



Beneficials on farmland: identification and management guidelines

Summer 2008

For the farmer, insects and other invertebrates fall into two main groups: pests and beneficials. It is important to distinguish between these as beneficials control pests naturally, pollinate crops and help to maintain soil fertility.

Identification

Beneficials can be classed as:

- pest predators which, as adults or larvae, eat pests
- pest parasites (parasitoids) that live within the pest
- pollinators which are important for yields of crops such as oilseed rape
- detritivores which help break down organic matter.

The few pests that occur only pose threats to crops when adverse weather or management reduces beneficial numbers, or when conditions especially encourage the pest.

Populations of many beneficial species such as bumble bees, butterflies, moths found in non-crop and arable crop habitats have declined in recent decades.

This guide aims to help farmers and advisers identify some key beneficials, especially predators and parasites.

Note: the scales (pages 3–12) indicate actual sizes of organisms and do not relate to the proportions of the photographs.

Managing habitats

To encourage beneficials, four criteria need to be met:

- Shelter
- Alternative prey
- Flower-rich habitat
- Environment

Many non-crop habitats, including those produced by Entry Level and Higher Level Stewardship schemes, can support substantial populations of beneficials.

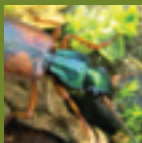
Appropriate management will encourage beneficial populations within crops. Adopting Integrated Pest Management (IPM) principles will ensure that insecticide inputs are only applied when necessary, helping to reduce spray costs and prevent insecticide resistance developing.

This guide outlines the 'SAFE' principles and describes their practical use. It provides key management options within and off-crop to encourage build-up of beneficial populations and help reverse recent declines.



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For information on crop pests:



Pest management in cereals and oilseed rape – a guide, HGCA (2003).

Flies (Diptera)

There are over 6,900 species of flies in Britain.

Two-winged, or true, flies have one pair of membranous wings.

Flies have sucking mouthparts, in some instances adapted for piercing. Shapes range from stout-bodied (house flies and bluebottles) to slender (crane flies and mosquitoes). There are also numerous smaller gnats and midges.

Predatory flies that commonly occur on farmland include hoverflies, dance flies, robber flies and long-legged flies.



Hoverfly (*Episyrphus balteatus*). Wild flowers in field margins attract hoverflies. Oilseed rape and other flowering crops attract large numbers.

3–4mm



Dance fly eating orange wheat blossom midge

Dance flies (Empididae)

- Adults congregate in dancing swarms, as do gnats
- Small to medium-sized, bristly
- Spherical head on slender neck
- Horny proboscis to suck insides out of other flies
- Larvae are partially predatory and live in decaying vegetation or water

10–25mm

depends on species

Robber flies (Asilidae)

- Some 28 UK species
- Medium to large, slender but strongly built
- Powerful legs
- Horny proboscis to pierce prey
- Adults predatory on insects



Robber flies eat a wide range of food materials ranging from other insects, dead matter, vegetation to pollen and nectar.

12–16mm

Hoverflies (Syrphidae)

- Approximately 270 British species
- Most are brightly coloured
- Mimic wasps and bees
- Adults feed on nectar and pollen
- Many larvae found on farmland are predatory, especially on aphids
- Fly long distances

Adults can be confused with wasps and bees; larvae with leaf beetle larvae



Syrphid pupa

8mm



Dolichopos wahlbergi

Long-legged flies (Dolichopodidae)

- Over 280 species in UK
- Small, bristly and metallic with long legs
- Adults predatory on other smaller insects
- Adults frequently visit flowers
- Larvae live in humus or are aquatic and mainly carnivorous

12–14mm



Each hoverfly larva eats about 400 aphids on arable crops. A ratio of 1 larva: 30 aphids can control severe infestations.

Beetles (Coleoptera)

Over 4,000 beetle species are found in Britain.

Beetles are rarely confused with any other insect group. There are typically two pairs of wings. The hard, or leathery, front pair meet along the middle of the back, forming 'wing-cases', to protect the membranous hind wings which are usually folded away out of sight. All beetles have biting mouthparts.

Some beetles and their larvae, and weevils (distinguished by a prominent snout), may be pests, eg leaf beetles (*Chrysomelidae*), but can also be important as food, particularly for game birds.

The diet of beetles includes other insects, slugs, weed seeds, fungi and detritus.

Most beetles can, and do, fly. However, they spend most of their time on the ground or in low vegetation.



Ground beetle (*Anchomenus dorsalis*)

© Roy Anderson



Pterostichus spp – present in fields all year round. Feed on slugs and other invertebrates. Overwinter as larvae in fields and so favoured by minimum tillage.



Demetrias atricapillus – overwinter as adults in field margins. Fly into crops during spring to forage. Feed on cereal aphids and other prey on foliage. Partially control low aphid populations. Favoured by beetle banks and grass margins.

Ground beetles (Carabidae)

- About 350 British species
- Variable size (2–25mm)
- Good runners and may climb
- Frequently black or brown, often with metallic sheens
- Many are nocturnal
- Overwinter as adults under tussocky grasses or as larvae underground in fields
- Many adults and larvae are carnivorous
- Many feed on insects, slugs and seeds

May be confused with weevils and soldier beetles



Rove beetle (*Anotylus mutator*)

Adult rove beetles climb cereal stems at night to feed on aphids.

Rove beetles (Staphylinidae)

- About 1,000 species
- Variable size (1–25mm)
- Good fliers and climbers
- Short wing cases, unlike ground beetles
- Overwinter as adults under tussocky grasses or as larvae underground
- Predatory, or fungal-feeding
- Favoured by beetle banks

1–10mm

7-spot ladybird (*Coccinella septempunctata*)

Larva



Eggs



Pupa

Adult ladybirds lay eggs among aphids on leaves. Larvae and adults are voracious feeders and can reduce aphid populations.

