfuron-methyl*, *thifensulfuron-methyl*, *iamzypyr* and *triclopyr*.

The requirements for a buffer zone are of particular relevance to field margins, as some ESA prescriptions support such zones and 6 m grass margins offer a simple means of achieving the label requirements. If 6 m margins are created adjacent to ditches and water courses, crops are grown 6 m away and compliance should be guaranteed.

Only a limited number of herbicides are allowed to be used **in or near** water. Details are given in: *Guidelines for the Use of Herbicides on Weeds in or near Watercourses and Lakes*, MAFF, 51 pp.

10. Information sources

British Trust for Ornithology

The Nunnery, Thetford, Norfolk IP24 2PU. Tel: 01842 750050;
Fax: 01842 750030; Email: rob.fuller@bto.org

English Nature

Northminster House, Peterborough, PE1 1UA. Tel: 01733 455000

Flora locale

Co-ordinator: Sue Everett MIEEM, 36 Kingfisher Court, Hambridge Road, Newbury, Berkshire RG14 5SJ
Tel: 01635 550380; Fax: 01635 550230; Email: floralocale@naturebureau.co.uk
WWW: http://www.naturebureau.co.uk/pages/floraloc/floraloc.htm

FWAG (Farming & Wildlife Advisory Group)

National Technical Adviser: Dr Richard Knight
Farming & Wildlife Advisory Group, National Agricultural Centre, Stoneleigh, Kenilworth, Warwickshire, CV8 2RX
Tel: 01203 696699; FAX: 01203 696760

Game Conservancy Trust

Peter Thompson
Burgate Manor, Fordingbridge, Hampshire SP6 1EF. *Tel:* 01425 652381;
Fax: 01425 655848
Dr N. D. Boatman**,** Allerton Research & Educational Trust, Loddington House, Loddington, East Norton, Leicestershire LE7 9XE. *Tel:* 01572 717220;
Fax: 01572 717408; Email: 100631.1625@compuserve.com

Institute of Arable Crops Research

IACR Rothamsted, Harpenden, Hertfordshire AL5 2JQ
Tel: 01582 763133; Fax: 01582 760981
IACR Long Ashton Research Station, long Ashton, Bristol BS41 9AF
Tel; 01275 392181; Fax: 01275 394007; Email: jon.marshall@bbsrc.ac.uk

Institute of Terrestrial Ecology

Monks Wood Experimental Station, Abbots Ripton, Huntingdon, Cambridgeshire, PE17 2LS. Tel: 01487 773381; Fax: 01487 773467

Royal Society for the Protection of Birds (RSPB)

The Lodge, Sandy, Bedfordshire, SG19 2DL
Tel: 01767 680551; Fax: 01767 692365

Willmot Pertwee Limited

Conservation Adviser: Marek Nowakowski, Tel & Fax: 01869 253808,
Mobile: 0585-252383
Main Office: 14 New Hythe Lane, Larkfield, Aylesford, Kent ME20 6PN
Tel: 01732 781200

11. Reading List

Andrews, J. & Rebane, M. (1994). *Farming & Wildlife. A practical handbook for the management, restoration and creation of wildlife habitats on farmland*. Royal Society for the Protection of Birds, Sandy, Bedfordshire, UK. 358 pp.

Anon (1994). *Biodiversity. The UK Action Plan*. HMSO, London. 187 pp.

Anon (1995a). *Biodiversity. The UK Steering Group Report. Volume 2: Action Plans*. HMSO, London. 324 pp.

Anon (1995b). *Biodiversity: The UK Steering Group Report. Volume 1: Meeting the Rio Challenge*. HMSO, London. 103 pp.

BAA (1997). *Arable Wildlife: Protecting Non-target Species*. The British Agrochemical Association, Peterborough. 90 pp.

Boatman, N. (ed) (1994) *Field Margins: Integrating Agriculture and Conservation*. BCPC Monograph No. 58. British Crop Protection Council, 49 Downing Street, Farnham, Surrey GU9 7PH. 404 pp.

Francis, G. & Dickie, G. (1996) *Planting Mixes based on the National Vegetation Classification.* H.V. Horticulture Ltd., The Street, Sutton Waldron, Blandford Forum, Dorset DT11 8NZ. 111 pp.

Game Conservancy (1994) *Game and Shooting Crops*. The Game Conservancy Ltd., Fordingbridge, Hants SP6 1EF. 97 pp.