Ladybirds (Coccinellidae)

- 40-50 species in Britain
- Variable size (1–10mm)
- Brightly coloured
- Usually red or yellow with black markings

- Virtually all predatory
- Adults and larvae feed on pests, particularly aphids

Larvae may be confused with leaf beetle larvae

Soldier beetles (Cantharidae)

- Narrow elongated beetles with soft bodies
- Variable size (1–10mm)
- Dull, matt appearance due to short hair on wing cases
- Frequently visit flowers, particularly cow parsley
- Carnivorous, feed on other flower visitors

May be confused with carabids

1–10mm

Soldier beetle (*Cantharis fusca*)

Adult soldier beetles hibernate off the crop.

1.5–10mm

Cereal leaf beetle (*Melanopa* spp)

Leaf beetles (Chrysomelidae) – Non-beneficial species

- Approximately 250 British species
- Variable size (1.5–10mm)
- Can be brightly coloured with metallic sheen and chunky legs
- Both adults and larvae important as bird food

- Some species are pests, eg flea beetle (*Halticini* spp)

Adults may be confused with weevils or carabids; larvae with ladybird larvae

Bees, wasps and ants (Hymenoptera)

Hymenoptera is a very large order with well over 6,500 species in Great Britain.

Usually have two pairs of wings – the front pair larger than rear. The wings are joined by a tiny set of hooks.

Hymenoptera can generally be split into:

- those without a waist – sawflies
- those with a waist – bees, wasps, ants, parasitic wasps.

Bees and wasps are divided into two main groups:

- parasitica
- aculeata.

Adults feed on pollen and nectar and therefore require suitable flowers.



Bumble bee (*Bombus carduorum*)

Parasitica – nearly all parasites in which the ovipositor, the egg-laying organ, is adapted for piercing host tissue. Sometimes the ovipositor is two or three times as long as the body allowing the insect to reach hosts that may tunnel inside a plant. Parasitica include ichneumonidae, braconidae, chalcidae and proctotrupidae. Adult parasitoids are very sensitive to insecticides, so timing must be accurate.



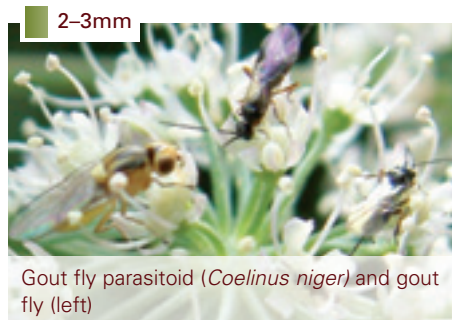
Ichneumonid wasp with moth caterpillar
© Tristan Bantock

Ichneumonidae

- Ovipositor visible
- Long antennae
- Parasitic, mostly on other insects, particularly larvae of butterflies and moths (Lepidoptera)
- Often attack other parasites

Proctotrupidae

- Small or minute parasites
- Slender black insects
- Parasitise other insects, including eggs



Gout fly parasitoid (*Coelinius niger*) and gout fly (left)

Braconidae

- Similar to Ichneumonidae
- One important group, eg *Aphidius* species parasitises aphids
- These cement host to plant before pupating
- Empty parasitised aphid skins, or mummies (usually golden), remain on plant



Macroglanes penetrans, a parasite of orange wheat blossom midge, does not prevent crop damage, but can give long-term population control if 80% of midge larvae are parasitised.

Chalcidae

- Small insects, mostly under 3mm long
- Often brilliantly coloured with metallic greens or blues
- Have elbowed antennae
- Include pteromalids with triangular abdomen in profile
- Almost all parasites of pests or parasites of parasites

Aculeata – social insects living in colonies. Social wasp, bee and ant colonies are headed by one or more queens which lay eggs. The workers, which are not fully-developed females, collect food, rear young, build the nest and rarely lay eggs. Male bees – drones – are much less common, appearing late in the year to mate with new queens.

Honey bee and ant colonies can last indefinitely with new queens replacing old ones from time to time.

Bumble bees and wasps start a new colony each year and only the mated queens survive overwinter.

In worker bees, wasps, and also some ants, the ovipositor has become a weapon and so only females can sting. Only the queens have an ovipositor.



True wasps (Vespoidae)

- Nine species in Britain (hornets are largest)
- Very powerful jaws
- Notched crescent-shaped eyes
- Wings folded lengthwise at rest
- Eat pollen but do not have nectar-sucking mouthparts
- Young feed on other insects
- Also known as social, or paper wasps
- Adults also eat insects, rotting fruit etc



Bumble bees

- Usually black with greater or lesser amount of yellow banding
- Usually nest underground
- Feed on nectar and pollen
- Important for pollination



Honey bees

- Social insects
- Feed on pollen and nectar
- Long, well-developed tongue
- Important pollinators



Solitary bees

- Over 200 species in Britain
- All feed on pollen and nectar
- Have no workers, female constructs a nest for her offspring
- Nest underground in hollow stems or any other suitable holes
- Groups include mining, mason, leaf cutter and carpenter bees



Ants

- About 50 species in Britain
- Some species are predatory
- Often 'farm' aphids
- Navigate using scent trails, the sun and by counting their steps
- Confined to uncultivated land

Bugs (Hemiptera)

There are about 1,650 species in Britain, most of which feed on plants; some are predatory.

Bugs are minute to large insects with a wide variety of shapes and habits. They all possess piercing mouthparts which can be used on plants or animals.

There are two groups:

Heteroptera include flower bugs, plant bugs, damsel bugs and shield bugs, some of which are predatory. The group also includes capsids, none of which are beneficials.

Homoptera are small to minute insects that include frog hoppers and aphids. None are beneficials.



Mirid plant bug (*Psallus ambiguus*)

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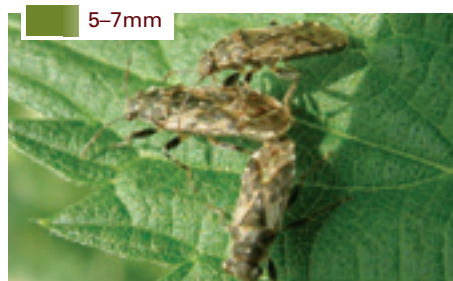
Heteroptera



Anthocoris nemorum © Tristan Bantock

Flower bugs (Anthocorinae)

- Found mainly on flowers and leaves
- Overwinter under bark or similar places
- Found on flowers throughout summer
- Feed on aphids and other soft-bodied insects



Tarnished plant bug (*Lygus rugulipennis*)

Plant bugs (Miridae)

- Small to medium-sized insects
- Common on many plant species in summer
- A few species prey upon mites and aphids



Green shield bug (*Palomena prasina*)

Shield bugs (Pentatomidae)

- Triangular region on back of body
- Whole body is shield-shaped
- Prefer hot summers
- Only a few species are predatory



Nabis rugosus

© Tristan Bantock

Damsel bugs (Nabidae)

- All 12 UK species are brown
- Four-segmented beak
- Slender with long legs
- Carnivorous, feeding on a wide range of insects
- Closely related to bed bugs

Homoptera

5–7mm



Philaeus spumarius

Non-beneficial species

Homoptera includes many important agricultural and horticultural pests such as aphids, whiteflies and scale insects, some of which are important in virus transmission. Frog and leaf hoppers are often eaten by birds.

Frog hoppers (Cercopidae)

- Also known as spittle bugs or cuckoo spit insects
- Nymphal stage is covered in a mass of froth or spittle
- Froth protects from dehydration and to some extent from predators

6–9mm



Cicadella viridis

Leaf hoppers (Cicadellidae)

- Usually found on leaves
- Over 250 British species
- Generally small and brightly coloured (mostly green)
- Good jumpers and can fly

Lacewings (Neuroptera)

There are about 60 species in Britain.

Small, medium and large soft bodied insects, generally green or brown. When at rest they have two similar delicate pairs of wings held roof-wise over the body. Wings are characterised by a network of veins. They have pronounced compound eyes and long, slender antennae. Larvae overwinter in leaf litter.

Green lacewings, the most common, are often found in houses, having been attracted by lights.

Adults have biting mouthparts but rarely seem to feed. Larvae are important predators of aphids.

12–16mm



Pearly green lacewing (*Chrysopa perla*)

Pearly green lacewing

- Adult is 12–16mm long
- Black eyes, brown antennae, fine green veins in wings
- Egg borne on fine thread fixed to a leaf
- Larva 7–10mm long, tapering at each end with small head with obvious pincers which act as sucking mouthparts
- Pupa is white spherical cocoon

Larvae can be confused with ladybird larvae

7–10mm



Larva of pearly green lacewing

Spiders and harvestmen (Arachnids)

Arachnids are not insects; they have four pairs of legs, no wings and no antennae. They have only two body regions.

There are about 640 species of spiders in the UK. Spiders are carnivorous and are unique in having a spinner near the hind end of the abdomen which produces silk. Some spiders spin webs which are used as snares. Some lie in wait for their prey and others actively hunt.

Harvestmen are closely related to, and easily confused with, spiders. In harvestmen the two parts of the body are broadly joined, whereas in the spiders the body is clearly divided into two parts joined by a narrow stalk. Harvestmen have only two eyes whereas spiders have six to eight.

Spiders and harvestmen are very efficient pest predators. However, they are very sensitive to pyrethroids. Both can be important for bird diets.

1.5–2.5mm



Theridion mystaceum

Comb-footed spiders (Theridiidae)

- Great variety of shapes and colours
- Most have abdominal pattern
- Legs have few spines
- Uses individual sticky catching threads or criss-cross strands on bushes or trees to trap prey

F 4.5–6mm

M 4.5–5.5mm



Pardosa palustris

Wolf spiders (Lycosidae)

- Hunting spiders, mostly at ground level but occasionally on low vegetation
- Mostly brownish, but attractively marked
- Clothed in dense hairs
- Good runners and can jump
- Females conspicuous from May/June onwards with brown or greenish-blue egg sacs

3mm



Money spider (*Erigone* spp)

Webs of money spiders typically trap around 30% of aphids flying through the crop as well as wheat blossom midge adults and other small flying insects.

Money spiders (Linyphiidae)

- Largest European family
- Small grey or black-bodied spiders
- Hunting or web building
- Drift through air on strands of silk
- Consume aphid BYDV vectors on ground in autumn

F

6.5–11mm

M

6–9mm



Tetragnatha extensa

Orb web spinners (Tetragnathidae)

- Spin orb webs
- May also hunt
- Elongated body with long legs

F 6–8mm

M 3–5mm



Xysticus cristatus

Crab spiders (Thomisidae)

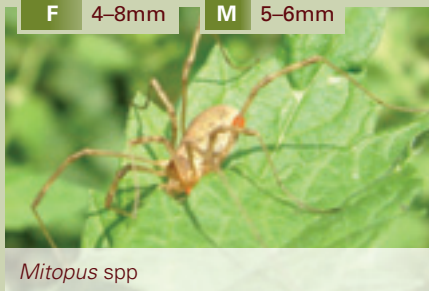
- Crab-like, with first two pairs of legs longer than rest
- Can walk sideways as well as forwards and backwards
- Most sit and wait for prey

F

4–8mm

M

5–6mm



Mitopus spp

Harvestmen (Opiliones)

- 24 species in Great Britain
- Oval body shape
- Mostly nocturnal feeders
- Actively hunt prey

Other beneficials

Invertebrates (eg mites, springtails and earthworms) that break down organic matter are sometimes referred to as detritivores. These play a vital role in incorporating organic matter in soil to maintain fertility and structure.

Species that feed on organic matter tend to be less active than predatory species and occur in very large numbers in soil.



Earthworms

There are about 24 species in Britain. Earthworms play a major role in breaking down organic matter and recycling nutrients. They improve soil structure by forming aggregates and improving conditions for plant growth.



Woodlice

Woodlice differ from insects and mites in having seven pairs of legs. Most live only in moist habitats. Most are beneficial, feeding on organic matter and accelerating nutrient return to soil, but they may damage seedlings.



Springtails (Collembola)

There are some 300 British species. Springtails are small wingless insects, usually found in soil, leaf litter and vegetation. They have a cylindrical, or globular, body shape and are rarely over 5mm long. They usually have a forked springing organ which enables them to leap into the air when disturbed.