Game Conservancy Trust (1997). Fact Sheet 2: *Guidelines for the management of field margins.* 16 pp. The Game Conservancy Trust, Fordingbridge, Hants SP6 1EF

Lack, P.C. (1992) *Birds on Lowland Farms*. London, HMSO.

Moss, S.R. (ed) (1997*) Revised Guidelines for Preventing and Managing Herbicide-Resistant Grass-weeds*. 8 pp. HGCA/Weed Resistance Action Group.

MAFF (1991). *Code of Good Agricultural Practice for the Protection of Water*. MAFF Publications, London.

MAFF (1992). *Code of Good Agricultural Practice for the Protection of Air*. MAFF Publications, London.

MAFF (1993). *Code of Good Agricultural Practice for the Protection of Soil*. MAFF Publications, London.

MAFF. *Guidelines for the Use of Herbicides on Weeds in or near Watercourses and Lakes*, MAFF Publications, London. 51 pp.

MAFF & HSE (1997). *Pesticides 1997*. The Stationery Office, London.

MAFF & Health and Safety Commission (1990*) Pesticides: Code of Practice for the Safe Use of Pesticides on Farms and Holdings*. HMSO, London. 75 pp.

Nick Sotherton and Robin Page (1998*) A Farmer's Guide to Field Margin Management*. The Daily Telegraph, The Countryside Restoration Trust & The Game Conservancy Trust.

PSD & HSE. *The Pesticides Register*. The Stationery Office, London.

Way, J.M. & Greig-Smith, P.W. (eds) (1987) *Field Margins. BCPC Monograph No. 35*. British Crop Protection Council, 20 Bridport Road, Thornton Heath, CR4 7QG. 128 pp.

Willmot Pertwee Ltd. (1997). *Field Margins: Making them work - and pay*. Willmot Pertwee Ltd, 14 New Hythe Lane, Larkfield, Aylesford, Kent ME20 6PN, 18 pp.

Whitehead, R. (ed). (1997) *The UK Pesticide Guide 1997*. CAB International and BCPC,

12. Scientific references

Anon (1994). *Biodiversity. The UK Action Plan*. HMSO, London.

Anon (1995a). *Biodiversity. The UK Steering Group Report. Volume 2: Action Plans*. HMSO, London.

Anon (1995b). *Biodiversity: The UK Steering Group Report. Volume 1: Meeting the Rio Challenge*. HMSO, London.

Barr, C.J., Bunce, R.G.H., Clarke, R.T., Fuller, R.M., Furse, M.T., Gillespie, M.K., Groom, G.B., Hallam, C.J., Hornung, M., Howard, D.C. & Ness, M.J. (1993). *Countryside Survey 1990. Main Report*. Department of the Environment.

Boatman, N.D. (1992) Effects of Herbicide Use, Fungicide Use and Position in the Field on the Yield and Yield Components of Spring Barley. *Journal of Agricultural Science*, **118**, 17-28.

Brenchley, W.E. (1911) The weeds of arable land. I. *Annals of Botany*, **25**, 155-165.

Brenchley, W.E. (1912) The weeds of arable land. II. *Annals of Botany*, **26**, 95-109.

Brenchley, W.E. (1913) The weeds of arable land. III. *Annals of Botany*, **27**, 141-166.

Burel, F. (1989) Landscape structure effects on carabid beetles spatial patterns in western France. *Landscape Ecology*, **2**, 215-226.

Boatman, N.D. & Bain, A.B. (1992) Evaluation Of Quinmerac and Fluoroxypyr Against Hedgerow Flora and Uncommon Arable Weeds. *Annals Of Applied Biology*, **120**(SS), 42-43.

Carreck, N.L. & Williams, I.H. (1997) Observations on two commercial flower mixtures as food sources for beneficial insects in the UK. *Journal of Agricultural Science, Cambridge*. **128**, 397-403.

Chancellor, R.J. (1985) Changes in the weed flora of an arable field cultivated for 20 years. *Journal of Applied Ecology*, **22**, 491-501.

Chancellor, R.J., Fryer, J.D. & Cussans, G.W. (1984) The effects of agricultural practices on weeds in arable land. *Agriculture and the Environment, ITE Symposium No.13*, (ed Jenkins, D.), pp. 89-94. Institute of Terrestrial Ecology.