Centipedes and millipedes

These are not insects but belong to the myriapoda, meaning "many legs". They have a variable, always odd, number of flattened segments.

Centipedes have one pair of legs on each segment. They are fast moving and mainly predatory.



Millipedes have two legs on each segment and are slow moving. They feed on live and dead plant material and can occasionally damage seeds, tubers and bulbs.



Mites (Acarids)

Mites have eight legs (larval stages sometimes have fewer). Like harvestmen, they have a single main body segment. They are at most a few millimetres long and are not easily seen.

One group of mites, the mesostigmata, are predators of thrips, other pest mites and small invertebrates.

'SAFE' principles to encourage beneficials

Beneficials need Shelter, Alternative prey, Flower-rich habitat and an appropriate Environment (SAFE) to thrive in farmland and keep pests in check naturally.

Shelter

Hedgerows, associated margins and other areas protected from insecticides and intensive tillage, provide habitats that enable beneficial insects to repopulate nearby crops. Strips of tussocky grasses and flower-rich grassland support high densities of some species.

Beneficials that only live for part of the year within a crop need other habitats in which to forage, breed or survive dormant periods.



Tussocky grasses support high densities of predators

Alternative prey

Pests may only be present for short periods of the crop's growing season. Prey, on which beneficials feed for the rest of the year, can be provided by:

- other crops
- uncropped areas
- undersowing
- weeds – deliberately left in the crop
- minimum tillage
- organic manures.

Minimum tillage and application of organic manures are especially valuable in providing suitable conditions for detritus-feeding invertebrates which serve as alternative prey for predators.



Dolichopod fly eating a springtail

Flower-rich habitat

Pollen and nectar – essential for parasitic wasps and hoverflies – are important food for other natural enemies including beetles and predatory flies. Alternative prey can

live in vegetation with a varied habitat structure. Annual and perennial flowering plants found in woodlands, hedges, margins and crops can supply pollen and nectar.



Flowers in margins support predators

Environment

Beneficials thrive in diverse vegetation that has not been treated with insecticides, such as field margins. All approved insecticides affect them to some degree, so it is important to minimise usage by adopting Integrated Pest Management (see *Pest management in cereals and oilseed rape – a guide*, HGCA (2003)) and only treating when thresholds are reached. Other pesticides may adversely affect beneficials, directly or indirectly, eg removal of weedy habitats.

Correct management will help create a habitat structure, providing beneficials with cover and a suitable microclimate.

The first step to maximise benefit from beneficials is to manage habitats so that they:

- are spread across the farm – some beneficials tend to remain close to margins
- are diverse – this encourages a range of beneficials providing robust biological control.



Weeds beneath crops provide diverse vegetation. Herbicide programmes should focus on yield-robbing weeds.

Landscapes

On some farms, a diverse landscape with many existing hedgerows and rough grassland provides beneficials with adequate habitat.

Elsewhere, especially in open simple landscapes and where there are large fields, extra provision is needed.

Making the most of agri-environment schemes

The costs of enhancing habitats can be recovered through some options in each national agri-environment scheme.



Diverse landscape – many non-crop habitats



Simple landscape – few non-crop habitats

Resources provided for beneficials by environmental schemes

Habitat type	Option availability [▲]	<u>S</u> helter	<u>A</u> lternative prey	<u>F</u> lowers	<u>E</u> nvironment
Hedgerow management	ELS, OELS, HLS, RSS, TG	***	***	*** ?	***
Protection/creation of uncultivated ground flora	ELS, OELS, HLS, TC	*** ?	***	*	**
Wild bird seed mixture	ELS, OELS, HLS, RSS, TC, TG	* ?	** ?	* ?	**
Pollen and nectar	ELS, OELS, HLS, TC	**	***	***	***
Floristically enhanced grass	HLS, TC	** ?	***	***	***
Overwintered stubbles	ELS, OELS, HLS, TG	**	*		*
Grass margins/buffer zones	ELS, OELS, HLS, RSS, TC, TG	***	***	N	*
Beetle banks	ELS, OELS, RSS, HLS	***	***	N	**
Skylark plots	ELS, OELS, HLS	N	* ?	*	N
Fallow plots	HLS	N	*	*	*
Conservation headlands	ELS, HLS, RSS	N	***	*	***
Low input crops	ELS, HLS, RSS, TG, TC	**	***	*	***
Undersown spring cereals	ELS, OELS, TG, HLS	***	**	N	
Uncropped, cultivated margins	ELS, OELS, HLS, TC, TG	N	** ?	**	***
Ditch management	ELS, RSS, TC, TG	***	***?	* ?	** ?
Non-inversion tillage		***	**	N	**

ELS = Entry Level Scheme in England
 OELS = Organic Entry Level Scheme in England
 HLS = Higher Level Scheme in England

▲ = As at spring 2008

RSS = Rural Stewardship Scheme in Scotland
 TC = Tir Cynnal in Wales
 TG = Tir Gofal in Wales

*** = High benefit
 ** = Moderate benefit
 * = Some benefit
 N = No benefit
 ? = Potential benefit but not tested

Shelter

Hedgerows

Hedgerows, with year-round shelter, provide the largest source of beneficials. Over 1,500 insect species have been found in them. Hedgerows provide alternative prey as well as pollen and nectar.

Beneficial populations fall after hedge cutting. Therefore, do not cut hedges every year to a standard height as this produces excessive scar tissue and few healthy shoots. It is best to cut different hedges at the end of winter in different years, ideally on a two or three year cycle.

To maintain insect diversity, manage hedges to create different structures with varied plant species. New hedge plantings should include a diversity of species. When gapping up, or planting new woodland, select species that support most invertebrates.



Well-managed hedgerow – flower-rich at base

Insect and mite numbers associated with some common hedgerow and woodland plants

Plant species	Number of insect and mite species
Willow species	450
Oak	423
Birch	334
Bramble	240
Hawthorn	149
Blackthorn	109
Beech	98
Poplar species	97
Crab apple	93
Alder	90
Elm	82
Hazel	73
Field maple	51
Ash	41
Lime	31
Hornbeam	28
Rowan	28
Sycamore	15
Holly	10
Sweet chestnut	5
Horse chestnut	4

Source: Kennedy and Southwood (1984)

Flowering shrubs and herbaceous plants, along the hedge base, are a rich source of pollen and nectar; nettles support a diversity of prey. Re-sow degraded hedge bases covered in noxious weeds, eg ragwort, thistles and sterile brome, with a flower-rich grass mix.



Tussocky grass along hedge base

Tussocky grasses, along hedge bases and fence lines, are particularly important for overwintering beetles and spiders. Protect this habitat from insecticide and herbicide drift.

All national agri-environment schemes have options for hedgerow management.

Managing uncultivated areas

Many ELS and OELS options do not permit cultivation. The aim is to protect ground vegetation associated with particular landscape features, including hedgerows, buffer strips, ditches, in-field trees and archaeological sites. Such areas can provide shelter for a diversity of beneficials. They have added value for pest control if flower-rich.

Grass margins and buffer zones

Grasses support a range of insects that can help maintain beneficials through the winter. Undisturbed ground under grasses suits species that overwinter in the soil. In summer, these habitats offer a refuge from disturbance and alternative foraging areas.

Tussocky grasses support large numbers (over 3,000/m²) of overwintering beetles and spiders.



Grass margin



Grassy strips, associated with post and wire fences, support high densities of beneficials



Ditch and dyke banks should be cut in alternate years, so that some well-grown habitat remains. Maintain shallow, sloping banks and avoid cutting ditch margins



Beetle bank

Beetle banks, formed by ploughing two furrows together to form a raised bank, create drier conditions favoured by insects. Beetle banks can be located to divide large fields. This reduces the distance over which beetles must disperse in spring, ensuring rapid, even coverage across the field.

Only mow during the first year to aid establishment.

Alternative prey

Pests often occur sporadically during the growing season. They have shorter life cycles than beneficials. Other food sources (alternative prey) within and outside fields are needed to maintain beneficial populations.

Many agri-environment options encourage alternative prey both in non-crop habitats and within crops. It is easier to encourage beneficials in non-crop habitats than within crops.

Non-crop options, such as conservation headlands and unmanaged field corners, support alternative prey. Arable flowers provide pollen and nectar. Such areas are used by birds, butterflies, small mammals and other wildlife.

Within crops, several agri-environment options help increase alternative prey within crops. These include fallow plots, overwintered stubbles, extensively farmed crops and minimum tillage. Up to 500 insect species, most of which beneficials eat, have been found within wheat fields. Many forage upon weeds, or detritus, and so are sensitive to farming practices.

Targeting weed control only at the most competitive weeds and using selective products, lower doses and fewer applications each season may allow a diversity of uncompetitive weeds to develop. Only use this approach where noxious weeds, eg black-grass and cleavers, are absent. Weed seeds are also important food for invertebrates and birds.

Herbicide inputs may be reduced within fields to encourage invertebrates. Highest numbers of the most desirable weeds survive when only one application is made each season. Inputs can be reduced without compromising yield on some soils where weed pressure is low.

Further details are available in *Enhancing Arable Biodiversity: Six practical solutions for farmers*, SAFFIE/HGCA (2007).

Plant species by desirability for biodiversity

Group 1 – Very desirable

All rare arable flowers
Annual meadow grass
Black bindweed
Charlock
Chickweed
Common fumitory
Fat hen
Groundsel
Knotgrass
Pale persicaria
Redshank
Runch

Group 2 – Desirable

Field pansy
Mouse-ears
Pineapple weed
Scented mayweed
Scentless mayweed
Sowthistles
Wild pansy

Group 3 – Neutral

All species not included in groups 1, 2 and 4
Volunteer kale
Volunteer linseed

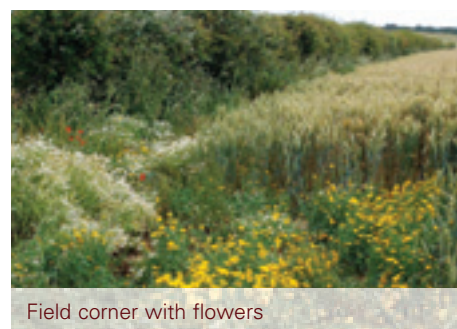
Group 4 – Not acceptable to leave in any numbers

Awned canary grass
Black-grass
Broad-leaved dock
Cleavers
Common couch
Creeping soft-grass
Creeping thistle
Great brome
Italian rye-grass
Meadow brome
Rye-grass
Soft brome
Spear thistle
Sterile/barren brome
Volunteers – beans, potatoes, sunflowers, oilseed rape, cereals
Wild oat
Winter wild oat

Source: HGCA Project Report 416 (2007)

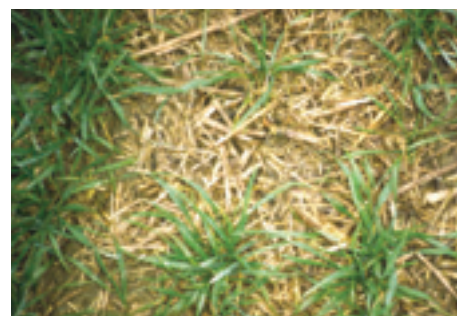


Conservation headland



Field corner with flowers

Organic matter – food for many detritus-feeding insects – can be boosted by returning crop residues and applying manure. Minimal tillage helps to ensure that organic matter remains available near the surface.



Crop debris on surface after minimal tillage

More mobile beneficials may forage outside the crop. Hedgerows and flower-rich margins provide an abundance of alternative prey, as do game and wild bird cover crops with a weedy understorey.