Cook, S.K. & Ingle, S. (1997) The effect of boundary features at the field margins on yields of winter wheat. *Aspects of Applied Biology 50. Optimising Cereal Inputs: Its Scientific Basis. Part 2: Crop Protection and Systems*,(ed Froud-Williams, R.J., Gooding, M.J., Davies, W.P. & Hart, B.), pp. 459-466. AAB, Wellesbourne.

Corbet, S.A. (1995) Insects, plants and succession: advantages of long-term set-aside. *Agriculture, Ecosystems and Environment*, **53**, 201-217.

Firbank, L.G. & Wilson, P.J. (1995) Arable weeds and set-aside: a cause for conservation or a cause for concern? *Insects, Plants and Set-aside* (eds. Colston, A. & Perring, F.), pp. 19-28. Botanical Society of the British Isles, London.

Fuller, R.J., Gregory, R.D., Gibbons, D.W., Marchant, J.H., Wilson, J.D., Baillie, S.R. & Carter, N. (1995) Population declines and range contractions among farmland birds in Britain. *Conservation Biology*, **9**, 1425-1441.

Gibson, C.W.D., Watt, T.A. & Brown, V.K. (1987) The use of sheep to recreate species-rich grassland from abandoned arable land. *Biological Conservation*, **42**, 165-183.

Greaves, M.P. & Marshall, E.J.P. (1987) Field margins: definitions and statistics. *Field Margins*, (eds. Way, J.M. & Greig-Smith, P.J.), Monograph No. 35 pp. 3-10. British Crop Protection Council, Thornton Heath, Surrey.

Green, R.E. & Griffiths, G.H. (1994) Use of preferred nesting habitat by stone curlews *Burhinus oedicnemus* in relation to vegetation structure. *Journal of Zoology*, **233**(Pt3), 457-471.

Jörg, E. (ed). (1994) *Field Margin - Strip Programmes*. Landesanstalt für Pflanzenbau und Pflanzenschutz, Mainz. 182 pp.

Kleijn, D. & Van der Voort, L.A.C. (1997) Conservation headlands for rare arable weeds: The effects of fertiliser application and light penetration on plant growth. *Biological Conservation*, **81**, 57-67.

Lack, P.C. (1992) *Birds on Lowland Farms*. London, HMSO.

Marrs, R.H. (1993) Soil fertility and nature conservation in Europe: theoretical considerations and practical management solutions. *Advances in Ecological Research*, **24**, 241-300.

Marshall, E.J.P. (1989a) Distribution patterns of plants associated with arable field edges. *Journal of Applied Ecology*, **26**, 247-257.

Marshall, E.J.P. (1989b) Susceptibility of four hedgerow shrubs to a range of herbicides and plant growth regulators. *Annals of Applied Biology*, **115**, 469-479.

Marshall, E.J.P. (1993) Exploiting semi-natural habitats as part of good agricultural practice. *Scientific basis for codes of good agricultural practice. EUR 14957* (ed. Jordan, V.W.L.), pp. 95-100. Commission for the European Communities, Luxembourg.

Marshall, E.J.P. & Nowakowski, M. (1991) The use of herbicides in the creation of a herb-rich field margin. *1991 Brighton Crop Protection Conference - Weeds*, pp. 655-660. British Crop Protection Council, Thornton Heath, Surrey, UK.

Marshall, E.J.P. & Nowakowski, M. (1994) The effects of fluazifop-P-butyl and cutting treatments on the establishment of sown field margin strips. *Field Margins - Integrating Agriculture and Conservation*, Monograph No. 58 pp. 307-312. British Crop Protection Council, Thornton Heath, Surrey, UK.

Marshall, E.J.P. & Nowakowski, M. (1995) Successional changes in the flora of a sown field margin strip managed by cutting and herbicide application. *Brighton Crop Protection Conference - Weeds*, pp. 973-978. British Crop Protection Council, Farnham, Surrey.

Marshall, J.K. (1967) The effect of shelter on the productivity of grasslands and field crops. *Field Crop Abstracts*, **20**, 1-14.

Moss, S.R. & Cussans, G.W. (1991) The development of herbicide-resistant populations of *Alopecurus myosuroides* (black-grass) in England. In*: Herbicide Resistance in Crops and Weeds*, (eds Caseley, J.C., Cussans, G.W. & Atkin, R.K.) pp. 45-55. Oxford, Butterworth-Heinemann.

Potts, G.R. (1991) The environmental and ecological importance of cereal fields. *The Ecology of Temperate Cereal Fields* (eds. Firbank, L.G., Carter, N., Darbyshire, J.F. & Potts, G.R.), pp. 373-397. Blackwell Scientific Publications, Oxford.