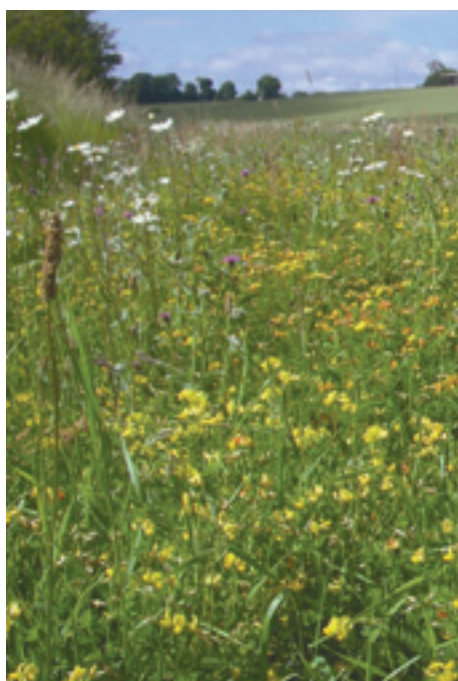


Weedy game crop

Flower-rich habitat

Pollen and nectar are important food for many beneficials. Nectar provides energy and nutrients essential for egg production and increases longevity of parasitic wasps and hoverflies. Parasitoids most readily obtain nectar from flowers with an open structure or nectaries on leaf petioles, and are often seen feeding on flowers of umbelliferous crops, eg cow parsley, hogweed and wild carrot. Flowers most utilised by hoverflies include yarrow, cow parsley, hogweed, white campion, common knapweed, rough hawkbit, field scabious, lady's bedstraw, bugle, self-heal and red clover.

Beneficials also feed on pollen and nectar from hedgerows, shrubs, herbaceous plants, broad-leaved weeds and flowering crops. These habitats may support other beneficials by providing a suitable habitat for foraging and over-wintering. Other farmland wildlife – currently in decline – including bumble bees, butterflies and farmland birds also use these habitats.



Floristically enhanced grass margin

Perennial habitats

Of the agri-environment options, **pollen and nectar mixes**, as well as **'floristically enhanced' grass margins**, provide the most floral resources.

Pollen and nectar flower mixtures

These mixtures, typically comprising clovers, vetches, birdsfoot trefoil and sainfoin, provide plants preferred by bumble bees and butterflies. They may be established with or without grasses, although the greatest numbers of beneficials occur in mixtures without grasses.

Floristically enhanced grass margins

Grasses in such margins initially prevent invasion by annual weeds. Non-aggressive, fine-leaved grasses, eg common bentgrass, crested dogstail and sheep's fescue, should be used. Proprietary pollen and nectar seed mixes contain many plants, eg birdsfoot trefoil, utilised by beneficials and species, that support insects. If an existing hedgerow base does not already contain many umbellifers, then add these and yarrow to the seed mix. To ensure an even spread of flower resources across the farm, establish flower-rich swards in fields where the hedge base contains few flowering plants. In large fields, a flower-rich sward next to a beetle bank ensures more even coverage of beneficials.

Annual habitats

Broad-leaved arable plants can provide significant amounts of pollen and nectar in uncropped, annually cultivated margins and fallows or beneath crops with low or no herbicide inputs, eg **conservation headlands** and extensively farmed crops.

Annuals, eg phacelia, buckwheat, alyssum or coriander, improve biocontrol levels in adjacent crops. They may be sown as a component of wild bird cover to provide a suitable foraging habitat for farmland birds.

Some principles on this page result from Project Report 356 (2004) *Managing biodiversity in field margins to enhance integrated pest control in arable crops (3-D Farming Project)*.



Pollen and nectar margin



Hoverfly on umbelliferous flower



Phacelia strip



Wild bird cover with flowering plants

Environment

The managed habitat created by crops and weeds influences the type and abundance of beneficials. There will be greater diversity, ensuring more robust pest control if habitat structures within the crop are diverse. Allow some weeds to survive, undersow, and use minimum tillage to retain crop residues near the surface. On a larger scale, avoid creating large areas of monoculture and maintain a diversity of crops and uncropped land across the farm.

Overall, aim to have a range of different types of vegetation. Avoid being too tidy. Leave 'scruffy' field corners and piles of rotting wood. Beneficial populations are most damaged by insecticides and molluscicides when they are active within the crop in spring and summer. Insecticide drift during autumn into overwintering areas may also reduce survival.

Adopting Integrated Pest Management (IPM) will ensure that insecticide inputs are only applied when necessary, helping to reduce spray costs and prevent insecticide resistance developing.

The main principles of IPM are:

- Minimise the risk of infestation through cultural means:
 - grow resistant varieties
 - rotate crops to reduce risk to susceptible crops
 - drill when there is less risk of infestation
 - consolidate soils to reduce pest movement.
- Avoid block cropping that allows pests to spread between fields.
- Monitor crops and only spray when thresholds are exceeded.

Establishing perennial flower-rich habitats

Seek advice from a seed supplier on suitable species for soil and farm conditions.

Where to sow

Along hedgerows or boundaries with few flowers, beside beetle banks and in field corners. Spread across the farm so that most fields are adjacent to a flower-rich habitat.

Management

Preparing a weed-free environment is vital to successfully establishing these mixtures. Mow regularly up to four times during the first year to prevent grasses from dominating. Mow once or graze in autumn. Remove invading noxious weeds, eg docks and thistles, by spot spraying or weed wiping. Adhere to stewardship regulations or GAEC12.

Floristically enhanced grass margin

What to sow

A mix of perennial fine grasses and wild flowers, including:

- suitable fine grass species, eg common bentgrass, crested dogstail and sheep's fescue
- wild flowers, including the most important for hoverflies and parasitic wasps: wild carrot, wild angelica, hogweed, yarrow, common knapweed, rough hawkbit, field scabious, lady's bedstraw and birdsfoot trefoil.

Species to avoid: aggressive, tussocky grasses, eg cocksfoot.

When to sow

April to October when moisture present.

How to sow

Create a fine, weed-free seedbed, broadcast the seed evenly on the surface and roll.



Floristically enhanced grass margin

Pollen and nectar flower mixes

What to sow

A mixture of at least three pollen and nectar-rich plants, eg clovers, vetches, birdsfoot trefoil and sainfoin to provide a long flowering period.

When to sow

March-September.

How to sow

Create a fine, weed-free seedbed, drill (1cm) and roll.



Pollen and nectar flower mix

Establishing overwintering grassy habitats

Areas of tussock-forming grasses support high densities of overwintering beetles and spiders. They provide a source of alternative prey throughout the year and are a refuge from disturbance.

Management

Little management is needed once grasses have established. To prevent herbicide drift onto sown grasses, create a sterile strip 0.5–1m wide alongside, according to agri-environment regulations. Preferably establish a **conservation headland** or flower-rich strip adjacent to the grass strip to provide alternative food and some pollen and nectar. This helps diversify the range of beneficials.

A combination of techniques also provides nesting cover and foraging habitat for farmland birds.



Beetle bank before grasses establish



Grass strip along field margin



Beetle bank and flower strip

Beetle banks

Where to sow

Divide large fields (over 20ha) with a beetle bank to ensure beneficials are present across the field as early as possible. More than one bank, spaced 200m apart across the field, may be required in very large fields. When built along contours, they can help slow down run-off.

Construction

In autumn, plough two furrows together to form a raised bank about 0.4m high and 1.5–2m wide. Leave a working gap at either end so that the field can still be worked as a single unit.

What to sow

A mixture of tussock and mat-forming grasses, eg timothy, cocksfoot, red fescue and meadow fescue. Suitable proprietary mixtures are available from most seed companies.

When to sow

Autumn (August–October) or spring (April–May).

How to sow

Hand sowing.

Grass field margins/buffer zones

Where to sow

Along hedgerows or boundaries, adjacent to flower-rich areas and alongside watercourses.

What to sow

Aim to create an overwintering habitat with a mixture of tussock and mat-forming grasses, eg timothy, cocksfoot, red fescue, meadow fescue and wild flowers. Most seed companies supply suitable proprietary mixtures.