Rands, M.R.W. (1985) Pesticide use on cereals and the survival of grey partridge chicks: a field experiment. *Journal of Applied Ecology*, **22**, 49-54.

Saville, N.M., Dramstad, W.E., Fry, G.L.A. & Corbet, S.A. (1997) Bumblebee movement in a fragmented agricultural landscape. *Agriculture, Ecosystems & Environment*, **61**, 145-154.

Schumacher, W. (1987) Measures taken to preserve arable weeds and their associated communities. *Field Margins. BCPC Monograph No.35*, (eds. Way, J.M. & Greig-Smith, P.W.), pp. 109-112. British Crop Protection Council, Thornton Heath, UK.

de Snoo, G.R. (1997) Arable flora in sprayed and unsprayed crop edges. *Agriculture, Ecosystems & Environment*, **66**, 223-230.

Snow, B. & Snow, D. (1988) *Birds and Berries*. T & A D Poyser, Calton. 268 pp.

Sotherton, N.W. (1984) The distribution and abundance of predatory arthropods overwintering on farmland. *Annals of Applied Biology*, **105**, 423-429.

Sotherton, N.W., Rands, M.R.W. & Moreby, S.J. (1985) Comparison of herbicide treated and untreated headlands on the survival of game and wildlife. *1985 British Crop Protection Conference - Weeds*, pp. 991-998. British Crop Protection Council, Thornton Heath, Surrey, UK.

Tapper, S.C. & Barnes, R.F.W. (1986) Influence of farming practice on ecology of the brown hare (*Lepus europeus*). *Journal of Applied Ecology*, **23**, 39-52.

Thomas, C.F.G., Cooke, H., Bauly, J. & Marshall, E.J.P. (1994) Invertebrate colonisation of overwintering sites in different field boundary habitats. *Arable Farming under CAP Reform. Aspects of Applied Biology No. 40*,(ed Clarke, J., Lane, A., Mitchell, A., Ramans, M. & Ryan, P.), pp. 229-232. Association of Applied Biologists, Wellesbourne, UK.

Thomas, M.B., Wratten, S.D. & Sotherton, N.W. (1991) Creation of 'island' habitats in farmland to manipulate populations of beneficial arthropods: predator densities and emigration. *Journal of Applied Ecology*, **28**, 906-917.

Thomas, M.B., Wratten, S.D. & Sotherton, N.W. (1992) Creation of 'island' habitats in farmland to manipulate populations of beneficial arthropods: predator densities and emigration. *Journal of Applied Ecology*, **28**, 906-917.

Tsiouris, S. & Marshall, E.J.P. (In press) Observations on patterns of granular fertiliser deposition beside hedges and its likely effects on the botanical composition of field margins. *Annals of Applied Biology*.

Verboom, B. & Huitema, H. (1997) The importance of linear landscape elements for the pipistrelle *Pipistrellus pipistrellus* and the serotine bat *Eptesicus serotinus. Landscape Ecology*, **12**, 117-125.

West, T.M. (1994). *The pre- and post-emergence selectivity of the herbicide amidosulfuron (HOE 075032)* No. Technical Report No. 110). IACR - Long Ashton Research Station.

West, T.M. & Marshall, E.J.P. (1996) Managing sown field margin strips on contrasted soil types in three Environmentally Sensitive Areas. *Aspects of Applied Biology 44. Vegetation Management in Forestry, Amenity and Conservation Areas*, pp. 269-276. Association of Applied Biologists, Wellesbourne, UK.

West, T.M., Marshall, E.J.P. & Arnold, G.M. (1997) Can sown field boundary strips reduce the ingress of aggressive field margin weeds? *1997 Brighton Crop Protection Conference - Weeds*, pp. 985-990. BCPC.

Whitehead, R. & Wright, H.C. (1989) The incidence of weeds in winter cereals in Great Britain. *1989 Brighton Crop Protection Conference - Weeds*, pp. 107-112. BCPC.

Wilson, P.J. (1994) Botanical diversity in arable field margins. *Field margins - integrating agriculture and conservation. BCPC Monograph No. 58.*, pp. 53-58. British Crop Protection Council.

Wratten, S.D. (1988) The role of field boundaries as reservoirs of beneficial insects. *Environmental Management in Agriculture: European Perspectives* (ed. Park, J.R.), pp. 144-150. Belhaven Press, London.

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