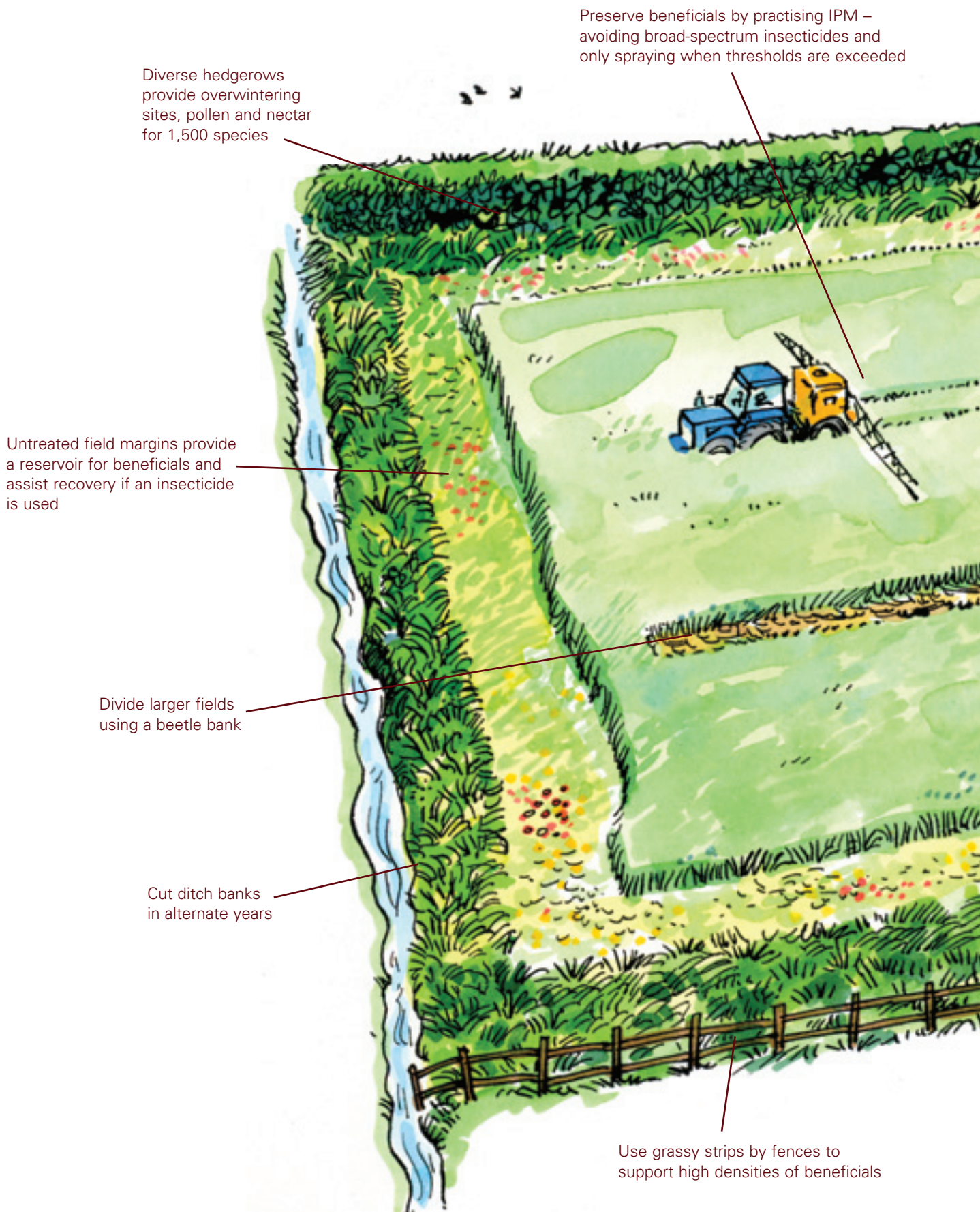
When to sow

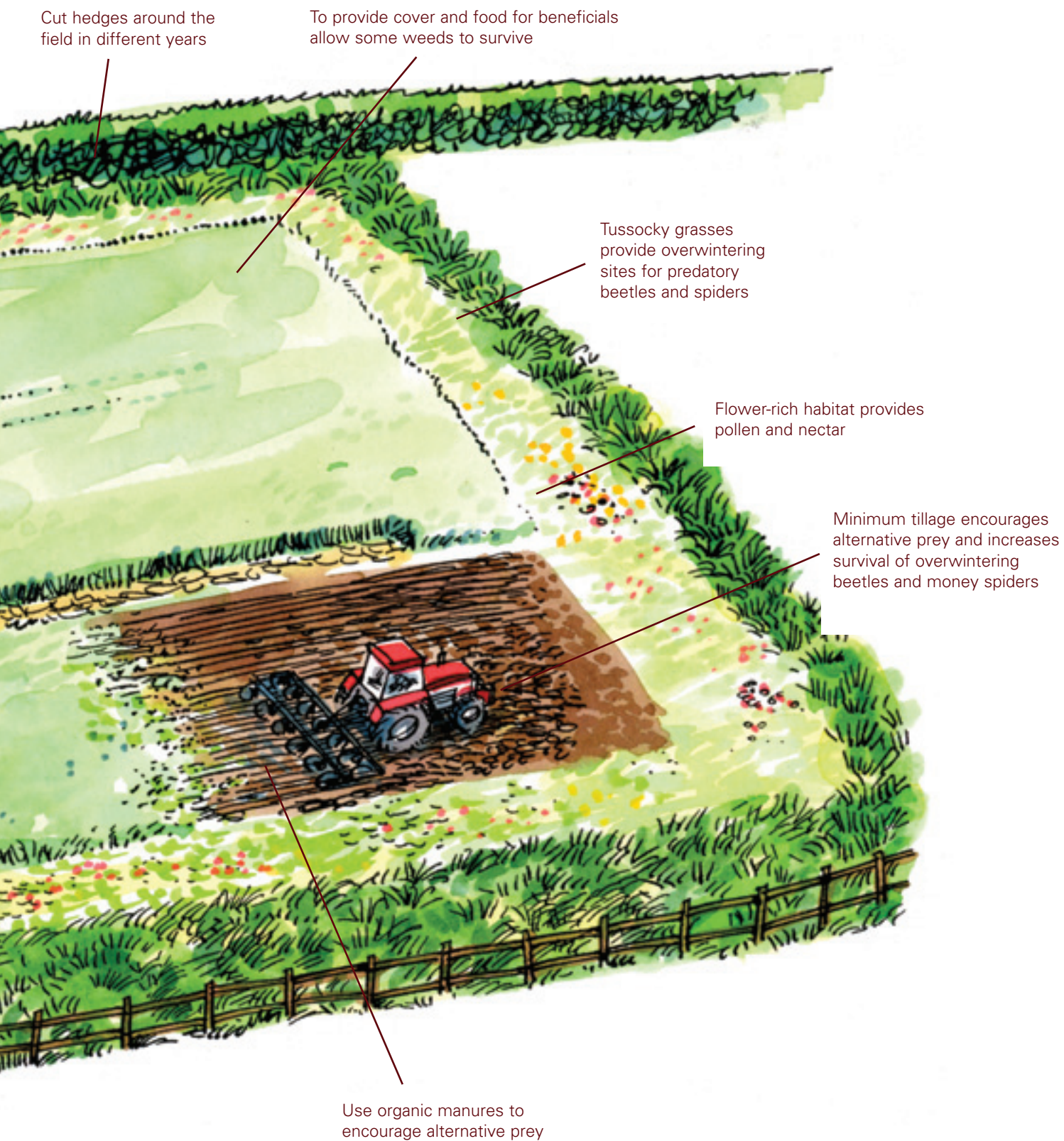
Autumn (August–October) or spring (April–May).

How to sow

Ideally drill; hand-sowing is possible.

Best practice to encourage beneficials in the field





Diverse habitats across the farm

The managed habitat created by crops and weeds influences the type and abundance of beneficials.



Further information



HGCA publications (all available from www.hgca.com)

Arable cropping and the environment – a guide (2002)

Pest management in cereals and oilseed rape – a guide (2003)

Field margins – guidelines for Entry Level stewardship in England (2005)

Orange wheat blossom midge – assessment and control (2005)

Enhancing Arable Biodiversity: Six practical solutions for farmers to enhance arable biodiversity, SAFFIE/HGCA (2007)

Topic Sheet 87 (2005) Controlling gout fly on wheat

Topic Sheet 98 (2007) Revised thresholds for economic cabbage stem flea beetle control

Topic Sheet 99 (2007) Predicting and controlling wheat bulb fly

Information Sheet 01 (2007) Controlling pollen beetle and combating insecticide resistance in oilseed rape

Project Report 173 (2004) LINK Integrated Farming Systems (a field-scale comparison of arable rotations), Volume I: Experimental work; Volume II: The economic evaluation of input decisions

Project Report 356 (2004) Managing biodiversity in field margins to enhance integrated pest control in arable crops (3-D Farming Project)

Project Report 416 (2007) The SAFFIE (Sustainable Arable Farming For an Improved Environment) project report

Research Review 64 (2007) Importance of arthropod pests and their natural enemies in relation to recent farming practice changes in the UK

Insect identification and biology

Habitat management for invertebrates (1992) (JNCC) by Peter Kirby

Insects of Britain and Northern Europe (1993) (Collins Field Guide) by Michael Chinery

Field Studies Council publications

<http://www.field-studies-council.org/publications/bycategory/terrestrial.aspx>

Online key to insect orders

<http://www.projects.ex.ac.uk/bugclub/bugid.html>

Kennedy, CEJ and Southwood, TRE (1984) The number of species of insects associated with British trees: a re-analysis. *J. Animal Ecology* 53:455-478

Insects and habitat management

Buglife

www.buglife.org.uk

Butterfly Conservation

www.butterfly-conservation.org

Game & Wildlife Conservation Trust

www.gct.org.uk

Royal Entomological Society

www.royensoc.co.uk

The Amateur Entomologists' Society

www.amentsoc.org

Agri-environment schemes

Department for Food Environment and Rural Affairs

www.defra.gov.uk/erdp/

Department of Agriculture and Rural Development Northern Ireland

www.ruralni.gov.uk/environment/countryside/schemes

The Scottish Government

www.scotland.gov.uk/Topics/Agriculture/Environment/Agrienvironment

Welsh Assembly Government

wales.gov.uk/topics/environmentcountryside/countryside_policy/farming/agri_env_schemes

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